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Design and Repair Strategies Based on Product–Service System and Remanufacturing for Value Preservation

Karina Cecilia Arredondo-Soto [1,2], Alejandro Jiménez-Zaragoza [3], Marco Augusto Miranda-Ackerman [3], Julio Blanco-Fernández [2], Alejandra García-Lechuga [3], Guadalupe Hernández-Escobedo [1] and Jorge Luis García-Alcaraz [4,*]

1 Department of Industrial Engineering, Tecnológico Nacional de México/Instituto Tecnológico de Tijuana, Calzada del Tecnológico S/N, Tijuana 22414, Baja California, Mexico; karina.arredondo@tectijuana.edu.mx (K.C.A.-S.); ghernan@tectijuana.mx (G.H.-E.)
2 Department of Mechanical Engineering, University of La Rioja, San José de Calasanz 31, 26004 Logroño, La Rioja, Spain; julio.blanco@unirioja.es
3 Chemical Sciences and Engineering Faculty, Universidad Autónoma de Baja California, Calzada Universidad #14418, Parque Industrial Internacional, Tijuana 22390, Baja California, Mexico; alejandro.jimenez.zaragoza@uabc.edu.mx (A.J.-Z.); miranda.marco@uabc.edu.mx (M.A.M.-A.); alejandra.garcia.lechuga@uabc.edu.mx (A.G.-L.)
4 Department of Industrial and Manufacturing Engineering, Autonomous University of Ciudad Juarez, Del Charro Ave., 450 N., Ciudad Juarez 32310, Chihuahua, Mexico
* Correspondence: jorge.garcia@uacj.mx; Tel.: +52-656-688-4843

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Citation: Arredondo-Soto, K.C.; Jiménez-Zaragoza, A.; Miranda-Ackerman, M.A.; Blanco-Fernández, J.; García-Lechuga, A.; Hernández-Escobedo, G.; García-Alcaraz, J.L. Design and Repair Strategies Based on Product–Service System and Remanufacturing for Value Preservation. *Sustainability* **2022**, *14*, 8560. https://doi.org/10.3390/su14148560

Academic Editor: Chia-Hsing Huang

Received: 9 March 2022
Accepted: 11 July 2022
Published: 13 July 2022

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Abstract: Remanufacturing is a production practice that requires the work of producers, consumers, and the government. There are benefits associated with this production model, such as improving the environment, opportunities for cost savings, and others. However, it is essential to identify the factors that affect the possibility of acceptance of this production model. This research proposes a model based on different analysis methodologies and techniques of SEM (Structural Equations Modeling) and the method of PLS (Partial Least Squares). A total of 403 responses to the survey were collected from 1 November 2021 to 15 January 2022. For the data treatment, SPSS, Excel, and WarpPLS software were used to identify the variables, factors, and their direct and indirect effects among the latent variables, referring to a scheme focused on consumer perception based on the acquisition remanufactured products. This created model served as a reference to create and develop a design and repair strategy for White goods or similar products in handling, logistics, and repair. This design strategy was transformed into a business model based on a circular economy, particularly on a Product–Service System with social, economic, and environmental benefits for producers and consumers.

Keywords: remanufacturing; service design; consumer perception; circular economy; responsible consumption; product–service system; canvas model; white goods; washing machines

1. Introduction

The dynamism implied by the changes in society influenced a little reflexive attitude regarding how the planet's resources are used. However, within this same context of lack of social interest, new thoughts, movements, and laws have arisen that seek to promote awareness of this problem to reduce the negative impacts on our planet. As if there were no other options that imply economic gains via responsible consumption, the capitalist economic model that encourages consumption creates surpluses in waste, wasting consumers' money and the environment's limited natural resources. According to the 2030 Agenda, one of the 17 Sustainable Development Goals is responsible consumption [1–3] that requires changing production processes and consumption of products and resources to lessen the ecological impact.

So, industries, enterprises, and consumers must be encouraged to recycle and decrease waste [4]. Remanufacturing ensures that a product is as good as new while saving money and focused on a circular economy for a more efficient end-of-life choice than the recycling concept and entails transforming the core into raw material and extending the product's useful life at least once more. Disassembly, cleaning, inspections, and the design of recovery procedures are all part of the process (to bring each product component back to design requirements), assembling, and final testing [5–7].

1.1. Product–Service System (PSS)

These are large appliances that produce environmental pollution, depletion of natural resources, climate change issues, and generations of microplastics, which cause cellular biological damage, inflammation, and toxicity when consumed by live beings. As a result, the Product–Service System (PSS) and remanufacturing appeal to the producer and the buyer, who may get a high-quality product with exceptional service and a reasonable price. A PSS is a kind of servitization; it is a market alternative different from the usual model of making, marketing, and utilizing a product, since it includes an added service value. On the other hand, remanufacturing is an end-of-life approach to preserving the product's added value to a more significant extent while also extending its life cycle [8].

PSS and remanufacturing have a similar emphasis on the added value, with PSS increasing it via service and remanufacturing preserving it through greater core use. China [6,9–11], India [12], Japan [13,14], the United States [15–17], the Netherlands [18], and Greece [19], among others, have focused on developing studies at this regard. From the customer perception perspective, studies on remanufactured products are limited in Mexico [5,20–22]; however, there existed a culture of repair or restoration in the past. Due to the advent of the linear economy, which is characterized by shorter product life cycles, companies have been working on various production system alternatives [20], and nowadays, there is a trend to acquire new items and discard old ones, which wind up at disposal sites or, in the best-case scenario, recycling centers, which recover just the raw materials' worth but lose any extra value gained during the manufacturing process.

1.2. PSS and Original Equipment Manufacturer (OEM)

Implementing product design methods based on programmed obsolescence to depict inevitable faults in a specified period of its useful life encourages these behaviors. These failures result in a catastrophic breakdown of a vital component, preventing the product from continuing to operate. Customers often believe it is more attractive to purchase a new product and trash the old one. The cost is higher, or the Original Equipment Manufacturer (OEM) does not supply replacement components. On the other side, the circular economy idea allows consumers to make their goods last longer by changing their features, and decreasing material demand (mining, energy, water usage, and garbage creation are only a few examples).

It is central to processes involving remanufacturing techniques to retain the value-added during the product's manufacturing process. In addition, the manufacturer can make a profit margin on that product so that the lengthening of the product life cycle does not conflict with the OEM's sales revenue. A well-designed PSS would allow the OEM to continue obtaining economic benefits after product sales. Profits would no longer come from selling products in large volumes but from providing services to the products (sale of service parts, such as critical components) [23–26].

1.3. Previous Research

The area of remanufacturing has been of interest to many researchers, so it has generated several lines of research, which focus on the customers' perception of the products, previous knowledge and reputation of the remanufactured products, the generation of standards and guarantees that customers receive, the psychological attitude of purchase,

among others. Table 1 summarizes the main research, tools, and methodologies used to study this topic.

Table 1. Identification of variables, models, and methodologies.

Indicators	Critical Variables	Research
Risk perception, personal benefits, knowledge about remanufactured products, environmental concerns, market strategy, attitude, subjective norms, control of perceived behavior, and purchase intention.	Risk perception Personal benefits Knowledge about products	Acceptance of remanufactured products in the circular economy: an empirical study in India [12].
Knowledge about products Personal benefits Risk perception	Knowledge about products Personal benefits Risk perception	Consumer Perception of Remanufactured Automotive Parts and Policy Implications for Transitioning to a Circular Economy in Sweden [27].
Subjective norms, motives, marketing mix factors, and purchase intention all influence how people feel about buying a refurbished laptop.	Attitude toward the purchase of a remanufactured laptop Subjective norms Motivations	Key drivers in the behavior of potential consumers of remanufactured products: a study on laptops in Spain [10].
Attitude, subjective norms, control of perceived behavior, purchase intention of remanufactured products, purchase-energy efficiency, new condition, and remanufactured.	Attitude, Subjective norms, purchase intention of remanufactured products. Purchase-energy efficiency, -new condition and remanufactured	Remanufactured products purchase intentions and behavior: Evidence from Malaysia [6].
Perceived value, perceived risk, purchase intention, knowledge about cost, environment knowledge, and quality knowledge.	Perceived value Perceived risk Purchase intention	Consumer product knowledge and intention to purchase remanufactured products [10].

1.4. Research Problem and Objective

This study focuses on PSS and remanufacturing to minimize environmental impact. The goal is to create a circular economy alternative to the linear economy, positively influencing the environment, economy, and society by encouraging responsible consumption. Consumer behavior and the elements that impact their decision to purchase remanufactured items must be identified. It is also vital to develop a good technique for constructing the PSS, examine the capability to maintain added value, present a plan, and test its viability.

Specifically, for the case study of white goods (washing machines), the current scenario implies that to manufacture a washing machine: The raw material is extracted, it is processed, it is distributed to the market, the customer uses it and is responsible for its maintenance, and finally, when a catastrophic failure occurs, it is discarded. The product is designed with a link within this system with a catastrophic failure, which translates into the impossibility of recovering the product's performance. Consequently, the product's appropriate life cycle has ended, and its additional value has been lost. This business model has a profit margin for the companies that manufacture it. Is it possible to propose a strategy to replace this linear model with a circular one in white goods, resulting in an attractive PSS to the manufacturer and the consumer?

This research process is a design and repair strategy for washing machines from the PSS and remanufacturing approach, which can be generalized in the context of white

goods. The specific goals of this research are: (a) to identify the consumer's perception of remanufactured products' purchase decision-making process, (b) to identify the factors that make up the customer's perception and that play a role in the customer's willingness to accept the proposal of a PSS for remanufactured washing machines, and (c) to adapt an existing methodology to develop a PSS proposal for remanufactured washing machines.

However, it is not possible to validate each of the white line products in the demonstration of the generalization, so only one case will be taken as a comparative example, leaving as future work the verification of the other cases. Likewise, the number of washing machine models to be studied is limited, considering only the most common in the San Diego-Tijuana region, including the following manufacturers: Mabe, LG, Maytag, Whirlpool, Samsung, Haier Group Company, AB Electrolux, Indesit Company, Arcelik, and Miele.

2. Methodology

2.1. Survey Development

The first step is the identification of variables, methodologies, and tools to understand remanufacturing operatively and considering the customer's perception of the design of services related to the remanufactured product, as appears in Table 1. The main variables identified are Risk Perception (RP), Remanufactured Products Knowledge (RPK), Personal Benefits Focused on Design Strategy (PBFDS), Concern for the Environment (CE), Market Strategy (MS), Attitude (A), Subjective Standards (SS), Perceived Control of Behavior (PCB), and Intent to Purchase Remanufactured Products (IPRP).

Table 2 indicates those variables and 36 items used to evaluate it and the reference to the author to justify a rational validation. Using those items, a survey was developed that are responded on a Likert scale. The scale used in the questionnaire was entered, and the data was captured using the numerical value of the corresponding scale (Likert type) for each item, where: (1) Strongly disagree: The respondent has sufficient reasons to reject the statement, and no such situation is ever presented for the evaluated argument. (2) Strongly Disagree: The respondent rarely agrees with that argument. (3) Neither agree nor disagree: The respondent has no argument to decide on the statement. (4) Strongly agree: The respondent frequently agrees with the argument in question. (5) Strongly Agree: The respondent has sufficient reason to accept the statement presented regarding remanufacturing. However, the survey is having a judge's validity because, based on their experience and regarding the items structure and the scales, the survey can be adapted to the regional context. The experts included academic and personnel with research experience in areas related to industrial engineering.

Table 2. Factors involved in customer perception of remanufactured products.

Risk Perception (RP) **Arguments Considered in the Instrument**	**Variable Evaluated and Author**
1. I have my doubts about the quality of remanufactured goods.	Quality [17].
2. I have to spend a lot and money on remanufactured product maintenance.	Maintenance expenses [28].
3. Remanufactured products, in my opinion, function poorly.	Performance [5].
4. If I purchase these items, others will ridicule me.	Self-perception [29].
5. Remanufactured products aren't as excellent as new ones, which could endanger my health.	Security [29].
6. Because remanufactured items may not function as well as new ones, their performance may be affected.	Functioning [13].
7. Buying remanufactured products is a bad investment.	Investment [30].

Table 2. *Cont.*

Risk Perception (RP) Arguments Considered in the Instrument	Variable Evaluated and Author
Remanufactured Products Knowledge (RPK)	
8. If remanufactured items come with a specified guarantee, I'll purchase them.	Warranty [31].
9. If remanufactured items offer the newest features, I will purchase them.	Modernity [32].
10. I'm acquainted with remanufactured items' performance and qualities.	Features [33].
11. I am aware of the differences in quality between remanufactured and new items.	Comparison [34].
12. I understand the distinctions between remanufactured and new items.	Differences [34].
13. I will purchase remanufactured products if replacement parts for critical components are available.	Spare parts [35].
Personal Benefits Focused on Design Strategy (PBFDS)	
14. Because of their reduced pricing, I will purchase remanufactured items.	Price [36].
15. I can obtain government subsidies if I purchase remanufactured items.	Government incentives [12].
16. If I consume remanufactured products, I may have additional discounts.	Discounts [37].
17. Buying remanufactured products instead of new ones saves me.	Savings [38].
18. I am willing to purchase remanufactured products if maintenance services increase the product's useful life.	Maintenance services [38].
Concern for the Environment (CE)	
19. I would buy remanufactured products because they lower the carbon footprint.	Carbon footprint [39].
20. I would buy remanufactured products because they decrease global warming.	Global warming [40].
21. I would purchase remanufactured items since they are environmentally friendly.	Concern for the environment [40].
22. If I buy remanufactured products instead of new ones, I can save resources and energy in the environment.	Resource-saving [40].
23. Buying remanufactured products reduces adverse effects on the environment.	Effects on the environment [41].
24. Buying remanufactured products reduces the over-extraction of primary (virgin) resources.	Resource extraction [42].
25. Buying remanufactured products help partially or recover their components at their end of useful life to reinsert them into the production process.	Recovery [43].
Market Strategy (MS)	
26. If remanufactured items had eco-labels, I would purchase them.	Eco-labels [44].
27. I would purchase remanufactured items from a more ecologically conscious brand.	Trademarks [45].
28. If the packing material for refurbished items is ecologically friendly, I would purchase them.	Packing [46].
Attitude (A)	
29. I'd want to see the number of remanufactured items expand.	Offer [38].
30. I am willing to purchase remanufactured products.	Will [47].
Subjective Standards (SS)	
31. I would purchase these items if my friends did as well.	Friendships [10].
32. I would purchase these items if my immediate and extended family members did.	Relatives [27].
Perceived Control of Behavior (PCB)	
33. I know where I can find remanufactured products for purchase.	Location [48].
34. I have enough time and money to purchase these remanufactured products.	Time and money [49].
Intent to Purchase Remanufactured Products (IPRP)	
35. I am motivated to start buying remanufactured products.	Purchase motivation [50].
36. In the future, I will purchase remanufactured items.	Future purchases [47].

2.2. Survey Application

The survey is developed to be answered online and is applied to companies established in the region of Ensenada, Mexicali, Tijuana, Playas de Rosarito and Tecate in the Mexican State of Baja California. With the help of the Asociación de Maquiladoras A.C. de Tijuana, potential respondents are identified and sent a link indicating the objective of the research and inviting them to participate in the survey.

The survey remains open for responses from 1 November 2021 to 15 January 2022. Respondents who did not respond to the survey within the first 15 days were sent an email with a reminder, and after one month without receiving a response, that case was omitted.

2.3. Preliminary Model and Hypotheses

According to variables identified in Table 2, an initial model is proposed. Each variable will be a parameter of the model, as it is represented graphically with a relationship of each variable to its corresponding factor. In addition, each of the hypotheses tested indicates a relationship between variables. Figure 1 proposes an initial model for assessing IPRP based on components that will serve the Design of the Value Conservation Strategy. With its 14 hypotheses, this model must be tested statistically to determine its validity. The proposed hypotheses are as follow:

Hypothesis 1 (H1). *Knowledge about Remanufactured Products (KRP) has a direct and positive effect on Personal Benefit Focused Design Strategy (PBFDS).*

Hypothesis 2 (H2). *Knowledge about Remanufactured Products (KRP) has a direct and positive effect on potential consumer's Intention to Purchase Remanufactured Products (IPRP).*

Hypothesis 3 (H3). *Knowledge about Remanufactured Products (KRP) has a direct and positive effect on the Risk Perception (RP) of the potential consumer.*

Hypothesis 4 (H4). *Knowledge about Remanufactured Products (KRP) has a direct and positive effect on the Attitude (A) of the potential consumer.*

Hypothesis 5 (H5). *Attitude (A) has a direct and positive effect on the Risk Perception (RP) of the potential consumer.*

Hypothesis 6 (H6). *Attitude (A) has a direct and positive effect on potential consumer's Intention to Purchase Remanufactured Products (IPRP).*

Hypothesis 7 (H7). *Risk Perception (RP) has a direct and positive effect on potential consumer's Intention to Purchase Remanufactured Products (IPRP).*

Hypothesis 8 (H8). *Personal Benefit Focused Design Strategy (PBFDS) has a direct and positive effect on potential consumers' Intention to Purchase Remanufactured Products (IPRP).*

Hypothesis 9 (H9). *Environmental Concern (EMP) has a direct and positive effect on potential consumer's Intention to Purchase Remanufactured Products (IPRP).*

Hypothesis 10 (H10). *Concern for the Environment (CE) has a direct and positive effect on the Market Strategy (MS) of the potential consumer.*

Hypothesis 11 (H11). *Market Strategy (MS) has a direct and positive effect on potential consumer's Intention to Purchase Remanufactured Products (IPRP).*

Hypothesis 12 (H12). *Perceived Behavioral Control (PCC) has a direct and positive effect on potential consumer's Intention to Purchase Remanufactured Products (IPRP).*

Hypothesis 13 (H13). *Subjective Standards (SS) have a direct and positive effect on potential consumer's Risk Perception (RP).*

Hypothesis 14 (H14). *Subjective Standards (SS) have a direct and positive effect on potential consumers' Intention to Purchase Remanufactured Products (IPRP).*

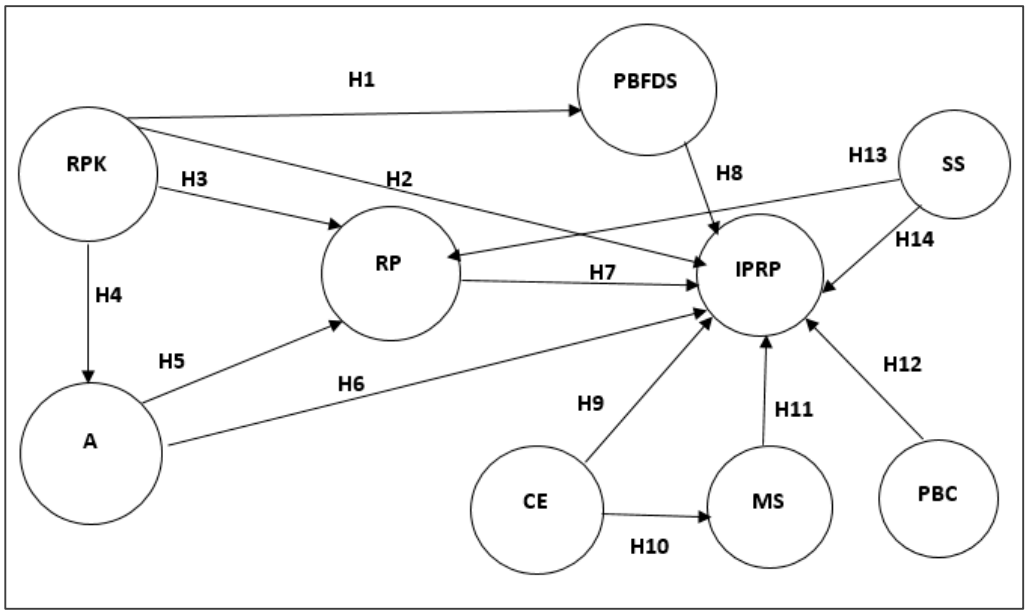

Figure 1. Preliminary Model to determine the Purchase Intention of Remanufactured Products based on components that will serve the Design of the Value Conservation Strategy. RPK (Remanufactured Products Knowledge), RP (Risk Perception), PBFDS (Personal Benefits Focused Design Strategy), CE (Concern for the Environment), MS (Market Strategy), A (Attitude), SS (Subjective Standards), PBC (Perceived Behavioral Control), and IPRP (Intention to Purchase Remanufactured Products).

2.4. Data Debugging and Information Validation

A database is downloaded from the platform where the survey is conducted. Before analyzing the information, it is cleaned according to the following activities:

1. Identify extreme values and the 36 items are standardized.
2. Identification of missing values, which are replaced by the median.
3. Identification of uncommitted respondents, for which each case is standardized.

Once the database has been cleaned, the validation indexes in Table 3 are applied, where the desired value is indicated. It is important to mention that if the indices do not meet the cut-off value, iterations are carried out by eliminating some items.

Table 3. Index for variable validation.

Index	Validation	Best If
R-squared	Parametric predictive validity	>0.02
Adjusted R-squared	Parametric predictive validity	>0.02
Composite reliability	Internal validity	>0.7
Cronbach Alpha	Internal validity	>0.7
Average variance extracted (AVE)	Convergent validity	>0.5
Full collinearity Variance Inflation Factor (VIF)	Collinearity	<5
Q-squared	Nonparametric validity	>0

2.5. Hypotheses Validation

The Structural Equation Modeling (SEM) and Canvas Model techniques were used to validate the proposed model, because it is a tool that allows using multiple variables that represent the model and observing the specific measurement error of each variable. Additionally, SEM considers the error in the measurement, and the selected software was WarpPLS v.7.0 (ScriptWarp Systems, Laredo, TX, USA) based on partial least squares (PLS) algorithms, because they are friendly [24–26] and recommended when sample size is small; data comes from assessments on ordinal scales or there is a lack of normal distribution [51].

The PLS-SEM combination has been applied in several studies; for example, Shrafat and Ismail [52] used it to find the most import lean manufacturing practices in Jordan, and García Alcaraz, et al. [53] used those techniques for relate the lean manufacturing tools with commercial benefits in the Mexican maquiladora. On the other hand, the Canvas Model was used to generate the value proposition simplified due to its versatility through its nine elements. Previously, some authors have already considered the application of SEM followed by the Canvas model, although they are scarce and very recent contributions [54,55].

Before being interpreted, the model is evaluated according to the following efficiency indices. If the model does not meet the indices, debugging is performed on the variables iteratively with a confidence level of 95%. The efficiency indices are as follows:

1. Average path coefficient (APC) and $p < 0.05$
2. Average R-squared (ARS) and $p < 0.05$
3. Average adjusted R-squared (AARS) > 0.02 and $p < 0.05$
4. Average block VIF (AVIF), acceptable if ≤ 5, ideally ≤ 3.3
5. Average full collinearity VIF (AFVIF), acceptable if ≤ 5, ideally ≤ 3.3
6. Tenenhaus GoF (GoF), small ≥ 0.1, medium ≥ 0.25, large ≥ 0.36

If the model meets the efficiency indices, then the relationships between the variables are evaluated, where, for each hypothesis, a standardized β value is obtained and tested at 95% confidence according to the null hypothesis H0. $\beta = 0$ versus the alternative hypothesis H1. $\beta \neq 0$. In this case, the Warp3 analysis algorithm and a bootstrapping resampling method of 100 have been used, while the missing data imputation algorithm was based on the median, since the values used in the analysis are on the ordinal scale [56].

3. Results

3.1. Sample Description

A total of 403 responses to the survey were collected, exceeding the minimum required [57], and Table 4 illustrates the distribution of the respondents according to cities where the survey was applied; where, according to gender, 216 (54%) were female and 187 (46%) were male. Additionally, observe that the most responders are in the range of 31–40 years old, and the responders are undergraduates.

Table 4. Distribution of informants by municipality, age, and education. Source: [57].

City	Population	Percentage	Informants
Ensenada	536,143	14.75%	57
Mexicali	1,087,578	29.91%	115
Tijuana	1,789,531	49.23%	190
Playas de Rosarito	107,859	2.97%	11
Tecate	113,857	3.13%	12
Totals	3,634,968	100.00%	385
Age	**Percentage (by Age)**	**Education**	**Percentage (by Education)**
<21	2.50%	Undergraduate	57.10%
21–25	8.40%	Technician	22.10%
26–30	25.10%	High School	10.40%
31–40	40.90%	Postgraduate	8.70%
>40	23.10%	Basic education	1.70%

3.2. Variables Validation

Table 5 illustrates the validation indexes obtained and according to those values, all variables fulfill the cutoff value and can be integrated to the model. These indices are explained in Table 3 and confirm the validity of each construct. In other words, there is enough parametric, nonparametric predictive, internal, and convergent validity. Additionally, there is not a high problem associated with collinearity, and only CE has a VIF higher than 5. According to those values, the variables and items are integrated in the model.

Table 5. Variables validation.

Index	RPK	A	RP	PBFDS	IPRP	SS	CE	MS	PCB
R-squared		0.558	0.32	0.607	0.772			0.726	
Adjusted R-squared		0.557	0.314	0.606	0.767			0.725	
Composite reliability	0.923	0.947	0.957	0.925	0.951	0.98	0.927	0.959	0.899
Cronbach Alpha	0.9	0.887	0.946	0.892	0.897	0.959	0.843	0.936	0.774
Average variance extracted	0.669	0.899	0.765	0.755	0.907	0.96	0.864	0.886	0.816
Full Collinearity VIF	3.074	4.192	1.342	4.489	4.792	1.211	5.044	4.079	1.658
Q-squared		0.567	0.296	0.602	0.797			0.718	

RPK = Remanufactured Products Knowledge, A = Attitude, RP = Risk Perception, PBFDS = Personal Benefits Focused on Design Strategy, SS = Subjective Standards, CE = Concern for the Environment, MS = Market Strategy, PCB = Perceive Control of Behavior, and IPRP = Intent to Purchase Remanufactured Products.

3.3. Preliminary Model Evaluation

The structural equation model is evaluated, and its efficiency indexes, according to the *p*-value or cut-off values, are adequate and indicates that there is enough predictive validity, no collinearity, and data has an acceptable fit to the model, so it is interpreted, and the results are shown in Figure 2.

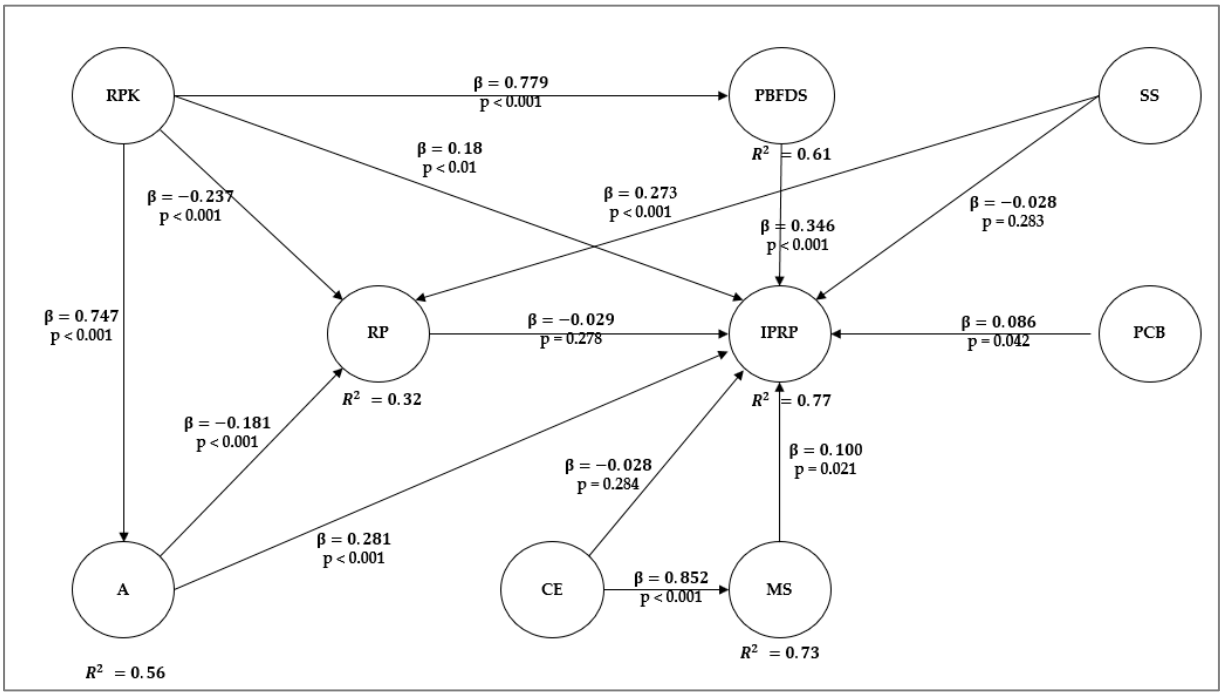

Figure 2. Model evaluated.

- Average path coefficient (APC) = 0.296, $p < 0.001$
- Average R-squared (ARS) = 0.597, $p < 0.001$
- Average adjusted R-squared (AARS) = 0.594, $p < 0.001$
- Average block VIF (AVIF) = 2.955, acceptable if ≤5, ideally ≤ 3.3
- Average full collinearity VIF (AFVIF) = 3.320, acceptable if ≤5, ideally ≤ 3.3
- Tenenhaus GoF (GoF) = 0.706, small ≥ 0.1, medium ≥0.25, large ≥ 0.36

3.4. Direct Effects—Hypotheses Validation

Figure 2 illustrates the standardized β value and the associated *p*-value for hypothesis testing, which allows us to conclude that many of the relationships are statistically non-significant, since the *p*-value is greater than 0.05. In addition, for each dependent variable, an R-squared value is reported as a measure of the variance explained by the independent variables.

Table 6 illustrates a summary of the hypotheses, the *p*-values, and the conclusion concerning the hypothesis. In general terms, it is observed that 11 hypotheses have a *p*-value associated with their β that is less than 0.05, and it is concluded that they are statistically significant, but in three hypotheses, the *p*-value is greater than 0.05, and it is concluded that there is no statistical relationship between the variables.

Table 6. Hypothesis conclusions.

Hi	Relationship	β Value (*p*-Value)	Conclusion	Hi	Relationship	β Value (*p*-Value)	Conclusion
H1	RPK→PBFDS	0.779 ($p < 0.001$)	Accept	H8	PBFDS→IPRP	0.346 ($p < 0.001$)	Accept
H2	RPK→IPRP	0.182 ($p < 0.001$)	Accept	H9	CE→IPRP	−0.028 ($p = 0.284$)	Reject
H3	RPK→RP	−0.237 ($p < 0.001$)	Accept	H10	CE→MS	0.852 ($p < 0.001$)	Accept
H4	RPK→A	0.747 ($p < 0.001$)	Accept	H11	MS→IPRP	0.100 ($p = 0.021$)	Accept
H5	A→RP	−0.181 ($p < 0.001$)	Accept	H12	PBC→IPRP	0.086 ($p = 0.042$)	Accept
H6	RP→IPRP	−0.029 ($p = 0.278$)	Reject	H13	SS→RP	0.273 ($p < 0.001$)	Accept
H7	A→IPRP	0.281 ($p < 0.001$)	Accept	H14	SS→IPRP	−0.028 ($p = 0.283$)	Reject

3.5. Indirect Effects and Total Effect

Table 7 summarizes the sum of indirect effects obtained when evaluating the model since the relationships between variables often occur through mediating variables. This model has only five indirect effects, of which three are statistically significant and two are not.

Table 7. Sum of thr indirect effects.

Relationship	β Value (*p*-Value)	Conclusion	Relationship	β Value (*p*-Value)	Conclusion
RPK→RP	−0.135 ($p < 0.001$)	Significant	SS→IPRP	−0.008 ($p = 0.410$)	No significant
RPK→IPRP	0.491 ($p < 0.001$)	Significant	CE→IPRP	0.086 ($p = 0.007$)	Significant
A→IPRP	0.005 ($p = 0.440$)	No significant			

The sum of the direct and indirect effects results in the total effects that appear in Table 8. It can be seen that there were some changes in the β values and associated *p*-values, but the same three relationships that were not statistically accepted using the direct effects are not accepted using the indirect effects, which leads to the conclusion that these relationships do not exist.

Table 8. Total effects.

Relationship	β Value (*p*-Value)	Conclusion	Relationship	β Value (*p*-Value)	Conclusion
RPK→PBFDS	0.779 ($p < 0.001$)	Significant	PBFDS→IPRP	0.346 ($p < 0.001$)	Significant
RPK→IPRP	0.673 ($p < 0.001$)	Significant	CE→IPRP	−0.057 ($p = 0.231$)	No significant
RPK→RP	−0.372 ($p < 0.001$)	Significant	CE→MS	0.852 ($p < 0.001$)	Significant
RPK→A	0.747 ($p < 0.001$)	Significant	MS→IPRP	0.100 ($p = 0.021$)	Significant
A→RP	−0.181 ($p < 0.001$)	Significant	PBC→IPRP	0.086 ($p = 0.042$)	Significant
RP→IPRP	−0.029 ($p = 0.278$)	No significant	SS→RP	0.273 ($p < 0.001$)	Significant
A→IPRP	0.286 ($p < 0.001$)	Significant	SS→IPRP	−0.036 ($p = 0.124$)	No significant

3.6. Canvas Model

With the information from the field study, we proceeded with developing the Canvas business model as an important product that materializes the strategy to be followed in the regional context. The business model canvas allows analyzing the different alternatives an organization must create a value strategy when offering a product. According to [58], the value proposition materializes the company's strategy for each customer segment, describing the unique combination of product, price, service, and image. The value proposition should communicate what the company expects to do better or differently than the competition for its customers. It offers a solution to consumers' problems and satisfies their needs (explicit and latent). A company can offer several related value propositions.

4. Discussion of Results

Regarding to H1 "*Remanufactured Products Knowledge (RPK) has a direct and positive effect on the Personal Benefits Focused on Design Strategy (PBFDS) of the potential consumer*", there is sufficient statistical evidence to affirm that (RPK) has a direct and a positive effect on (PBFDS), the value of the direct effect is 0.78. Knowledge about remanufactured products can bring personal benefits to the consumer in the design of business strategy. These benefits are mainly associated with reduced prices, extended warranties and increased functionality-durability of the product.

About H2 "*Remanufactured Products Knowledge (RPK) has a direct and positive effect on the Intention of Purchase of Remanufactured Product (IPRP) of the potential consumer*", there is sufficient statistical evidence to affirm that (RPK) has a direct and positive effect on (IPRP), since when the first latent variable increases by one standard deviation, the second one increases by 0.18 units. Therefore, the hypothesis is accepted. As consumers become more informed about the implications of buying remanufactured products, their purchase intent becomes more robust.

For H3 "*Remanufactured Products Knowledge (RPK) has a direct and positive effect on the Risk Perception (RP) of the potential consumer*", there is enough statistical data to argue that (RPK) directly affects (RP). There is a positive direct effect of 0.24, which means that when the first variable increases by one standard deviation, the second variable increases by 0.24 units. Therefore, this hypothesis is accepted. If the consumer is more aware of remanufactured products, the perception of risk towards remanufactured products improves, and he/she has a better idea of the implications of the purchase.

Regarding to H4 "*Remanufactured Products Knowledge (RPK) has a direct and positive effect on the Attitude (A) of the potential consumer*," there is sufficient statistical evidence to state that (KPR) directly affects (A), since when the first latent variable increases by one standard deviation, the second one increases by 0.75 units. Therefore, the hypothesis is accepted. As consumers become informed about the implications of buying remanufactured products, their attitude changes and they recommend remanufactured products to others and start consuming them.

About H5 "*Attitude (A) has a direct and positive effect on the Risk Perception (RP) of the potential consumer*", there is sufficient statistical evidence to state that (A) directly affects (RP). However, there is not enough statistical evidence to claim that the direct effect is positive. There is a negative direct effect of 0.18, which means that when the first variable increases by one standard deviation, the second decreases by 0.18 units. Therefore, this hypothesis is partially accepted. As the consumer's attitude improves, his perception of the risk associated with them decreases, thus normalizing their consumption.

For H6 "*Attitude (A) has a direct and positive effect on potential consumer's Intention of Purchase of Remanufactured Product (IPRP)*", there is sufficient statistical evidence to state that (A) has a direct and positive effect on (IPRP). When the first latent variable increases by one standard deviation, the second one increases by 0.28 units. Therefore, the hypothesis is accepted. As the consumer's attitude improves, his intention to purchase remanufactured products improves.

According to H7 "*Risk Perception (RP) has a direct and positive effect on Intention of Purchase of Remanufactured Product (IPRP)*", there is not sufficient statistical evidence to affirm that (RP) has a direct and positive effect on (IPRP). When the first latent variable increases by one standard deviation, the second one decreases by -0.03 units, and the p-value is >0.05. Therefore, the hypothesis is rejected. The Mexican consumer is not very picky or hesitant about the possibility of risks associated with the purchase of remanufactured products. Therefore, it does not influence their purchase decision.

About H8 "*Personal Benefits Focused on Design Strategy (PBFDS) has a direct and positive effect on Intention of Purchase of Remanufactured Product (IPRP)*", there is sufficient statistical evidence to state that (PBFDS) has a direct and positive effect on (IPRP). When the first latent variable increases by one standard deviation, the second one increases by 0.35 units. Therefore, the hypothesis is accepted. The benefits associated with reduced

prices, extended warranties, and increased functionality-durability of the product impacts purchase intention.

For H9 "*Concern for the Environment (CE) has a direct and positive effect on potential consumer's Intention of Purchase of Remanufactured Product (IPRP)*", there is not sufficient statistical evidence to affirm that (CE) has a direct and positive effect on (IPRP). When the first latent variable increases by one standard deviation, the second one decreases by −0.03 units, and the *p*-value is >0.05. Therefore, the hypothesis is rejected. To the extent that consumers are concerned about the environment, their intention to purchase remanufactured products will increase. Contrary to expectations, concern for the environment is not the main motivation of Mexican consumers, although this variable is strongly used as a marketing strategy, this is reiterated by H10.

According to H10, "*Concern for the Environment (CE) has a direct and positive effect on the Market Strategy (MS) for the potential consumer*". There is sufficient statistical evidence to accept the H10, when the first latent variable increases by one standard deviation, the second one increases by 0.85 units.

For H11 "*Market Strategy (MS) has a direct and positive effect on potential consumer's Intention to Purchase Remanufactured Products (IPRP)*", there is sufficient statistical evidence to accept the H11. Although the main motivation for Mexican consumers to purchase remanufactured products is not environmental considerations, they are useful as a marketing strategy, providing a positive and reliable image of the product.

Regarding to H12 "*Perceived Behavioral Control (PBC) has a direct and positive effect on potential consumer's Intention to Purchase Remanufactured Products (IPRP)*", there is sufficient statistical evidence to accept the H12. It is important that the potential customer knows where to find the remanufactured products offered and the price range to strengthen their purchase intention.

According to H13 "*Subjective Standards (SS) have a direct and positive effect on potential consumer's Risk Perception (RP)*", there is sufficient statistical evidence to accept the H13. The purchase of remanufactured products can be cultural in the case of Mexican consumers, there is a lot of confidence in the recommendation of the products by relatives and close contacts.

For H14 "*Subjective Standards (SS) have a direct and positive effect on potential consumers' Intention to Purchase Remanufactured Products (IPRP)*", there is sufficient statistical evidence to accept the H14. Finally, the recommendations and culture regarding remanufactured products have an impact on the intention to purchase them.

This model is essential for creating the value strategy proposal referring to design and repair strategies based on PSS and remanufacturing for the conservation of value in white line products. Sufficient evidence is presented to affirm that the final model can be used to identify the variables that compose the customer's perception of remanufactured products. This affirmation is supported through the validation process, since the global R-Squared of the model turned out to be 0.77, which corresponds to the percentage of variation of the response variable that explains its relationship with one or more related variables.

Canvas Modeling, the value strategy. In [59], there are three scenarios (product-oriented, use-oriented, and result-oriented) where he defines eight archetypes for the three scenarios. There are two archetypes in the first product-oriented scenario: (1) Product-related and (2) Advice and consultancy. This scenario is considered as the traditional way in which a need is satisfied through the purchase of products for consumption, where the customer acquires consumption responsibilities with them, as shown in Figure 3 where it can be seen that most of the responsibilities for purchasing the washing machine during its life cycle fall on the end customer.

There are three archetypes in the second use-oriented scenario: (3) Product leasing, (4) Product rental/sharing, and (5) Product bundling. In this scenario, the customer does not own the washing machine. A supplier offers the service of using the washing machine in exchange for a fee, where the responsibilities for the consumption of the product are distributed between the customer and the supplier, as shown in Figures 3 and 4

(archetypes 3–5). Finally, archetypes are service-oriented, as shown in Figures 4 and 5 in archetypes 6 to 8. In archetypes 6 and 7, the customer takes his clothes to the laundry, and the supplier performs the cleaning service and then delivers his clean clothes to the customer. As shown in Figure 5, in archetype 8, the supplier handles all the responsibilities of using the washing machine. Even in both cases of archetypes 6, 7, and 8, the supplier is responsible for the washing quality of the garments in the case of the washing machine. At the same time, the customer is only responsible for paying a fee for cleaning his clothes.

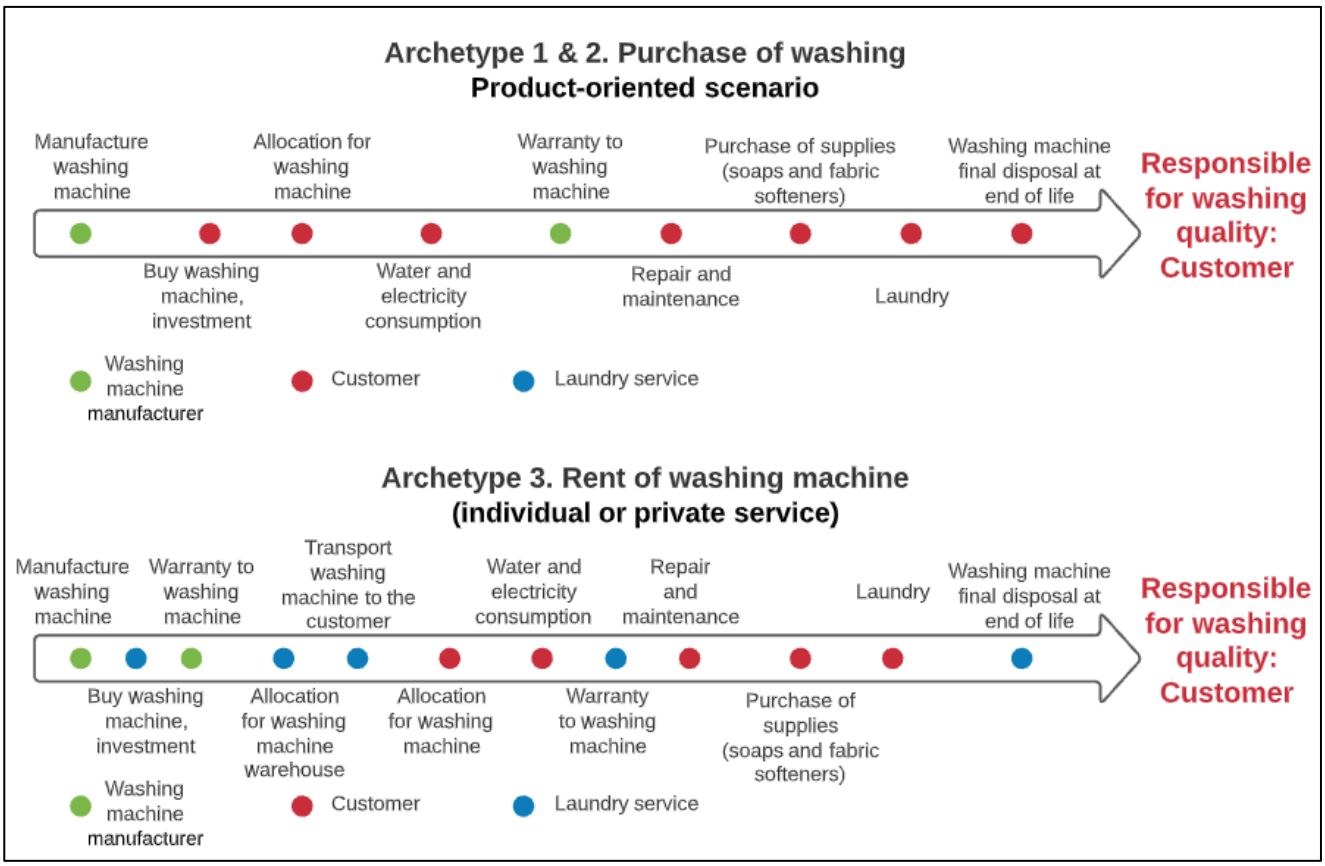

Figure 3. Applied archetypes 1–3 for washing machines PPS.

After identifying the different archetypes related to Product–Service Systems involving washing machines, archetype 3 was selected, as this model provides convenience for the user, since he/she will have availability of a highly functional washing machine without the need to invest travel time. In addition, the user will not have to dispose of the products once their life cycle is over. Archetype 3 is presented in Table 9 as a lean canvas business model.

The project arises from the current need for companies, consumers, and the government to be condescending to sustainable development in the region of Baja California. From this situation, the relationship that exists between consumers and the use of remanufactured products was identified, which is the basis for developing a business model that uses a PSS focused on the use of the product. During the study, it was possible to determine that consumer perception of remanufactured products is a critical factor in purchasing them. In parallel, it was found that including the intervening factors [49], for example, the most important according to the cited study, is related to the personal benefits that consumers can acquire through the customer's decision making concerning buying or using such products coming from remanufacturing operations, as well as the application of them through a service. This, in turn, makes it possible to generate a design and repair

strategy for a PSS for White goods. Of the fourteen hypothesis that were initially studied and proposed, three of them turned out to be the ones that were rejected.

The methodologies available in the literature have sufficient characteristics to be adapted to the case of leasing remanufactured washing machines in Mexico, since there are similar conditions to be performed. Through Structural Equation Modeling (SEM) analysis, it was possible to identify that the Concern for the Environment factor (CE) plays a fundamental role in the decision-making process of the Market Strategy; therefore, it is vital to keep the processes of acquisition and disposal of the leased washing machines transparent.

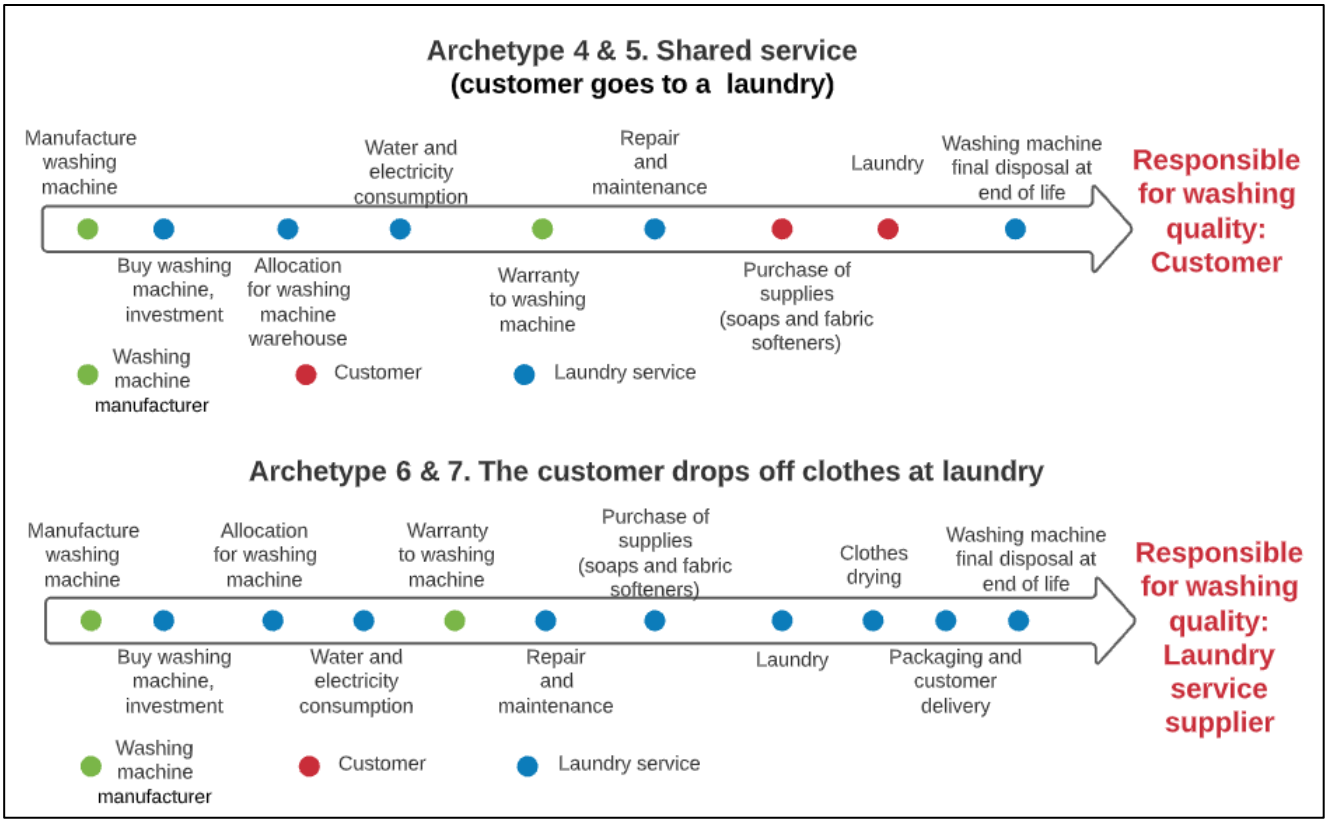

Figure 4. Archetype 6 and 7 for a laundry service supplier.

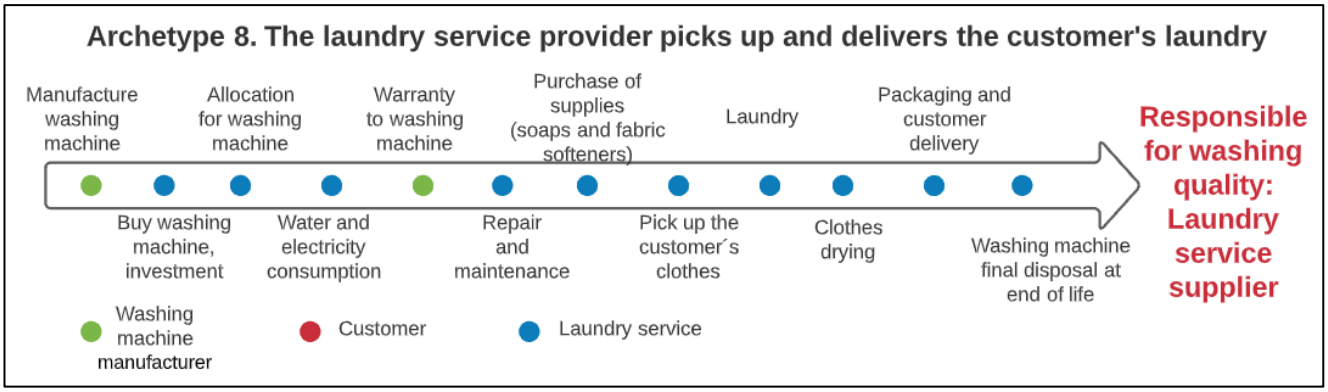

Figure 5. Archetype 8 for a laundry service supplier.

Table 9. Lean canvas business model.

<table>
<tr><th>Problem</th><th>Solution</th><th>Value Propositions</th><th>Customer Relationships</th><th>Customers Segments</th></tr>
<tr><td rowspan="4">There is pollution and waste of natural and economic resources due to excessive washing machines and programmed obsolescence.
Key Partners:
Mobile application provider
Washing machine suppliers
Maintenance technicians</td><td>Application of a business model based on remanufacturing where washing machine rentals are generated (individual or private service) the washing machine is delivered, installed, maintained, and leased to a private home.</td><td rowspan="4">Your washing machine is always in optimal conditions, having access to maintenance, repair, and replacement of washing machines. At the end of its life cycle, the final disposal is the company's responsibility for providing the service.
Affordable price
Efficient response time
Safety in products and services.</td><td>Personalized service. The convenience of service.
Social, economic, and environmental awareness.
Efficient service.
Guarantee of the conditions of the leased washing machines.</td><td rowspan="4">Men and women between the ages of 18 and 65 from the middle class and up.
Occupation:
Employees
Entrepreneurs
Retail
Self-employed
Marital status:
Single, separated-divorced.</td></tr>
<tr><td>Metrics</td><td>Channels</td></tr>
<tr><td>People who do not have their own washing machine and are looking for personalized attention in the installation and maintenance of the product.</td><td>Personal home care
Internet
Social Networking</td></tr>
<tr><td></td></tr>
<tr><td colspan="2">Cost structure</td><td colspan="3">Revenue streams</td></tr>
<tr><td colspan="2">Management fees, insurance, advertising, warehouse.</td><td colspan="3">Commission for leasing services, more advanced service plans</td></tr>
</table>

According to the interviews conducted, and using the variables and factors of the final model, it was obtained that the factor with the highest effect value corresponding to 0.346 is the Personal Benefits Focused on Design Strategy (PBFDS), particularly the variables associated with reduced prices, extended warranties, and increased functionality–durability of the product; this translates into the importance of working with a brand recognized for its quality regarding the impact it has on the environment, as well as the need to contribute to the recovery of the products used and the implementation of an eco-label on the leased washing machines.

The factors are closely following Attitude (A) and Remanufactured Products Knowledge (RPK) with effects of 0.28 and 0.18, respectively. The variable offers and will for (A), and warranty, modernity, features, comparison, differences, and spare parts for (RPK), were analyzed in these two factors. Therefore, the service characteristics should present washing machines with state-of-the-art models, guaranteed durability, accessible to repairs, and services. The factors with the lowest value are Risk Perception (RP), Subjective Norms (SS), and Concern for the Environment (CE), which are more related to quality, performance, self-perception, security, global warming, carbon footprint, resource extraction, and effects on the environment, where mainly supply plays a significant role in the acceptance of this business model.

National Opportunity. Once the business model is successfully implemented, the conditions may be replicable in different country regions, since the laws, brands, and culture tend to have similarities that can be developed.

Experience. The customer will be able to use the product in optimal conditions, being the installation, repair, and improvement, the most desirable features of the rental of washing machines. At the same time, the user will be aware of the improvements propitiated in the environment thanks to the extension of the life cycle of the products and, therefore, the saving of resources.

Characteristics of the service. The service can be requested through web page applications or directly by dialing via telephone with an effective appointment system that allows giving the user peace of mind when there is a problem related to the operation of the washing machine. The differentiating factor will be the reliability and quality of the services provided.

Value proposition. The added value consists of the efficiency and quality with which the products are installed, and the maintenance provided at an affordable cost.

Channels. Mainly through the internet (mobile applications) due to the accessibility currently available to users.

The proposed business model presents acceptable characteristics to be developed in the region, and ideally, it will be replicated in other regions and with other products with similar characteristics. It would be interesting to analyze the consumer behavior of remanufactured products in future work, considering that the system benefits from government funding to strengthen the policy of responsible consumption [60].

5. Conclusions

This project made it possible to propose a business design strategy for a washing machine leasing service, focused on using the product, where the product is delivered to a private home for installation, maintenance, and disposal. It was possible to identify the consumer's perception when deciding to purchase or not to purchase a remanufactured product through the identification and study of the variables and their correlations and the study of the factors that comprise such variables. The proposed methodology of the Product–Service System is convenient to focus on the scenario oriented as the "use", since this generates the advantage that the client has the freedom to use the washing machine at the moment he/she requires it with the facility of having an efficient service at the moment of maintenance and disposal of the product at the end of its useful life.

This research had a focus on the consumer's perception of remanufactured products, so it is convenient to develop the study from other approaches that encompass more deeply the complexity in the design of the service and the experience that the users obtain, as well as the time of permanence using this PSS. Through the development of this research, areas of opportunity for future research were found. There is the case of the design of a remanufactured product designed to fulfill the function of being used as a leased object and analyze the possibility of producing them through companies where there is an agreement in which the products can retain their functional properties for an extended time and, in turn, that the producing company can generate income by producing and selling their products, taking into account the reduction of the planned obsolescence factor. On the other hand, it is also essential the creation of laws that promote the creation and use of remanufactured products, as well as the dissemination of the favorable properties that are induced when they are used and that strengthen the three pillars of sustainability corresponding to the environmental factor (reduction of resources, emissions, and waste); the economic factor (an increase of business opportunities and efficiency in materials); and finally, the social factor (generation of jobs and the acquisition of quality products) [61]. It is concluded that remanufacturing incorporated into a PSS is feasible and convenient to achieve sustainable development. It is expected that updating the current legislation will be possible to normalize this type of practice in our society.

Author Contributions: Conceptualization, K.C.A.-S., A.J.-Z. and A.G.-L.; methodology, J.L.G.-A.; software, J.L.G.-A.; validation, J.B.-F. and G.H.-E.; formal analysis, M.A.M.-A.; investigation, A.J.-Z. and A.G.-L.; resources, A.J.-Z.; data curation, K.C.A.-S.; writing—original draft preparation, K.C.A.-S.; writing—review and editing, J.L.G.-A.; visualization, G.H.-E. and M.A.M.-A.; supervision, J.B.-F.; project administration, J.L.G.-A.; and funding acquisition, K.C.A.-S. and A.J.-Z. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by National Council of Science and Technology (CONACYT), grant number 985214.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest. The funder had no role in the design of the study; in the collection, analyses, or interpretation of the data; in the writing of the manuscript; or in the decision to publish the results.

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