Repairable Smartphones: How do policy targets, environmental information, emotional attachment, and socio-demographic factors influence consumers' WTP?

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Abstract

This study presents a contingent valuation experiment to identify the willingness to pay of consumers for smartphones with increased repairability. It analyses how this valuation changes when consumers are presented with environmental or government policy. It also analyses how factors such as emotional attachment and a participant's socio-demographics influence their WTP. To this end, an online survey was designed and conducted with a representative sample size of 429; 310 of these responses were valid. The results of the survey show that consumers have increased willingness to pay after viewing either environmental information or government policy information. The former bearing an increased WTP of £30 and the latter £37.73 compared to the control group. Emotional attachment is also shown to have a significant positive relationship with WTP; participants who had higher emotional attachment exhibit a higher WTP. The analysis of socio-demographic influence on WTP assesses how socio-demographic group's WTP differed from one another. For example, consumers who had high levels of education exhibited higher WTP. Furthermore, the study identifies the interaction effect when different socio-demographic groups view environmental or government policy information. It finds that BAME and unemployed respondents had negative interactions with both sets of information, causing them to reduce their WTP. Whereas older and high-income respondents increased their WTP after seeing environmental information but reduced it after seeing government policy information. These findings have important implications for policymakers and producers in understanding consumer behaviour.

Keywords: *Circular Economy; Environmental information; Policy targets; Repairability; Smartphones; WTP*

1. Introduction

In most modern societies, smartphones are ubiquitous. There are now approximately 6 billion users worldwide (Ericsson, 2022). In 2020, the UK accounted for 62.8 million of these users (Statista, 2021). By this time, greenhouse gas (GHG) emissions caused by smartphones reached 125 megatons of carbon dioxide equivalent, reflecting a 730% increase from 2010 to 2020 (Bigerna, Micheli & Polinori, 2021). Around 90% of these emissions are released during the manufacturing stage, since a significant amount of energy is required for the mining of rare and often irreplaceable elements (such as lithium) for phone batteries (Suckling and Lee, 2015; Manhart et al., 2016; Bigerna et al., 2021).

The Circular Economy (CE) aims to address problems of this nature by increasing resource efficiency, extending product life cycles and minimising waste (European Commission, 2020). This requires long-term changes in design, maintenance, repair, reuse, and recycling activities (Geissdoerfer et al., 2017). Recently, the repair movement has been gaining momentum, with countries such as France adopting stringent laws to give consumers rights over repair (BBC, 2021a). To 'repair' can be defined as the 'return of a faulty product to a condition where it can fulfil its intended use' (Cordella et al., 2021) Smartphone repairability comprises two main aspects: disassemblability and the availability of repair information. Therefore, for smartphones to be 'repairable' are required to have easily removable and replaceable batteries, displays, and back covers. Producers should provide tools and information that is easily accessible for users and professional repairers (Cordella et al., 2021).

Despite the needed structural changes, consumers' preferences and behaviours have been overlooked in the CE literature. For example, Pretner et al. (2021) have highlighted the lack of scholarship around consumers' willingness to pay (WTP) for 'circular products'. WTP can be defined as 'the maximum amount a consumer accepts to pay for a given set of goods or services' (Le Gall-Ely, 2009). It is measured by the consumer's valuation of the product for its utility (Estes et al., 2018). Research has suggested that products with fewer environmental impacts or positive environmental attributes tend to increase consumers' perceived value of the product (Biswas, 2016; Pretner et al., 2021). For circular products, this is achieved through attributes such as decreasing waste or GHG emissions (Sarti, Darnall & Testa, 2018). To elicit this increased valuation, design processes need to be adapted to incorporate aspects such as repair and remanufacture (Bocken et al., 2014).

As smartphones have widespread use globally and create high environmental costs, it is important to analyse whether smartphones with increased repairability (hereafter, repairable smartphones) elicit a higher valuation. Therefore, this paper will evaluate how information and socio-demographics can influence respondents' WTP. This will further efforts to focus scholarship on consumers within the CE, whilst generating real-world implications for governments and producers. To this end, this paper aims to answer the following questions:

i. What are consumers' WTP for repairable smartphones?
ii. What factors influence consumers' WTP for repairable smartphones? How do they do this?

This paper is structured as follows. Section 2 outlines a background on repairability in the UK. Section 3 provides the theoretical framing for the research. Section 4 describes the research methods used. Section 5 discusses the results and addresses limitations. Finally, Section 6 concludes the paper and analyses policy implications.

2. UK's Repairability movement

The UK government aims to move towards a more Circular Economy, promoting resource efficiency and minimising waste (GOV, 2020). Many of their waste policies aim towards the Circular Economy Package legislative framework of the European Union (European Commission, 2020). As shown, to varying degree, by UK Nation's policy packages such as Scotland's *Making Things Last*.

The policy landscape is quickly evolving; one area that is gaining increasing traction is repairability. In July 2021, the UK introduced 'Right to Repair' regulation aiming to extend the lifespan of large household appliances such as fridges and washing machines (GOV, 2021). Producers are required to keep spare parts in circulation even after a product is discontinued, with simple parts available to consumers and more technical parts to professional repairers (BBC, 2021b).

This move is symptomatic of a growing repairability movement, which advocates for inclusive access to repair through policy, promotion, and awareness (Rogers, Deutz & Ramos, 2021). For example, Peake et al. (2018) showed that 60% of people believe a drastic shift towards a resource efficient society is needed, even if it substantially changes the way individuals live, with only 13% opposing this notion. Currently in London, there are approximately 190 certified repair businesses (The Restart Project, 2022). Additionally, a recent YouGov (2021) poll found that 81% of people supported the government expanding 'Right to Repair' legislation to include personal electronic items such as smartphones, tablets, and laptops. This is an area where important policy shifts could occur, with consumer support.

3. Theoretical Framework

3.1. Emotional Attachment

Design for emotional attachment has been discussed as a strategy to promote product longevity; motivating users to delay replacement decisions or engage in repair and refurbishment activities (Evans & Wu, 2021; van Nes & Cramer, 2005). In this paper, emotional attachment is defined as 'the emotional bond a consumer experiences with a product' (Schifferstein & Zwartkruis-Pelgrim, 2008). Products trigger varying emotions depending on their users, making it difficult to quantify subjective and individual criteria that predict emotional attachment (Ekman, 1992). Nonetheless, Norman (2004) has developed a widely used framework to establish consumer attachment to a product based on: appearance and aesthetic appeal, effectiveness and pleasure of use, and personal satisfaction of using the product.

Positive memories, pleasure and usability have been found to be central to emotional attachment (Mugge, 2018; Page, 2014). Nostalgia was greater for older products, as sentimentality grew over time and past experiences triggered feelings of happiness. Whereas enjoyment and pleasure were the main causes for attachment towards newer items (van der Velden, 2021). In the case of smartphones, consumers' personalities could be mirrored through the choice of colours and patterns, whilst the presence of some wear and tear was connected to fond experiences (Lee & Sundar, 2015; Page, 2014). Van der Velden (2021) and Page (2014) have observed that attachment plays an important role in people's decision to repair their products, whilst high consumer-product attachment is related to higher product care and reuse (Ackermann, Mugge & Schoormans, 2018; Kunamaneni, Jassi & Hoang, 2019). Furthermore, Elsantil & Hamza (2019) have also suggested that emotions are a significant factor in determining willingness to buy sustainable products. Thus, a positive relationship between emotional attachment and WTP for repairable smartphones is expected.

3.2. Role of Environmental Information

Environmental information positively increases consumers' awareness and improves their perceptions about the effectiveness of their purchasing decision, leading consumers to purchase products with positive environmental attributes and fewer negative environmental impacts (Cerri et al., 2018). The provision of information increases perceived consumer effectiveness (PCE) (Sharma & Jha, 2017), which reflects consumers' belief in being able to affect environmental outcomes (Roberts, 1996; Hanss and Doran, 2019). Providing clear information on the environmental attributes of a product and their positive impact on the environment helps consumers quantify the real contribution towards environmental protection and contribution towards a common societal challenge through their purchase, reinforcing their PCE (Pretner et al., 2021). At the same time, clear information also limits cognitive demand, as large amounts of complex information can lead to consumers ignoring it entirely (Akcura, 2013). Additionally, motivation of a respondent may influence their WTP, as increased motivation means they are more likely to scrutinise presented information (Ajzen, Brown & Rosenthal, 1996).

Michaud and Llerena (2011) have found that consumers are not willing to pay premium prices for a remanufactured product, despite being informed about their environmental attributes. Interestingly, consumers were also less WTP for the conventional product when informed about its negative environmental impact (Michaud & Llerena, 2011). Refurbished products are also associated with a lower WTP; however, this could be mitigated with the addition of an eco-certificate, returning WTP to a similar level to the conventional product (Harms & Linton, 2016) Environmental information certified by third parties has led consumers to significantly raise their WTP for circular products (Pretner et al., 2021). For example, a Korean study found consumers willing to pay a premium for eco-labelled LED TVs (Min, Lim & Yoo, 2017). Similarly, perceived environmental benefits and awareness of refurbishing has a positive effect on consumers' purchase intention for refurbished smartphones (Mugge, Ruth, Jockin & Bocken, 2017). Therefore, the provision of environmental information could enhance consumers' perceived product value and their WTP.

3.3. Role of Policy Information

Consumers' preferences and WTP for sustainable products and services are influenced by environmental concern, functional value, social value, and generativity (Zaidi et al., 2022). However, the effects of environmental policy and targets on WTP have been mainly overlooked in the literature and merits further study.

Communicating policy effectively is a complex task, especially if there are multiple outcomes, uncertainties and long timescales (Brick et al., 2019). However, policy can make sustainable practices more feasible. Pro-environmental attitudes are more likely to turn into behaviour if they are easy to do (Gifford and Sussman, 2012). As exemplified by the popularity of the 'Right to Repair' policy, which has increased repairability accessibility (YouGov, 2021).

Targets and messaging can have important impacts on behaviour. Abrams et al. (2021) have shown that when given messaging that prompts social norms and effective outcomes, individuals are more likely to change to pro-environmental behaviour. Thus, to achieve higher adoption rates for environmental products, governments need to create stronger social norms (Ozaki, 2011). Therefore, providing consumers with a national policy target for smartphone waste reduction alongside the right to repair policy could influence their WTP.

3.4. Socio-demographic factors

Socio-demographic factors, such as age, gender, income, education level, ethnicity, employment status and number of dependents have been analysed in relation to green consumption and the adoption of environmentally friendly behaviours (do Paço, Raposo & Filho, 2009).

The relationship between age and environmental concern is contested; Roberts (1996) has suggested a positive correlation, whilst others have found a negative correlation (Klineberg et al., 1998; Mostafa, 2016). Older people (over 50 years old) have been found to keep their mobile devices for longer and are more likely to repair them (Pérez-Belis et al., 2017; Wieser & Tröger, 2018). However, Rogers et al. (2021) have indicated that whilst age is not a

significant predictor for engaging in repair activities, it could be a factor in product-specific repair behaviour.

Several studies (Pretner et al., 2021) found that participants with higher education levels are more likely to exhibit environmentally friendly behaviours. (Yin, Gao & Xu, 2014) demonstrated that respondents in China with higher education levels are also associated with higher WTP for mobile phone recycling. Similarly, Rogers et al. (2021) also found that participants with a higher education degree have a greater willingness to participate in the repair economy.

In terms of gender, females are more prone to green consumption choices (Fisher, Bashyal & Bachman, 2012) and have higher environmental concern (do Paço, Raposo & Fillho, 2009). Additionally, female respondents have shown a higher WTP for premium green products (Aguilar & Vlosky, 2007) and carbon labelled products (Mostafa, 2016). Despite the male dominance of engagement with the repair industry (Mykkänen & Repo, 2021; van der Velden, 2021) , Pérez-Belis et al. (2017), one study found that Spanish women are more likely to have small household electric and electronic appliances repaired, particularly through professional services.

The relationship between ethnic minorities and environmental awareness or consideration is also a contested one. BAME communities are associated with a lower WTP for climate adaptation (Derkzen, van Teeffelen & Verburg, 2017) and are less likely to engage in environmentally friendly behaviour, particularly African Americans when compared to Asian Americans and white people (Royne et al., 2016; Saphores & Nixon, 2014). Conversely, Klineberg et al. (1998) have contended that ethnicity does not predict the level of environmental concern, arguing that BAME communities are more concerned about environmental justice issues than White communities and are 'just as concerned' about traditional environmentalism (Lazri & Konisky, 2019). Although current research does not fully concur on the role of ethnicity in environmental purchasing trends, Hashim et al. (2018) have highlighted the scarcity of research around ethnicity and purchasing of green electronic products.

Regarding family size, research has shown that both married people (Mensah & Mensah, 2013), and parents with small children (Min, Lim & Yoo, 2017) prefer and are willing to pay a premium for eco-friendly products. In addition, both McCollough (2010) and Pérez-Belis et al. (2017) have associated larger family sizes with a higher probability to repair durable household products and small electric and electronic appliances.

Rather than employment status, most of the scholarship in this field has focused on income level. In general, high-income levels have been associated to a higher WTP for green product premiums (Aguilar & Vlosky, 2007; Yang et al., 2021), as these participants have greater disposable income. However, there seem to be regional differences: whilst Yin et al. (2014) found that higher monthly income participants have a higher WTP for waste mobile phone recycling in China, Rogers et al. (2021) did not observe any significant difference in attitudes towards repair activities between low-income and high-income participants in the UK.

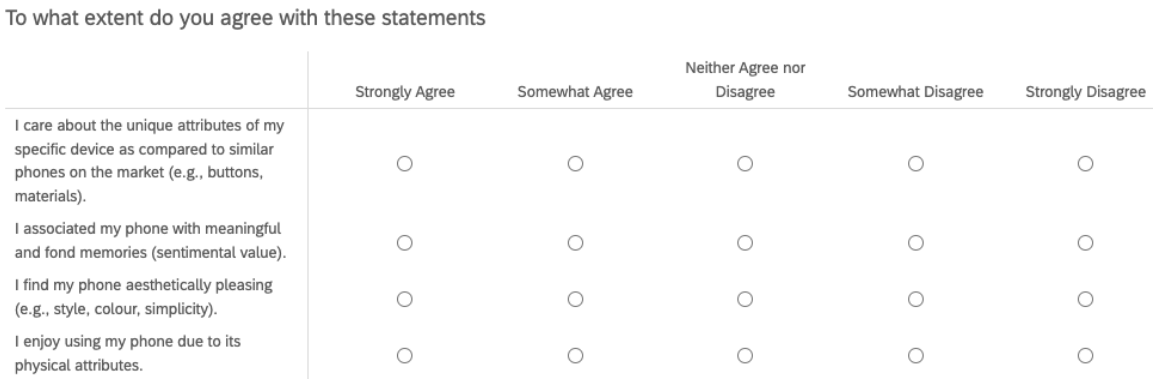
4. Research Methods

4.1. Survey design

Contingent valuation is used to determine consumers' WTP for repairable smartphones. While there is criticism around the validity and reliability of results from this method, it provides a simple and flexible nonmarket valuation that is adequate for an exploratory analysis of the research questions at hand (Venkatachalam, 2004). An online survey with 15 questions was designed in Qualtrics to investigate the research questions (Appendix I). This approach reduces both the cost and time of the design, allowing for a wide distribution whilst providing participants anonymity. However, as it is a digital platform accessibility can be limited, particularly for older participants (Van Selm & Jankowski, 2006). In addition to the valuation question, participants were asked about their emotional attachment to their phones as well as their sociodemographic information, including age, gender, ethnicity, income, employment status, education, and family size. General information about their current phone, namely the brand, the state of the phone when purchasing and the cost of the phone was also collected.

4.1.1. Determining emotional attachment

Following Norman's (2004) framework, determinants for emotional attachment included its unique utility, aesthetic attributes, association with personal memories or its enjoyment of usage (Page, 2014). To identify participants' emotional attachment to their mobile phones, respondents were asked to what extent they agreed to a series of statements (Figure 1), each attributing to one predictor of emotional attachment.


To what extent do you agree with these statements

	Strongly Agree	Somewhat Agree	Neither Agree nor Disagree	Somewhat Disagree	Strongly Disagree
I care about the unique attributes of my specific device as compared to similar phones on the market (e.g., buttons, materials).	○	○	○	○	○
I associated my phone with meaningful and fond memories (sentimental value).	○	○	○	○	○
I find my phone aesthetically pleasing (e.g., style, colour, simplicity).	○	○	○	○	○
I enjoy using my phone due to its physical attributes.	○	○	○	○	○

Figure 1. Statements to determine participant's emotional attachment to their smartphones (adapted from Page, 2014; Norman, 2004).

4.1.2. Environmental information and government policy

Initially, survey participants were given a definition of repairability and a working example, before being randomly assigned to one of the three different versions of the valuation question: control, environmental or governmental information treatment (Figure 2). Each asked the participants to select the maximum additional value they were willing to pay for a phone with

built-in repairability, considering the cost of their current phone, using a slider with the default value starting at zero. The assumption that repairability is a feature that does not require compensation was made. If participants were not willing to pay or if they chose to give a value of zero, a follow up question was given (Qcontrol) to identify the reason for this response, isolating true zeros from protest zeros.

The control question provided a benchmark WTP for repairability against the two treatments. The environmental treatment contained information on general mobile phone statistics and carbon emissions impact, including the carbon emissions benefits of extending a mobile phone's lifecycle through repair. The government policy treatment mentioned the UK government's intent on waste reduction with a realistic waste reduction target and complementary enabling policy.

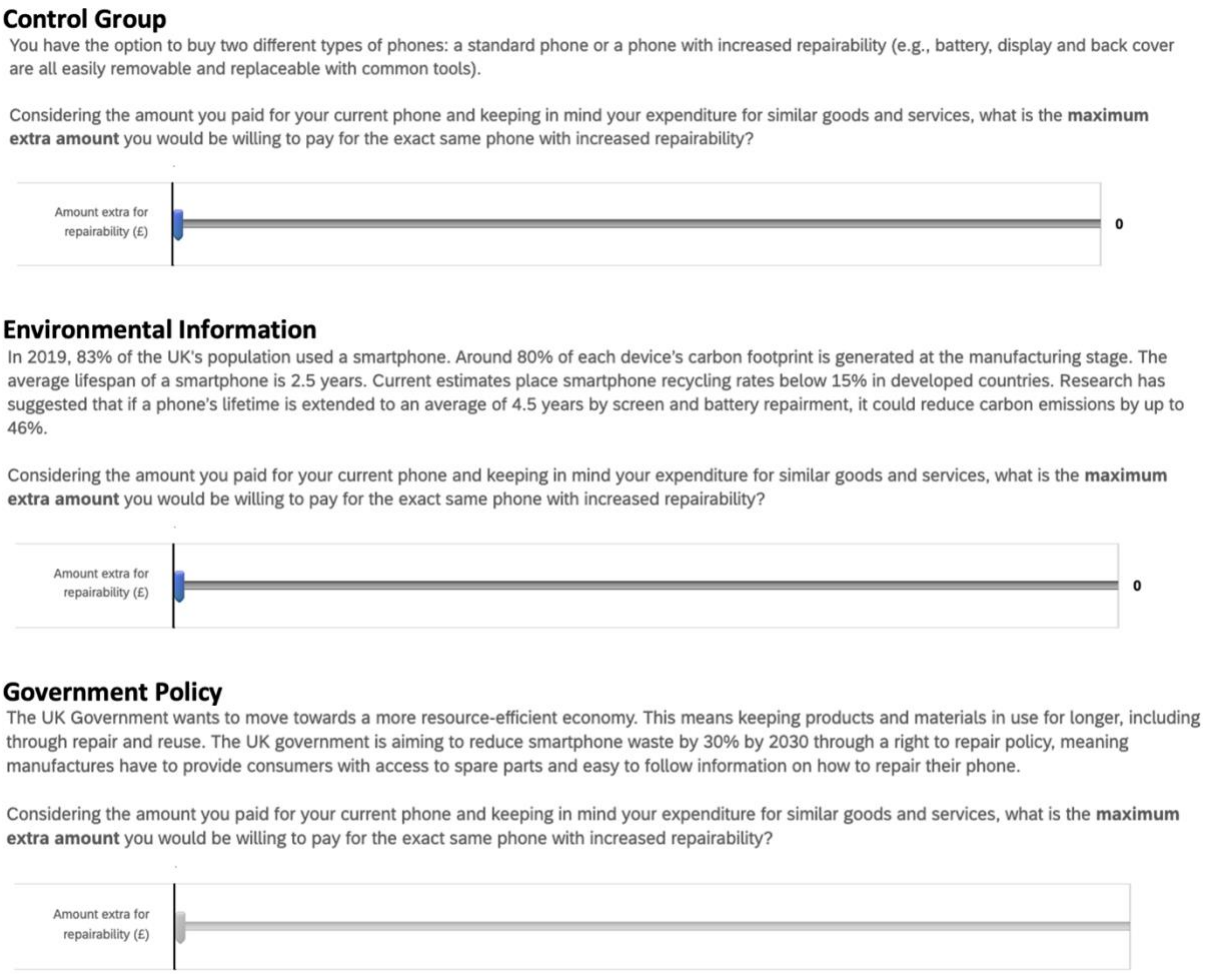


Figure 2. Experiment stimuli.

4.2. Data Sampling and Processing

The survey was distributed using snowball sampling through the authors' institutional and social networks. This network-based, convenient form of sampling was the most accessible way of collecting the largest amount of data within the research timeframe. However, this sampling method has shortcomings as it reduces the representativeness of the sample, thereby creating a biased dataset (Parker, Scott & Geddes, 2020).

The survey yielded a total of 429 responses. Data from participants who are currently paying for their phone through a contract were excluded from the analysis, as their method of payment (monthly and including cellular service) may affect the perceived value of their phone and hence, their WTP. Protest responses were isolated by answers such as “It should be the producer’s responsibility to pay” to the follow up question (Qcontrol), suggesting a value for repairability that was not expressed. These responses were excluded, along with incomplete surveys and responses from participants that did not give data consent, resulting in a total of 310 (72.3%) valid responses. Figure 3 shows valid responses were distributed almost evenly across each of the treatments.

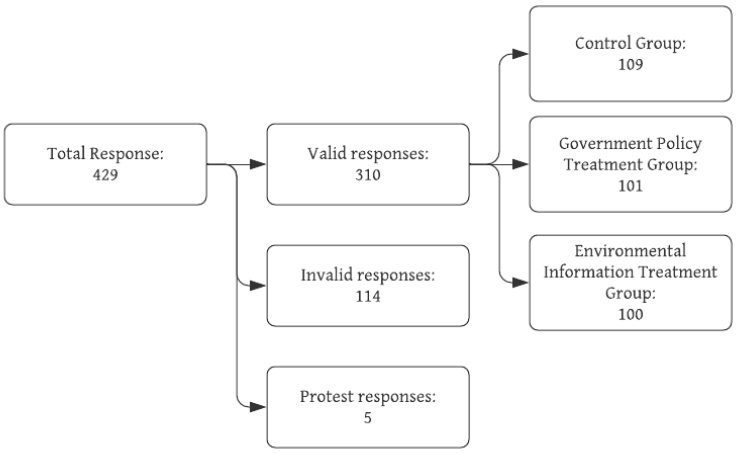


Figure 3. Total responses and distribution per survey type.

Raw survey responses were then cleaned and processed. For emotional attachment, the four Likert responses were converted to numerical data, being assigned values from 0 (*strongly disagree*) to 4 (*strongly agree*), then summed, resulting in the individual’s emotional attachment score. Table 1 presents the demographic variables and emotional attachment chosen for the regression models. Categorical values, except treatments, were converted into binary based on chosen cut-offs. The binary cut-off for income level was based on the UK median and mean household income (Office for National Statistics, 2021a), whilst the age and education cut-offs were chosen to evenly split the data set. The emotional attachment cut-off threshold was determined through experimentation (see Section 5.2). Jupyter lab with Python3 was used for data cleaning and analysis.

Table 1. Regression variables - data type, baseline category, binary cut-off, and binary baseline category.

Variable	Data Type	Baseline	Binary cut-off	Binary Baseline
WTP value	numerical	N/A	N/A.	N/A
Treatment	categorical	Control	N/A	N/A
Emotional attachment	numerical	N/A	13	Low
Age	categorical	18-24	Age 45 and above	Young
Gender	categorical	Female	Female/Male	Female
Ethnicity	categorical	White	White/BAME	White
Income	categorical	Below £10k	£40k and above	Lower income
Education	categorical	Master's degree	Master's and above	Bachelor's and below
Family Size	categorical	No dependants	Have dependents	No dependant
Employment	categorical	In full-time employment	Employed/ unemployed	Employed
Original phone cost	numerical	N/A	N/A	N/A

OLS regressions represented by Equations (1-3) are applied to create WTP estimations. Subscript i represents the individual responses, interested coefficients are represented by β and control variables are represented with the γ coefficient. All regressions control for the individual's reported original phone cost. Our first model regresses the reported WTP of individuals on all non-baseline binary sociodemographic variables and emotional attachment, as described in Equation 1:

$$WTP_i = \alpha + \beta_1 TreatmentEnv_i + \beta_2 TreatmentGov_i + \beta_3 Ethnicity_i + \beta_4 Gender_i + \beta_5 Age_i + \beta_6 Income_i + \beta_7 Employment_i + \beta_8 FamilySize_i + \beta_9 Education_i + \beta_{10} EmotionalAttachment_i + \gamma PhoneCost_i + \epsilon_i \quad (1)$$

To further investigate the influence of emotional attachment on the reported WTP of individuals, a regression model with just the emotional attachment as the independent variable is applied, described in Equation 2:

$$WTP_i = \alpha + \beta_1 TreatmentEnv_i + \beta_2 TreatmentGov_i + \beta_3 EmotionalAttachment_i + \gamma PhoneCost_i + \epsilon_i \quad (2)$$

To explore the heterogeneous treatment effects, estimations were made from regression models with interaction variables for each demographic variable of both treatments (represented below β_4 and β_5), while using the rest of the variables as control (Equation 3):

$$WTP_i = \alpha + \beta_1 TreatmentEnv_i + \beta_2 TreatmentGov_i + \beta_3 Demographic_i + \beta_4 Demographic_i * TreatmentEnv_i + \beta_5 Demographic_i * TreatmentGov_i + \gamma_1 PhoneCost_i + ...\gamma_{n-1} Variables_i + \epsilon_i \quad (3)$$

4.3. Sample characterisation

4.3.1. Phone ownership trends

Most participants are Apple iPhone users (60%), followed by Samsung Galaxy users (20.3%). The rest of the respondents are split between brands, such as Google, Huawei, Motorola, and OnePlus, which aligns with broader UK market data (StatCounter, 2022). Also, most participants bought their phone outright and in a brand-new state. Only 13% of respondents purchased a refurbished phone. Generally, participants who chose 'other' in either of these questions were gifted their phone by friends or family.

Table 2. Summary of general phone brand, ownership and state.

Category	Description	Total	Percentage
Phone Brand	Apple (iPhone)	186	60.0%
	Samsung (Galaxy)	64	20.6%
	Google (Pixel)	11	3.5%
	Other	50	16.1%
Phone Ownership	Bought outright	240	60.0%
	Bought on contract (fully paid)	49	15.8%
	Other	21	6.8%
Phone State	Brand New	257	82.9%
	Secondhand – Manufacturer Refurbished (e.g.Apple)	15	4.8%
	Secondhand – Private Seller (e.g. eBay)	15	4.8%
	Secondhand – Third-party retailer refurbished (e.g. CEX, BackMarket, GiffGaff)	15	4.8%
	Other	8	2.6%

4.3.2. Socio-demographic variables

Regarding socio-demographics, there is an overrepresentation of Asians in the sample (30.2%) compared to the 2011 UK census, where approximately 7.8% of respondents classified themselves as ethnically Asian (UK Gov, 2020). Correspondingly, there was an underrepresentation of other ethnic groups, such as White and Black individuals. In addition, the overall sample had a large proportion of participants with at least one higher education degree (86.5%), which is highly uncommon for a UK sample. The 2011 UK census list 27% of the UK population as being educated at Level 4 or above (i.e., higher degree, professional qualifications or equivalent) (Office of National Statistics, 2013). Moreover, there is an underrepresentation of those in full-time employment and those earning less than £40,000 (before tax), whilst participants without dependents are overrepresented in the sample.

Table 3. Socio-demographic characterisation of the sample.

		Qty	Proportion
Ethnicity	White	176	56.6%
	Asian or Asian British	94	30.2%
	Arab	17	5.5%
	Mixed	12	3.9
	Black or Black British	7	2.3%
	Other, prefer not to say	8	2.6%
Age	Under 18	5	1.6%
	18 - 24	111	35.7%
	25 - 34	91	29.3%
	35 - 44	37	11.9%
	45 - 54	29	9.3%
	55 - 64	32	10.3%
	65 or older	5	1.6%
Gender	Female	167	53.7%
	Male	132	42.4%
	Non-binary / third gender	5	1.6%
	Prefer to self describe	4	1.3%
	Prefer not to say	3	1.0%
Education	Primary school	6	1.9%
	Secondary school	8	2.6%
	Further education (16+)	21	6.8%
	Undergraduate	115	37.0%
	Master's degree	125	40.2%
	Doctoral degree	29	9.3%
	Other, prefer not to say	6	1.9%
Employment	In full-time employment	146	46.9%
	In full-time education	81	26.0%
	Not in employment	41	13.2%
	In part-time employment	25	8.0%
	Self employed	18	5.8%
Income	Less than £10,000	54	17.4%
	£10,000 - £19,999	27	8.7%
	£20,000 - £29,999	39	12.5%
	£30,000 - £39,999	47	15.1%
	£40,000 - £49,999	32	10.3%
	£50,000 - £59,999	21	6.8%
	£60,000 or more	31	10.0%
	Prefer not to say or not sure	57	18.3%
Family Size	No dependents	221	71.1%
	1 dependent	29	9.3%
	2 dependents	42	13.5%
	3 dependents	13	4.2%
	4 dependents	5	1.6%
	5 dependents or more	1	1.6%

5. Results and Discussion

5.1. General Discussion

The sample generated an average WTP of £106.91 for a smartphone with increased repairability. Both the environmental and government policy treatments exhibit higher WTP when compared to the control group (Figure 4). On average, respondents were willing to pay 28.7% of their original phone cost for a repairable smartphone, with respondents primed with governmental information willing to pay 37.9% of their original phone cost.

A 2018 European Commission's study (Cerulli-Harms et al., 2018) reported a WTP of 48-98€ (app. £40-82) for increased repairability of smartphones. Independent-sample t-tests were conducted to compare both study results, showing that the difference between our findings and the 2018 study is statistically significant. This increase in WTP could be justified by an increase in awareness of repairability and CE practices (van Langen et al., 2021), by spatial factors (e.g., EU-wide study *vs* UK-based study) and by market factors such as an increase of the global average of smartphone selling prices around 5% annually since 2016 (StatInvestor, 2021).

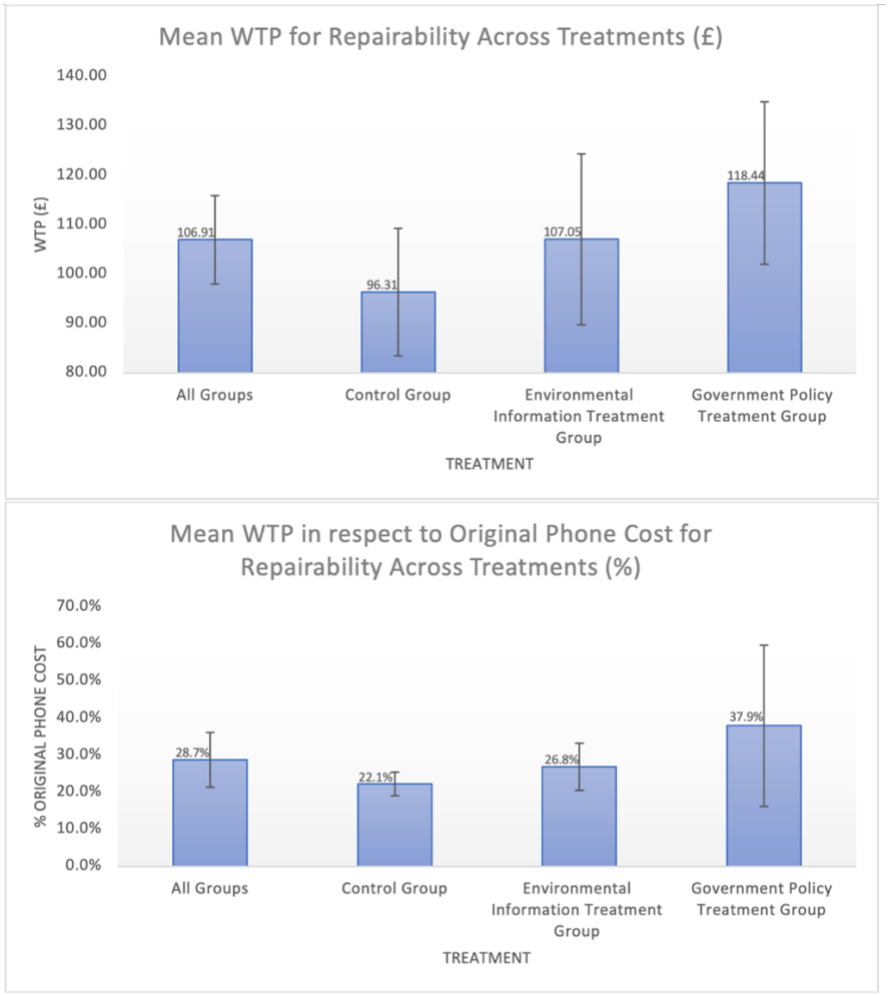


Figure 4. Summary results of average WTP for repairability - absolute values and percentage of original phone cost (95% confidence interval).

5.2. Emotional attachment

The consumer-product emotional attachment is subjective and varies between consumers and product categories (van Nes and Cramer, 2005). Participants' emotional attachment to their smartphones was measured through their level of agreement with four statements around physical attributes, aesthetics, positive memories, and enjoyment in using their devices, varying between 0 (*no attachment*) and 16 (*very high attachment*). To transform emotional attachment into a categorical variable (*low or high attachment*), an initial cut-off at the average score of 8 was considered for high attachment (Figure 5).

When considering an emotional attachment score of 8, the WTP for repairable smartphones is approximately £26 higher than the WTP for the baseline group (*low attachment*). The WTP steadily decreases for emotional attachment scores between 9 and 12 with all confidence intervals including zero. Thus, it is uncertain that a cut-off point between scores 9 and 12 is an accurate representation of change in emotional attachment. For emotional attachment scores of 13 and higher, a significant positive relationship between WTP and emotional attachment is observed, indicating that emotional attachment has an effect on the WTP. Based on this analysis, a cut-off emotional attachment score of 13 was defined as the basis for *high attachment*.

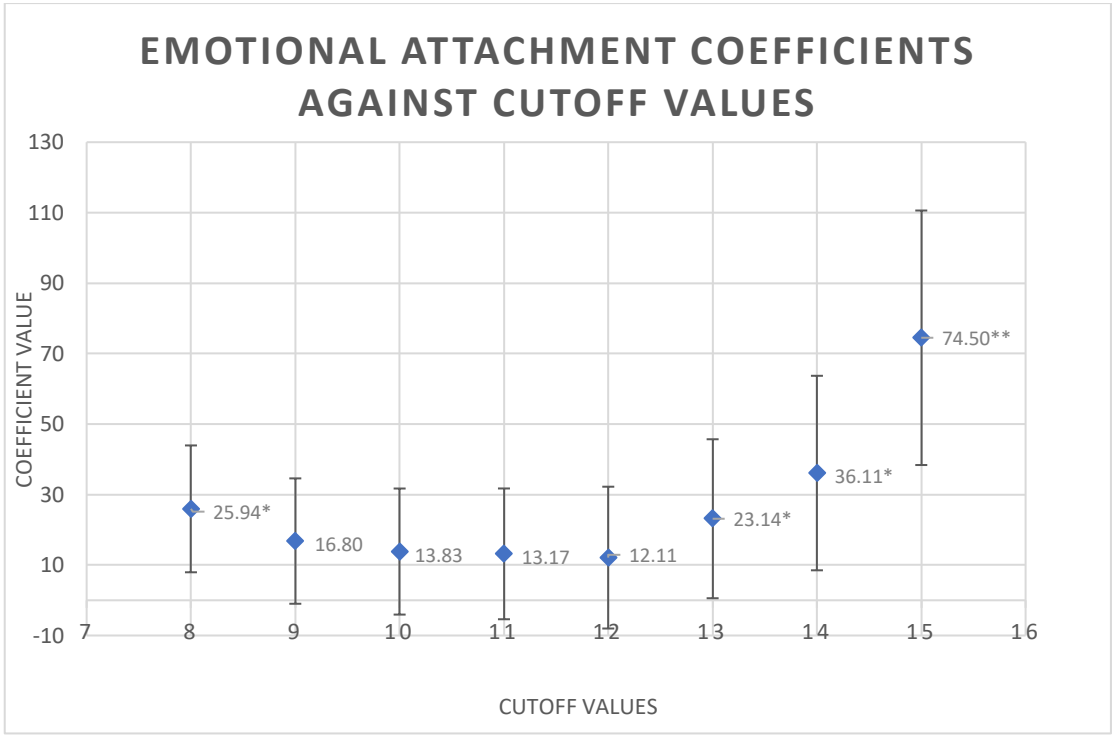


*Figure 5. Emotional attachment coefficients from models with increasing cut-off values (*p<=0.95, **p<=0.99).*

Table 4 shows the effect of high emotional attachment on consumers' WTP. A significant positive relationship between high attachment and WTP is observed, where participants with high emotional attachment are more likely to pay £23 more than participants with low consumer-product emotional attachment. This suggests that high attachment participants have a higher perceived intrinsic value of their smartphones, leading to an increase of their

WTP. These findings corroborate what has been previously reported in the literature around emotional attachment and repair (Page, 2014; van der Velden, 2021). However, although respondents with a high emotional attachment have a higher WTP, it is not possible to predict whether participants will engage in repair activities.

Table 4. Effect of emotional attachment on WTP from equation 2 (p<=0.05).*

Category	Sub-category	Coefficient
Emotional Attachment	High	£23.14*

Table 5 shows the interaction effect of both information treatments on high emotional attachment participants compared to its relative baseline group. Participants with low emotional attachment, when primed with environmental information, are willing to pay £12 more than participants with high emotional attachment who were given the same information. Similarly, participants with low attachment are also willing to pay approximately £26 more than high attachment participants when primed with government policy information. Therefore, the effect of both environmental and government policy information is higher on respondents with lower emotional attachment. This may be because high emotional attachment individuals already attribute more intrinsic value to their phones generating a higher WTP irrespective of additional information. Whereas those who do not already associate intrinsic value with their phone are more primed by the additional information.

Table 5. Interaction effect of treatments on WTP of participants with high emotional attachment as compared with low emotional attachment.

Category	Sub-category	Environmental Coefficient	Government Coefficient
Emotional Attachment	High	-£12.07	-£25.79

5.3. Information treatments and Socio-Demographics variables

Table 6 shows the WTP for all binary socio-demographic variables and both information treatments (detailed results in Appendix II). Participants primed with environmental information are likely to pay £30 more than respondents from the control group. Providing environmental information, in this case carbon emission reduction due to battery repair and smartphone lifecycle extension, has allowed participants to understand the environmental attributes of the product, quantifying its contribution towards environmental protection and thus reinforcing their PCE (Roberts, 1996; Hanss and Doran, 2019). Additionally, environmental information has increased consumers' perceived value of repairable smartphones, thereby leading to an increase in their WTP.

Interestingly, respondents primed with policy target information are likely to pay around £37 more for a repairable smartphone than participants from the control group, representing a 25.7% increase in the WTP between information treatments.

*Table 6. Effect of treatments and socio-demographic variables on WTP (**p<=0.01).*

Category	Sub-category	Coefficient
Treatment	Environmental Info	£30.00**
	Government Policy	£37.73**
Ethnicity	BAME	£3.00
Gender	Male	-£3.32
Age	Age 45 and above	£4.16
Education	Master's and above	£15.95
Employment	Not employed	£12.85
Income	£40,000 and above	£1.81
Family Size	Have dependents	£1.99

Regarding socio-demographics, all binary variables have a positive and statistically non-significant relationship with WTP, except for gender. BAME participants are likely to pay £3 more for repairable smartphones than white respondents. The non-significant relationship between ethnicity and WTP suggests that ethnicity is not a good predictor of WTP, and other factors associated with these communities, such as education and income level, may have a higher effect on WTP. Similarly, gender is a non-significant predictor of WTP, even though females in the sample have higher WTP which is in line with current literature (Mostafa, 2016; Pérez-Belis et al., 2017).

Education level and employment status are the variables most likely to increase WTP when compared to the respective baseline groups. Participants with a Master's degree and above are willing to pay around £15 more than participants with lower levels of education, in agreement with findings from Yin et al. (2014), McCollough (2010) and Rogers et al. (2021).

Surprisingly, unemployed respondents are willing to pay around £13 more than employed respondents. This can be explained by the overrepresentation of full-time students in the sample (included in the 'not employed' category). Most students in the sample are studying environment-related subjects, thus having a high environmental concern and preference for products with fewer negative environmental impacts. These factors are likely to lead to a higher perceived value of repairable smartphones, increasing their WTP; 'full-time students' are willing to pay £36 more for a repairable smartphone than 'in full-time employment' respondents. Income has a positive relationship with WTP, however its effects on WTP are negligible, as high-income earners are likely to pay £2 more than participants in lower income levels.

Older participants have a higher WTP for repairable smartphones than younger respondents, confirming findings from Wieser and Tröger (2016) and Pérez-Belis et al. (2017). Nonetheless, the relationship between age and WTP is not linear. Respondents 35-44 years old have the highest WTP compared to participants in the baseline group (18-24 years old), willing to pay around £48 more for a repairable smartphone. This is an expected result, given that most participants in this age group are employed with an annual disposable income approximately £7,000 higher than those aged 18-24 years old (Office for National Statistics, 2021b). However, 45-54 year old respondents were willing to pay £6 less than the baseline group despite having the highest disposable income in the UK (on average £42,850 per year) (Office

for National Statistics, 2021). Interestingly, in a recent YouGov (2021) poll, 82-86% of the participants aged 45-54 years old supported the expansion of the right to repair policy in the UK to cover small electronic equipment (e.g., smartphones). Therefore, their lower WTP is not indicative of the undesirability of built-in repairability features, but rather reflects their unwillingness to incur the costs for this feature.

In terms of family size, participants with one dependent are willing to pay £23 more than participants without dependents, respondents with two or more dependents have a lower WTP than participants without dependents, a result which is not in line with the findings of recent literature (Mensah & Mensah, 2013; Min, Lim & Yoo, 2017). This could be explained by this group having less disposable income available to pay for a premium for products with environmental attributes.

5.4. Socio-demographic effects on treatments

The information treatments had varying effects on socio-demographic group's WTP. Whilst these findings are not indicative of every individual in a group, they can provide useful insights into decision-making profiling. Table 7 shows the interaction effect of the treatments on a socio-demographic group compared to its relative control group. For example, the first row shows men's WTP after interaction with a treatment, relative to women's WTP.

*Table 7. Interaction effects of treatment with socio-demographic variables (*p<=0.05, **p<=0.01).*

Category	Sub-category	Environmental Coefficient	Government Coefficient
Gender	Male	-£14.54	-£26.840
Ethnicity	BAME	-£46.05*	-£40.94*
Age	Age 45 and above	£17.38	-£22.49
Income	£40,000 and above	£33.84	-£25.22
Employment	Not employed	-£77.59**	-£30.31
Family Size	Have dependents	£11.41	£2.27
Education	Master's and above	-£34.36	-£38.51

Differences in ethnicity, employment and education created strong interaction effects. BAME respondents were willing to pay £46 less after seeing the environmental treatment, compared to white respondents, which was statistically significant. While the literature on ethnicity and environmental concern is contested, there might be potential explanations specific to the current UK context. For example, direct interaction with nature has been suggested to increase environmental concern (Hausbeck, Milbrath & Enright, 1992; Palmer, 1993). However, BAME individuals have on average eleven times less access to greenspaces and only 20% of BAME children visit the countryside in the UK (CPRE, 2021). Thus, it could be a factor contributing to lower WTP after viewing environmental information, relative to White respondents.

Unemployed respondents also had a statistically significant interaction effect with the environmental treatment. Their WTP after viewing the environmental treatment was £76 lower

than employed participants, reflecting a large interaction as unemployed people had an overall higher WTP (see Section 5.3). This can be explained by the overrepresentation of environmental students in the unemployed group. Environmental students are expected to have a higher awareness about environmental costs of smartphones, meaning that the given information elicits a much weaker response compared to employed people. This may also explain why respondents with high education levels are willing to pay £34 less after viewing the environmental treatment, relative to those with lower education.

BAME, unemployed and high education respondents also showed decreased WTP relative to their control demographic after viewing the government policy treatment. There is not significant literature on the potential causes of this. However, Gifford and Sussman (2012) identified that there might be important psychological barriers that prevent pro-environmental behaviours after positive messaging such as the perception of financial or social risk. Participants with dependents showed a £2 higher WTP after viewing the government treatment, relative to those without. While this is a negligible result, those with dependents showed a £11 higher WTP after viewing the environmental treatment, which might be associated with concerned for their children's wellbeing and future (Min, Lim & Yoo, 2017).

To a lesser extent, gender also generated differences in response to the treatment. Men's WTP was £14.54 lower than women's after seeing the environmental treatment. Most studies have found women to show higher levels of environmental concern than men (do Paço, Raposo & Fillho, 2009). Therefore, as the given treatment had information to prompt environmental concern it may have elicited a larger response in women. However, men's WTP was also £26.84 lower after seeing the government treatment, relative to that of women, indicating that there are other compounding factors influencing their WTP.

Interestingly, differences in age and income generated entirely different responses between the treatments. Older participants have an increased WTP of £17 when shown the environmental treatment, relative to younger respondents. This supports the notion that age, and environmental concern are positively correlated (Roberts, 1996), contrary to other studies (Pretner et al., 2021). However, this may be due to the younger respondents in our sample having prior environmental knowledge and less disposable income. This interaction is mirrored and amplified for high income earners, relative to lower income earners as they are willing to pay £34 after viewing environmental information. This may be because increased disposable income means information can be responded to more generously.

However, older people and high-income earners had reduced WTP after viewing the government policy information, relative to younger people. Older people are WTP £22 less than younger people after viewing the government policy information. High-income earners have a stronger interaction effect as they are willing to pay £25 less relative to lower-income earners. Without further research, it is difficult to pinpoint what causes this shift in valuation. However, Hine and Gifford (1991)suggested that for environmental messaging to be well received it is important for it to tap into an individual's mental model, as feelings of personal and collective responsibility are key to determining environmental attitudes and behaviours (Kaiser & Shimoda, 1999; Kaiser et al., 1999). In terms of voting trends, young people in the UK strongly identify with political parties that promote collective responsibility. Whereas older people tend to associate with personal responsibility parties (Curtis, 2019), which may

translate into reactions to national targets that encourage social norms around collective responsibility.

5.5. Study limitations and Future research

This study has some limitations that present avenues for future research. Firstly, the size of the sample was small, with approximately 100 valid responses per survey type. Secondly, the overrepresentation of ethnic minorities and educated respondents means that it would be desirable to shift from the snowball sampling to random and quota sampling, as well as increase sample size in future research. Thirdly, there is risk associated with the provision of environmental and governmental policy information. For example, it is uncertain that the information supplied was read and understood by all respondents before they provided their WTP, as it is not possible to limit individual cognitive demand. Future research could also include the length of ownership and frequency of use (Schifferstein & Zwartkruis-Pelgrim, 2008) as part of the framework for emotional attachment; including these factors would further strengthen the prediction of emotional attachment.

The survey did not allow responses from consumers leasing their smartphones or currently in contract with their mobile service providers. These schemes raise several implications surrounding questions of repairability for repair and their impact on WTP merits further research. There is also a need to further understand the effects of warranties and brand repair services (e.g., AppleCare) on consumers' WTP for repairability. Additionally, the authors recommend examining the impact of providing both policy targets and environmental information together on WTP.

Finally, focusing on specific demographic groups would allow for more resolute conclusions than this work permits. Whilst speculation can be made about reasons for a particular socio-demographics interaction with the treatments, it will be important for future research to establish the main drivers for such responses. More specifically, it would be interesting to identify the role of government policy and government targets on WTP in isolation.

6. **Conclusion and Policy Implications**

This paper analysed consumers' WTP for increased smartphone repairability and how WTP is affected by sociodemographic and emotional attachment factors, and by the provision of environmental and government policy information.

Demand for increased repairability and its incorporation into government policy is rising in the UK, partially attributable to a growing environmental concern. This study has found that consumers are willing to pay more for repairable smartphones, after being presented with concise environmental information. Consumers also have strong positive response to government policy information and targets, raising their WTP further. Certain socio-demographic groups respond to the treatments in slightly different ways. Whilst this study cannot pinpoint the reasons of such differences, it presents an opportunity for future research. Therefore, the findings provide the building blocks to inform environmental policymaking and communication. Additionally, this study has the potential to be grounded into the wider trend of the Circular Economy, as it demonstrates the need of understanding consumer behaviour to a greater extent to benefit policy provision.

This research has important implications for both policymakers and producers. Current waste is often a by-product of producers wanting to fend their market share through selling more phones. This study demonstrates that consumers are willing to pay an increased price for repairable smartphones, thus signalling to smartphone manufacturers that higher costs associated to producing repairable goods might be compensated through higher product prices. This price has the potential to be raised further if policymakers and producers can produce clear environmental information. Additionally, collective repair policy and targets can also be used to increase product prices. Targeted advertising can be used to ensure information that elicits a large response in a particular demographic group. If successfully carried out, producers do not have to sacrifice their profits or market share and governments can achieve their aims on e-waste and GHG emissions reduction. The authors recommend the active and continuous engagement between policymakers, producers, and consumers.

WORD COUNT: 6900 words

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Appendix I - Complete survey questionnaire

Please see next page

Appendix II – Expanded model and results for consumers' WTP on all non-baseline categorical sociodemographic variables and emotional attachment

$$WTP_i = \alpha + \beta_1 TreatmentEnv_i + \beta_2 TreatmentGov_i + \beta_3 Ethnicity_i + \beta_4 Gender_i + \beta_5 Age_i + \beta_6 Income_i + \beta_7 Employment_i + \beta_8 FamilySize_i + \beta_9 Education_i + \beta_{10} EmotionalAttachment_i + \gamma PhoneCost_i + \epsilon_i \quad (4)$$

	coef	std err	t	[0.025	0.975]
treatment_env	22.1926	10.079	2.202	2.349	42.036
treatment_gov	28.7063	10.075	2.849	8.869	48.543
ethnicity_BAME	3.9515	10.642	0.371	-17.002	24.905
gender_Male	-11.7245	8.872	-1.321	-29.193	5.744
age_25 - 34	14.0464	11.06	1.27	-7.73	35.823
age_35 - 44	46.5549	18.08	2.575	10.957	82.153
age_45 - 54	-7.3935	19.488	-0.379	-45.763	30.976
age_55 - 64	21.0319	19.175	1.097	-16.722	58.785
age_Over 65	30.7755	41.167	0.748	-50.276	111.827
age_Under 18	-93.4357	43.417	-2.152	-178.917	-7.955
education_Doctoral degree	-0.5621	17.005	-0.033	-34.043	32.919
education_Further education (16+, A-Levels, BTEC, etc.)	8.3667	17.818	0.47	-26.715	43.448
education_Primary school	129.7378	39.358	3.296	52.247	207.229
education_Secondary school (up to 16 years)	65.326	31.564	2.07	3.18	127.472
education_Undergraduate degree	8.7507	9.947	0.88	-10.834	28.335
employment_status_In full-time education	35.9602	11.932	3.014	12.468	59.453
employment_status_In part-time employment	37.607	17.335	2.169	3.477	71.737
employment_status_Not in employment	9.6715	15.55	0.622	-20.944	40.287
employment_status_Self employed	-23.057	20.1	-1.147	-62.631	16.517
income_¬£10,000 to ¬£19,999	10.603	16.134	0.657	-21.163	42.369
income_¬£100,000 to ¬£149,999	39.2173	35.475	1.105	-30.628	109.063
income_¬£150,000 or more	134.9584	40.764	3.311	54.701	215.216
income_¬£20,000 to ¬£29,999	27.8779	14.613	1.908	-0.893	56.649
income_¬£30,000 to ¬£39,999	22.6331	14.604	1.55	-6.119	51.385
income_¬£40,000 to ¬£49,999	6.1734	16.525	0.374	-26.361	38.708
income_¬£50,000 to ¬£59,999	7.6204	19.625	0.388	-31.018	46.258
income_¬£60,000 to ¬£69,999	11.3332	29.5	0.384	-46.748	69.415
income_¬£70,000 to ¬£79,999	52.0014	34.822	1.493	-16.558	120.561
income_¬£80,000 to ¬£89,999	42.0825	35.481	1.186	-27.775	111.94
income_¬£90,000 to ¬£99,999	20.4937	49.793	0.412	-77.542	118.529
family_size_1	23.6667	16.638	1.422	-9.092	56.425
family_size_2	-10.1085	16.081	-0.629	-41.77	21.553
family_size_3	-35.8463	26.426	-1.356	-87.876	16.184
family_size_4	-4.5043	35.16	-0.128	-73.73	64.721
family_size_5 or more	-261.8488	91.894	-2.849	-442.774	-80.923
emotional_attachment_high	11.4638	11.772	0.974	-11.714	34.641
phone_cost	0.087	0.015	5.984	0.058	0.116