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When a Strategy for Sustainability is Sustainable: The Impact of Refurbished Products in Markets with Network Effects and Standards Competition

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Abstract

While introducing refurbished products has become a prevalent practice for sustainability, little is known about whether and when such an environmentally sustainable strategy is sustainable (i.e., profitable) for manufacturers. Given the fact that refurbished products are remanufactured from product returns, introducing refurbished products can create a negative connotation of poor product quality, thereby imposing challenges on the corresponding brand-new products. The authors conduct an empirical study and four experimental studies to investigate the conditions under which introducing refurbished products increases or decreases consumers' purchase intentions and valuations of the brand-new counterparts in markets with network effects and standards competition. These studies consistently reveal that the availability of refurbished products can positively affect consumers' evaluations of brand-new products that employ a new technology standard, given that the sales of refurbished products increase the installed user base of the new technology standard and lead to strong positive network effects. However, for products that employ an established standard, these studies show that introducing refurbished products reduces consumers' purchase intentions and valuations of the brand-new counterparts. These findings provide important implications for this green product strategy.

Keywords: Sustainability, green product strategy, refurbished products, network effects, standards competition, quality connotation

While the notion of sustainability has long been of interest in energy-related industries such as automotive, chemistry, metal, and mining businesses, it was not until recent years that companies have related this concept to consumer goods (United Nations Global Compact 2013). One prominent practice for sustainability that has gained increasing attention is to offer refurbished products – reconditioned and repackaged products that were previously owned and returned by consumers (Giuntini and Gaudette 2003). According to the U.S. International Trade Commission, the sales of refurbished IT products increased by 17 percent from $4.4 billion in 2009 to $5.2 billion in 2011 (USITC 2012). This sustainable move, starting from the operations and supply chain side of firms, can help regenerate the value of returned products, reduce energy waste, and extend products' lifecycle (Ferrer and Ayres 2000; Vorasayan and Ryann 2006). In concordance with this trend, several major online retailers (e.g. Amazon, BestBuy, and Newegg) now have webpages to display and promote refurbished products separately from their brand-new counterparts.

Despite the increasing prevalence of refurbishing and remanufacturing practices among retailers and manufacturers, little is known about how consumers perceive this new concept of refurbished products, and how they react to the availability of refurbished products in the marketplace. To determine whether or not to introduce refurbished versions of brand-new products, there is a pressing need for manufacturers to understand how the presence of refurbished products would affect consumer behavior and the market performance of primary brand-new products. In this paper, we seek to address this managerially relevant, but underexplored question. We particularly focus on the markets of consumer electronics and digital technology products (e.g., tablets, smartphones, smartwatches), which are among the most active remanufacturing sectors of refurbished products (USITC 2012).

In the markets of consumer electronics and digital technology products, consumers often face several sets of incompatible technology standards that compete for market dominance (Shapiro and Varian 1998). In particular, many types of emerging consumer digital products use proprietary operating systems that govern the principal functions of these devices and determine the compatibility of software application programs. For example, in the smartphone and tablet markets, there have been two major operating systems, Google Android and Apple iOS, along with a few other minor systems such as Microsoft Windows, HP WebOS, and Blackberry OS. In the digital audio/video product markets, multiple technology formats have been available to users (e.g., AAC, MPS, WMA, RM, WAV, MPEG-4, and AVI). Recently, RealD 3D and IMAX 3D are competing in the 3D video technology market.

Prior research suggests that consumers' utility in adopting a technology standard generally increases as the size of its installed user base increases (e.g., Farrell and Saloner 1985; Katz and Shapiro 1985). Such network effects (or network externalities) become more crucial when a new technology standard is introduced to markets and competes with other incompatible technology standards. In this case, introducing refurbished products may be an effective competition strategy because it can help increase the number of consumers for products that employ the new technology standard and in turn increase the perceived value of the corresponding brand-new products.

However, the introduction of refurbished products may not only cannibalize the sales of their brand-new counterparts, but may also create a negative connotation toward them. Refurbished products are generally more available in the digital product markets due to a high volume of product returns, which is often attributed to the technical and functional complexity of digital products and the resulting defects (Hazen et al. 2012; Vorasayan and Ryan 2006).

Because consumers are generally aware that refurbished products are previously opened and returned, the availability of refurbished products may be perceived as an indicator of poor quality with regard to brand-new products, thereby negatively affecting consumers' evaluations of the new technology standard.

Given these conflicting effects created with the introduction of refurbished products, it is critical to investigate if and under what conditions this green product strategy can benefit not only the environment, but also brand-new products and the underlying new technology standard. In this study, we take into account these potential opposite effects of introducing refurbished products and examine how they jointly influence consumers' evaluations of the brand-new counterparts in two contrasting conditions: (1) products employing an established technology standard and (2) products employing a new technology standard. We propose that introducing refurbished products may generate different impacts on the perceived value of brand-new counterparts, depending on the developmental stage of the underlying technology standard employed in the products.

We first explored the effects of introducing refurbished products using an empirical data of tablet markets from February to July 2012.[1] Building on our initial empirical investigation, we further conducted a series of experimental studies to examine the impacts of introducing refurbished products in more controlled settings. In our preliminary empirical analysis, we used the number of refurbished product sellers as a proxy for the extent to which refurbished tablets were available in the marketplace. We found that greater availability of refurbished tablets was positively associated with the selling price of the brand-new tablets that employed relatively newer operating systems at the time of data collection (Windows tablets). In comparison, the

[1] We are thankful to Wang, Mai, and Chiang (2013) for providing this dataset published in *Marketing Science*.

availability of refurbished tablets was associated less (or not at all) with the price of brand-new tablets using established operating systems (iOS and Android tablets). Because the selling price of a product generally reflects its perceived value in markets, these results demonstrate empirical evidence that introducing refurbished products benefits the brand-new counterparts that employ new technology standards more than those employing established standards.

In our experimental studies, we investigated how consumers' purchase intentions and willingness to pay (WTP) for brand-new counterparts are affected by the introduction of refurbished products in the two aforementioned conditions. Our results showed that the availability of refurbished products increased both the purchase intention and WTP for the brand-new counterparts when these products employ a new technology standard. These findings suggest that the positive effects from consumers' expectations concerning the growth of the user base and the increased network externalities outweigh the negative effects from low-quality connotation and cannibalization. In sharp contrast, the overall effects of refurbished products on both the purchase intention and WTP for brand-new counterparts are negative when these products employ an established technology standard. Our experimental studies using different types of products (i.e., smartwatches and video streaming devices) provided consistent findings regarding the opposite impacts of introducing refurbished products, which further enhanced our confidence in these key findings.

With the prevalence of refurbished products, prior research in operations management has examined important issues such as the pricing strategies of refurbished products (e.g., Ferrer and Swaminathan 2006), different suppliers of refurbished products (original equipment manufacturers vs. third-party firms) (e.g., Agrawal, Atasu, and Ittersum 2015), the existence of green segments (e.g., Atasu, Sarvary, and Van Wassenhove 2008), and others related to the

production planning, logistics, and inventory control of refurbished products (e.g., Ayres et al. 1997; Ferrer and Ayres 2000; Guide and Li 2000; Kekre et al. 2003; Richter and Sombrutzki 2000). Surprisingly, scholars have paid little attention to relevant marketing issues involving refurbished products. In particular, how the availability of refurbished products would affect consumers' perceptions and valuations of the brand-new counterparts remains largely underexplored. This study contributes to the literature on green marketing and sustainability by narrowing this gap. To our knowledge, our work is among the first in the literature to study the impacts of introducing refurbished products on consumer behavior, and to investigate when this green product strategy can benefit or harm the sales of brand-new products, which are a primary source of revenue for most firms. We provide evidence from both empirical and experimental studies regarding the consequence of introducing refurbished products and its important moderator – the developmental stage of the technology standards employed in the products.

Our work also contributes to the literature on network effects. In markets with network effects and standards competition, the introduction of a new technology standard often experiences a so-called chilling effect and suffers from a high failure rate (e.g., Rogers 2003; Goldenberg, Libai, and Muller 2010; Wang, Chen, and Xie 2010). We introduce the concept of refurbished products to this literature and highlight the benefits of introducing refurbished products in promoting a new technology standard, with consideration of the potential mediation role of network effects. While a potential cannibalization effect and a negative connotation effect may arise from refurbished products that employ a new technology standard, our findings demonstrate the overall benefits from this green product strategy in increasing consumers' purchase intentions and WTP for the brand-new counterparts, thereby significantly enhancing the success rate of the new technology standard.

The rest of the article is organized as follows. We first discuss the theoretical background of our research and then develop our hypotheses regarding the impact of introducing refurbished products. This is followed by a description of a preliminary empirical study and four experimental studies, along with a discussion of their results. We conclude with a remark on the managerial implications of our findings, as well as the limitations and directions for further work.

THEORETICAL BACKGROUND AND HYPOTHESIS DEVELOPMENT

While several studies in operations management have examined various issues involving the practice of refurbished products (e.g., Atasu et al. 2008; Ferrer and Swaminathan 2006; Ferguson and Toktay 2006; Agrawal et al. 2015), how the presence of refurbished products affects consumers' evaluations of manufacturers' primary products (i.e., brand-new products) remains understudied. Two recent studies have taken a first step in examining whether and how the introduction of refurbished products affects manufacturers' primary products and advanced our understanding regarding this issue (Agrawal, Atasu, and Van Ittersum 2015; McKie, et al. 2018). However, they either focus on the risk of introducing refurbished products or on the supply-side issue of this green product strategy (i.e., whether refurbished products are remanufactured by third-party OEMs or the original OEMs). Our research investigates the impact of introducing refurbished products from consumers' perspectives and by focusing on network effects. Specifically, we propose that the availability of refurbished products can create both positive and negative responses from consumers. Positive responses are expected to arise from enhanced network effects, while negative responses may arise due to the low-quality connotation from the presence of refurbished products. In what follows, we elaborate on each expected effect and

discuss how the overall impact of refurbished products on brand-new counterparts would vary for products that employ different technology standards (i.e., new vs. established technology standards).

Network Effects and Standards Competition

Markets with network effects (or network externalities) and standards competition have been extensively studied in marketing, economics, and other disciplines (e.g., Basu, Mazumdar, and Raj 2003; Farrell and Saloner 1985; Gupta, Jain, and Sawhney 1999; Katz and Shapiro 1985; Rogers 2003; Wang, Chen, and Xie 2010; Wang and Xie 2011). These studies have reported that the markets of various consumer electronics and digital products exhibit strong direct and/or indirect network effects. One of the prominent characteristics of such markets is the interdependence of consumers in their product evaluation. Specifically, consumers' utility from a product increases as the size of the installed user base increases (Katz and Shapiro 1985). In markets with direct network effects such as phones, fax machines, and video conferencing equipment, the usability of these products increases as more people adopt them. In markets with indirect network effects such as personal computers and video game consoles, the availability of complementary products (e.g., software applications and games) is one of the critical determinants regarding the hardware's success. Along these lines, studies have shown that, all else being equal, the more complementary products are available, the higher the value of the product to consumers (e.g., Basu, Mazumdar, and Raj 2003; Brynjolfsson and Kemerer 1996; Gupta, Jain, and Sawhney 1999; Stremersch, et al. 2007).

Network effects are particularly prominent for products that use technology standards or platforms that are not compatible with each other (e.g., Brynjolfsson and Kemerer 1996; Rohlfs 2001; Suarez 2005). When there are multiple incompatible technology standards competing in

the same market (e.g., MS Windows and Apple macOS as PC operating systems), consumers often face the challenge of which particular technology standard to adopt and commit to upfront. Because it can be very costly to switch to other alternatives later, consumers typically choose a strategy of "wait and see" and only adopt the technology standard that can eventually stand the test of time and can provide them the highest level of network effects (Wang, Chen, and Xie 2010; Wang and Xie 2011; Goldenberg, Libai, and Muller 2010).

This fierce standards competition leads to a significantly high level of uncertainty regarding the success of new technology standards. Recent studies have shown that the diffusion of a new technology standard could suffer from slow initial growth, referred to as the "chilling effect" (Rogers 2003; Goldenberg, Libai, and Muller 2010). For a new technology standard that few users have adopted or known, positive network effects may be difficult to reach without a significant body of early adopters *ex ante*. Hence, we expect that if such a green product strategy of introducing refurbished products is adopted, firms can benefit not only from the sales of refurbished products, but also from an increase in the perceived value of primary products due to the positive network effects gained from a rapid increase in the early user base of the underlying technology. In other words, the network effects from a larger user base (i.e., resulting from the sales of refurbished products) would lead to an increased value of the primary brand-new products, as well as the refurbished products.

Low-Quality Connotation and Cannibalization Effects

Introducing refurbished products can however create negative effects on their brand-new counterparts. Because consumers are generally aware that refurbished products are previously opened and returned, the availability of refurbished products may be perceived as an indicator of poor quality with respect to brand-new products. In turn, this would negatively affect consumers'

evaluations and purchase intentions of the products.

Wernerfelt (1988) shows that introducing a low-quality product under the same brand name can lead consumers to believe that all other products are also of low quality, creating a negative connotation effect on the product line. Later studies suggest that such a negative connotation effect between a parent brand and its brand extension is due to the linkage of consumers' quality perceptions with the brands (e.g., Balachander and Ghose 2003; Lei, Dawar, and Lemmink 2008; Zikopoulos and Tagaras 2007). In a similar vein, refurbished products are generally considered as a somewhat risky option with less quality assurance in comparison to brand-new products (Hazen et al. 2011; Subramanian and Subramanyam 2012). Thus, we expect that the presence of refurbished products may lead to the spillover effect of a negative connotation on brand-new products, resulting in lower product evaluations, and hence, a lower propensity for consumers to purchase brand-new products.

Introducing refurbished products can also create a cannibalization effect on their brand-new counterparts (e.g., Atasu, Sarvary, and Van Wassenhove 2008; Guide et al. 2010; Kima and Chhajed 2001; McKie et al. 2018). Consumers who are environmentally conscious and/or who care only about the functionality of the product rather than its newness would choose to buy refurbished products rather than brand-new ones (Atasu, Sarvary, and Van Wassenhove 2008). Refurbished products can be also attractive to price-sensitive consumers, as they can enjoy the same level of the product attributes and features offered in the brand-new products at a much lower price.

Moderating Role of the Developmental Stages of the Technology Standard

As previously discussed, the availability of refurbished products can affect consumers' evaluations of brand-new products by creating both positive network effects and negative effects

arising from a low-quality connotation and cannibalization. The overall impact would then be determined based on the magnitude of the positive and negative effects.

We argue that the magnitude of the positive network effects can vary, depending on the developmental stage of the technology standards employed in the products. Specifically, we expect that introducing refurbished products can create stronger network effects for products that employ a new technology standard than for those using an established standard. This is because the same size of an increase in the installed user base can lead to largely different changes in the network effects, depending on the size of the existing user base. For an established technology standard that already has a sufficiently large user base (e.g., Android operating systems for smartphones), introducing refurbished products may help attract more consumers to adopt the technology. However, the resulting change to the network effects would only be marginal, and hence, would have little impact on consumers' perceived value of brand-new products.

In comparison, the same increase in the installed user base may lead to much stronger network effects for a new technology standard with a small user base. As a cheaper option with the exact same product specifications as the brand-new counterparts, introducing the refurbished version may help the firm quickly attain a critical mass of early adopters in the product network. Moreover, the more people adopt products using a new technology, the more complementary products (e.g., apps) will become available for that technology, and the more retailers will be likely to carry products using the new technology in the market. As a result, consumers may find it more valuable to adopt the brand-new counterparts.

With respect to the negative effects of introducing refurbished products, the introduction of refurbished products may cannibalize the brand-new counterparts; however, we expect the cannibalization effect to be the same, regardless of what technology standard is employed (i.e., a

new or established technology standard). The magnitude of cannibalization would rather largely depend on the market size of price-sensitive and/or environmentally conscious consumers. However, we note that the negative connotation effect might be stronger for products using a new technology standard than for those using an established standard, when refurbished products are introduced. Given that the established technology standard has been widely adopted in markets, when consumers see the introduction of refurbished products using an established standard, they may only be concerned about whether the brand-new counterparts have any hidden problems in their hardware attributes (e.g., camera or battery in smartphones), but not about the underlying technology standard employed (e.g., the operating system). For products using a new technology standard, on the contrary, consumers may have higher uncertainty not only about the brand-new products' hardware attributes, but also about the technology standard itself.

Combining the above discussions, we expect that introducing refurbished products can create a negative impact on consumers' perceived value of brand-new counterparts employing an established technology standard with a large existing user base. This happens because when their refurbished version becomes available, the negative effects of a low-quality connotation and cannibalization together may be so large that they dominate the marginal positive network effects resulting from the sales of refurbished products. However, for products employing a new technology standard, the overall impact of introducing refurbished products depends on the relative strength of the positive and negative effects. Accordingly, we hypothesize a negative impact of introducing refurbished products that employ an established technology standard. However, we propose two competing hypotheses regarding the impact of introducing refurbished products that employ a new technology standard.

H1: For products that employ an established technology standard, introducing refurbished products negatively affects consumers' purchase intentions of the brand-new counterparts.

H2: For products that employ a new technology standard,
(a) Introducing refurbished products positively affects consumers' purchase intentions of the brand-new counterparts;
(b) Introducing refurbished products negatively affects consumers' purchase intentions and valuations of the brand-new counterparts.

PRELIMINARY EMPIRICAL STUDY

We first explore if and how the valuation of primary brand-new products changes in the presence of refurbished alternatives by examining an empirical dataset of tablet PCs sold on Amazon.com. Specifically, we adopt a hedonic pricing model to examine how the sales price of a brand-new tablet varies with the availability of its refurbished version and the developmental stage of the technology standard (i.e., the operating system) that each tablet employs. Based on the notion that the price of a product reflects its market value, hedonic pricing models have been widely used in capturing the effects of product characteristics and other relevant factors in the market valuation of products (e.g., Gandal 1994; Chwelos et al. 2008). Formally, we specify Amazon's sales price of tablet *i* (at the UPC level) at week *t* as:

$$P_{it} = f(S_i,\ N_{it},\ S_i \times N_{it},\ X_{it},\ T_t),$$

where P_{it} represents the selling price of a brand-new tablet *i* on Amazon. S_i is a vector of the dummy variables that indicate the operating system used in tablet *i,* N_{it} includes the number of non-Amazon merchants selling new, refurbished, and used products of tablet *i* at week *t*, respectively. Because we could not obtain the total number of refurbished tablets sold on Amazon for each operating system, we use the number of refurbished product sellers as a proxy for the extent to which refurbished tablets are available in the marketplace. $S_i \times N_{it}$ is a vector of

the interaction terms between the indicators of the operating systems and the numbers of non-Amazon merchants with respect to new, used, and refurbished tablets. The vector X_{it} includes product characteristics that may affect the sales price of the tablet (e.g., the size of the screen and storage). T_t is a variable that accounts for an unobserved time trend. The variable is set to 1 for the first week of the data period and increases over the weeks. For the functional form of the model, we employ a linear regression model, consistent with several prior studies using hedonic pricing models (e.g., Gandal 1994; Chwelos et al. 2008).

Table 1 lists the covariates included in S_i, N_{it}, and X_{it}, respectively. For technology standards, which involve the operating systems used in tablets, we consider the effects of Google Android, Apple iOS, and MS Windows Tablet PC Edition, in comparison to HP WebOS as the baseline case.[2] Based on the tablets' release time and their popularity in the tablet computer market during the data period in 2012, we categorized the tablet operating systems into three groups: Android and iOS as established standards, Windows Tablet Edition as a newer standard, and WebOS as an old and declining standard. This categorization is consistent with consumers' perceptions toward these operating systems, as well as their market shares in 2012 (Gartner 2011; IDC 2012; NetMarketShare 2014). By categorizing these tablet operating systems into different developmental stages, we examine how the presence of refurbished products affects the price of brand-new tablets with technology standards in different stages.

<INSERT TABLE 1 HERE>

We use data provided by Wang, Mai, and Chiang (2014), which are publicly available at *Marketing Science*. The data contain information regarding tablet PCs sold at Amazon.com from February to July in 2012, such as the brand, price, product characteristics (e.g., storage size,

[2] We do not include Blackberry OS in our analysis due to the very limited number of observations involving Blackberry tablets in the data.

screen size, and memory), product conditions (i.e., brand-new, used, or refurbished), and the number of sellers for each tablet condition. A detailed description of the data and the summary statistics of the variables are available in Wang, Mai, and Chiang (2014).

Estimates of the model parameters are presented in Table 2. The coefficients for the operating systems indicate that Amazon's selling price of a brand-new tablet using Windows or iOS is higher than that using WebOS. From the significantly negative coefficients for the interaction terms *Windows*×*N_New*, *Android*×*N_New*, and *iOS*×*N_New*, we find that for all operating systems, the selling price of a brand-new tablet decreases as the number of non-Amazon merchants selling the same product increases. This result is in line with the negative effect of competition on the market price, reported in prior studies (e.g., Chevalier and Goolsbee 2003; Fisher et al. 2018).

The next set of results is of primary interest to us. From the significantly positive coefficients for *Windows*×*N_Refurbished* (p-value = .035), we note that the price of a Windows tablet increases as more merchants sell refurbished products of the tablet. Thus, for tablets that employ a newer technology standard (i.e., Windows), a greater availability of refurbished products increases the market valuation of their brand-new counterparts. This result provides empirical evidence in support of H2(a), implying that the positive network effects resulting from the availability of refurbished products dominate the negative effects of low-quality connotation and cannibalization. From the significantly positive coefficient for *Windows*×*N_Used*, we also find that introducing used tablets presents the same effect when introducing refurbished tablets: a greater availability of used tablets increases the market value of brand-new tablets when the products use a newer operating system. This may be the case, given that (similar to refurbished products) the availability of used products also helps increase the installed user base of the new

operating system; hence, this creates a higher network effect that enhances consumers' valuations of brand-new counterparts. Notably, the coefficients for *Android*×*N_Refurbished* and *iOS*×*N_Refurbished* are 3.85 (p-value = .080) and 1.78 (p>0.1), respectively, which are much smaller than that of the coefficient (i.e., 14.78) for *Windows*×*N_Refurbished*. These results suggest that the price of brand-new tablets using established operating systems (i.e., Android and iOS) is less or not associated with the number of refurbished tablet sellers. Although these results do not support H1, all of our results together indicate that introducing refurbished products creates more positive impacts on the valuation of brand-new counterparts employing a new technology standard than those using an established standard.

<INSERT TABLE 2 HERE>

While these findings can provide important guidance to marketers considering the green product strategy with refurbished products, there are potential concerns involving the data and analysis. Most critically, because Windows was a dominant operating system in the PC market in 2012, and the tablets using the Windows operation system were compatible with Window PCs to some extent, one may question whether the Windows Tablet Edition can be considered as a newer technology standard, even though it has a much smaller market share than Android and iOS in the tablet market during the data period. To overcome this limitation, we conduct experimental studies in which we explicitly manipulate the conditions of established and new technology standards in examining the impacts of refurbished products.

EXPERIMENTAL STUDIES

We conducted four experimental studies to examine how introducing refurbished products would affect consumers' purchase intentions and valuations of the corresponding brand-new products.

As discussed, we expect the effect of introducing refurbished products to be moderated by the developmental stage of the technology standards (i.e., new vs. established). In the first study, we chose smartwatches as the experimental products and asked participants to indicate their purchase intentions for a brand-new smartwatch under two market conditions: with and without the presence of refurbished products, respectively. To validate our findings from the first study, we conducted the second study by using a different consumer digital product—a smart video streaming device—as the experimental product. As another means of checking the robustness of the findings, we conducted two additional studies in which we ask participants to indicate their WTP for a brand-new product, instead of their purchase intentions. We chose these two consumer electronic products because both markets exhibit strong standards competition and network effects. Specifically, in both markets, products employ different operating systems (OS) competing for market dominance (e.g., Android, iOS, and many other proprietary operating systems in the market of smartwatches, and Apple TV and Amazon Fire TV in the market of video streaming devices). Accordingly, network effects play an important role in consumers' evaluations of these products: consumer evaluations are based not only on their hardware features, but also on their software availability (e.g., the number of applications available for each smartwatch OS and the number of TV programs that can be played with video streaming devices in each OS).

Study 1

Design. We designed a 2 (technology standard: new or established) × 2 (presence of refurbished products: yes or no) between-subjects experiment. In each of the four conditions, participants were presented with two choice alternatives ("Purchase a brand-new smartwatch" and "No purchase") and were asked to make a choice decision. We chose Android, which was one of the

most popular operating systems for smartwatches at the time of our study, as an established standard. For a new standard technology, we devised a hypothetical operating system and named it "Alpha." In the study, the Alpha operating system was described as being incompatible with the major smartwatch operating systems, including Apple iOS and Google Android. We then designed a hypothetical smartwatch, the "Watchasay Smartwatch," which employs either Android or Alpha as its operating system. Figure 1 shows the description of the Watchasay smartwatch with the Alpha operating system, presented to the study participants.

<INSERT FIGURE 1 HERE>

To specify our Watchasay smartwatch alternatives, we conducted a pretest in which 43 college students were surveyed about their WTP for a smartwatch and important product attributes they would consider in their smartwatch purchase decisions. Based on the survey results, the three most important attributes of smartwatches were identified: price, memory size, and battery life. To ensure that our Watchasay smartwatches reflected reality, we also referred to the specifications of real smartwatches sold at Amazon.com at the time of our study. Accordingly, we set the price levels of the smartwatches at $100 and $115 and specified the two attributes of memory and battery life at two levels: 2 GB and 4 GB for memory, and 3 days and 7 days for the battery.

With respect to the refurbished version of the Watchasay smartwatches, we set the price at either 60% or 70% of the original price of the corresponding brand-new smartwatches. These price discount levels were also determined based on the average discount level of real refurbished smartwatches at Amazon.com. Other than price, by its nature, a refurbished product has the same features and attribute levels as its brand-new counterpart. Table 3 summarizes the product attributes and their corresponding levels for both the brand-new and refurbished

products. With the attributes and their levels, we ran a 100% D-Efficiency fractional factorial design in SAS statistical software (Kuhfeld 2010) and obtained eight profile sets of the brand-new and refurbished versions of the Watchasay smartwatches, shown in Table 4. We then designed questionnaires to collect consumer responses for each of eight profiles involving the brand-new products in four settings (i.e., 2 operating systems (Android vs. Alpha) × 2 scenarios of refurbished products (with vs. without the presence of refurbished products)). As stated earlier, the participants were asked to choose from two alternatives: whether to purchase a brand-new Watchasay smartwatch or not. Additionally, we asked participants questions regarding their agreement on five statements about refurbished products (as shown in Table 5) after they completed their choice tasks.

<INSERT TABLES 3, 4, AND 5 HERE>

Procedure. We conducted our experimental study on MTurk and collected responses from 138 participants. Each participant was paid at a rate of $1 per HIT to complete the assigned questionnaire. To ensure the quality of responses, we selected participants based on the criteria of a 98% approval rate, based on past studies in which they participated. The participants were first randomly assigned to either of the Android and Alpha conditions, and then to either of the experimental and control groups, as described in Figure 2.

<INSERT FIGURE 2 HERE>

Upon their group assignment, participants were asked to read an overall description of a new Watchasay smartwatch and complete the questionnaire. In each question of the study, participants assigned to the control group were presented with a description of the brand-new Watchasay smartwatch without information about its refurbished version. In comparison, participants in the experimental group were informed about the availability of a refurbished

Watchasay smartwatch and a description of the refurbished product, as well as the corresponding brand-new smartwatch. That is, the description of the refurbished smartwatch was given to participants in the experimental group, but not to participants in the control group. Table 6 shows sample questions asked to participants in the Android condition.

<INSERT TABLE 6 HERE>

Analysis and Results. We begin our analysis of the study data by computing the percentages of participants who chose the option of "prefer to buy a brand-new smartwatch" over the "no purchase" alternative. Figure 3 compares the results between the control and experimental groups in each of the Android and Alpha conditions. In the Android condition, the percentage is 65.6% in the control group, which decreases to 60.7% in the experimental group. In contrast, in the Alpha condition, the percentage is 48.6% in the control group, which increases to 60.7% in the experimental group. Thus, the availability of refurbished Android smartwatches decreases participants' likelihood of choosing their brand-new counterpart, while the availability of refurbished Apple smartwatches increases the likelihood.

<INSERT FIGURE 3 HERE>

While these results directionally support H1 and H2(a), they do not take into account or control for other relevant factors available in our data. To address this issue, we analyze the data using a logistic regression model given by:

$$\Pr(Y_{ij} = 1) = \frac{\exp(\beta X_{ij})}{1 + \exp(\beta X_{ij})},$$

where Y_{ij} equals 1 if participant i chose the option of "prefer to buy a brand-new smartwatch" in the jth question, and 0 if she chose the "no purchase" alternative, X_{ij} is a vector of the variables to be elaborated below, and β is a vector of the coefficients for X_{ij}.

The variable vector X_{ij} includes (1) a dummy variable, *Android* (or *Alpha*), which

represents the operating system used in the smartwatch; (2) a dummy variable, *Refurbished*, which indicates whether the participant was informed about the availability and description of the refurbished version of the brand-new product (i.e., whether the participant was assigned to the control group); (3) the interaction term of *Android* and *Refurbished* (or the interaction term of *Alpha* and *Refurbished*); (4) a set of three dummy variables, labeled as *Price115* (=1 if the price of the brand-new smartwatch is $115, and 0 otherwise), *Memory4* (=1 if the memory size is 4 GB, and 0 otherwise), and *Battery7* (=if the battery life is 7 days, and 0 otherwise), which represent the attribute levels of the brand-new smartwatch presented in the question;[3] (5) a dummy variable, *Experience*, which indicates whether the participant has purchased a refurbished product in the past; and (6) a set of five interval-scaled variables, *MoreApps*, *SameAttributes*, *SaveMoney*, *SameQuality*, and *Hygiene*, which represent the participant's responses to the statements in Table 5. With these variables, our model enables us to capture how the availability of refurbished smartwatches affects participants' likelihood of choosing the brand-new counterpart, and how this effect is moderated by different operating systems employed by the products, while controlling for product characteristics and participants' experiences and perceptions of refurbished products.

To facilitate the interpretation of the results, we estimated two versions of our model that differ from each other in terms of the composition of the independent variables in X_{ij}. The first version (Model 1) includes *Android* and *Android*×*Refurbished,* while in the second version (Model 2), the two variables are replaced with *Alpha* and *Alpha*×*Refurbished*. Other independent variables remain the same between the two models. Table 7 reports their parameter estimates.

[3] We do not include a dummy variable for price discounts (30% or 40%) on the refurbished products in X_{ij}, because the variable is undefined for participants in the control groups to whom the availability and description of the refurbished products were not presented.

We first focus on testing H1 with respect to the impact of the availability of refurbished products when an established technology standard (i.e., the Android operating system in our study) is employed. Note that the impact is captured by $\beta_2 + \beta_3$ in Model 1, which is the sum of the coefficients for *Refurbished* and *Android*×*Refurbished*. Following the procedures described in Jaccard, Wan, and Turrisi (1990) and Bauer and Curran (2005), which can be easily implemented using statistical software packages (e.g., Stata), we find that $\beta_2 + \beta_3$ is significantly negative, with an estimate of -.383 and a standard error of .203 (*p*-value = .059). This finding suggests that the availability of refurbished Android smartwatches decreases participants' likelihood of choosing their brand-new counterpart over the "no purchase" option. Thus, H1 is supported. Next, to test H2 regarding the impact of the availability of refurbished products when a new technology standard is employed (the Alpha condition in our study), we turn our attention to $\beta_2 + \beta_3$ in Model 2, which is the sum of the coefficients for *Refurbished* and *Alpha*×*Refurbished*. We find that $\beta_2 + \beta_3$ is significantly positive, with an estimate of .310 and a standard error of .183 (*p*-value = .091), which indicates that the availability of refurbished Alpha smartwatches increases participants' likelihood of choosing the brand-new version over the "no purchase" option. This result is in support of H2(a) instead of H2(b).

<INSERT TABLE 7 HERE>

Lastly, we examine the mediation process for the effect of introducing refurbished products. In our hypothesis development, we stated that introducing refurbished products can positively affect consumers' purchase intentions of the brand-new counterparts because the sales of refurbished products can increase the installed user base, thereby strengthening network effects. Given our results in support of H1 and H2(a), we further look into our data to explore the possible mediation process. Note that at the end of the experiment, we asked participants to

indicate their attitudes regarding five statements, as listed in Table 5, with particularly the first statement about their agreement toward "More people buying refurbished products can help increase the number of applications for the operating system." We compute the mean value of the participants' agreement with this statement for each of the control and experimental groups, which are 3.87 in the experimental group, and 3.53 in the control group. As shown in Figure 4, the former value is significantly larger than the latter (p-value < .001), which indicates that the participants formed stronger expectations toward the larger availability of applications for the operating system when they were informed about the presence and description of the refurbished products, which could help enlarge the installed user base, and hence, strengthen network effects. Moreover, in Table 7, the coefficient of *MoreApps* is significantly positive (β_8=.437, p<0.01), indicating that respondents who expected a higher availability of more apps, given the presence of refurbished products, were more likely to choose the option of "prefer to buy a brand-new smartwatch." These results together provide empirical evidence regarding the mediation role of network effects in our hypotheses. Moreover, the results explicitly demonstrate that, because of the perceived network effects, introducing refurbished products leads to an increased choice of brand-new counterparts employing a new technology standard.[4]

<INSERT FIGURE 4 HERE>

Study 2

To check the robustness of our results, we ran another choice study by using a different consumer digital product – a smart video streaming device (e.g., Apple TV, Amazon Fire TV). This study mimicked study 1 and consisted of 2 (technology standard: new or established) × 2

[4] We also compared the means of participants' agreement with the first statement between the Android and Alpha conditions. We found that the difference was not significant, indicating that the benefits of refurbished products to increase the technology networks were equally perceived in the two conditions.

(presence of refurbished products: yes or no) between-subject experiments. Consistent with the previous study, we adopted the same brand name ("Watchasay" streaming box), and the same established and hypothetical operating systems (Android and Alpha). Figure 5 shows the description of the Watchasay streaming box that uses the Alpha operating system, presented to the study participants.

<INSERT FIGURE 5 HERE>

Based on the nature of the product and our market research, we set the price levels of the streaming device at $100 and $120, and specified the product alternatives with respect to the memory size (4 GB and 8GB) and the number of free channels (25 and 50). Similar to study 1, the refurbished versions of the Watchasay streaming box were priced at either 60% or 70% of the price of the corresponding brand-new products. With the attributes and their corresponding levels, we ran a 100% D-Efficiency fractional factorial design in SAS statistical software and obtained eight profile sets of the brand-new and refurbished versions of the Watchasay streaming box, shown in Table 8. We then designed a questionnaire to collect consumer responses for each of the eight profiles in four settings (i.e., Android vs. Alpha, and with vs. without the presence of refurbished products). For the data collection, we followed the procedures of the previous study and recruited 138 participants. These participants were randomly assigned to either of the Android or Alpha conditions, and then to either of the control or experimental groups. Similar to the previous study, participants in the experimental (control) group were presented with a description of the brand-new Watchasay streaming box with (without) information about the availability of its refurbished version in the market.

<INSERT TABLE 8 HERE>

Figure 6 presents the percentages of participants who chose the option of "prefer to buy a

brand-new streaming box" over the "no purchase" alternative in the control and experimental groups in each of the Android and Alpha conditions. Similar to the patterns shown in Figure 3, the likelihood of choosing the brand-new counterpart was reduced in the Android condition, but increased in the Alpha condition when the refurbished products are available in the market.

<INSERT FIGURE 6 HERE>

We also estimated the logistic regression models for a formal analysis of study 2. As shown in Table 9, the estimation of the models in study 2 provides consistent results as those in study 1, which further support H1 and H2(a). For example, the estimate of $\beta_2 + \beta_3$ in Model 1, which is significantly negative, with an estimate of -.339 and a standard error of .197 (p-value = .085), suggests that the availability of a refurbished streaming device employing the Android operating system decreases participants' likelihood of choosing the brand-new counterpart over the "no purchase" option, which supports H1. In Model 2, $\beta_2 + \beta_3$ is estimated to be significantly positive, with an estimate of .587 and a standard error of .198 (p-value = .003). This finding suggests that the availability of a refurbished streaming device with the Alpha operating system increases participants' likelihood of choosing the brand-new counterpart, which supports H2(a).

<INSERT TABLE 9 HERE>

Lastly, to confirm the mediation role of network effects, we also compared the mean values of the participants' responses to the first statement in Table 5 between the control and experimental groups. The mean of the statement variable is 3.46 in the control group and significantly larger at 3.59 in the experimental group (p-value = .024), as shown in Figure 7. This finding indicates that the participants formed stronger expectations that the availability of refurbished products could help enlarge the installed user base when they were informed about the presence and description of the refurbished products. Similarly, Table 9 also shows a

significantly positive coefficient of MoreApps (β_8=.401, p<0.01), indicating the positive relationship between the likelihood of purchasing brand-new products and agreement with the first statement. Together, these results further confirm the mediation role of network effects associated with refurbished product introduction.

<INSERT FIGURE 7 HERE>

Additional Robustness Check

We conducted two additional experimental studies to examine the robustness of our results by varying respondents' responses in the studies. Study 3 was designed in the same way as study 1, except that the participants were asked about their WTP for a brand-new smartwatch, instead of their purchase intentions, with and without the presence of the refurbished counterpart. Similarly, study 4 mimicked the experimental design of study 2, but participants were asked about their WTP for a brand-new video streaming box. We collected responses from 151 participants in study 3, and 149 participants in study 4.

We ran a linear regression model to analyze the data obtained from the two WTP studies. The dependent variable of the regression model is participants' WTP for a brand-new product. In each study, we estimated two versions of the regression model that differ from each other in terms of two independent variables: Model 1 with *Android* and *Android*×*Refurbished* and Model 2 with *Alpha* and *Alpha*×*Refurbished*. Tables 10 and 11 report the estimation results for studies 3 and 4, respectively. In both studies, we found that participants' WTP for a brand-new product employing the Android operating system significantly decreased when they were informed about the availability of its refurbished version ($\beta_2 + \beta_3$ =-6.398, p<0.01 in study 3, and $\beta_2 + \beta_3$ =-3.311, p<0.01 in study 4). In contrast, participants were willing to pay more for a brand-new product using the Alpha operating system upon the availability of its refurbished version ($\beta_2 + \beta_3$

=18.392, $p<0.01$ in study 3, and $\beta_2 + \beta_3 = 13.424$, $p<0.01$ in study 4). Overall, therefore, all four experimental studies (two choice studies 1&2 and two WTP studies 3&4) on two different products (smartwatches and smart video streaming devices) offer robust results in support of H1 and H2(a) and demonstrate the benefits (harms) of introducing refurbished products to brand-new counterparts using a new (established) technology standard.

<INSERT TABLES 10 AND 11 HERE>

DISCUSSION AND CONCLUSION

With increasing efforts devoted to sustainable marketing strategies, there is a pressing need for companies to understand how consumers respond to their sustainable offerings (Kotler 2011). In particular, as introducing refurbished products has become a prominent sustainability practice, it is imperative for manufacturers to understand whether consumers are willing to accept this new practice, and whether this green product strategy benefits or hurts manufacturers. The current study investigates these issues by taking into account network effects and standards competition, the unique characteristics of the consumer electronics and digital product markets, which are among the most active sectors for refurbished products. Our five studies (one empirical and four experimental studies) reveal several key findings that contribute to the literature on green marketing, sustainability, and network effects, which provide important implications to practitioners.

Theoretical Contribution

In the literature on green marketing and sustainability, prior studies have examined the effectiveness and challenges in marketing various green products such as natural or organic products, fair trade products, and green or sustainable products (Chen 2001; Dangelico and

Pujari 2010; Ginsberg and Bloom 2004; Griskevicius and Tybur 2010; Kumar and Ghodeswar 2015). Yet, little attention has been paid to refurbished products, an increasingly prevalent green product strategy. Our research calls attention to this green product strategy for scholars in sustainability and contributes to the literature by filling this void.

We show that this sustainable practice is a double-edged sword—introducing refurbished products could either benefit or hurt manufacturers' primary products. Focusing on the markets of consumer electronics and digital products, which exhibit strong network effects and standards competition, we highlight an important contingency on the influences of this green product strategy—the developmental stage (i.e., new vs. established) of technology standards. With consideration of this contingency, our analyses uncover a condition under which manufacturers can benefit from introducing refurbished products: when these products employ a new technology standard. In contrast, our studies suggest that manufacturers' sustainability could face a challenge by implementing the green product strategy with refurbished products under another condition in which the products employ an established technology standard.

Our research also adds to the literature on network effects. We draw attention to a sustainable product strategy – the introduction of refurbished products – which can help boost the installed user base of a new technology and can enhance the success of the new technology in markets with network effects and standards competition. Intuitively, manufacturers may be reluctant to introduce refurbished products in the face of strong standards competition if their products adopt a new technology standard, as they may be afraid that the presence of refurbished products in markets can convey a negative spillover of poor quality to their primary brand-new products. Counter-intuitively, our analyses show that introducing refurbished products can in fact benefit manufacturers by increasing the installed user base of the new technology standard,

which can in turn strengthen network effects and enhance the success chance of the new technology.

Managerial Implication

From a managerial perspective, our findings provide practical insights regarding when and how manufacturers can implement the refurbished product strategy in their best interest. Our study shows promising strategic insights into the introduction of refurbished products when a brand adopts a new technology standard. On the other hand, we also raise a warning to manufacturers offering refurbished products that adopt an established technology standard. Given the fact that refurbished products are remanufactured from product returns, an inherent negative effect can arise from introducing refurbished products: a negative connotation of poor quality. Our findings regarding the negative effects of introducing refurbished products reveal the downside of such a sustainable product strategy for the manufacturers' primary products (i.e., brand-new counterparts).

However, as product lifecycles have been tremendously shortened over recent decades, and a vast number of electronic products are discarded every year, how to reuse this electronic waste is an unavoidable issue for the whole society. To understand how manufacturers can attenuate the negative effects from implementing refurbished products with established technology standards, we look into our data and investigate whether the magnitude of the negative effect may vary with the product characteristics. Insights into such questions are particularly important because in practice, many firms compete in markets with established technology standards.

Specifically, we compared the percentages of participants who chose brand-new counterparts in the control and experimental groups under the Android condition (i.e.,

established technology) in studies 1 and 2. As shown in Panel A of Table 12, the percentage of respondents who chose the option of "prefer to buy a brand-new smartwatch" in study 1 decreased by 25.9% when the refurbished version of high-end smartwatches (i.e., product attributes of 4GB memory and a 7-day battery life) is available in the market. However, with the presence of the refurbished version of low-end products (i.e., product attributes of 2GB memory and a 3-day battery life), such a negative effect from the introduction of refurbished products could be dramatically reduced from -25.9% to 9.2%.[5] Using the data collected under the Android (i.e., established technology) condition in study 2, we also find similar patterns (i.e., the percentage difference decreasing from -11.8% to -8.4%), as shown in Panel B of Table 12.

<INSERT TABLE 12 HERE>

To further demonstrate how the negative effect varies from introducing a refurbished version of low- to high-end products, we rerun the logistic regression analyses in Tables 7 and 9 using the data collected only under the Android (i.e., established technology standard) condition in studies 1 and 2. To examine if the negative effect of introducing refurbished products is lower for low-end products than that for high-end products, we incorporate two interaction terms, *Refurbished*×*Memory2* and *Refurbished*×*Battery3* (*Refurbished*×*Memory4* and *Refurbished*×*Channel25*), into the logistic regression analyses of study 1 (2). As shown in Part A of Table 13, the coefficients of *Refurbished*×*Memory2* and *Refurbished*×*Battery3* are significantly positive, indicating that introducing a refurbished version of low-end products leads to weaker negative impacts on brand-new counterparts. The results for the Android condition in study 2, presented in Part B of Table 13, also demonstrate a similar pattern regarding the weaker

[5] Surprisingly, we find that the effect from introducing low-end refurbished products can even be positive, with an increase of 9.2% in respondents' choice of brand-new counterparts between the control and experimental groups. However, such a pattern is not found in the same analysis of study 2 using the data collected under the Android condition.

negative effect from introducing a refurbished version of low-end products, although the coefficients of the two interaction terms, *Refurbished×Memory4* and *Refurbished×Channel25,* are insignificant.

<INSERT TABLE 13 HERE>

Together, these results reveal that, for products that employ an established technology standard, the negative effect from introducing a refurbished version of low-end products is weaker, as compared to that from introducing a refurbished version of high-end products. This result may occur because consumers would have lower expectations regarding the product quality when considering lower-end products (Grewal 1995; Jacoby et al. 1971). Therefore, the negative effect of a low-quality connotation from the presence of refurbished products would be weaker for lower-end products. While the adverse effect could be mitigated in various ways, this result suggests that manufacturers can focus on low-end products when they introduce refurbished products that employ established technology standards.

Limitations

This study has several limitations that future studies can potentially address and explore further. First, given the main focus of our research, to highlight the influences of refurbished products on brand-new counterparts, we designed our experimental studies with two choice alternatives only (i.e., "prefer to buy a brand-new smartwatch" vs. "no purchase") in both conditions, with and without the presence of refurbished products. Future work can extend our studies to consider more complex scenarios with, for example, multiple product lines, different generations, and competing brands. It would be fruitful to explore the potential impacts of introducing refurbished products not only on other company product lines or products of different generations, but also

on competitors' products. Second, we focused on examining the effect of introducing refurbished products in the markets of consumer electronics with network effects and standards competition. Future research may investigate how the availability of refurbished products would affect consumer behavior in markets with different characteristics. Lastly, as stated earlier, a crucial issue for manufacturers in pursuing this green product strategy is how to attenuate potential harms from introducing refurbished products, particularly when the products employ established technology. While our study suggests that manufacturers could mitigate these negative effects by introducing the refurbished version of low-end products, future research can investigate other strategies, such as adjusting the timing of refurbished product introduction, and providing additional warranties and certifications, so as to help mitigate the adverse influences from implementing this green product strategy.

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Table 1. Description of Variables

	Name	Description
S_i	*Windows*	1 if the tablet uses MS Windows, and 0 otherwise
	Android	1 if the tablet uses Google Android, and 0 otherwise
	iOS	1 if the tablet uses Apple iOS, and 0 otherwise
N_{it}	*N_New*	The number of non-Amazon merchants selling brand-new products of the tablet in a given week
	N_Refurbished	The number of non-Amazon merchants selling refurbished products of the tablet in a given week
	N_Used	The number of non-Amazon merchants selling used products of the tablet in a given week
$S_i \times N_{it}$	*Windows*×*N_New*	Interaction of Windows and NumNew
	Android×*N_New*	Interaction of Android and NumNew
	iOS×*N_New*	Interaction of iOS and NumNew
	Windows×*N_Refurbished*	Interaction of Windows and NumRefurbished
	Android×*N_Refurbished*	Interaction of Android and NumRefurbished
	iOS×*N_Refurbished*	Interaction of iOS and NumRefurbished
	Windows×*N_Used*	Interaction of Windows and NumUsed
	Android×*N_Used*	Interaction of Android and NumUsed
	iOS×*N_Used*	Interaction of iOS and NumUsed
X_{it}	*Lowest new price*	Lowest new product price of the tablet sold by non-Amazon merchants
	Lowest refurbished price	Lowest refurbished product price of the tablet sold by non-Amazon merchants
	Lowest used price	Lowest used product price of the tablet sold by non-Amazon merchants
	Storage	Storage size of the tablet
	Screen	Storage size of the tablet
	Memory	Memory (RAM) size of the tablet
T_t	*Time Trend*	1 for the first week of the data period and increases over the weeks

Table 2. Estimation Results

Variable	Estimate (S.E.)	
Intercept	12.788	(20.117)
Windows	58.316**	(25.939)
Android	-5.103	(12.865)
iOS	204.103***	(24.556)
N_New	-.112	(.086)
N_Refurbished	-.230	(1.043)
N_Used	.266	(.196)
Windows×N_New	-9.558***	(1.373)
Android×N_New	-1.029***	(.338)
iOS×N_New	-3.917***	(.440)
Windows×N_Refurbished	14.780**	(6.972)
Android×N_Refurbished	3.845*	(2.192)
iOS×N_Refurbished	1.785	(1.815)
Windows×N_Used	10.797***	(1.712)
Android×N_Used	.852*	(.455)
iOS×N_Used	.145	(.267)
Lowest new price	.538***	(.048)
Lowest refurbished price	.186***	(.053)
Lowest used price	.213***	(.069)
Storage	.072	(.180)
Screen	.821	(1.045)
Memory	17.625	(13.064)
Time Trend	.886***	(.271)

Notes: *, **, *** represent significance at the 0.10, 0.05, and 0.01 levels, respectively.

Table 3: Smartwatch Attributes and Their Levels

	Price	Memory	Battery
Brand-new smartwatch	$100, $115	2 GB, 4 GB	3 days, 7 days
Refurbished smartwatch	60% or 70% of the brand-new counterpart	2 GB, 4 GB	3 days, 7 days

Table 4: Profiles of Smartwatch Alternatives

Profile	Brand-new Product			Refurbished Counterpart		
No.	Price	Memory	Battery	Price	Memory	Battery
1	$100	2 GB	3 days	$60	2 GB	3 days
2	$115	4 GB	3 days	$70	4 GB	3 days
3	$100	2 GB	7 days	$70	2 GB	7 days
4	$100	4 GB	7 days	$60	4 GB	7 days
5	$115	2 GB	7 days	$70	2 GB	7 days
6	$100	4 GB	3 days	$70	4 GB	3 days
7	$115	2 GB	3 days	$80	2 GB	3 days
8	$115	4 GB	7 days	$80	4 GB	7 days

Table 5. Question Statements

	Statement (1: Completely Disagree, 5: Completely Agree)
Q1	"I think more people buying refurbished products can help increase the number of applications for the operating system."
Q2	"Refurbished products have the same product attributes as brand-new products."
Q3	"Buying refurbished products can help me save money compared to buying brand-new products."
Q4	"I have quality concerns about refurbished products."
Q5	"Psychological comfort and hygiene are important when it comes to buying refurbished products."

Table 6: Sample Questions for the Android Condition

Control Group	Experimental Group
Please choose your preferred option: New Watchasay Smartwatch Alpha operating system Average 3 days of battery life 2 GB Built-in Memory Storage $100 □ Prefer to buy □ Prefer not to buy	Given that there is also a refurbished version of the same Watchasay Smartwatch offered at the same time from us at $ 60, please choose your preferred option: New Watchasay Smartwatch Alpha operating system Average 3 days of battery life 2 GB Built-in Memory Storage $100 □ Prefer to buy □ Prefer not to buy

Table 7: Parameter Estimates of Logistic Regression Models in Study 1 (Choice Study Using Smartwatches)

Variable	Model 1 Estimate (S.E.)		Model 2 Estimate (S.E.)	
Constant (β_0)	-4.338***	(.559)	-3.685***	(.539)
Android (β_1)	.652***	(.200)		
Alpha (β_1)			-.652***	(.200)
Refurbished (β_2)	.310*	(.183)	-.383*	(.203)
Android×*Refurbished* (β_3)	-.693***	(.269)		
Alpha×*Refurbished* (β_3)			.693***	(.269)
Price115 (β_4)	-.354***	(.132)	-.354***	(.132)
Memory4 (β_5)	.372***	(.132)	.372***	(.132)
Battery7 (β_6)	.354***	(.132)	.354***	(.132)
Experience (β_7)	.555***	(.139)	.555***	(.139)
MoreApps (β_8)	.437***	(.077)	.437***	(.077)
SameAttributes (β_9)	-.028	(.070)	-.028	(.070)
SaveMoney (β_{10})	.075	(.079)	.075	(.079)
SameQuality (β_{11})	.171**	(.069)	.171**	(.069)
Hygiene (β_{12})	.411***	(.071)	.411***	(.071)

Notes: *, **, *** represent significance at the 0.10, 0.05, and 0.01 levels, respectively.

Table 8: Profiles of Streaming Device Alternatives

Profile No.	Brand-new Product			Refurbished Counterpart		
	Price	Memory	No. of Free Channels	Price	Memory	No. of Free Channels
1	$100	4 GB	25	$60	4 GB	25
2	$120	8 GB	25	$72	8 GB	25
3	$100	4 GB	50	$70	4 GB	50
4	$100	8 GB	50	$60	8 GB	50
5	$120	4 GB	50	$72	4 GB	50
6	$100	8 GB	25	$70	8 GB	25
7	$120	4 GB	25	$84	4 GB	25
8	$120	8 GB	50	$84	8 GB	50

Table 9: Parameter Estimates of Logistic Regression Models in Study 2 (Choice Study Using Streaming Devices)

Variable	Model 1 Estimate (S.E.)		Model 2 Estimate (S.E.)	
Constant (β_0)	-2.977***	(.537)	-2.824***	(.526)
Android (β_1)	.153	(.197)		
Alpha (β_1)			-.153	(.197)
Refurbished (β_2)	.587***	(.198)	-.339*	(.197)
Android×Refurbished (β_3)	-.926***	(.277)		
Alpha×Refurbished (β_3)			.926***	(.277)
Price120 (β_4)	-.591***	(.133)	-.591***	(.133)
Memory8 (β_5)	.228*	(.133)	.228*	(.133)
Channel50 (β_6)	.332**	(.133)	.332*	(.133)
Experience (β_7)	.009	(.152)	.009	(.152)
MoreApps (β_8)	.401***	(.078)	.401***	(.078)
SameAttributes (β_9)	-.111	(.097)	-.111	(.097)
SaveMoney (β_{10})	-.168	(.106)	-.168	(.106)
SameQuality (β_{11})	.207***	(.073)	.207***	(.073)
Hygiene (β_{12})	.422***	(.073)	.422***	(.073)

Notes: *, **, *** represent significance at the 0.10, 0.05, and 0.01 levels, respectively.

Table 10: Parameter Estimates of Regression Models in Study 3 (WTP Study Using Smartwatches)

Variable	Model 1 Estimate (S.E.)		Model 2 Estimate (S.E.)	
Constant (β_0)	62.906***	(1.579)	98.057***	(1.665)
Android (β_1)	35.151***	(1.873)		
Alpha (β_1)			-35.151***	(1.873)
Refurbished (β_2)	18.392***	(1.859)	-6.398***	(1.895)
Android×Refurbished (β_3)	-24.790***	(2.655)		
Alpha×Refurbished (β_3)			24.790***	(2.655)
Memory4 (β_4)	4.139***	(1.325)	4.139***	(1.325)
Battery7 (β_5)	6.391***	(1.325)	6.391***	(1.325)

Notes: *, **, *** represent significance at the 0.10, 0.05, and 0.01 levels, respectively.

Table 11: Parameter Estimates of Regression Models in Study 4 (WTP Study Using Streaming Devices)

Variable	Model 1 Estimate (S.E.)		Model 2 Estimate (S.E.)	
Constant (β_0)	69.814***	(1.660)	94.119***	(1.689)
Android (β_1)	24.304***	(1.923)		
Alpha (β_1)			-24.304	(1.923)
Refurbished (β_2)	13.424***	(1.937)	-3.311*	(1.976)
Android×Refurbished (β_3)	-16.735***	(2.767)		
Alpha×Refurbished (β_3)			16.735***	(2.767)
Memory8 (β_4)	2.619*	(1.382)	2.619*	(1.382)
Channel50 (β_5)	3.265**	(1.382)	3.265**	(1.382)

Notes: *, **, *** represent significance at the 0.10, 0.05, and 0.01 levels, respectively.

Table 12: Percentage of Participants who Chose the Brand-New Counterparts in the Android Condition in Studies 1 and 2

Panel A. Study 1

Profile (Memory, Battery)	Control Group (C)	Experimental Group (E)	Difference (=E-C)
(4 GB, 7 days)	89.1%	63.2%	-25.9%
(4 GB, 3 days)	68.8%	63.2%	-5.6%
(2 GB, 7 days)	59.4%	61.8%	2.4%
(2 GB, 3 days)	45.3%	54.5%	9.2%

Panel B. Study 2

Profile (Memory, Free Channels)	Control Group (C)	Experimental Group (E)	Difference (=E-C)
(8 GB, 50 channels)	50.0%	38.2%	-11.8%
(8 GB, 25 channels)	35.1%	29.4%	-5.7%
(4 GB, 50 channels)	39.2%	32.4%	-6.8%
(4 GB, 25 channels)	37.8%	29.4%	-8.4%

Table 13: Parameter Estimates of the Logistic Regression Model for the Android Condition in Studies 1 and 2

Part A. Study 1			Part B. Study 2		
Variable	**Estimate (S.E.)**		**Variable**	**Estimate (S.E.)**	
Constant (β_0)	-3.615***	(.884)	*Constant* (β_0)	-1.631**	(.711)
Refurbished (β_1)	-1.574***	(.408)	*Refurbished* (β_1)	-.456	(.321)
Price115 (β_2)	-.319	(.207)	*Price115* (β_2)	.197	(.182)
Memory2 (β_3)	-1.545***	(.319)	*Memory4* (β_3)	-.182	(.246)
Battery3 (β_4)	-1.029***	(.315)	*Channel25* (β_4)	-.363	(.247)
Refurbished × *Memory2* (β_6)	1.276***	(.422)	*Refurbished* × *Memory4* (β_6)	.038	(.364)
Refurbished × *Battery3* (β_7)	.836**	(.418)	*Refurbished* × *Channel25* (β_7)	.076	(.364)
Experience (β_6)	.694***	(.220)	*Experience* (β_6)	.363*	(.214)
MoreApps (β_7)	.467***	(.109)	*MoreApps* (β_7)	.314***	(.108)
SameAttributes (β_8)	-.175	(.127)	*SameAttributes* (β_8)	-.153	(.136)
SaveMoney (β_9)	.407***	(.119)	*SaveMoney* (β_9)	-.117	(.160)
SameQuality (β_{10})	.362***	(.119)	*SameQuality* (β_{10})	.0001	(.110)
Hygiene (β_{11})	.385***	(.133)	*Hygiene* (β_{11})	.365***	(.106)

Notes: *, **, *** represent significance at the 0.10, 0.05, and 0.01 levels, respectively.

Figure 1. Description of Hypothetical Smartwatch

This is "Watchasay" smart watch!

"Watchasay" smart watch runs on a proprietary (unique) new operating system — "Alpha" which is not compatible with Apple iOS, Google Android, or Windows operating system.

At this moment, "Alpha" operating system allows you to get live email, message updates and to download other applications from our apps store to your smart watch.

The more people using "Watchasay" smart watch, the more applications you will get from this new "Alpha" operating system as a user.

GENERAL FEATURES

Compatible with Alpha operating system

Allow you to view notifications from smart phone SMS, calls, and calendar

Install your favorite Alpha system Apps (ESPN, Facebook, Twitter, etc.) on your smart watch

Rechargeable battery

Figure 2. Participant Assignment Process

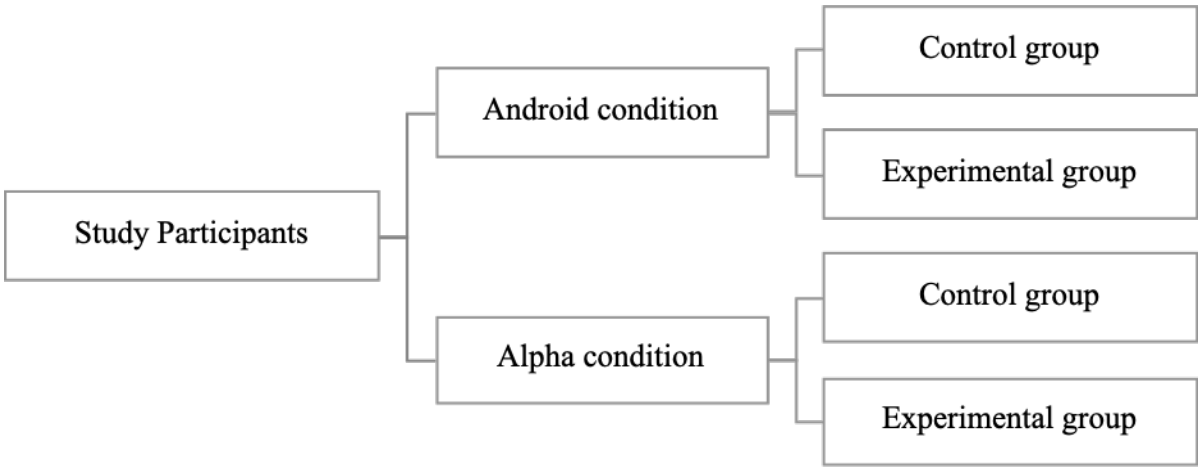


Figure 3. Descriptive Results of Study 1

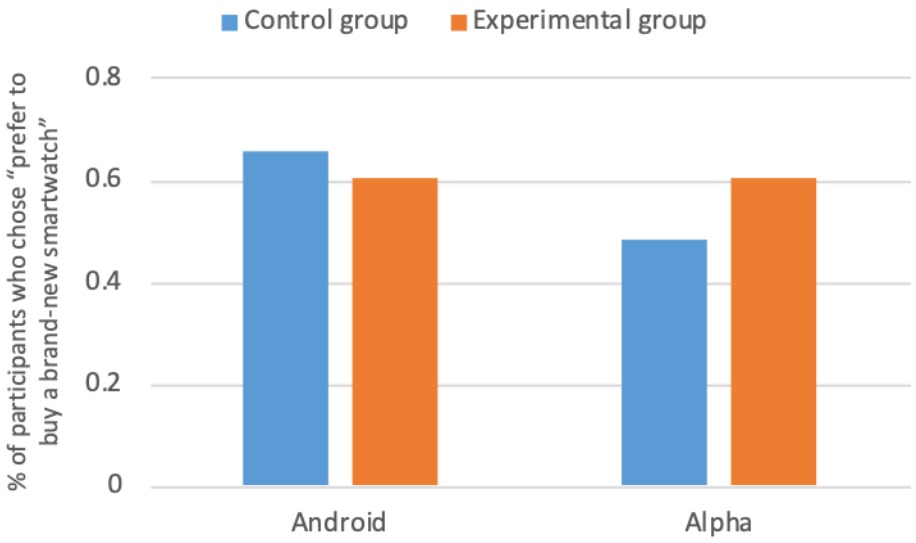
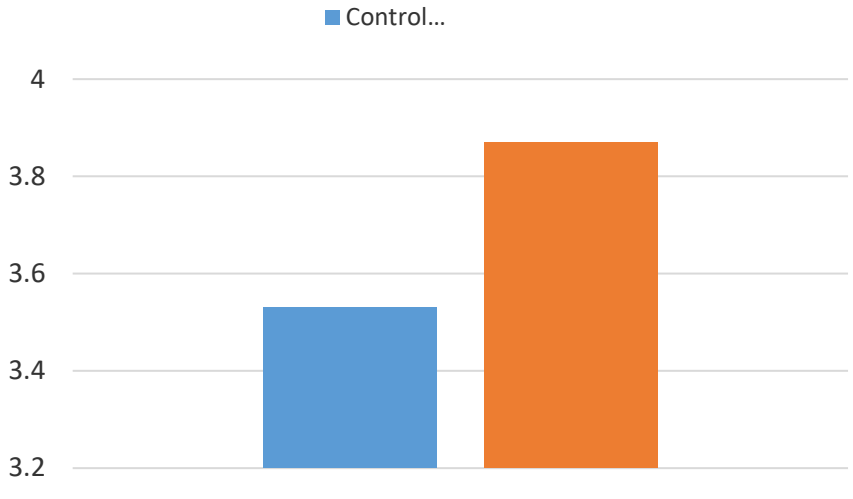


Figure 4. Average Agreement of Respondents Regarding Statement 1 in Study 1



Statement 1: "I think more people buying refurbished products can help increase the number of applications for the operating system."

Figure 5. Description of Hypothetical Streaming Device

About Our Streaming Devices:

This is our "Watchasay" streaming box!

Watchasay streaming box runs on a new operating system called "Alpha".

At this moment, the streaming box allows you to get live email and message updates and to download other applications from Alpha App store to your streaming box.

The more people using "Watchasay" streaming box, the more applications you will get from the Android operating system as a user.

GENERAL FEATURES

Compatible with Alpha operating system

Allow you to watch free and paid online streaming contents

Install your favorite Alpha system streaming Apps (Youtube, Vimeo, Sling, Netflix, Hulu, etc.) on your streaming box

One HDMI Port & Three USB 3.0 ports

Figure 6. Descriptive Results of Study 2

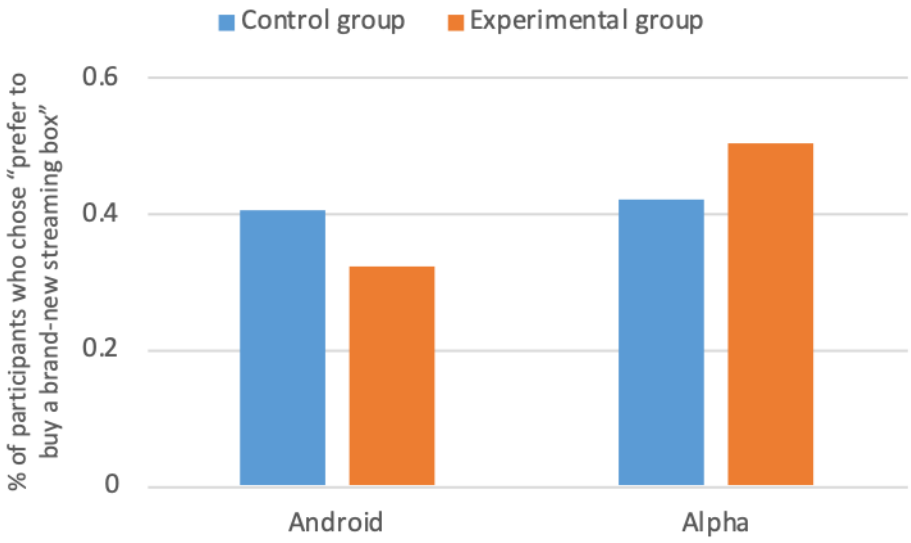
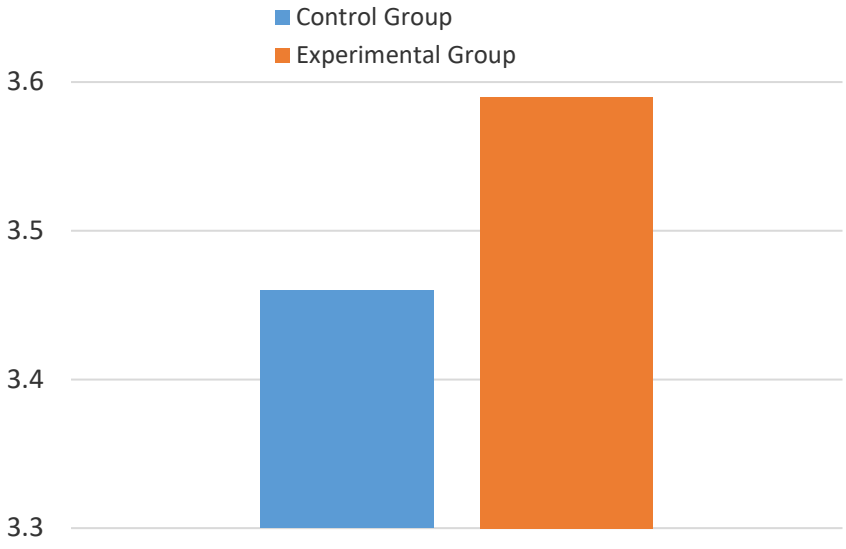


Figure 7. Average Agreement of Respondents Regarding Statement 1 in Study 2



Statement 1: "I think more people buying refurbished products can help increase the number of applications for the operating system."