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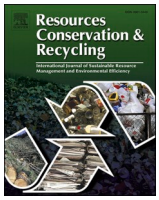

Full length article

Marketing strategies for refurbished products: Survey-based insights for probabilistic selling and technology level

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ABSTRACT

The selling of refurbished products is considered a sustainable practice for businesses looking for strategies to improve their market image. However, companies still struggle to sell refurbished products for different reasons ranging from consumer's attitudes towards refurbished products to in-efficient pricing policies adopted by remanufacturing and manufacturing companies due to the lack of understanding of the actual market of refurbished products. This impacts the profitability of the remanufacturing industry on a large scale. This paper aims to discuss the importance of understanding the market of the refurbished product and the role of consumer purchase behavior. With an emphasis on the refurbished cellphone market, this study has run a survey analysis to test several hypotheses about consumer's viewpoint toward refurbished electronics and identify marketing strategies that may benefit promoting the sale of refurbished consumer electronics in the market. The survey analysis results suggest that consumers' willingness to pay for refurbished cellphones depends on the degree of the technological obsolescence of the product. Consumer's willingness to purchase refurbished cellphones is higher for more technologically obsolete products. Also, the use of probabilistic selling or opaque selling might be a good strategy for selling refurbished products. Therefore, companies may consider using opaque selling as a marketing strategy since consumer choice decisions would change when dealing with an uncertain deal or probabilistic deals.

1. Introduction

The desire to maintain market leadership as well as factors such as scarcity of resources, extended producer responsibility, pressure from society, consumers, and competitors force businesses to consider different sustainable practices strategies, among them selling refurbished products. For example, in the consumer electronics market, selling refurbished products has received some attention from the industry as most recently, more consumers from developing regions are entering the market. To this end, companies who embrace selling refurbished products as a sustainable practice have started creating a positive market image. However, there are still issues remaining at a large scale for the marketing of refurbished products.

For various business and market image concerns, many Original Equipment Manufacturers (OEMs) also would instead enter the refurbished electronics market themselves rather than allowing third-party remanufacturers to refurbish their products and sell them to the market. For example, a recent agreement between one of the biggest e-commerce websites in the US and an OEM has restricted third parties to sell OEM-branded refurbished products on the e-commerce website, where only authorized-refurbishers by the OEM can offer their products on the website (Kan, 2019). Also, most OEMs started implementing product take-back programs to encourage consumers to return their used electronics to their original OEM in exchange for money or discount for their future purchases. Therefore, it seems that the marketing of refurbished products is of interest to both OEMs and third-party remanufacturing companies.

While selling refurbished products is important to both OEM and remanufacturers (Liu et al., 2018), our understanding of the refurbished electronics market is limited. Consumer's willingness to purchase refurbished products and their attitude towards refurbished products require further research. While recent studies have investigated the

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impact of price on consumer's intention to purchase refurbished products (Pisitsankkhakarn and Vassanadumrongdee, 2020; Chen et al., 2020; Hamzaoui-Essoussi and Linton, 2014) and predicted market demands of refurbished products by utilizing data mining approaches (Van Nguyen et al., 2020), (Netoa and Dutordoira, 2020), little attention has been given to identifying novel marketing strategies that can help manufacturers explore selling refurbished products as a business line.

To this end, the main objective of this study is to capture consumer's attitudes towards purchasing refurbished cell phones and identifying new marketing strategies that may help OEMs and refurbishers in better marketing of used electronics. With a particular focus on investigating the possibility of using opaque or probabilistic selling in the context of refurbished products, over 200 people have been surveyed to provide insights on three hypotheses related to the consumer's attitude towards refurbished products and identifying proper marketing strategies.

The remainder of this paper is structured as follows. Section 2 reviews the literature. Section 3 discusses the survey study. The hypotheses and results are discussed in Section 4, and finally, Section 5 concludes the paper and provides directions for future research.

2. Background and related work

The literature related to this work can be classified into three major groups: the importance of the refurbished products market, the consumer purchase behavior, and theories for understanding consumer pro-environmental behavior.

2.1. The importance of refurbished products market

The world's population is generating more waste and consuming more resources than ever. In the most recent survey (conducted by the United Nations), 2.3 million people from all countries, genders, education levels, and age groups were asked to vote on the top priorities for improving the world. Surprisingly, the environment (action was taken on climate change) was ranked the lowest among the 16 available options (My Analytics 2014). A look at the consumer electronics market reveals the depth of the problem. The e-waste generated globally reached a new maximum of 41 million tons in 2014 with an increasing rate of 3 to 5% a year (Kumar et al., 2017). Among the e-waste, obsolete cell phones play a pivotal role. Factors such as technological innovation and the pursuit of fashion drastically reduced the life expectancy of cell phones (Liu et al., 2019). The life expectancy of mobile phones dropped from 2.9 years in 2011 to 2.21 years in 2018. Besides technological innovation, the high cost of repair and the lack of sufficient infrastructure push many consumers to just replace their failed products with new ones instead of getting them repaired. The not-repair decision of consumers may result to 331 million dollars revenue loss for manufacturers over a period of five years (Sabbaghi and Behdad, 2018).

In addition to consumers, businesses all too often treat the environment and waste-based externalities arising from production as a secondary consideration. Indeed, even when product design and manufacturing processes are implemented in a sustainable and resource-efficient way, the manner in which products are often promoted, which encourages overconsumption, can be problematic.

The concept of promoting and educating consumers to be more mindful or 'conscious' of how purchases affect other people, the planet, and, as a result, limiting purchases to what is truly needed is recognized as "conscious consumerism." For example, consider the domain of new products. Often the cost of a new product is more than just the price of the item (e.g., there are hidden costs to both people and the environment). A greater focus on environmental sustainability can make people more conscious about these hidden costs of their new product purchases and cause them to seek out alternatives (such as refurbished goods). Although the cost of a refurbished product is less than that of a new product, consumers frequently underestimate the cost differential in this regard (i.e., the true value of a refurbished product).

Although there might be some quality-related risks when it comes to buying refurbished electronics, one reason why consumers ignore such products has to do with the "refurbished" label itself (Gåvertsson et al., 2018). Generally, purchasing refurbished products do not involve a higher level of risk related to faulty components for new products. In some cases, the refurbished products maybe even more reliable since the product has been tested already, and faulty components have been replaced (Abbey et al., 2017). Refurbished products can originate from different sources, including consumer returns and canceled orders, damaged items, overstocked inventory, and products that have been featured in stores for demonstration, shows, and fairs. Hence, a refurbished item, especially when it comes to consumer electronics, does not necessarily mean used or of poor quality. It just cannot by law be referred to and sold as a brand-new product. We should note that there are some misconceptions about the terms 'refurbished' and 'remanufactured.' Refurbished is defined as restoring a device to an acceptable working condition, while remanufactured is a process of returning a used device to the original state, like-new condition, and often giving the resulting device a warranty at least equal to that of a newly manufactured equivalent (Reike et al., 2018).

Very little literature research, however, has explored consumer choices toward purchasing refurbished products and the proper marketing strategies. Moreover, not enough research has been done on identifying the innovative strategies for selling refurbished products at the time of this writing.

2.2. Consumer purchase behavior

Consumer behavior is a very complex and diverse field of study. The American Marketing Association defines consumer behavior as "the dynamic interaction of affect and cognition, behavior, and the environment by which human beings conduct the exchange aspects of their lives." (Bennett, 1998). Most published studies in this field are done by marketing researchers who vary considerably in their objectives and methods. The three major objectives of studying consumer behavior are: understand consumption and its meanings, describe consumer decision-making, and predict consumer choices (Fig. 1).

Different methods and techniques, ranging from interviews and focus groups to simulation and analytical models, have been employed to achieve those objectives (Peter et al., 1999). Among different types of behavior, consumer purchase choices and pro-environmental behavior are the focus of this project.

Human purchase behavior increasingly influences the sustainability of our planet, both directly through the extraction of materials and

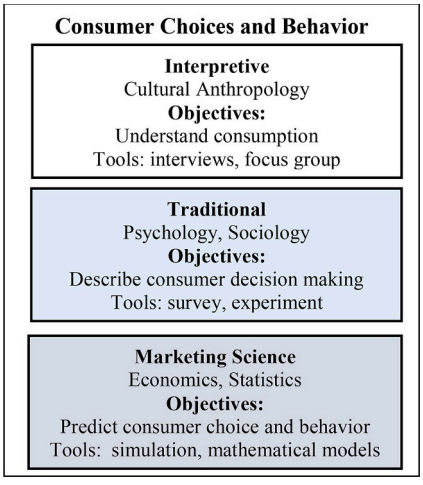

Fig. 1. Available approaches to assess consumer behavior across a broad range of disciplines (summarized from (Clarke, Jun. 2004) (MacInnis and Folkes, 2010)).

indirectly through the creation of unpleasant consumption culture and future changes in the market demand of unnecessary products (Gilg et al., 2005), (Staats - MSE 301 McGill). Roozmand et al. (Roozmand et al., 2011) suggested that consumer purchasing behavior is affected by the culture at a macro-level and by personality at a micro-level. Generally, understanding consumer purchase behavior is a complicated issue. This is because decision making consists of many interconnected aspects (such as knowledge, attitudes, values, demographic information, product features, market conditions) that need to be considered while making a purchase decision (Kobayashi et al., 2007), (Yada et al., 2004), (Xiaojing Yang et al., 2007). Consumers' purchase behavior becomes even more complicated when we expect consumers to consider the environmental aspects of their decisions.

2.3. Theories of understanding consumer pro-environmental behavior

Overall, two types of theories exist for analyzing consumer pro-environmental behavior: psychological theories and economic theories.

The focus of psychological theories is mainly on linking internal or psychological variables (such as motivation, environmental knowledge, attitude, value) to behavior. However, the focus of economic theories is on external conditions (such as income, price, and socioeconomic characteristics) (Wiles et al., 2010).

Most of the economic theories are based on the assumption that consumers are rational decision-makers (Liu, 2010); for example, they make decisions based on maximizing their expected utility. Some studies have experimentally tested consumers' willingness to pay for environmental products. Veisten (May 2007) used a survey-based approach and choice-based conjoint analysis to measure consumers' willingness to pay for eco-labeled wood furniture. Vlosky et al. (1999) suggested that there are positive correlations between consumers' willingness-to-pay and their environmental consciousness, concluding that environmentally conscious consumers were willing to pay more for environmentally friendly products. In another study, Laroche et al. (2001) showed that around 13 percent of respondents were willing to pay a higher price for green products. However, unlike green and/or energy-efficient products, refurbished products are offered at a lower price in the market, and, in some cases, purchasing refurbished items will reduce the environmental burden. However, consumer attitudes toward purchasing refurbished products may not be the same as their attitude towards green products (i.e., brand new products with pro-environment features).

A literature review of the previous studies reveals that existing environmental behavior research has employed various traditional, rational theories from both psychology (e.g., Theory of Planned Behavior and Theory of Reasoned Action) and economic (e.g., maximizing expected utility), to describe the eco-behavior of consumers. However, in order to fully capture the exact behavior of consumers, the current environmental behavior theories should be integrated with 'bounded rationality' theories. The first step in implementing such an approach is to analyze the consumer's viewpoint towards refurbished products.

A considerable number of survey studies have investigated consumer's green attitudes by using questionnaires and statistical analyses. Table 1 summarizes several samples of them and the type of analytical models they have used to analyze and interpret the collected data. The studies have focused on various types of green behavior and used a wide range of methods such as descriptive statistics, hypothesis testing, confirmatory factorial analysis, and regression analysis (Varela-Candamio et al., 2018; Mostafa, 2007; Norton et al., 2015; Mainieri et al., 1997; Tanner and Kast, 2003; Kim and Choi, 2005; Chan, 2001; Jansson et al., 2010; Finisterra do Paço and Raposo, 2010; Griskevicius et al., 2010; Y. Wang et al., 2018). In the current study, besides descriptive statistics, we use machine learning techniques to further analyze the survey data.

2.4. Consumer intention to purchase refurbished products

Consumer' behavior in purchasing refurbished products as an eco-behavior has been the point of attention in the literature. The behavior in purchasing refurbished products is affected by a wide variety of factors. Studies suggest that consumers' perceived quality affects their intention to purchase refurbished products. van Weelden et al., Feb. 2016) highlighted the importance of a distinctive and positive image of refurbished products in consumer acceptance. Gaur et al. (2015) also discussed factors such as societal norms, price, and demographics on the behavioral intentions of consumers. Mugge et al. (2017) discussed the influence of awareness and the incentives that guarantee continued performance on purchase intention. Chen et al. (2020) highlighted that consumers pay more attention to price than environmental protection. Y. Wang et al. (2018) empirically studied the consumers' preferences towards remanufactured products in terms of green and price attributes. They concluded that consumers' greenness attributes strongly correlated with the purchase of remanufactured products. Also, when the discount for remanufactured products increases, consumers' preference increases. However, a steeper discount causes distrust and hence weakens the consumer preference. Mhatre and Srivatsa (Mhatre and Srivatsa, 2019) also described the difference in the

Table 1
Results from various journal papers about Green Behavior.

Reference	Objectives	Data Collection Method	Region	Analysis Methods
(Varela-Candamio et al., 2018)	Impact of education on green behavior	Survey	Spain	Descriptive Statistics, Factorial Analysis.
(Mostafa, 2007)	Impact of cultural values and psychological factors on green purchase behavior	Survey	Egypt	Descriptive Statistics, Confirmatory Factorial Analysis, Hypothesis Testing
(Norton et al., 2015)	Factors influencing employee green behavior	Literature review	–	Iterative multistage approach
(Mainieri et al., 1997)	Impact of awareness, environmental beliefs, attitude, and demographic on buying behavior	Survey	–	Hierarchical Multiple Regression Analysis
(Tanner and Kast, 2003)	Factors influencing green consumption	Survey	Switzerland	Correlation and Regression Analysis
(Kim and Choi, 2005)	Impacts of collectivism, environmental concern and perceived consumer effectiveness on green purchase	Survey	–	Structural Equation Modeling
(Chan, 2001)	Impacts of cultural and psychological factors on green purchase behavior	Survey	China	Descriptive Statistics and Hypothesis Testing
(Jansson et al., 2010)	Impacts of values, beliefs, norms, and habit on consumers' willingness to adopt eco-innovation products	Survey	Sweden	Descriptive Statistics and Regression Analysis
(Finisterra do Paço and Raposo, 2010)	identify distinct market segments of green and regular consumers based on environmental factors	Survey	Portugal	Multivariate Statistical Analysis
(Griskevicius et al., 2010)	Impact of altruism signals on green purchase behavior	Focus Group	–	Hypothesis Testing, ANOVA
(Y. Wang et al., 2018)	Factors influencing consumer perceived value and purchase intention	Survey	China	Hypothesis Testing, Structural Equation Modeling

purchase intention of two groups of consumers including millennial and Generation X consumers, in buying refurbished cellphones in India. Pisitsankkhakarn and Vassanadumrongdee (Pisitsankkhakarn and Vassanadumrongdee, 2020) also explored the key drivers to enhance the consumer demand for the remanufactured products with a focus on the consumers' willingness to purchase auto parts and concluded that attitude and subjective norm plays a vital role in purchase intention. Long et al. (2019) investigated the optimal recycling and remanufacturing decisions of manufacturers by considering the heterogeneity of consumer's willingness to pay for remanufactured products. Singhal et al. (2019) concluded that consumers' purchase intention is affected by marketing strategies along with other factors. Van Nguyen et al. (2020) carried out a data mining approach to predict customer demand for remanufactured products.

Consumer behavior towards the refurbished product is complex and unique as besides attitude, subjective norms, product-related and price-related attributes (Pisitsankkhakarn and Vassanadumrongdee, 2020), factors such as quality concern, negative feelings, and loss aversion biases may influence consumer's behavior towards purchasing refurbished products. In these situations, behavioral economics guides us to different solutions. In making decisions such as whether to purchase a refurbished product or not, we have to rely on the underlying theory, possibly an unstated one about the product and its consequences. This performs the 'mental model' of consumers. No matter how effective a refurbished product is, it is critical to identify small behavioral interventions that can have unreasonable significant effects. While the primary focus of prior studies was mainly on identifying factors that influence purchase intention, the focus of this study is to shed light on possible marketing strategies such as probabilistic selling on helping consumers make purchase decisions.

The objective of this study is to test several hypotheses related to the sale of refurbished cellphones in the market with the ultimate purpose of understanding consumer's viewpoints toward accepting refurbished products.

We should mention that there is a stream of literature focused on determining price and the volume of products that manufacturers should refurbish to maximize their profits (Behdad and Thurston, 2011; Ferrer and Swaminathan, 2006; Kwak and Kim, 2013; Mitra, 2007). Studies have used different optimization and simulation models to examine the optimality condition with the primary purpose of determining the operations and production planning of remanufacturing products with no consideration of consumer intention to purchase refurbished products. Besides, a significant number of studies have addressed the reverse logistic aspect of remanufacturing and addressed decisions related to the number of remanufacturing facilities, their location, and product flows between them (Sasikumar et al., 2010; Rezapour et al., 2015; Govindan et al., 2015).

3. Survey design

To identify the possibility of using probabilistic selling as marketing strategies, we have conducted a survey study to capture the stated behavior of potential consumers. To better organize the objective of the survey, we have presented the objectives in terms of the hypothesis. After survey data is collected, we have used conventional statistical analysis and, in some cases, machine learning techniques to further analyze and interpret the results. Hypothesis testing is widely used in the scientific community to present research objectives and corresponding data collection needs. As we are testing the impact of old technology, probabilistic selling, and consumer's perspective about refurbished mobiles through a survey, the hypothesis is a helpful method to state the research objectives.

The survey has been developed and employed to examine basic propositions with respect to the influence of consumers' attitudes toward refurbished products and product features on purchase intentions for both used and new products. This activity will evaluate the relative importance of various factors (e.g., lower price, favorable or unfavorable appraisal of refurbished products, individuals' perception of purchasing refurbished products, technological obsolescence, type) in consumer decisions (intention) to purchase refurbished products versus a brand new product. The survey consists of several questions to understand why consumers may or may not purchase refurbished products. The survey used a set of close-ended questions (e.g., scales, multiple-choice) to collect quantitative assessments as well as information offered by respondents, which can be used to interpret the data better. It should be noted that some information included in the questions, such as some cellphone prices, are assumed values.

The survey was conducted through google forms in November 2018. The target participants were students. The focus of the study was on students as the young generation who might be willing to have access to the most recent technology, but on the other hand, due to their budget limitations, their willingness to pay a high price might be lower. Therefore they are potential consumers of refurbished products. A total of around 600 students have been invited to participate in the survey. Of these, around 38% responded to the survey. After removing the outliers , 227 responses have been collected to test three different hypotheses and run several predictive analyses. Approximately 66% of the respondents are using Apple cell phones, and the rest are Android users.

To avoid the non-response bias, we have tried to keep the survey short, only covering seven questions that take about 5–7 min to respond. Also, we sent two reminders to encourage students to respond to the survey.

The student sample is used as an approximation of the young generation population who may consider buying refurbished products. While the sample size of 227 is limited, it is compatible with the previous studies that addressed refurbished product markets (Mugge et al., 2017), (Harms and Linton, 2016). Besides, although the sample size was limited, narrowing down the scope of analysis to students enables us to alleviate the impact of other confound factors such as income, age, and market segments that exist in a general population.

4. Hypotheses and results

The description of the hypotheses and their corresponding survey questions are described in this section.

Hypothesis 1: **Regardless of price, there is always a fraction of the market who are not interested in purchasing refurbished products.**

At the beginning of the survey, the following question has been asked from respondents to approximate the percentage of individuals who do not have a positive perception of refurbished products.

Q1. *If you are in the process of purchasing a new cellphone, but suddenly received a notification that you could potentially purchase a cellphone with the excellent/almost-new condition while only paying the price of a refurbished cellphone, would you be intrigued to learn more?*

The question is framed such that it assures consumers that the quality of the product will be like-new condition while the price is affordable and lower than new products. However, still, 22% of respondents are not interested in learning more about refurbished products. We could consider this group as those who do not have a positive perception of refurbished products and do not consider purchasing refurbished products, regardless of the product price and like-new condition.

Fig. 2 shows the scatter plot of the consumer willingness to learn about refurbished products (yes or no, 1, 0) and their current cellphone price and age.

In addition, as shown by Guide et al. (Guide V Daniel R and Li, 2010) there is always a fraction of the market whose perception of remanufactured products is somehow dirty and not-positive and will not proceed with purchasing remanufactured products, no matter what would be the price. Therefore, hypothesis 1 is already supported by the literature.

Putting the above-mentioned fraction of the market aside, we would

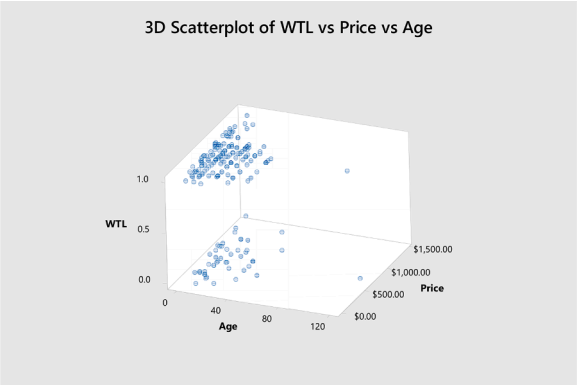

Fig. 2. Consumer willingness to learn (WTL) about refurbished products versus their current product age and price.

like to focus on the fraction of the market that may consider purchasing refurbished products for different reasons such as affordable prices, environmentally conscious decisions, among other factors.

It is not an invalid assumption to assume that the main reason for selecting refurbished products is their affordable price. The following two questions have been asked from respondents. The product targeted in these questions is the most recent version of the smartphone (most recent technology) with the highest price in the market.

To further investigate whether "consumers' willingness to learn about refurbished products" can be predicted by using their current cellphone attributes such as brand, age, and price, we have used several machine learning techniques including Random Forest (hereafter RF), Support Vector Machine (SVM) and Logistic Regression. While statistical analyses can help in parameter inference and interpreting models, machine learning tools perform better when it comes to prediction and interpreting decisions. Therefore, we use several basic prediction and classification models in this study to show the value of machine learning tools in predicting consumer decisions and classifying them based on data collection activities. The Python library Scikit learn is used for the analysis.

RF is a kind of decision tree. The difference is that it has a forest of trees, i.e., having more than one individual tree, unlike a decision tree. Thus, the prediction is based on the majority vote of the trees in the random forest for the classification predictions. Unlike RF, which can be used for both regression and classification problems, SVM and Logistic Regression are mainly used for classification problems. SVM tries to create a boundary to separate the different classes and maximize the gain. Logistic Regression is mainly used for modeling one binary dependent variable against one or more independent variables.

The survey dataset is divided in to test and train dataset. The training dataset consists of 80% of the data and the test dataset contains the remaining data. The data are picked randomly for both train and test datasets. As the collected data includes a variety of brands, we grouped low count brands into one category named 'Others' to help improve the prediction accuracy.

The initial Exploratory Data Analysis (EDA) is carried out using NumPy, pandas, seaborn, and matplotlib libraries. The histogram is plotted to identify the distribution. Box plot and scatter plot is used to identify the outliers. The identified outliers are removed to improve accuracy.

The consumers' willingness to learn about refurbished products (Q1) is modeled with data regarding their current cellphone brand, age, and price. First, the Logistic Regression classifier is tried, which yields 45% prediction accuracy. Second, the Random Forest classifier is used, which yields 80% prediction accuracy. Third, the Support Vector Machine is used, and it yields a prediction accuracy of 78%. Thus, Random Forest has clearly outperformed Logistic Regression and slightly better than the Support Vector Machine. The one more advantage of Random Forest when compared to SVM is that its prediction accuracy is based on Brand and Age attributes, unlike SVM whose prediction accuracy is based on all the three attributes. Decreasing attributes in SVM decreases the prediction accuracy. The results are further improved by finding optimal value for the parameters through optimization techniques.

Also, hyperparameter optimization (HPO) was used to improve the performance of machine learning techniques. Random Forest has many parameters that control the learning rate. RandomizedSearchCV is used instead of GridSearchCV to reduce computation time. The parameters which on tuning yielded good results are max_depth and n_estimators. The maximum depth that the tree can go is given by max_depth and n_estimator gives the number of trees in the random forest. The max_depth is assigned with a start and stop value of 1 and 50, respectively. The n_estimator is assigned with the start value of 1 and an end value of 100. Then the parameters are passed into the RandomizedSearchCV to find the optimum value. The analysis yields a value of 5 for max_depth and 20 for n_estimator. Thus, these values are applied to the RandomForestClassifier function, and prediction is carried out. The rest of the parameters are set to default values. The resulted model yielded a prediction accuracy of 85%.

Table 2 summarizes the accuracy of prediction of Q1 using three different classification techniques and three different attributes of brand, cellphone age, and price. The results show that RF is the top-performing technique for prediction of consumer's willingness to learn about refurbished products using the cellphone's age and brand.

Q2. *As of Nov 2018, the iPhone X costs $999 (64GB, unlock). Suppose that you want to purchase an iPhone X. Which of the following option would you select?*

- *Pay $999 and receive a new iPhone X*
- *Pay $699 and receive a refurbished iPhone X*

Q3. As of Nov 2018, the iPhone X costs $999 (64GB, unlock). Suppose that you want to purchase an iPhone X. *Which of the following option would you select?*

- *Pay $699 and receive a refurbished iPhone X*
- *Pay $799 and with some chance, you receive a refurbished iPhone X and with some chance, you receive a new iPhone X.*

The responses to Questions 2–4 are listed in Table 3.

The responses to Q3 was insightful, in which most of the respondents (56.5%) would rather purchase a refurbished product (priced $699) rather than paying an extra $100 (price $799) in which with some chance they receive a new iPhone and with some chance they receive a refurbished one. The price of a new product is set based on the market price on the e-commerce website at the time of conducting the survey. The price of the refurbished option was set $100 lower than the new product based on the general price gap between refurbished and new products for several previous models of iPhones. We should note that the prices are intentionally set, such that there is no significant difference between both options to see how important it is for consumers to avoid refurbished products. We should note that our assumption was that $100 might not be a significant price difference; in this case, however, for some consumers, it may be significantly different.

Table 2
Result Summary.

	Classification Method		
	Random Forest	Support Vector Machine	Logistic Regression
Predictive Variables	Brand, Age	Brand, Age, Price	Brand, Age, Price
Accuracy (%)	80	78	45
Accuracy after HPO (%)	85	_	_

Table 3
The survey responses to Questions 2–4.

	Q2	Q3	Q4
Model	iPhone X		
Release date	2018		
Price of new product (as of Nov 2018)	$999		
Price of a refurbished product	$699		
% who buy new	**40.7%**		**31%**
% who buy refurbished	**59.3%**	**56.5%**	**42.6%**
% who pay $799 and with some chance receive a refurbished product and with some chance a new one		**43.5%**	**26.4%**

Looking at Q2 and Q3 shows that in Q3 purchasing new products is no longer an option. Therefore consumers who would like to avoid purchasing refurbished products would naturally select the second option, which covers 43.5% of the responses.

Hypothesis 2: **Probabilistic products can change consumers' local choice context, therefore probabilistic selling can improve the brand's profit for refurbished products.**

Probabilistic selling or opaque selling is a type of sale in which the sales outcomes or product featured are not displayed to buyers until after the payment is made. The probabilistic selling has been widely used in booking hotels and travel deals. In this study, we would like to test the feasibility of employing the concept of probabilistic selling in the market of the refurbished product and studying the business outcomes of adopting such a policy for sellers of both refurbished and new products. To test the possibility of adopting probabilistic selling in the market of the refurbished product, we have asked Q4 in the survey and tried to compare the obtained results with the result of Q2.

Q4. *As of Nov 2018, the iPhone X costs $999 (64GB, unlock). Suppose that you want to purchase an iPhone X. Which of the following option would you select?*

- *Pay $999 and receive a new iPhone X*
- *Pay $699 and receive a refurbished iPhone X.*
- *Pay $799 and with some chance, you receive a refurbished iPhone X and with some chance, you receive a new iPhone X*

Comparing the results of Q4 and Q2 shows that almost 30% of users are interested in purchasing a probabilistic deal. In the case of refurbished products, the results suggest that consumer overweigh the quality of a new product, so are more willing to pay for a probabilistic deal that may result to a new product than a deal in which they purchase a refurbished product with lower price. There might be other reasons such as avoiding refurbished products at any cost due to loss aversion bias or the impacts of buyers' previous purchase experience.

The insight derived from this analysis is that the probabilistic case can change the consumer's local choice. In fact, consumers overweight the quality of the product and the probabilistic deal and increase their willingness-to-purchase of the probabilistic product. In Q2, almost 40% of customers are interested in purchasing new products, while 60% are interested in refurbished products. When the third option is offered to consumers in which they can pay $100 more than ($799) a refurbished product deal ($699) and receive a probabilistic deal, around 20% out of %60 will decide to move forward with the probabilistic deal. An important insight of this simple question is that the probabilistic products can change consumer's choice.

This confirms the first hypothesis that consumers do not have a positive perception of refurbished products and would rather pay more with the hope of receiving new products. This will open an opportunity for the sellers of both refurbished and new products to adopt the probabilistic selling as a strategy for offering new and refurbished products simultaneously and the point that consumers pay more for probabilistic deals than for purchasing refurbished products.

In Q2, Q3, and Q4, there is no mention of manufacturer warranties provided on the new and the refurbished mobile. The product is only stated as a "refurbished iPhone X." It should be noted that the responses could have been different if the users were informed who the refurbisher was and what warranties were provided with the purchase. Therefore, depending on prior experience of users, buying a defective product from a third party refurbisher or buying from an OEM refurbished product with a warranty, consumers may have different intentions to purchase refurbished products. For example, previous studies have shown that prior experience of users in repairing electronics by OEMs or the third party will influence their decision to repair by either party (Sabbaghi and Behdad, 2017).

Hypothesis 3. ***The older is the technology, the higher is the chance of purchasing refurbished products compared with new products.***

To test this hypothesis, the following questions have been included in the survey.

Q5. *Suppose that you want to purchase an iPhone 7. Which of the following option would you select? The features of each option are listed in* Table 4.

- *Option A*
- *Option B*

Now, we would like to provide some further descriptive statistics of the survey data. Table 5 provides the basic statistics of the cellphone price and product age reported by the respondents. The average price is $593.7, and the average age is 17.61 months. The mean is within the price range of Options A and B in Q5. Both price and age have a low Coefficient of Variation (CV), which can be derived from the standard deviation and the mean.

Q6. *As of Nov 2018, the 64GB iPhone 5scosts $399. Suppose that you want to purchase an iPhone 5s. Which of the following option would you select?*

- *Pay $399 and receive a new iPhone 5s,*
- *Pay $119 and receive a refurbished iPhone 5s.*

Table 6 shows the results of Questions 5 and 6. As can be seen, iPhone 7 was released to the market in 2016, while iPhone 5s was released to the market in 2013 and is considered old technology.

In the case of iPhone 5s, the price of iPhone 5s is lower than iPhone X (released in 2018). Still, around 69% of individuals mentioned their willingness to purchase refurbished iPhone 5s compared to the new one. Since the price of the product is not a big concern for this version of the iPhone, the willingness of consumers can be attributed to the point that iPhone 5s is pretty old technology, and consumers would rather not invest in purchasing new versions and instead of purchasing refurbished one. In addition, comparing the% of consumers who are willing to purchase refurbished products is increased as we move from iPhone 7 to iPhone 5s. The Minitab analysis also supports that people are more likely

Table 4
Features of Option A and Option B.

	Option A	Option B
	Apple iPhone 7	Apple iPhone 7
Price	$649	$349
Battery Life	10 h	7 h
Weight	0.3 oz	0.3 oz
Operating System	iOS	iOS
Color	Rose Gold	Rose Gold
Item Dimension	5.44 * 2.64 * 0.28 in	5.44 * 2.64 * 0.28 in
Screen Size	4.7 in	4.7 in
GSM	Unlocked	Unlocked
Condition	New	Certified Refurbished
Customer Rating	4.6 out of 5 stars (119 reviews)	3.5 out of 5 stars (876 reviews)

Table 5
The descriptive statistics of price and product age.

Variable	Mean	SE Mean	StDev	Min	Max
Price ($)	593.7	20.4	296.3	0.0	1459.0
Product Age (months)	17.61	1.09	15.77	0.10	120.00

Table 6
Individual responses on purchasing iPhone 5s (older technology with a lower price).

	Q5	Q6
Model	iPhone 7	iPhone 5s
Release date	2016	2013
Price of new product (as of Nov 2018)	$649	$399
Price of refurbished product	$349	$119
% of individuals who buy new	**49.5%**	**30.6%**
% of individual who buy refurbished	**50.5%**	**69.4%**

to answer in a similar manner for both Q5 and Q6. They are statistically significant, with the P-value of less than 0.001.

Brand owners can extend this analysis further to identify the best time to stop offering new products to the market and instead offer refurbished ones.

However, we should note that if we compare the responses to Q2, Q5, and Q6, we get interesting insights that although consumers are more likely to go with refurbished options in the case of older technology, the price is an important factor that may change their decision for the case of newer technology. For example, comparison of Q2 (iPhone X) and Q5 (iPhone 7) shows that 60% of students will select refurbished option when decide to purchase iPhone X, while only 50% of them select refurbished option when they decide to purchase iPhone 7, and the reason simply might be the high cost of the most recent technology. Therefore, there is a breakeven point for the price that simply push consumers towards purchasing refurbished options. Fig. 3 summarizes the survey responses for different questions and cellphone models.

4.1. Participation in give-back programs

In addition to the above-mentioned question, we have added one question about respondents willingness to participate in a take-back program for returning back their used cellphone to gage their level of willingness to receive a discount when they upgrade their devices as well as their willingness in bringing back their products for future reuse and refurbishment.

Q7. *Apple Giveback program offers money for trade of your used Apple products. You may trade in your eligible device for aStore Gift Card or a refund on your purchase. For example, as of Nov 2018, the iPhone X costs $999 (64GB, unlock) and* the trade-in*program offers* max *$500 for your used iPhone X. Are you interested in using the trade-in program?*

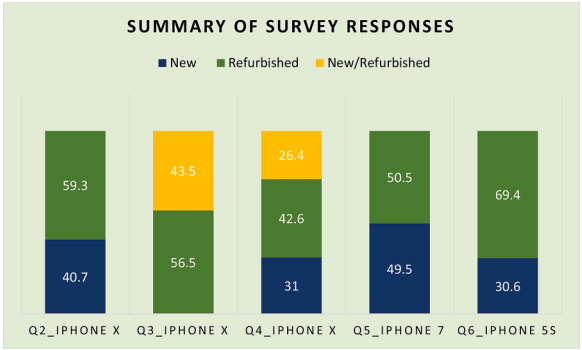

Fig. 3. comparison of survey responses on different questions.

- *Yes*
- *No*

75% of respondents mentioned that they are interested in participating in the trade-in program.

Fig. 4 also shows the distribution of the cellphone price, which is grouped based on the responses to Q2 (those who purchased new cellphones,1, and those who would rather purchase refurbished one, 0).

Similar to Q1, we wanted to see if we can predict consumer willingness to take part in trade-in programs based on the information about their current cellphone's brand, age, and price. Exploratory Data Analysis reveals that the consumers who paid higher prices for their cell phone are reluctant to participate in the Apple give back program as the consumers who paid the relatively lower price are willing to participate in the give-back program. It holds true for all the brands. The difference is high for brands other than Apple and Samsung. Also, consumers who are not willing to participate in the Apple give back program are using their cell phones for a long time when compared to the consumers who said 'Yes.' Again, the variation is higher for 'Other' brands than Apple and Samsung. The results are summarized in Tables 7 and 8.

For the predictive analytics part, we used our previous experience to eliminate SVM and Logistic Regression to choose Random Forest. The data is split into 80% train and 20% test data. The model yields only 63% prediction accuracy. Thus, we decided to change the train and test data percentage to 70 and 30, respectively. This time the model yields a 71% accuracy.

The same hyperparameter optimization has been carried out for the apple give-back program prediction. This time the max_depth obtained is 5, and n_estimators obtained is 25. The tuned parameter has been applied to the model, and the prediction accuracy has been improved to 77% from 71%.

The random forest is a classification method that can help manufacturers identify the consumer's willingness to learn about the take-back program based on the brand, age, and price of their cellphones. If we fed a new data record of customers to Random Forest algorithm, each tree in the forest predicts a value for output (i.e., consumer's interest in participating in the take-back program, Yes or No).

4.2. Implications of the survey results

Given the above-mentioned limitations, the survey opens several new perspectives on analyzing the market for refurbished products. Marketing strategies such as probabilistic or opaque selling, or the importance of considering the technology level when defining the price

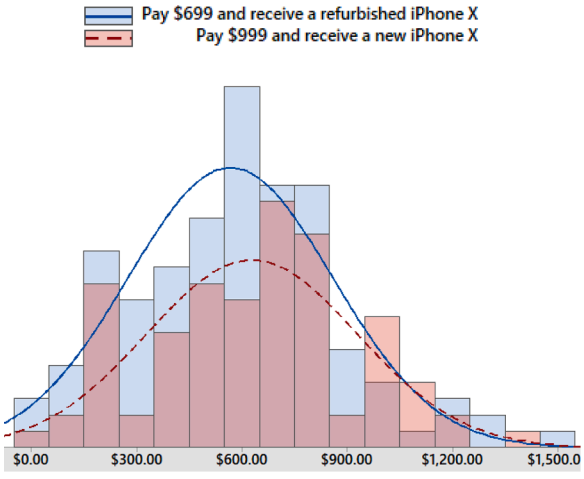

Fig. 4. Distribution of the product price for two groups of respondents (those who are interested in purchasing new cellphones and those who are interested in refurbished products).

Table 7
Mean price of users grouped by brand and response to Q7.

Brand	Q7	Price
Apple	No	711.3
	Yes	665.7
Others	No	501.1
	Yes	389.2
Samsung	No	552.0
	Yes	526.9

Table 8
Mean Age of Cell Phone grouped by brand and response to Q7.

Brand	Q7	Cellphone Age (Months)
Apple	No	19.9
	Yes	17.8
Others	No	21.8
	Yes	10.8
Samsung	No	15.5
	Yes	11.3

range for refurbished electronics, are examples of new insights derived from the survey. In addition, while the focus of the survey was not on quantifying willingness-to-pay for refurbished products, the indirect survey questions on available purchase options open the door for identifying the range of prices that alter consumer decisions in switching to refurbished products.

While the previous studies in the marketing of refurbished products have highlighted the role of offering incentives or increasing consumer awareness on enhancing willingness to purchase refurbished products (Mugge et al., 2017), (Abbey et al., 2015), no investigation on the way that product information can be presented and marketed to consumers on e-commerce website has been investigated so far (e.g., Q1, Q4). The outcomes of the survey in the current study reveal the importance of considering new marketing strategies such as opaque selling, the establishment of take-back programs by OEMs, and direct marketing among multi-channel supply chain design.

We should note that the risk attitude of a consumer affects the consumer's purchase decision. In addition, attitudes towards probabilistic goods depend on not only the shape of utility functions and the degree of risk aversion coefficient but also the consumer's disposition toward risk. According to Fay and Xie (Fay and Xie, 2008), with extreme risk aversion, probabilistic selling is a poor alternative. Future work includes the identification of the choice differences between different groups of consumers based on their risk attitudes.

To summarize, several takeaways from this study can help manufacturers to influence the decision-making process of consumers towards selling refurbished items. Although the first hypothesis confirms the previous studies' results that a fraction of the market is not interested in purchasing refurbished products, regardless of price, still a considerable portion might be interested in learning about refurbished items. The second hypothesis shows that probabilistic goods can change consumers' choices. Therefore, remanufacturers can identify ways of drafting product information to guide consumers' decisions during the purchase process. Decision making under uncertainty requires considering both behavioral and economic theories simultaneously. Behavioral economics should be used to describe the economic decision-making of individuals for purchasing refurbished items as behavioral economic consider the bounded rationality of decision-makers with limited ability to process information. Therefore, analyzing the consumer's decision in probabilistic deals may help businesses guide consumers to avoid their disgust of refurbished items.

Speaking of the insights of this study, unlike previous literature, the focus of the study is not on why or why not consumers purchase refurbished products but on identifying marketing strategies that can change consumer's choices and promote purchasing refurbished items. While refurbished products present a significant opportunity for device makers to advance sustainability, the market share of refurbished products is very low. Even green consumers may not appreciate the environmentally friendly attributes of refurbished products (Abbey et al., 2015). The current study opens the door for integrating both psychological theories and economic theories together towards promoting the market of refurbished products. While it was not the focus of this study, proper design of opaque selling on e-commerce websites and offering of refurbished products with different quality and technology levels through well-studied versions of probabilistic selling and lottery can help remanufacturers reduce consumer's poor perceptions of refurbished products. For example, consumers who are comparing two refurbished items together and finally get their preferred option may not indicate a disgust perception of refurbished products and feel like a winner. Bundling of products and services and offering incentives to consumers are other types of marketing strategies that should be investigated for refurbished products.

4.3. Limitations of the survey study

We would like to acknowledge several limitations of the current survey. First, the respondent group is limited to only the young generation and students with a sample size of 227 responses. Second, some questions in the survey may have been interpreted differently by different participants. For example, the interpretation of "some chance" could have varied significantly between respondents. The term "price of a refurbished cell phone" is variable and may not necessarily be considered affordable. Third, there is no mention of other factors that influence consumer's purchase decisions, such as manufacturer warranties provided on the new and the refurbished products. This could have altered the respondent's perception of purchasing the device depending on their past experience of purchasing from OEMs or third-party refurbishers. Also, since the survey targets student consumer and refurbished cellphones, it is hard to generalize the student consumer's attitude towards purchasing refurbished cellphones to the consumer's attitude towards purchasing refurbished products.

Finally, the generalization of the results would require addressing the current limitation of the study, where the survey questions are drafted around only one brand. The price elasticity may be different from one brand to another. Therefore, further analysis is needed to identify if and how the responses vary among product brands. While the survey respondents own different brands, the survey questions are focused on the iPhone. Consumers might be more sensitive to certain brands compared to others. Overall, the purpose of the study was by no means to comment on the performance of a particular brand or consumers' willingness to purchase specific products and brands, but to identify potential marketing strategies that may motivate the market of refurbished electronics regardless of brand. The iPhone was used just as an example.

5. Conclusion and future work

The purpose of the study was to understand consumers' willingness toward purchasing refurbished electronics and identifying potential marketing strategies that would benefit businesses in changing consumer's choices and selling refurbished products.

A survey of 227 respondents has been conducted to test three different hypotheses: (1) Hypothesis 1: Regardless of price, there is always a fraction of the market that are not interested in purchasing refurbished products. (2) Hypothesis 2: Probabilistic products can change consumers' local choice context. Therefore probabilistic selling can improve a brand's profit for refurbished products and (3) Hypothesis 3. The older is technology, the higher is the chance of purchasing refurbished products compared with new products. The percentage of the responses provided by people were in favor of these hypotheses.

The study should be extended in several ways. First, the survey has

been designed to target students as the young generation who may have less willingness to purchase refurbished products but, on the other hand, consider refurbished products due to their affordable prices. The study should be extended to consider other groups of the market. Second, various other factors contributing to consumer's decision to purchase a product can be included in the survey ranging from consumer's loyalty to specific brands to consumer's green attitude as well as quality concerns and loss aversion biases. Third, the study just introduces the concept of probabilistic selling or opaque selling for refurbished products. Future research is needed to investigate this strategy further and investigate its suitability for this market. Fourth, the survey should be extended to other product categories beyond just cellphones. Finally, different types of choice models and decision analysis techniques are needed to study this market. The risk attitudes of consumers play a critical role in the consumer's purchase decision. Therefore, an extensive analysis of the degree of risk aversion of users and its impact on purchasing probabilistic products is needed.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A: Questions used to capture individuals' willingness to purchase refurbished cellphones

	What is the brand and model of your current cellphone?
	What was the purchase price of your cellphone?
	How long have you been using your current cellphones?
Q1	If you are in the process of purchasing a new cellphone, but suddenly received a notification that you could potentially purchase a cellphone with excellent/almost-new condition while only paying the price of a refurbished cellphone, would you be intrigued to learn more? Yes, No
Q2	As of Nov 2018, the iPhone X costs $999 (64GB, unlock). Suppose that you want to purchase an iPhone X. Which of the following option would you select?
	Pay $999 and receive a new iPhone X
	Pay $699 and receive a refurbished iPhone X
Q3	As of Nov 2018, the iPhone X costs $999 (64GB, unlock). Suppose that you want to purchase an iPhone X. Which of the following option would you select?
	Pay $699 and receive a refurbished iPhone X
	Pay $799 and with some chance you receive a refurbished iPhone X and with some chance you receive a new iPhone X.
Q4	As of Nov 2018, the iPhone X costs $999 (64GB, unlock). Suppose that you want to purchase an iPhone X. Which of the following option would you select?
	Pay $999 and receive a new iPhone X
	Pay $699 and receive a refurbished iPhone X.
	Pay $799 and with some chance you receive a refurbished iPhone X and with some chance you receive a new iPhone X
Q5	Suppose that you want to purchase an iPhone 7. Which of the following option would you select? The features of each option are listed in Table 4.
	Option A
	Option B
Q6	As of Nov 2018, the 64GB iPhone 5s costs $399. Suppose that you want to purchase an iPhone 5s. Which of the following option would you select?
	Pay $399 and receive a new iPhone 5s
	Pay $119 and receive a refurbished iPhone 5s
Q7	Apple Giveback program offers money for trade of your used Apple products. You may trade in your eligible device for a Store Gift Card or a refund on your purchase. For example, as of Nov 2018, the iPhone X costs $999 (64GB, unlock) and the trade-in program offers max $500 for your used iPhone X. Are you interested in using the trade-in program?
	Yes
	No

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