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From trash to treasure: The impact of consumer perception of bio-waste products in closed-loop supply chains

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ABSTRACT

Increasing efforts are made to convert waste into new materials for replacing "traditional" ones. In particular urban bio-waste represents a primary source of concern for both government and society. A new type of polyhydroxyalkanoates (PHA) have been very recently developed to convert food waste into a biodegradable multifunctional raw material to help solving the plastic waste problem. However, little is known about consumers' reactions to products made from PHA. Hence this study aims at understanding consumers' intentions to purchase, pay for, and switch to those bio-based products. Both multivariate analyses of variance and mediation analyses are run, addressing product involvement, consumer values, expertise and demographics within an experimental study based on a representative sample of UK respondents. Findings reveal no effects for product involvement and gender on the dependent variables, but for green self-identity, attitude towards bio-based product, age and past purchase experience of eco-friendly products. Results can help the adoption of PHA-based bioplastics to solve the pressing problem of the disposal of bio-waste. In particular, understanding the drivers of consumers acceptance of bio-based products poses opportunities to build new closed loop system and for successfully marketing the reuse of urban food-waste. Theoretical and managerial implications are addressed.

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1. Introduction

Most developed economies are rooted in linear consumption models. Unfortunately, these models are not sustainable in the long-term, and might require direct intervention in the immediate term in order to correct emerging social, financial, and environmental impacts derived therefrom. To this end, research suggests that governments and business leaders adopt closed-loop supply chain (CLSC) models and practices as mechanisms for sustainable business operations. Indeed, both academics and practitioners pay increasing attention toward creating more efficient, low cost, and sustainable closed loop systems by employing circular economy (CE) practices (Bell et al., 2013; Govindan et al., 2015; Mirabella et al., 2014; Sgarbossa and Russo, 2017; Liu et al., 2018). Although some elements of circularity such as recycling and composting are already present in the linear economy, a CE takes a step beyond the pursuit of waste prevention and reduction to inspire technological, organizational and social innovation across supply chains. One important area of innovation has to do with transforming waste back into a raw material suitable for replacing natural raw materials; in other words, turning otherwise "disgusting" refuse into raw material "treasures." As such, the current research concerns how consumers respond to the introduction of products made from regenerated bio-waste.

Waste is traditionally categorized with respect to its provenance, and includes: agricultural, industrial, animal, and municipal (urban) wastes (Chen et al., 2016). Specific to this study, urban bio-waste includes the organic components of municipal solid waste (i.e., from households and restaurants), excess sludge (i.e., from urban wastewater treatment), garden and park waste, and commercial food-processing waste. Private household generation is the primary source of food waste (53%) and the costs associated with managing this type of waste total nearly 100 billion euros per year (Stenmarck et al., 2016). Current treatments of food waste involve several valuable disposition strategies, ranging from incineration, composting, and bio-gasification (including use of residual material

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as fertilizer), to feed for livestock and even redistribution for human consumption. However, more research is needed in order to guide development and implementation of additional disposition options (Takata et al., 2013).

From a CE perspective, food waste can be a resource rather than simply a cost, thus becoming a primary constituent of a new generation of bio-based products. Indeed, the European Commission recently adopted a new ambitious CE package as part of its strategy to move toward a more competitive, resource-regenerative economic structure (van Weelden et al., 2016). This package "closes the loop" by diverting urban bio-waste streams from landfilling to new processing mechanisms that can transform waste back into a useful product or raw material. Although there are more developments underway to improve the bio-waste transformation process, (Papargyropoulou et al., 2014), these technologies are already demonstrating an economically feasible means of generating raw materials from waste.

Recently, polyhydroxyalkanoates (PHA) have been produced via a series of bioconversion processes where food waste is converted into volatile fatty acids (VFS) and then stored at cell level by mixed microbial biomass (Basset et al., 2016; Villano et al., 2014). PHA is the generic name of a family of thermoplastics formed by combining hydroxy-butirate with 5–20% hydroxy-valerate. PHA possesses the unique characteristic of being biodegradable in the environment, which helps to allay the plastic waste stream problem, as evidenced for example by ocean plastic littering (Rodriguez-Perez et al., 2018). Specifically, the goal of transforming urban bio-waste into environmentally friendly bio-based products can be achieved via producing PHA-based bioplastics. As such, this and similar innovations can help to solve some of today's most pressing issues regarding the treatment, disposal and reuse of organic waste. In summary, biodegradable plastics and bio-based polymer products could form the basis of a portfolio of sustainable, CE-enabled products (Mumtaz et al., 2010).

To make disposition activities feasible for a company to adopt, those activities have to be profitable. Indeed, comparability of bio-based products versus fossil-based or otherwise "new" alternatives is a key issue in the literature (Reinders et al., 2017). The eventual success of products produced using PHA-based bioplastics depends upon consumer acceptance of such products. Yet, despite the relevance of understanding the consumer's role in these CLSCs, the literature disproportionately focuses on technical, chemical and engineering aspects of such materials (Dietrich et al., 2017; Dilkes-Hoffman et al., 2018) and the organization of efficient CLSC systems (Govindan and Soleimani, 2017). In this vein, recent literature calls for more research that can increase understanding of how consumers perceive products generated from food waste (Geissdoerfer et al., 2017; Reinders et al., 2017). This greater understanding can help to inform the design and implementation of CLSC models in support of CE.

To date, consumers have not shown a propensity toward adopting, for example, remanufactured products as a substitute for new products (Abbey et al., 2015). Indeed, few consumers perceive remanufactured goods to be as good as new ones, which presents a major barrier to more widespread adoption (Hazen et al., 2017). Furthermore, previous research has mainly focused on psychological and psychographic aspects, attitudes, personal values and moral obligation (see for instance Barbarossa et al., 2017; Akehurst et al., 2012). However, these aspects do not necessarily translate into behaviors or behavioral intentions toward products from regenerated bio-waste. Accordingly, the present research explicitly addresses behavioral intentions such as willingness-to-pay for, buy and switch to bio-based product.

Thus, the current research answers this call and examines for the first time how consumers might respond to this new generation of bio-based products. The current research intends to answer the following questions. (1) Do consumers' purchase intentions, willingness-to-pay for and intention to switch to bio-based products depend upon the degree to which consumers are involved in the product itself? (2) Do consumers' personal values affect their purchase intention and willingness-to-pay for bio-based products? In addition, do these values lead consumers to switch from purchasing traditional new products to products made with bio-based materials? (3) How do consumer demographics and previous purchasing experiences affect one's intention to purchase or switch to bio-based products?

Investigating these questions contributes to research and practice in several ways. First, the current research identifies and tests factors that might affect consumer acceptance of bio-based products derived from organic waste. The importance of this contribution stems from the fact that if consumer markets are not fully understood, then forces related to them become barriers to mass adoption, no matter how well the operational system is designed.

Second, the research generates new insights with respect to how organizations might better integrate consumers into a CE construct. Governments from across the globe are developing CE initiatives. For instance, China continues to promote and fund CE initiatives such as waste reclamation and remanufacturing (Wang et al., 2018a,b). In the EU, the Juncker Commission and its "Plastic Strategy" aim toward developing a system that will make "all plastic packaging reusable or recyclable in a cost-effective manner by 2030" (p. 1, EU Commission, 2018). Further, "long-term goals entail reduced use of landfilling and increased opportunities for reusing and recycling key waste streams such as municipal and packaging wastes" (p.1, EU Commission, 2015).

Third, this research can guide practitioners toward understanding how to develop and operationalize their CLSC strategy. Although bio-based products are for all intents and purposes supposed to be the same as their new product counterparts in terms of quality, research on products derived from other CE practices like remanufacturing suggests that consumers still perceive a difference, which affects purchase intentions and behaviors (Khor and Hazen, 2017). As such, it is critical for managers to understand these differences in the context of new bio-based products so that they can plan production and marketing activities to help reduce these perceived differences and support diffusion of these products.

The remainder of this paper is organized as follows. First, theory and literature are used to form the research model and associated hypotheses. Then, the experimental research design is described, as well as the data analyses. Finally, the findings are presented, and theoretical and managerial implications are discussed.

2. Framework and hypotheses development

Environmental impacts of food waste manifest themselves in many ways. For instance, the carbon footprint related to the food product lifecycle (i.e., growing, transporting, storing, and selling otherwise good food that goes to waste) is significant (Soysal et al., 2014). Chen et al. (2016) suggest that the majority of studies on bio-based products investigate treatment and disposal methods, energy byproducts, operational conditions and innovative bio-hydrogen production. Because of the dearth of research on consumer perception of bio-based products, here we leverage literature and theory about perceptions of products derived from similar reclamation processes, such as remanufactured products, to identify potential drivers of (or barriers to) one's intention to purchase and willingness-to-pay for bio-based products.

Due to their being renewable and biodegradable, bio-based products are generally considered an eco-friendly alternative to

new products derived from natural (i.e., fossil) resources (Mugge et al., 2017; Reinders et al., 2017). As such, literature on remanufactured products provides a meaningful initial framework to help understand the market for bio-based products because remanufacturing operations begin with reclaiming used materials that would otherwise be at their end of life, instead of using new raw materials. Like bio-based products, remanufacturing restores used products to as-new condition, often with the same warranty as the equivalent new product (Atasu et al., 2010; Jiménez-Parra et al., 2014). To increase the share of products derived from circular economy activities in the consumer market, one needs to understand how to make both remanufactured and bio-based products appealing to consumers (Atlason et al., 2017; van Weelden et al., 2016).

Although the environmental benefits of products derived from reclaimed materials have attracted much attention from both industry and the media, consumers remain generally unreceptive towards such goods (Hazen et al., 2017). In this vein, recent studies in remanufacturing have adopted a consumer-based perspective and suggest that providing information about product quality, cost, and green attributes affects consumers' perception of both value and risk associated with acquiring remanufactured products, and finally their purchase intention (Wang and Hazen, 2016).

Studies on consumer perceptions of products derived from remanufacturing, recycling, refurbishing, and other reclamation processes typically leverage behavioral and economic theories. Of these, prospect theory is not only suggested to be a powerful yet underutilized theory for explaining supply chain phenomena (Cegielski et al., 2012; Gligor et al., 2018), but has proven to be a useful lens through which to predict how consumers respond to offerings of products derived from reclaimed materials (e.g. Wang and Hazen, 2016).

Prospect theory helps inform investigations into consumers' propensity to choose outcomes associated with certain levels of risk and uncertainty, with respect to their personal value considerations; the theory also helps to explain how these considerations impact consumer behavior (McDermott et al., 2008; Tversky and Kahneman, 1992). According to prospect theory, consumer choice processes involve both editing and evaluation mechanisms (Tversky and Kahneman, 1992). First, the consumer formulates a number of choice prospects. Then, the consumer assigns a value to each prospect in order to inform the final decision via evaluation. Consumer choice is affected when an external source (i.e., advertiser) is able to influence one's perception of risk and level of uncertainty associated with each prospect via influence on perceived value.

Both theory and empirical evidence consistently suggest that perceived value is an antecedent to attitudes and behavior (Homer and Kahle, 1988). As such, this research considers consumer value propositions with respect to both product involvement and green self-identity. Hypotheses regarding each are proposed in the remainder of this section.

2.1. Product involvement

Product involvement is commonly defined as a consumer's enduring perceptions of the importance of the product category based on the consumer's inherent needs, values, and interests (Laurent and Kapferer, 1985; Lin and Chen, 2006; Mittal, 1995). Product categories range from inexpensive, low involvement products such as fast-moving consumer goods to costly, high involvement products such as interior design products.

Although bio-based products are made from clean plastics, consumers might not like higher involvement in these products because of the perception of them being "used" or "dirty" (Abbey et al., 2015). This idea is consistent with research suggesting the impact of perceived quality on consumer attitudes toward products derived from reclaimed materials (Jiang et al., 2016). The gap between perceived and objective quality is often ascribed to the information asymmetry between producers and consumers, and leads to value depletion across the CLSC (Michaud and Llerena, 2011; Wang and Hazen, 2016). As such, in the case of consumer choice between bio-based products and products made from all-new materials, prospect theory suggests the value functions assigned by consumers to alternatives might not be accurate.

Research on the relationship between product involvement and consumer purchase behavior addresses heterogeneous consequences of involvement. For instance, Bauer et al. (2006) found that higher involvement leads to higher loyalty, less spontaneity and less price consciousness, while Xue (2008) found that consumers' values and self-concept were predictors of choice only for consumers who were highly involved with the product. Similarly, van Weelden et al. (2016) suggest low involvement and lack of familiarity as potential causes for consumers' low acceptance of refurbished products. Regardless of the specific effects for high- and low-involvement products, most studies agree that different levels of involvement lead to different outcomes in the decision and, specifically, that higher involvement in a product facilitates choice, though with few notable exceptions (for instance, Bian and Moutinho (2011) found no relationship with purchase intention). Thus, based on theory and literature, it follows that product involvement might influence consumer perceptions and behaviors with respect to bio-based products. Specifically, this study proposes that involvement affects one's willingness-to-pay for, purchase, and switch to bio-based products.

H1. Higher involvement in the product leads to higher levels of consumer willingness-to-pay for (H1a), intention to purchase (H1b) and intention to switch to (H1c) bio-based products.

2.2. Green self-identity

Recent literature has associated bio-based products with eco-friendliness (Sijtsema et al., 2016; Tseng and Hung, 2013). Green products are those that actually prevent, reduce, or correct harmful environmental impacts on water, air, soil and society. These characteristics are related to products derived from circular processes (remanufacturing, recycling, bio-based, etc.), hence they can logically be considered as similar product categories. Related instead to consumers, green self-identity refers to an individual's overall perceived identification with the typical green consumer and is a well-recognized antecedent to a variety of eco-friendly behaviors (Oliver and Rosen, 2010). Yet, mixed findings emerge from the literature with regard to its exact role. For instance, Barbarossa and De Pelsmacker, (2016) found that acceptance of green products is driven by green self-identity that emerged as a crucial construct mediating the relationship between consumers' values and pro-environmental behavior (Barbarossa et al., 2017). Though other studies agreed on the key relevance of green self-identity, they conceptualized instead consumer greenness as a direct rather than indirect antecedent to adoption (Dono et al., 2010).

Research suggests that remanufactured products should be offered at a lower price when the green segment of consumers (consumers particularly sensible to environmental issues) is smaller; higher prices can be sought when this segment is larger in order to maximize profit (Wang and Hazen, 2016).

In the case of remanufactured products, knowledge about green product attributes is shown to be of interest to consumers; yet such knowledge does not necessarily allow remanufactures to demand a higher price (Hazen et al., 2012). Reinders et al. (2017) found

evidence that consumers prefer brands that offer bio-based products over those that do not. Considering the theoretical arguments with respect to prospect theory and consistent with the literature on remanufactured products, it follows that green self-identity will play a mediating role in the relationship between product involvement and intention to purchase bio-based products. In addition, the present research also addresses the mediating role of green self-identity with respect to the relationship between consumers' involvement in bio-based products and their willingness-to-pay for them.

H2. Green self-identity mediates the relationship between attitude towards bio-based products and: consumers' intention to purchase them (H2a); consumers' willingness-to-pay for them (H2b); and consumers' intention to switch to them (H2c).

2.3. Age and purchase experience

Previous research has addressed the impact of demographic characteristics in predicting consumer behaviors toward eco-friendly products (Namkung and Jang, 2013; Olson, 2013; Roberts, 1996; Tseng et al., 2013). For instance, some studies suggest that younger consumers could be more sensitive to green issues than older consumers (Lee, 2009; Straughan and Roberts, 1999), and more likely to purchase eco-friendly products (Namkung and Jang, 2017), having grown up in a time period where environmental issues have been a more central topic (Lee, 2009). However, other studies found no correlation between age and purchase of eco-friendly products (Akehurst et al., 2012). Given the heterogeneity of previous findings about age, the present study considers age as a control variable, acknowledging its potential impact on behavior.

Furthermore, a growing stream of literature is starting to examine consumer intentions to adopt bio-based products as a replacement for a traditional new products (Abbey et al., 2015; Jiménez-Parra et al., 2014). The initial evidence suggests that few consumers will pay a premium price for environmentally-friendly products, and suggests that behavior in one environmental context might translate into comparable behavior in another context (Groening et al., 2018). Thus, the present study addresses the role of past product experience to empirically assess whether it might influence intention to purchase and willingness-to-pay for bio-based products.

H3. Past purchase of eco-products positively influences intention to purchase (H3a), willingness-to-pay for (H3b) and intention to switch to (H3c) bio-based products.

3. Method

3.1. Stimuli selection

In the furniture industry there is a growing interest for sustainable and recycled materials (Zutshi et al., 2016), as witnessed by the presence of reusable components in several kinds of furniture (Ashley, 2014; Zutshi et al., 2016). Market and production figures consistently show that recycled furniture is a multi-billion dollar market, and recycled office furniture alone accounts for nearly three billion dollars in sales per year (Wood Working Network). Particular attention is being given to different uses of bio-based components, such as the use of bio-based polyurethane foams in the upholstery of chairs and sofas (Grand View Research, 2015).

Among furniture items, chairs are those where recycled materials are most commonly used (WasteRecycling, 2018). In-depth interviews conducted by the authors of this article with managers and researchers in the biotechnology industry suggest that chairs are one of the most likely products to be produced using bio-based PHA material. A focus group with 10 participants revealed that chairs are a viable focal item for consideration in this research. Furthermore, chairs are well-known items to the general public, not subject to particular cross-cultural issues or safety risks, and can represent both high and low involvement items. Accordingly, chairs were chosen as the product category for the current research.

Two chairs were considered in this research: one for high involvement and one for low involvement. The high involvement product was a designer chair, and the low involvement product was a convenience chair. Designer chairs from recycled materials serve an established market segment, and have dedicated categories and awards at international designer fairs (e.g. at the London Design Festival). It is not rare for international design stars to use 100% recycled materials to create furniture like chairs (e.g. Paul Borrero's award-winning UNA chair). Thus, the authors selected two pictures representing modern chairs: one mock-up photo from a Kartell catalogue served as stimulus for the designer chair, one mock-up photo from an Ikea catalogue served instead as stimulus for the convenience chair. For each photo, a short description was written to prime either high or low involvement. The descriptions were inspired by actual descriptions of designer and mass-produced convenience furniture, respectively.

3.2. Pre-test of stimuli

One hundred British respondents ($M_{age} = 55.03$; 57% female) were recruited from a panel provided by Toluna, a leading provider of on-demand consumer insights with a community of over 14 million consumers in 68 countries. Participants completed a short, online pretest questionnaire. After reading a short explanation about bio-waste-generated PHA material, respondents were randomly assigned to consider either the convenience or the designer chair. They were also asked if the explanation was clear, how much the chair appeared to be "designer" or "convenience" (on a scale ranging from 1 = "convenience" to 7 = "designer"), and product attractiveness (Fuchs et al., 2015; on a scale from 1 = "not all" to 7 = "completely").

Results from the pretest confirm that the two stimuli were perceived as being different in a consistent manner ($M_{design} = 4.28$ S.D. = 1.67 vs. $M_{conv} = 3.22$ S.D. = 1.92, $F(1, 98) = 8.69$, $p < 0.01$) yet equally likable ($M_{design} = 4.12$ S.D. = 1.86 vs. $M_{conv} = 4.14$ S.D. = 1.74, $F(1, 98) = 0.00$, $p = 0.96$). As an example the stimulus for the high involvement chair can be found in Appendix A.

3.3. Sample and measurements

Two-hundred and thirty respondents from the same panel who did not participate in the pretest were recruited for the main study and randomly assigned to one of the two treatment conditions (high vs. low involvement chair) in a between-subjects design. Ten responses were not usable due to failing the manipulation check, leading to a final usable sample of 220 participants ($Mean_{age} = 52$; $Median_{age} = 54$; 54.60% female). Overall, 37.10% of the respondents had purchased eco-friendly products in the past (mean = 8.91 products; median = 2.50 products. Sample demographics are provided in Appendix B.

Respondents read the pretested explanation about bio-based-generated PHA material (a timer function ensured participants had adequate time to read it). The ensuing questionnaire asked them to indicate their attitude toward the product (Hazen et al., 2017; 3 items), purchase intention (Mugge et al., 2017; 2 items), green self-identity (Barbarossa et al. 2016; 4 items) and switching

intention (Hazen et al., 2017, 3 items). All items ranged from 1 ("not at all") to 7 ("completely"). Furthermore, respondents were asked their willingness-to-pay for, and past purchase experience regarding eco-products (a short definition of eco-products from the Oxford dictionary was provided alongside the question). Then, respondents were asked standard demographics (age, gender, education, income, location).

As a manipulation check, respondents rated the degree to which the chair appeared to be more "designer" or "convenience" in nature (on a scale ranging from 1 = "convenience" to 7 = "designer").

Chronbach alphas for the scales range between 0.90 and 0.96. There is some ambiguity regarding what level of Cronbach's alpha should be considered acceptable. For instance, Nunnally (1978) suggested a minimum of 0.80 and 0.90 for basic and applied research, respectively, while others suggest that 0.60 or 0.70 should be obtained (Deković et al., 1991). Further, Clark and Watson (1995) suggest that Cronbach's alpha should be not lower than 0.80 and Guilford (1954) suggests that alphas higher than 0.90 show a very dependable relationship. However, very high values can also indicate strongly intercorrelated items and therefore redundancy (Clark and Watson, 1995). As such, redundancy might lead to reduced levels of validity, and researchers are warned to ensure further testing of validity when alphas are well above 0.90. Thus, on one hand, a scale should aim for high internal consistency, on the other hand if consistency is achieved by making the scale narrower than its target construct, then "increasing the internal consistency (…) may occur at the expense of validity" (Clark and Watson, 1995, p.316). This is known in psychometric theory as the attenuation paradox. Consequently, items should be factor-analyzed (Cortina, 1993) and load high on the factor representing the scale but low on the other factors (Clark and Watson, 1995). Accordingly, we followed Anderson and Gerbing (1988) procedure to ensure measure adequacy and a confirmatory factor analysis was conducted first. Results provide support for the convergent validity of the measures, with all factor loadings exceeding the recommended 0.60 threshold (Bagozzi and Yi, 1988), and the composite reliability (CR) and the average variance extracted (AVE) exceeding the recommended 0.70 and 0.50 thresholds, respectively (Fornell and Larcker, 1981). Next, a test of discriminant validity was run based on the comparison of the AVE estimate for each construct to the squared correlation between any two constructs (Fornell and Larcker, 1981). Discriminant validity is confirmed because the lowest AVE exceeds the highest squared correlation between any two variables. The measurement model therefore meets the relevant psychometric standards. Details about the measurements are reported in Appendix C.

3.3.1. Consideration of alternative explanations

Previous studies suggest that value might affect consumers adoption of green products (Khan and Mohsin, 2017; Lin and Huang, 2012). Thus, to rule out value as an alternative explanation, value was measure alongside the other variables (Lin and Huang, 2012). Moreover, previous studies have advanced risk-based explanations of consumers' adoption of green products (Chen and Chang, 2012), willingness-to-pay (Hazen et al., 2012) and purchase intention (Barbarossa and De Pelsmacker, 2016). Therefore, to rule out risk-based alternative explanations, participants' perceived risk was measured (Wang and Hazen, 2016; 4 items).

Finally, respondents were asked about product attractiveness (Fuchs et al., 2015; on a scale from 1 = "not all" to 7 = "completely") to rule out alternative explanations based on product attractiveness.

4. Results

The manipulation check ensured that respondents correctly identified the designer and convenience chairs ($M_{design} = 5.04$ S.D. = 1.66 vs. $M_{conv} = 4.10$ S.D. = 1.71, $F(1, 205) = 15.97$, $p < 0.001$). A Multivariate Analysis of Variance was then conducted considering willingness-to-pay, intention to switch and purchase intention as dependent variables. No significant main effect was found for involvement (Wilks $\lambda = 0.99$, $F(3, 189) = 0.786$, $p = 0.50$), thus rejecting hypothesis H1. Instead, significant effects at the multivariate level were found for green self-identity (Wilks $\lambda = 0.50$, $F(3, 189) = 62.07$, $p < 0.001$), age (Wilks $\lambda = 0.95$, $F(3, 189) = 3.11$, $p = 0.03$) and previous purchase of eco-products (Wilks $\lambda = 0.94$, $F(3, 189) = 4.10$, $p = 0.01$), thus providing initial support for hypotheses H3 and H4. Furthermore, a significant interaction emerged between age and green self-identity (Wilks $\lambda = 0.95$, $F(3, 189) = 3.02$, $p = 0.03$).

Table 1 reports the estimated marginal means for purchase intention, willingness-to-pay and intention to switch. Follow-up univariate analyses revealed that green self-identity has a significant impact on purchase intention ($F(1, 206) = 111.77$, $p < 0.001$), willingness-to-pay ($F(1, 206) = 18.10$, $p < 0.001$) and intention to switch ($F(1, 206) = 166.60$, $p < 0.001$). Specifically, the higher the green self-identity, the higher the values for each of the dependent variables.

Age was found to impact willingness-to-pay ($F(1, 206) = 8.82$, $p < 0.01$), but not the intention to purchase or switch. Furthermore, age interacts significantly with green self-identity on willingness-to-pay ($F(1, 206) = 8.67$, $p < 0.01$). Specifically, as can be seen in Table 1, older consumers display significantly higher willingness-to-pay than younger consumers (+41.97£), especially when green self-identity is high (+92.84 £).

Contrary to age, past eco-products purchase experience was found to impact purchase intention ($F(1, 206) = 5.03$, $p = 0.03$) and switching intention ($F(1, 206) = 11.67$, $p < 0.001$), but not willingness-to-pay, thus supporting hypotheses H4a and H4c, but not H4b. No significant interaction emerged. In other words, the impact of age and past purchase experience on the dependent variables appears to be complementary.

A further analysis was performed on the data from the 37.10% of participants who have previously purchased eco-products. Based on the median number of past purchases (2.50), participants were split into light and heavy buyers. The comparison between light and heavy buyers of eco-products revealed no significant effect on any of the dependent variables. Thus, the impacts on the dependent variables are attributed to sampling having some or no purchase experience, regardless of the intensity (number of) such experiences.

Finally, to investigate H2, the mediation model was tested using the PROCESS macro in SPSS following the procedure outlined by Hayes and Preacher (2014), using 5000 bootstrap samples to create bias-corrected confidence intervals (CIs; 95%). Although the scale for willingness-to-pay differs from the other scales (ranging from 0 to 1000 £ vice a Likert-type scale), scores were not standardized. On one hand, this implies that some coefficients might appear to be quite large in the analysis; on the other hand, standardizing mediation models is not recommended (Hayes and Preacher, 2014).

Results show that green self-identity partially mediates the relationship between attitude toward bio-based products and intention to purchase (Mediation = 0.41, SE = 0.06; $p < 0.05$) and to switch to (Mediation = 0.49, SE = 0.13; $p < 0.05$) bio-based products. Furthermore, green self-identity fully mediates the relationship between attitude toward bio-based products and willingness-to-pay (Mediation = 33.50, SE = 13.51; $p < 0.05$). This evidence supports hypothesis H2. Table 2 summarizes the results of the

Table 1
Estimated marginal means for purchase intention, willingness-to-pay and switching intention.

	Purchase Intention	Willingness-to-Pay	Switching Intention
Involvement with the product			
Low	4.10 [a]	64.31 [a]	4.59 [a]
High	4.23 [a]	84.38 [a]	4.71 [a]
Green self-identity			
Low	3.05 [a]	44.28 [a]	3.49 [a]
High	5.29 [b]	104.40 [b]	5.81 [b]
Age			
Younger	4.03 [a]	53.35 [b]	4.61 [a]
Older	4.31 [a]	95.33 [c]	4.69 [a]
Past purchase of eco-products			
No	3.93 [a]	67.09 [a]	4.34 [a]
Yes	4.41 [b]	81.59 [a]	4.96 [b]
Main effect of involvement			
F	0.37	2.02	0.45
(df1, df2)	(1, 206)	(1, 206)	(1, 206)
Partial η^2	0.00	0.01	0.00
Main effect of green self-identity			
F	111.77***	18.10***	166.60***
(df1, df2)	(1, 206)	(1, 206)	(1, 206)
Partial η^2	.37	.09	.47
Main effect of age			
F	1.64	8.82*	0.18
(df1, df2)	(1, 206)	(1, 206)	(1, 206)
Partial η^2	0.01	0.04	0.00
Main effect of past experience			
F	5.03*	1.05	11.67***
(df1, df2)	(1, 206)	(1, 206)	(1, 206)
Partial η^2	0.03	0.01	0.06
Interaction of green self-identity × age			
F	0.09	8.666**	0.277
(df1, df2)	(1, 206)	(1, 206)	(1, 206)
Partial η^2	0.00	0.04	0.00

Notes: scales range from 1 to 7; Means with a different superscript (a, b) indicate a significant difference; ***p 0.001; **p 0.01; *p 0.05.

Table 2
Results of the mediation analyses.

	Coeff (se)	t	LLCI; ULCI
Attitude on green self-identity	0.63 (0.08)	7.39***	0.46; 0.80
Green self-identity on purchase intention	0.59 (0.07)	8.44***	0.45; 0.73
Purchase intention	0.39 (0.07)	5.63***	0.27; 0.53
Attitude on green self-identity	0.63 (0.08)	7.39***	.46; .80
Green self-identity on WTP	53.06 (17.65)	3.00*	17.85; 88.28
WTP	−13.27 (.16.91)	−0.78	−47.00; .20.45
Attitude on green self-identity	0.63 (0.08)	7.39***	0.46; 0.80
Green self-identity on intention to switch	0.77 (0.12)	6.52***	0.54; 10.01
Switching intention	0.23 (0.11)	2.06*	0.010; 0.46

Note: SE = standard error; LLCI = Lower level of 95% confidence interval; ULCI = Upper level of 95% confidence interval; ***p 0.001; *p 0.05.

mediation analyses.

4.1. Ruling out of alternative explanations

A MANOVA shows no significant effect of perceived value (Wilks $\lambda = 0.97$, $F(3, 161) = 1.01$, $p = 0.39$) on the considered dependent variables, thus ruling out value-based alternative explanations for any type of value (functional, social, emotional, conditional, epistemic and overall value; Lin and Huang, 2012. Similarly, no significant effects emerge for risk (Wilks $\lambda = 0.99$, $F(3, 161) = 0.39$, $p = 0.76$), ruling out also risk-based alternative explanations.

Finally, the convenient and designer chairs were equally liked, ruling out also alternative explanations based on product liking ($M_{design} = 4.53$ S.D. $= 2.03$ vs. $M_{convenience} = 4.14$ S.D. $= 1.82$, $F(1, 205) = 0.18$, $p = 0.67$).

5. Discussion

This study makes a number of contributions to potentially enrich the existing operations and supply chain management literature. Those contributions can be addressed both from a theoretical and a managerial perspective, as highlighted in the following section.

5.1. Theoretical implications

The present research aimed at answering three questions pertaining to purchase intention, willingness-to-pay for, and intention to switch to bio-based products. Specifically, it aimed at addressing the role of involvement, personal values and demographics on the intention to purchase bio-based products recovered from urban food waste. Extant literature on traditional green products provides

a set of potentially relevant variables for consideration. However, little is known about consumers' perceptions of PHA-based bioplastics from urban waste, given their novelty. This study contributes by assessing this new type of material.

Although prior studies suggest that in certain cases product involvement affects consumers' purchase intentions (Lin and Chen, 2006), the first contribution of the current research is that product involvement does not affect purchase intention for bio-based products. This is a relevant finding as it encourages the production of a broad spectrum of this new generation of bio-based green products, encompassing both high- and low-involvement products. Bian and Moutinho (2011) also failed to find support for a relationship between purchase intention and high involvement in the context of their study, while this current research extends our knowledge of this phenomenon with respect to bio-based products. However, it is important to note that van Weelden et al. (2016) found that involvement can affect purchase intention, yet the role coincides with product familiarity, which was kept constant in the present study.

Second, results show that green self-identity partially mediates the relationship between attitude toward bio-based products and the intention to purchase and to switch to bio-based products. Furthermore, green self-identity mediates the relationship between attitude toward bio-based products and willingness-to-pay. These findings complement previous literature where values such as eco-friendliness were positively related with consumers' perception of green products (Sijtsema et al., 2016; Oliver and Rosen, 2010). Furthermore, the present research specifically addresses and resolves the ambiguity about the direct (Dono et al., 2010) and indirect (Barbarossa and De Pelsmacker, 2016) effects of green self-identity. The current research shows an indirect effect of green self-identify on willingness-to-pay, and both direct and indirect effects on intentions. In addition, findings about consumers green self-identity also contribute to a better understanding of its relationship with price. This finding extends this stream of literature (Reinders et al., 2017) by showing effects on the price consumers would pay for a green product, acting as a mediator of the relationship between attitudes and willingness-to-pay.

Third, the findings regarding consumers' demographics show that perceptions of and reactions to bio-based products are not affected by gender, but are affected by age and past purchases. Specifically, older consumers display higher willingness-to-pay, and those who already purchased eco-products had higher intentions to purchase and switch to bio-based products, regardless of the number of times they purchased eco-products in the past. By jointly addressing age and past purchase experience, and by separating between willingness-to-pay for and purchase intentions, the present research clearly shows that age affects the former and experience affects the latter. This helps reconciling contradictions in some of the previous studies, where for instance age was sometimes positively related with behavior toward green products (Namkung and Jang, 2017) and sometimes not (Akehurst et al., 2012; Wiidegren, 1998).

Taken together, the findings from the present research contribute to knowledge regarding circular economy and closed loop supply chains. The findings suggest new approaches for diffusing bio-based products, thus improving waste management and recycling efforts. In line with previous research on closed loop supply chains and remanufactured products (Abbey et al., 2015; Wang et al., 2018b), understanding the drivers of consumer acceptance of bio-based products provides useful information to producers and consumers beyond the basic idea that urban food waste can potentially be recovered for reuse.

By adopting the theoretical lens of prospect theory, the present research helps to frame consumers' perceptions of bio-based products in terms of risk and uncertainty with respect to their personal values. In turn, it provides further understanding of how these values might impact intention to purchase, to switch to, and willingness-to-pay for bio-based products. Previous studies investigated green products from the theoretical lenses of prospect theory and found that perceived risk could have a significant influence on purchase intention, willingness-to-pay for, and perceived costs of switching to green products (Wang and Hazen, 2016). This evidence suggests that controlling the perceived risk associated with purchasing a green product might be potentially useful when investigating consumers' general acceptance of the specific type of green product considered in the present research. Our results allow us to rule out risk-based explanations and show that behavioral intentions for bio-based products stem directly from attitude and indirectly from green self-identity.

5.2. Managerial implications

The need to understand green purchasing behavior is particularly timely due to increasing concerns with new environmental priorities including the Plastic Strategy proposed by the European Commission, which includes innovative projects aimed toward converting urban bio-waste into raw materials. In this vein, the findings can help practitioners to better understand how to manufacture and market bio-based products. Although bio-based products look like new products, it is relevant for practitioners to have insights into consumers' attitudes toward them and how those attitudes might be influenced.

Another practical contribution of the present research is that the findings send a clear message to governments and regulatory bodies: consumers are generally willing to participate in CE initiatives seeking to replace traditional plastic by transforming waste into a new raw material suitable for bio-based products. Biogas and compost are more consolidated and easier-to-use materials for closing the loop, compared to the emerging technology of PHA-based bioplastics from urban food waste. Nonetheless, the findings from the present research are encouraging for companies planning to change actual supply chain operations and treatments in consideration of new opportunities presented by PHA-based bioplastics. These systems operate with the particular objective of helping managers and practitioners to create lower cost, more sustainable closed-loop systems.

Finally, our study contributes to developing a deeper understanding of the potential opportunities to build new closed loop systems and strategies around reclaimed waste. The findings suggest that the market is ready for these products and that investing in supply chain reconfiguration can be viable. Of course, additional cost-benefit analyses are required for any specific application. Yet, the findings of this study are encouraging for those assessing the tenability of new, greener processes.

6. Limitations and future research

The current research is not exempt from limitations. However, these limitations highlight fruitful directions for future research. First, consumer attitudes and values vary greatly amongst Europe, North America, Asia, and other regions. The findings of this research are based on participants from the UK and show a consistent pattern. Nonetheless, consumers from other European countries, North America, Asia and other populations might have different attitudes towards green products, green self/identity and bio-based materials (Vicente-Molina et al., 2013). Thus, a potential avenue for future research would be to explore acceptance of products generated from food waste in consideration of cultural and regional differences.

Second, the present research considered products with differing levels of consumer involvement, with an additional focus on designer versus traditional chairs. Broadening the spectrum of sustainably-produced product types in future research is advised. For instance, Starbucks already uses coffee cups made from green (though not bio-based) silicon (Starbucks Newsroom, 2018). Are these cups perceived in the same way as bio-based cups might be? Further, Coca-Cola, Kellogg's, Nestle Danone, H&M, L'Oréal, Mars and Unilever are major brands that have agreed to eliminate plastic waste (Forrest, 2018), and there are several alternatives that might take their place. Thus, instead of focusing on PET recycling, which is already well-established in industry (Shen et al., 2010; Eriksen et al., 2018; Changwichan et al., 2018), future research should instead investigate the use of compostable bioplastics that can be safely reintegrated into soil. This is how a CLSC can be advanced into a true CE. Although compostable bioplastics are being used on a very small scale today, this area is quickly growing (Imbert et al., 2019). For example, Ekoplaza is a plastic-free supermarket in the Netherlands that has substituted most plastic films with compostable films (Taylor, 2018). More research is needed to examine other viable use cases, such as interior design products and food packaging applications as well as plastic components used in the electronic and automotive industries.

Third, the present research compliments Reinders et al. (2017) to suggest that future research should focus on creating better understanding of how costs, production methods, logistics network designs, life cycle assessment options, and consumer perceptions differ across types of green products. Such research could also help to identify which bio-based products fit better with the right closed loop strategy.

Finally, future research could benefit from distinguishing products based on how consumers interact with them, other than addressing the level of involvement. For instance, research could consider the level of physical contact with the product, thus comparing high- and low-touch products such as eyeglasses, toys, shopping bags, bottles and furniture. This could also help advance understanding of how green self-identity affects acceptance of bio-based products. Future research could therefore investigate whether product category, level of contact, brand, price and retail channel moderate the strength of the relationships hypothesized and tested in the present research. Similarly, considering real rather than fictional brands in further research would allow scholars to examine additional engagement considerations as they pertain to brand perception and loyalty.

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Appendix A. Supplementary data

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