BAR - Brazilian Administration Review
ISSN: 1807-7692
ANPAD - Associação Nacional de Pós-Graduação e Pesquisa em Administração

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BAR - Brazilian Administration Review, vol. 18, no. 3, e210004, 2021
ANPAD - Associação Nacional de Pós-Graduação e Pesquisa em Administração

DOI: https://doi.org/10.1590/1807-7692bar2021210004

https://bar.anpad.org.br

BAR – Brazilian Administration Review
Vol. 18, No. 3, Art. 2, e210004, 2021
https://doi.org/10.1590/1807-7692bar2021210004

Research Article

Servitization as a Strategy for Remanufacturing: An Experimental Study

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Received 29 June 2021. This paper was with the authors for one revision. Accepted 14 July 2021.
First published online 02 August 2021.
Editors-in-chief: Carlo Gabriel Porto Bellini (Universidade Federal da Paraíba, João Pessoa, PB, Brazil); Ivan Lapuente Garrido (Universidade do Vale do Rio dos Sinos, Porto Alegre, RS, Brazil)
Associate editor: Renan Felinto de Farias Aires (Universidade Federal Rural do Semi-Arido, Mossoró, RN, Brazil)
Reviewers: Two anonymous reviewers
Editorial assistants: Kler Godoy and Simone Rafael (ANPAD, Maringá, PR, Brazil)

ABSTRACT

Although remanufacturing has attracted the attention of academia and practitioners, there is a lack of empirical studies regarding servitization strategy in a remanufacturing context. We aim to address this gap by examining how servitization may influence the likelihood of purchasing a remanufactured battery for an electric vehicle. We also test if price increases the purchase likelihood, even when additional services are provided as part of the service package. We conducted a 2 x 2, full factorial, between-subjects experiment. The results reveal that the offer of additional service influences the effect that price has on the purchase likelihood. Our study contributes to fill the gap in the literature by identifying under which conditions low price is not a significant predictor of the likelihood of purchasing a remanufactured EV battery. Our findings may help managers develop strategies to improve the sales of remanufactured products, especially considering the use of additional services. New studies can benefit from our findings by focusing on how additional services can improve perceived value and reduce the perceived risk of remanufacturing. Finally, we conclude that servitization is a promising strategy for increasing the perceived value and the purchasing intentions of remanufactured products.

Keywords: price; service; perceived value; perceived risk; experiment

JEL Code: M1, M19

INTRODUCTION

Green supply chain management (GSCM) has caught the attention of researchers and practitioners due to its importance to the environment and business strategy (Srivastava, 2007). Based on this interest and expansion of the concept, GCSM has been expanded to sustainable supply chain management (SSCM). Thus, SSCM encompasses not just the environmental dimension of sustainability, but also its economic and social dimensions (Carter, Hatton, Wu, & Chen, 2020; Fracarolli Nunes, Lee Park, & Paiva, 2020; Seuring & Müller, 2008).

The closed-loop supply chain (CLSC) is one of the central aspects of SSCM implementation (Tsai et al., 2021). CLSC encompasses the traditional forward flow of the supply chain with the reverse logistic flow (Govindan, Soleimani, & Kannan, 2015). Reverse logistics provides for the proper disposal of discarded goods, and recaptures at least part of the market value (Bouzon, Govindan, & Rodriguez, 2018; Hanafi, Kara, & Kaebernick, 2008). Thus, CLSC contributes to SSCM by reducing the environmental impact and achieving economic and social goals (Tsai et al., 2021).

Remanufacturing is one of the better-known operations in reverse logistics (Turki, Sauvey, & Rezg, 2018), and responsible for reducing environmental impact and for economic gains, with reductions in production costs and lower prices for consumers (Fu, Qiang, Ke, & Huang, 2021). Remanufacturing also has a relevant role to play in the circular economy (CE) (Jensen, Prendeville, Bocken, & Peck, 2019). In general, remanufacturing can offer a purchase option that is 20% to 60% less expensive than for a corresponding new product (Steinhilper, 2001) and is importantly recognized as having a cleaner production process (Liu, Shang, Ding, Guo, & Zhang, 2019).

Remanufacturing is increasing in several markets, including for automobile products (Chakraborty, Mondal, & Mukherjee, 2019). In this particular market, the increasing demand for electric automobiles has created a new environmental challenge: battery disposal. For example, Nissan has a specialist plant for recycled and remanufactured lithium-ion electric vehicles (EV) to meet growing demand (Loughran, 2018). According to the Global EV Outlook 2019, the US is the third largest EV market (International Energy Agency [IEA], 2019). At the same time, a remanufactured EV battery (REVB) is a less expensive option for replacing the battery used in EV cars (Evarts, 2018b).

Environmental threats, such as the disposal of used batteries, can be mitigated by reusing them for other purposes (Evarts, 2018a), although this does not solve issues related to the second-hand EV market, for example. A second-hand EV is an option for those who cannot afford a new one (EDF Energy, 2021). The second-hand EV market may be as much as three times larger than the market for new EVs (Pedrosa & Nobre, 2018).

One of the major issues of purchasing a second-hand EV is the condition of the battery, due to the price of replacing it with a new one (Gibson, 2020); this is one of the main barriers to purchasing a second-hand EV (Pedrosa & Nobre, 2018). Replacing the battery with a remanufactured one, therefore, can be a viable alternative in such cases (EDF Energy, 2021). This

option contributes toward a sustainable agenda by reducing the disposal of materials, boosting the life cycle of EVs, and making them more affordable.

Price, however, is one of the main factors influencing decisions about purchasing remanufactured products (Liu, Diallo, Chen, & Zhang, 2019; Michaud & Llerena, 2011; Vafadarnikjoo, Mishra, Govindan, & Chalvatzis, 2018; Xu & Gong, 2016). Price difference may give consumers the perception that remanufactured products are lower in quality (Singhal, Tripathy, & Jena, 2019), but remanufacturing not only recovers a used or damaged product, it can also lead to substantial improvements in the product when it undergoes the remanufacturing process (Hartwell & Marco, 2016). In light of these considerations, servitization can help increase the perceived value and purchase intention of a remanufactured product.

For the purposes of this study, servitization means adopting a product service system (PSS) strategy into a remanufactured product (Opresnik & Taisch, 2015). In general, a servitization strategy offers opportunities for new business as well as improved competitiveness, including remanufacturing (Chalal, Boucher, & Marques, 2015; Khan, Mittal, West, & Wuest, 2018). Therefore, it is important to address whether moving from a strict remanufacturing offer to a broader offer that has a service focus has an influence on the likelihood of a consumer purchase. New service models for remanufactured products might be studied, for example, such as an extended warranty or leasing (Zhu, Li, Zhao, & Lun, 2016).

There is still a gap in the literature when we analyze the integration of servitization into the remanufacturing process. When the role of servitization is associated with remanufactured products, the effect can be a relevant issue for the future of electric automobiles. We expect servitization and remanufacturing to reduce the consumer perception that remanufactured products are of poor quality.

Based on this gap, our research question, therefore, is: How do price and servitization affect the likelihood of buying a remanufactured EV battery? Here we use the context of EV batteries to examine whether price affects the purchase likelihood of a remanufactured battery for an electric vehicle when companies adopt a servitization strategy and additional services are provided as part of the offer. Since perceived value and perceived risk play an important role in the purchasing decision, we also evaluate if servitization moderates the relationship between price and purchase likelihood when accounting for perceived value and perceived risk. To achieve our goal, we developed a 2 x 2, full factorial, between-subjects, scenario-based, role-playing experiment.

This is one of the first studies to empirically test the influence of servitization on remanufacturing. Our study also helps fill the gap in the literature by identifying under which conditions low price is not a significant predictor of the likelihood of purchasing a remanufactured EV battery. The results suggest that consumers are more likely to pay a higher price for remanufactured products when there is servitization. Our study also can help managers configure more valuable remanufacturing offers, which result in the promotion of economic, environmental, and social benefits.

The article is organized as follows: First, we present the theoretical framework, the hypotheses, and the model. Second, we present the methodological procedures. Third, we present the results. Fourth, we discuss the results and present the contributions and limitations. We conclude by summarizing the study.

THEORETICAL FRAMEWORK AND HYPOTHESIS DEVELOPMENT

Theoretical framework

Remanufacturing is a process whereby the condition of a used or discarded product is restored to its original state, or is even improved (Ijomah, 2009), and the warranty is the same or better than that of a new product (Hartwell & Marco, 2016). Remanufacturing can also be considered a production strategy (Jensen et al., 2019; Wang & Hazen, 2016) and a supply chain capability (Bag, Gupta, & Foropon, 2019). Due to resource recovery and reductions in transformation costs, remanufactured products can be offered in the market at lower prices (Ijomah, 2009).

One of the major concerns regarding remanufacturing is whether the quality of the product is as good as that of a new product. This perception of lower quality is partly due to its lower price (Singhal, Jena, & Tripathy, 2019), but also a lack of information about the quality of remanufactured products (Hazen, Boone, Wang, & Khor, 2017) and uncertainty with regard to after-sales service (Zhu et al., 2016). These characteristics demonstrate the uncertainty that surrounds the decision to buy a remanufactured product (Bittar, 2018; Liao, 2018).

In this study, we considered price as a key factor of purchase likelihood. We also understand that servitization has a potential influence on the likelihood of purchasing a remanufactured product. Servitization can be understood as a strategy for creating value by adding services to products (Vandermerwe & Rada, 1988). For instance, additional services contribute to the consumers' choice of products (Liao, 2018), including remanufactured products (Zhu et al., 2016), since servitization has the potential to reduce the perception that remanufactured products are of inferior quality (Opresnik & Taisch, 2015). Therefore, both factors were manipulated in our experiment.

Figure 1 shows our conceptual model that examines the effect of price and service on the purchase likelihood of remanufactured batteries for EVs. Our model also examines the direct and moderating effect of perceived value and perceived risk and their respective hypotheses.

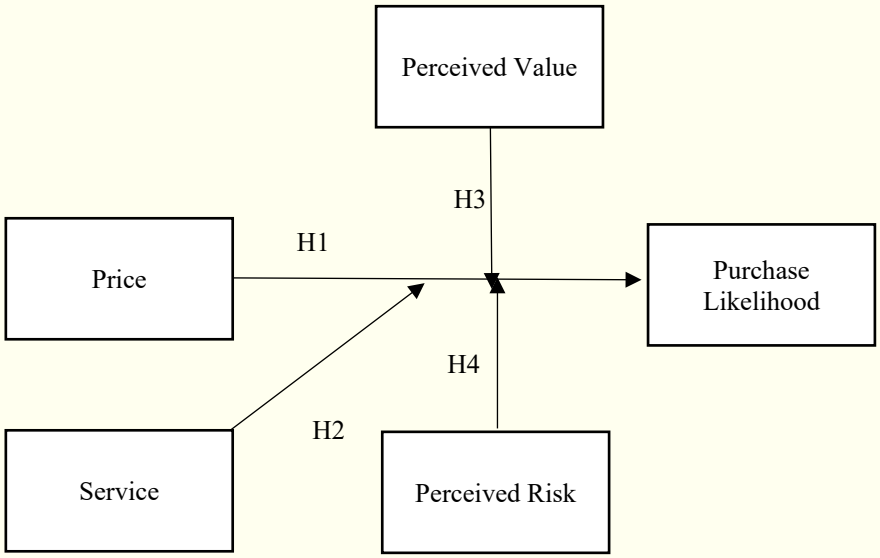

Figure 1. Conceptual model

Our study is guided by a comprehensive set of assumptions. First, price is the main factor influencing the likelihood of purchasing a remanufactured product (Abbey, Kleber, Souza, & Voigt, 2017; Singhal, Jena, et al., 2019). Second, an alternative assumption is that besides remanufacturing lowering price, servitization may also influence the purchase likelihood of remanufactured products (Jensen et al., 2019; Zhu et al., 2016). Thus, examining how servitization may influence the relationship between price and likelihood of purchasing a remanufactured battery for an electric vehicle may challenge current remanufacturing assumption. In addition, a third assumption refers to the positive role of perceived value on purchasing likelihood (Zeithaml, 1988). Thus, we assume that the greater the consumers' perceived value of remanufacturing, the more willing they will be to purchase a remanufactured battery (Hazen et al., 2017). On the other hand, a fourth assumption has to do with the negative role of perceived risk on purchasing likelihood (McCorkle, 1990; Mitchell & Boustani, 1994). We assume that the greater the perceived risk associated with remanufacturing, the less willing consumers will be to purchase a remanufactured battery (Matsumoto, Chinen, & Endo, 2018; Wang & Hazen, 2016).

Hypothesis development

Price

Price and quality are the main factors considered when making a decision about buying a remanufactured product (Liu, Diallo, et al., 2019; Michaud & Llerena, 2011; Vafadarnikjoo et al., 2018; Xu & Gong, 2016). Remanufacturing reduces production costs (e.g., energy and material savings), allowing manufacturers to lower the selling price of products (Dowlatshahi, 2000; Ijomah, 2009; Zhang et al., 2020). This cost advantage, when compared to new products, is one of the benefits of remanufactured products that are most perceived by customers (Chen &

Chen, 2019; Wang & Hazen, 2016). In other words, price discounts have a positive effect on the attractiveness of remanufactured products (Abbey, Meloy, et al., 2015).

Considering how important price is to consumers, the remanufactured product market relies on a low-cost strategy (Sun, Zhou, Li, Govindan, & Han, 2020; Wang & Hazen, 2016), and for consumers this is an alternative to buying new products (Wang, Hazen, & Mollenkopf, 2018). Consumers are generally price-sensitive with regard to remanufactured products (Jin, Muriel, & Lu, 2016; Singhal, Jena, et al., 2019), and price plays a pivotal role when considering a remanufactured product as a purchasing option. Thus:

H1: The likelihood of buying a remanufactured EV battery increases as its price decreases.

Servitization

Servitization is attracting attention in managerial and research perspective terms, and companies are developing specific capabilities for competing in this market by moving from a product-focused offer to a wider, innovative-services offer. Remanufacturing is one of these innovative services (Bustinza, Vendrell-Herrero, & Baines, 2017). By definition, a remanufactured product must have, at least, the same performance, quality, and warranties as a new product (Hartwell & Marco, 2016; Ijomah, 2009). Due to a lack of knowledge of the advantages of a remanufactured product (Hazen et al., 2017; Wang & Hazen, 2016), however, and its lower price (Singhal, Jena, et al., 2019), customers may consider a remanufactured product to be inferior to a new product, and this consequently reduces their willingness to buy a remanufactured product (Abbey, Meloy, Guide, & Atalay, 2015; Wang et al., 2018; Wang & Hazen, 2016).

One alternative for increasing the attractiveness of the option to purchase a remanufactured product is servitization. This entails integrating services (Jensen et al., 2019; Zhu et al., 2016), or offering remanufacturing as a service, thus moving the orientation away from product to service (Opresnik & Taisch, 2015). The whole value of remanufacturing in the CE will be possible when companies move their remanufacturing offer from a narrow focus (e.g., just profitability) to a more integrated triple-bottom-line approach (Jensen et al., 2019; Vogtlander, Scheepens, Bocken, & Peck, 2017).

In the light of this, companies should explore the entire value of remanufacturing, not just lower price, but also additional services (Bag et al., 2019; Khan et al., 2018; Zhu et al., 2016). The lack of competitiveness of remanufactured products is also due to the inability of companies to offer remanufacturing using a PSS business model (Kurilova-Palisaitiene, Sundin, & Poksinska, 2018). For example, remanufacturing with upgrading to introduce technology improvements in remanufactured products enhances the value perception of consumers (Khan et al., 2018). Therefore, we suggest the following hypothesis:

H2: The effect of price on the likelihood of purchasing a remanufactured EV battery is affected by the level of service offered.

Perceived value

From a strategic perspective, perceived value can be used by organizations as a source of competitive advantage (Chen & Dubinsky, 2003; Chou, 2014). Perceived value can be understood as a general assessment of the usefulness of a product (Zeithaml, 1988). This is reinforced by the fact that perceived value has a positive effect on purchase intention in general (Wang & Hazen, 2016; Zeithaml, 1988).

As remanufactured products have become better known, consumers have also begun to notice their value more (Hazen et al., 2017; Jeng, 2017; Wang & Hazen, 2016). Perceived value affects the price of (Zhou & Gupta, 2019) and demand for (Li, Wu, Jin, & Lai, 2017) new and remanufactured products. It is a central factor in the likelihood of purchasing a remanufactured product (Hazen et al., 2017; Li et al., 2017; Wang & Hazen, 2016; Zhou & Gupta, 2019). Therefore, we suggest the following hypothesis:

> *H3*: The effect of price on the likelihood of purchasing a remanufactured EV battery is moderated by the perceived value of a remanufactured EV battery.

Perceived risk

Perceived risk can be understood as the consumer's perception of the uncertainty and negative consequences caused by the decision to purchase a product or service (McCorkle, 1990; Mitchell & Boustani, 1994). In the context of remanufacturing, uncertainty about the product is one of the main inhibitors of the purchase of this type of product, and generates a perceived risk because of a lack of knowledge of the processes that are employed during remanufacturing (Wang, Wang, Yang, Li, & Song, 2020; Wang, Wiegerinck, Krikke, & Zhang, 2013).

When purchasing a product is considered to be risky, it reflects a negative attitude toward remanufactured products and reduces the purchase intention (Hamzaoui-Essoussi & Linton, 2014; Matsumoto et al., 2018; Wang & Hazen, 2016), especially because consumers may have some concern about the quality of a remanufactured product (Abbey et al., 2017). In this sense, perceived risk is a relevant aspect that negatively affects the likelihood of purchasing remanufactured products (Jena & Sarmah, 2015; Singhal, Tripathy, et al., 2019; Wang et al., 2018). Therefore, we suggest the following hypothesis:

> *H4*: The effect of price on the likelihood of purchasing a remanufactured EV battery is moderated by the perceived risk of a remanufactured EV battery.

METHODOLOGY

To achieve our main goal and test our hypotheses, we collect data using a 2 x 2, full factorial, between-subjects, experimental vignette methodology (EVM) (Aguinis & Bradley, 2014), or a scenario-based role-playing experiment (Rungtusanatham, Wallin, & Eckerd, 2011). This method

of data collection is useful for manipulating specific levels of factors of interest in order to influence judgments, preferences, or decisions (Rungtusanatham et al., 2011). An EVM is also suitable for our study as we intend to check the influence of price manipulation and service on the likelihood of purchasing a remanufactured EV battery.

Vignette design and validation

We developed four versions of the vignette (Appendix in the online Supplement) based on guidance with regard to the stages of vignette creation and validation (Rungtusanatham et al., 2011). In the pre-design stage, we searched for information on EV batteries on specialist websites, in magazines, and from Facebook groups for electric automobile owners. The first draft of the vignettes was discussed in the design stage with faculty members of an AACSB accredited business school in Brazil. In the post-design stage, a first assessment of the realism and manipulation checks was carried out with 252 subjects, mainly PhD students from several countries.

After this first analysis, we returned to all three stages and adjusted the vignettes, the manipulated variables, and the manipulation-check variables. The second version of the experiment was tested with 19 MBA students from an AACSB accredited business school in Brazil. Based on the second analysis, a third version of the vignettes was sent to 121 US nationals recruited by Prolific (www.prolific.co retrieved on November 1, 2019). Of the total number of participants, 73 are female and 48 are male. All the subjects are at least 18 years old. Finally, the validated vignettes were submitted to 232 US nationals recruited by Prolific. This final sample and results are described in the following sections.

Experimental cues of price and service

The two independent variables included in the vignette were price and service. For price, we manipulated two levels related to a new EV battery costing $8,500. The lowest price for a remanufactured EV battery was fixed at 50% of the new battery price, or $4,250. Conversely, the highest price for a remanufactured EV battery was fixed at 80% of the new battery price, or $6,800.

We manipulated two levels in terms of service: no additional service, and some additional service. The manipulation with no additional service only gives the subject information about the remanufactured battery warranty. For the manipulation with additional service, the subject was offered a remanufactured EV battery, including an inclusive remanufacturing service program, and free upgrades, leasing, roadside assistance, and warranties.

Main variables

After reading the descriptive vignette, subjects answered questions about the dependent variable. They used a seven-point scale from one (very unlikely) to seven (very likely) to indicate how likely they were to consider purchasing the remanufactured EV battery. Subjects then answered general questions regarding their perceptions of perceived value, perceived risk, and sustainable

orientation, and their personal characteristics, as the Appendix in the online Supplement shows.

Perceived value was measured by a single item, with which we asked subjects to indicate their agreement, or otherwise: Compared to new electric vehicle batteries, remanufactured electric vehicle batteries have a better performance/cost ratio. Perceived risk was also measured by a single item, with which we asked subjects to indicate their agreement, or otherwise: I am concerned that the performance of remanufactured electric vehicle batteries is inferior to the performance of new electric vehicle batteries. These two variables were adapted from Wang and Hazen (2016).

Subjects

A total of 232 US nationals, who are not currently students, who live in the US, and who use a car at least once a month, were recruited by Prolific to participate in this experiment. To ensure the quality of the data, we kept only data from subjects who already own or have owned an electric/hybrid car, or have considered buying an electric/hybrid car, which left 123 subjects in our sample.

Experimental procedures

All subjects were randomly assigned to one of the four versions of the vignette by an A/B test provided by SurveyMonkey Inc. Random assignment increases the internal validity of experiments (Huang, Gattiker, & Schwarz, 2008; Thomas, Thomas, Manrodt, & Rutner, 2013). They were taught about remanufacturing in general and told to assume the situation of being an EV automobile owner. After reading the vignette, they answered a question on the likelihood of them buying a remanufactured EV battery, an attention checking question, and vignette realism questions. At the end, the subjects answered a short questionnaire with questions about the perceived value of the remanufactured EV battery, the perceived risk of the remanufactured EV battery, environmental consumption, and some demographic questions.

Experimental checks

Attention checks

Attention check questions are useful for detecting inattentive responses, thus contributing to the quality of the results in experimental models (Abbey & Meloy, 2017). To ensure data quality, subjects answered two attention check questions (see the Appendix in the online Supplement). We observed only one inattentive response, which is a very low average loss (Abbey & Meloy, 2017). To ensure the quality of the data, this particular response was excluded.

Realism checks

Realism checks are useful for verifying to what extent subjects found the vignette to be realistic and believable (Eckerd, 2016), which is one of the post-design stage verifications recommended

by Rungtusanatham, Wallin, and Eckerd (2011). Subjects answered two questions (see the Appendix in the online Supplement). The results show that subjects found the scenarios to be realistic, with an average score of 5.72 on a seven-point scale, and interesting, with an average score of 5.28 on a seven-point scale.

Manipulation check

Another key post-design stage verification of vignette validation is the manipulation check (Rungtusanatham et al., 2011). This verification is vital for ensuring subjects perceive any differences between levels of experimental treatment, thereby ensuring convergent validity (Bachrach & Bendoly, 2011). Subjects answered three questions for each manipulated variable. The results are presented in the following section and summarized in the Appendix in the online Supplement. We asked three manipulation check questions for price using a seven-point scale ranging from one (strongly disagree) to seven (strongly agree), and labeled MC1 price, MC2 price, and MC3 price.

A one-way ANOVA revealed significant differences between subjects assigned to the lower price condition compared with subjects assigned to the higher price condition for the MC1 price (average score 1.95 and 4.24, respectively, $F_{1, 118} = 27.388$, $p < 0.001$), for the MC2 price (average score 6.16 and 1.31, respectively, $F_{1, 118} = 437.738$, $p < 0.001$), and for the MC3 price (average score 1.59 and 6.53, respectively, $F_{1, 118} = 400.059$, $p < 0.001$). The results support the finding that the subjects perceive the difference in the levels of treatment for price, as planned in the designed vignettes.

We also asked three manipulation check questions about service using a seven-point scale, ranging from one (strongly disagree) to seven (strongly agree), labeled MC1 service, MC2 service, and MC3 service. A one-way ANOVA revealed significant differences between subjects assigned to the 'no additional service' condition in relation to subjects assigned to the 'with additional service' condition for the MC1 service (average score 2.72 and 6.31, respectively, $F_{1, 118} = 144.367$, $p < 0.001$), for the MC2 service (average score 5.77 and 3.39, respectively, $F_{1, 118} = 43.755$, $p < 0.001$), and for the MC3 service (average score 5.42 and 2.49, respectively, $F_{1, 118} = 67.282$, $p < 0.001$). The results support the finding that the subjects perceive the difference in the levels of treatment for service as planned in the designed vignettes.

ANALYSIS AND RESULTS

Control variables

We tested for the effects of five individual measures, two relating to a sustainability-focused value orientation (SO1 and SO2), two relating to experience with automobiles (CAR1 and CAR2), and one relating to their life characteristics (LIV). The results presented in Appendix A show that only SO1 and LIV are significant predictors of the likelihood of purchasing. Subjects who consider saving resources and those who live in rural or urban areas are more likely to purchase

a remanufactured EV battery.

Effect of price and service on the likelihood of purchasing an REVB

Table 1 shows the regression model results using a macro process based on Hayes (2018). The direct effect of price (H1) on the likelihood of purchasing an REVB is negative and not significant (b = -0.1105, se = 0.2545, t = -0.4338, p = 0.6652). This reveals that purchase likelihood is higher when the price is low, although not significantly so. Thus, we found no support for H1.

Table 1

Direct effect of price and service on REVB purchase likelihood

Dependable variable	Purchase likelihood	
	b	SE
(Constant)	4.90****	0.77
Control variables		
SO1	0.31***	0.10
LIV	-0.37**	0.18
Experimental variables		
Price	-0.1	0.25
Service	-0.07	0.26
Interactions		
Price x Service	1.00*	0.51
R^2	0.1339***	
R^2 change	0.0286*	
F-statistic	2.5869	
n	122	

Note. Unstandardized coefficients are reported. * p > 0.05 < 0.10; ** p < 0.05; *** p < 0.01; **** p < 0.001; bootstrapping 10,000 subsamples.

The direct effect of service on the likelihood of purchasing an REVB is also negative and not significant (b = -0.0679, se = 0.2555, t = -0.2656, p = 0.7910). This reveals that purchase likelihood is higher when the service level is low, but not significant. Table 1 also shows that the effect of the interaction between price and service on the likelihood of purchasing an REVB is positive and partially significant (b = 1.0036, se = 0.998, t = 1.9584, p = 0.0526). Thus, we found partial support for H2. Figure 2 illustrates the interaction effects. Purchase likelihood decreases when price is high and there is no additional service, while purchase likelihood increases when price is low and there are additional services.

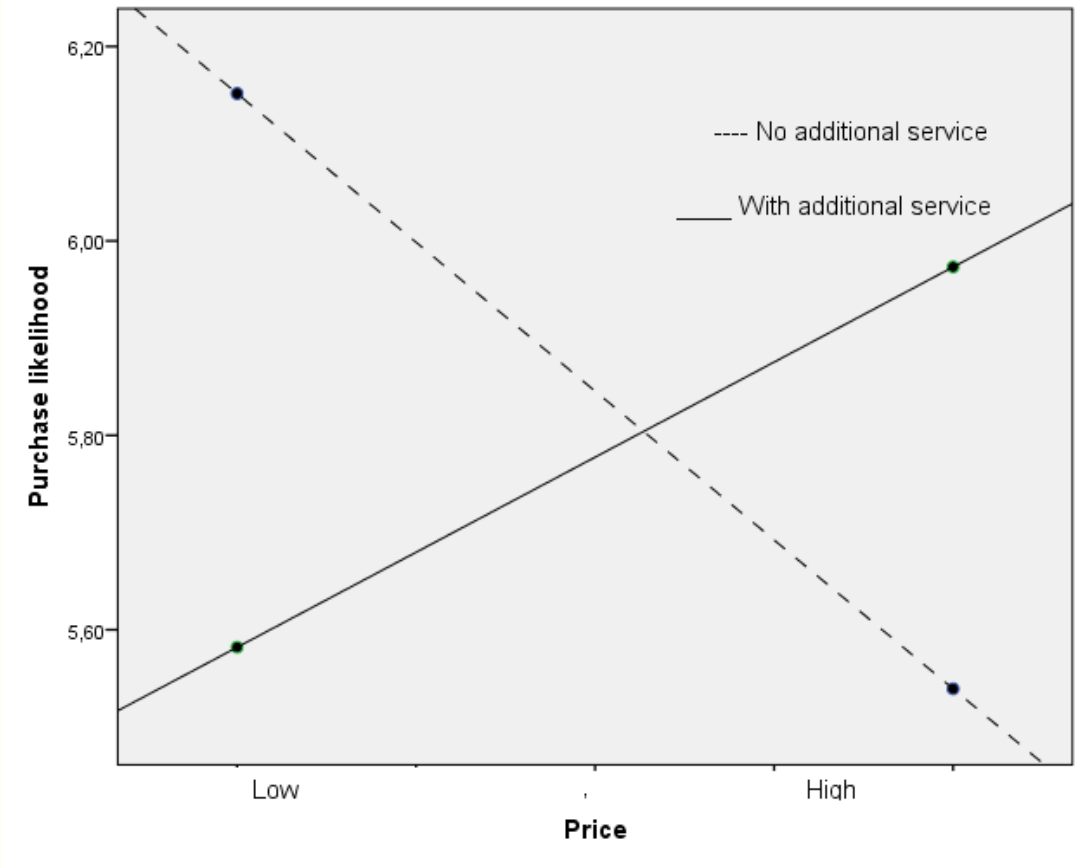

Figure 2. Interaction of price and service on REVB purchase likelihood

Moderator effect of perceived value

Table 2 shows the results of the interaction between price and service on the likelihood of purchasing an REVB and the moderation effect of perceived value. Unlike what was observed previously, price has a negative and significant direct effect on the likelihood of purchasing an REVB (b = -1.9576, se = 0.8692, t = -2.2521, p = 0.0262). Service, however, still has no significant direct effect on REVB.

Table 2 also shows that the effect of the interaction between price and service on the likelihood of purchasing an REVB is positive and partially significant (b = 0.8846, se = 0.4725, t = 1.8720, p = 0.0638). Perceived value has a positive and significant direct effect on the likelihood of purchasing an REVB (b = 0.334, se = 0.0906, t = 4.1232, p = 0.0001). This reveals that purchase likelihood is higher when the REVB is perceived as having a better cost/performance ratio than that of a new battery.

Table 2

Moderator effect of perceived value and service on the relationship between price on REVB purchase likelihood

Dependable variable	Purchase likelihood	
	b	SE
(Constant)	4.90****	0.77
Control variables		
SO1	0.31***	0.10
LIV	-0.37**	0.18
Experimental variables		
Price	-0.1	0.25
Service	-0.07	0.26
Interactions		
Price x Service	1.00*	0.51
Price x Value	0.35**	0.17
R^2	0.2801****	
R^2 change — price x service	0.0221*	
R^2 change — price x value	0.0267**	
R^2 change — both	0.0524**	
F-statistic	6.3379	
n	122	

Note. Unstandardized coefficients are reported. * p > 0.05 < 0.10; ** p < 0.05; *** p < 0.01; **** p < 0.001; bootstrapping 10,000 subsamples.

Table 2 shows that perceived value moderates the effect of price on the likelihood of purchasing an REVB (b = 0.3496, se = 0.1700, t = 2.0568, p = 0.0420). Thus, we found support for H3.

The Johnson-Neyman test for conditional effects reveals that value and service together influence the effect of price on the likelihood of purchasing an REVB. As Table 3 shows, when there are no additional services and scores of perceived values are (> 6), the effect of price on the likelihood of purchasing an REVB is negative and significant. Conversely, when there are additional services the effect of price on the likelihood of purchasing an REVB is not significant, which provides additional support for H2 and H3.

Table 3

Conditional effect of price on REVB purchase likelihood moderated by service and price

Service	Value	Effect	se	t	p	LLCI	ULCI
-.5000	4.0000	-1.0015	.3467	2.8885	**.0046**	**-1.6884**	**-.3147**
-.5000	5.0000	-.6519	.3183	-2.0479	**.0429**	**1.2826**	**-.0213**
-.5000	6.0000	-.3024	.3745	-.8074	.4211	-1.0442	.4395
-.5000	4.0000	-.1170	.3898	-.3000	.7647	-.8892	.6553
-.5000	5.0000	.2326	.3494	.6658	.5069	-.4596	.9248
-.5000	6.0000	.5822	.3873	1.5034	.1355	-.1850	1.3494

Moderator effect of perceived risk

Table 4 shows the results of the interaction between price and service on the likelihood of purchasing an REVB and the moderation effect of perceived risk. Price and service have no significant direct effect on the likelihood of purchasing an REVB. Table 4 also shows that the effect of the interaction between price and service on the likelihood of purchasing an REVB is

positive and partially significant (b = 0.9489, se = 0.5081, t = 1.8676, p = 0.0644). Perceived risk has a negative and significant direct effect on the likelihood of purchasing an REVB (b = -0.1567, se = 0.0748, t = -2.0959, p = 0.0383). This reveals that purchase likelihood is low when the REVB is perceived as being an inferior performance option compared to a new battery. Table 5 also shows that perceived risk does not moderate the effect of price on REVB purchase (p = 0.7984). Thus, we found no support for H4.

Table 4

Moderator effect of perceived risk and service on the relationship between price and on REVB purchase likelihood

Dependable variable	Purchase likelihood	
	b	SE
(Constant)	5.60****	0.89
Control variables		
SO1	0.36**	0.10
LIV	-0.39**	0.17
Experimental variables		
Price	0.09	0.73
Service	-0.11	0.25
Moderator		
Risk	-0.16**	0.07
Interactions		
Price x Service	0.95*	0.51
Price x Risk	-0.05	0.15
R^2	0.1673***	
R^2 change — price x service	0.0255*	
R^2 change — price x risk	0.0008	
R^2 change — both	0.0268	
F-statistic	3.2727	
n	122	

Note. Unstandardized coefficients are reported. * p > 0.05 < 0.10; ** p < 0.05; *** p < 0.01; **** p < 0.001; bootstrapping 10,000 subsamples.

DISCUSSION AND IMPLICATIONS

Discussion

Our results show that low price is a significant predictor of the likelihood of purchasing an REVB, even when there is no service added to the remanufactured offer; in other words, there is no servitization. Our results also show that when the price of a remanufactured battery is higher, additional service is required (Figure 2). Moreover, the results also show that when consumers perceive a remanufactured product to be a better cost benefit option, extra services are not required. On the other hand, when companies offer a remanufactured battery combined with services, consumers would be willing to pay a higher price. These results suggest, therefore, that servitization plays a relevant role in remanufacturing offers.

Considering the context of REVB, this study contributes to the topic by identifying under what conditions price is a significant predictor of the likelihood of purchasing a remanufactured product. The results reveal that when the offer of a remanufactured battery shifts from a product focus to a service focus, i.e., shifts to servitization, the effect of low price on the likelihood of

purchasing an REVB is not significant. Our results, like those of Zhu, Li, Zhao, and Lun (2016), indicate that customers may choose to pay a higher price for a remanufactured product when new services are offered. Our results suggest that servitization may have a similar effect, and also be a valuable strategy for selling remanufactured products. However, unlike that previous study, we isolated the effect of no additional services and additional services, combined with low and high price in the remanufactured offer, on the purchasing behavior of consumers. Instead of focusing on the potential profit of the manufacturer, we focused on the decision of consumers.

This study also found that perceived value has a positive and significant effect on the likelihood of purchasing an REVB. This finding is consistent with previous studies (e. g., Hazen et al., 2017; Zhou & Gupta, 2019). In addition to the current literature, our study reveals that perceived value also moderates the effect of price and service on the likelihood of purchasing an REVB. When the subject perceives a higher value on remanufactured products, the effect of price becomes not significant, highlighting the importance of perceived value as a predictor of the likelihood of purchasing an REVB. This finding contributes to the literature by identifying the fact that the use of a servitization strategy in the context of remanufacturing does not necessarily need to be extensive. Servitization in this context tends to be valid for reaching customers who perceive that the performance/cost ratio is lower than that of a new product.

Finally, this study found a negative and significant effect of perceived risk on the likelihood of purchasing an REVB, which is consistent with previous studies (Matsumoto et al., 2018; Wang & Hazen, 2016). We also found that perceived risk does not have the same moderation role on the effect of price on the likelihood of purchasing an REVB. This suggests that perceived risk may have a considerable negative effect. The results of our experiment contribute to the literature by identifying that when the consumer perceives that purchasing a remanufactured product is very risky, a lower price and the offer of additional services do not matter. An alternative explanation for our findings is possible. A consumer who is concerned about sustainability is more likely to purchase a remanufactured battery, regardless of the price or the additional service being offered.

Implications for theory, research, and practice

Remanufacturing literature highlights the importance of price and quality to purchase intention. Previous studies generally state that lower price is the main factor when consumers choose a remanufactured product (e.g., Vafadarnikjoo et al., 2018). Previous literature also highlights the perception of lower quality as the main factor when consumers choose a new product (Abbey et al., 2017).

This study contributes to the literature on remanufacturing, as it is one of the first to empirically test the effect of servitization using the context of an REVB. We contribute to the literature because servitization may be a strategy that companies can adopt for increasing the perceived value of remanufactured products, thus making the offer more profitable. Furthermore, servitization may reduce the preconception that a remanufactured product is of lesser quality than a new one (Jensen et al., 2019; Zhu et al., 2016).

From the methodological perspective, our study employs a 2 x 2, full factorial, between-subjects EVM. An experimental approach can better explain the influence of the manipulated independent variables, price and service, on the likelihood of purchasing an REVB. Previous studies (e.g., Abbey, Blackburn, & Guide, 2015; Hazen et al., 2017) highlighted the advantage of experiments over surveys for explaining consumer purchase decisions. EVM enabled this study to control the exposure of the subject to four stimuli relating to the remanufactured offer, using a combination of low/high price and service. Our approach also allows us to identify how the manipulation of independent variables interacts with value and risk perception, and their effect on the likelihood of purchasing an REVB.

From a practical perspective, managers can benefit from the results of this study by developing strategies to make the remanufactured product more valuable to consumers. More specifically, managers should focus on how to associate servitization with remanufacturing instead of just selling remanufacturing as a low-cost option. Managers may consider servitization as a strategy for reducing the prior perception that remanufacturing is only a low-cost option, by adding extra services to reduce consumer uncertainty with regard to the performance of remanufactured products in order to reduce the risk perception of consumers.

With regard to the automotive industry, companies should be aware that remanufacturing is an alternative and a sustainable option to the issue of used EVs, thus helping reduce the environmental impact of its products. Remanufacturing can also be a social strategy, opening up the EV market to lower-income consumers from different countries.

From the environmental perspective, our study contributes by showing that there are alternatives for promoting consumers' intentions with regard to remanufactured products. As remanufactured products become more attractive, the environment will benefit from the increment in the effectiveness of reverse logistics in terms of disposal and the recapture of the market value of products, in this case, EV batteries. This corroborates the CLSC objectives, by reducing the need for new products, reducing the consumption of raw materials, extending the useful life of products, and reducing landfill issues.

CONCLUSION

Remanufacturing has the potential to contribute to all the dimensions of sustainability (D'Agostini et al., 2017; Tseng, Lim, & Wong, 2015) because it recaptures the economic value of discarded or used products (Bakker, Wang, Huisman, & Hollander, 2014), reduces the environmental impact of the production process (Saavedra, Barquet, Rozenfeld, Forcellini, & Ometto, 2013), and enables those on lower incomes to buy products cheaper (Tondolo et al., 2020). Remanufacturing is also an important focus in operations management research due to its importance to the circular economy (Jensen et al., 2019).

This study examined how price and service affect the likelihood of buying a remanufactured EV battery, both directly and as moderated by perceived value and perceived risk. The EVM approach

allowed us to suggest that offering additional services may reduce the effect of low price on the likelihood of purchasing an REVB. Perceived value and risk have direct effects on the likelihood of purchasing an REVB. Perceived value moderates the effect of price on the likelihood of purchasing an REVB; the price effect decreases the more value is perceived. Based on our findings, we contribute to the literature by providing evidence that servitization is a strategy that manufacturers can use to increase the perceived value of remanufactured products, and the intention to purchase such products. Our findings highlight the limits to the assumption that price is the main factor influencing the purchasing likelihood of remanufactured products.

Our study has its limitations, however. We manipulated only two levels of two variables. We do not cover aspects such as the type of provider of remanufactured products, the battery's technological specifications, or the social aspects of sustainability. Further studies can increase the scope of the manipulations, using intermediate levels of price and service. This opens up opportunities for new studies, such as those clarifying how servitization can increase the perceived value of remanufactured products and how it can reduce the perceived risk associated with them.

Further studies may also include other independent variables, such as type of provider, comparing the effect between third-party remanufacturers and original equipment manufacturers (OEM). We also did not cover all the marketing, technological, and operational aspects of EV batteries. Further studies should explore new generations of EV batteries and the improvements introduced by manufacturers, thus enabling generalizations to be suggested for the automotive industry.

Laboratory experiments may also contribute by establishing a decision simulation that is more dynamic. Further studies can also investigate how the social dimension of sustainability affects consumer intentions to buy remanufactured products (Tondolo et al., 2020). Finally, further studies could focus on factors that affect purchase intention to buy/produce hybrid products (new products using remanufactured parts and components), such as new cars with remanufactured engines (Moosmayer, Abdulrahman, Subramanian, & Bergkvist, 2020). Despite these limitations, our study contributes to the theory and practice of remanufacturing by providing evidence that servitization is valuable for a CLSC proposal.

ACKNOWLEDGEMENTS

The authors acknowledge that this study was made possible thanks to Federal University of Pelotas and FGV/EAESP.

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APPENDIX A

Table A1

Control variable results

Dependable variable	Purchase likelihood	
	b	SE
(Constant)	4.91***	1.22
Control variables		
SO1	0.28**	0.11
SO2	0.04	0.09
CAR1	0.04	0.08
CAR2	-0.13	0.38
LIV	-0.37**	0.17
Experimental variables		
Price	-0.12	0.26
Service	-0.06	0.26
Interactions		
Price x Service	1.03*	0.53
R^2	0.1379**	
R^2 change	0.0287*	
F-statistic	2.2592	
n	122	

Note. Unstandardized coefficients are reported. * p > 0.05 < 0.10; ** p < 0.05; *** p < 0.01; **** p < 0.001; bootstrapping 10,000 subsamples.
SO1: I think it is more important to save environmental resources than to be able to consume a lot.
SO2: In my opinion, it is reasonable that consumers have to pay higher prices for products that cause environmental damage. (SO1 and SO2) are adapted from Buerke, Straatman, Lin-Hi, and Müller (2017); Haws, Winterich, and Naylor (2014); Kuckertz and Wagner (2010).
CAR1: How necessary is a car in your daily life? ( ) unnecessary ( ) relatively necessary ( ) very necessary.
CAR2: Which of the alternatives below best describe you? ( ) already own or have owned an electric/hybrid car ( ) have considered buying an electric/hybrid car ( ) have never considered buying an electric/hybrid car.
LIV: Would you consider your home to be in a rural, urban, or suburban area? ( ) rural area ( ) urban area ( ) suburban area.