

Article

# Consumer Perception of Remanufactured Automotive Parts and Policy Implications for Transitioning to a Circular Economy in Sweden

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**Abstract:** Promoting longer lifetimes and efficient re-use of products has a significant potential to save resources and reduce adverse environmental impacts, especially for products that have large resource footprints related to extraction and production processes, as for instance automobiles. Remanufacturing is a product life extension strategy promoting the effective and efficient re-use of products by replacing worn-out components with used or end-of-life parts restored to “like-new” condition and functionality. For developing remanufacturing processes, it is important to take into account the consumers’ perception of remanufactured products, together with factors such as technology and operations management. Previous research has concluded that the perception of a product or service constitutes a critical factor in consumers’ decision-making. However, there is a lack of studies exploring consumers’ perceptions of remanufactured parts, especially in Europe. This contribution analyses the results of an on-line survey (n = 203) of Swedish consumers, concerning their familiarity with remanufactured auto parts and their perceptions on associated benefits and risks. The survey revealed that Swedish car owners have limited knowledge about remanufactured parts. On the other hand, they do recognise the benefits of using such parts, without showing a significant risk aversion in their purchase decision. The survey also explored consumers’ opinion on potential measures to bridge the identified gap in knowledge, revealing that although they would trust a quality certification scheme for remanufactured auto parts—preferably set up by an industry association—that would not be the most critical factor in their purchase decision. Concluding, the article points out the potential of policy interventions to raise consumers’ perception of remanufactured parts to create a market pull for expanding their uptake, and thus increasing the overall resource efficiency in the automotive sector.

**Keywords:** remanufacturing; circular economy; consumer perceptions; resource efficiency; policy

## 1. Introduction

A constantly growing world economy, sustained by high consumption levels both in developed and emerging economies, raises concerns over the detrimental consumption of the earth’s natural resources, coupled with associated environmental impacts and impending resource shortages [1–3]. In response, several governmental and supra-governmental initiatives have taken form over the last decades with the aim to increase resource efficiency in the economy and reduce adverse environmental and socio-economic impacts [4,5]. The political consensus in the European Union (EU) is gradually shifting towards a vision of transforming the current resource extractive “linear” economic system to a system of higher resource efficiency and intensive material re-use—the so-called circular economy.

The introduction of new policies, intervening at all life-cycle stages of a product, are imperative for the transition to a circular economy in Europe [6,7]. EU and national waste policies have contributed to some extent in increasing the recycling of materials in the economy [8]. However, an important aspect, which has been less prominent in legislation, concerns the preservation of the functionality and economic value of products or components, rather than just mere material recovery [9].

Remanufacturing constitutes an industrial process by which used or end-of-life products can retain the same quality and functionality as new products and can be awarded a similar warranty period [10]. Remanufacturing is broadly defined by Östlin [11], building on research by Sundin [12], as “an industrial process whereby products, referred to as cores, are restored to useful life. During this process, the core passes through a number of operations, e.g., inspection, disassembly, part reprocessing, reassembly, and testing, to ensure it meets the desired product standards”. Historically, there has been extensive research on a wide array of operational aspects of remanufacturing, particularly in the field of technical, organisational, and supply chain aspects. More precisely, previous research has analysed topics such as operational issues that determine the cost-effectiveness of remanufacturing operations, including product design in relation to disassembly efforts [13], the optimization of material recovery planning [14], lead time scheduling and floor plan control [15], product and parts inventory management [16,17], and the design of reverse supply networks for the acquisition of cores [18–20]. Concerning the specific area of automotive parts remanufacturing, previous research has looked into production process improvements [21], stabilization of reverse flows for lean remanufacturing operations [22], effective material planning [23], optimal product pricing decision analysis [24,25], potential demand forecasting [26], quality assessment [27], and consumer perceptions of remanufactured parts in America and Asia [28–30].

The rich literature analysing various aspects of remanufacturing has identified a multitude of barriers to effective and efficient remanufacturing operations. The most widely identified barriers include: (1) the effective collection of cores by means of an efficient reverse logistics network and appropriate collection strategies [20]; (2) uncertainty in the quality and quantity, the timing of arrival of collected cores [31], and achieving a predictable and steady flow of cores [32]; (3) the development of an efficient remanufacturing process due to the high variability of collected products, which complicates disassembly and assembly processes [33], and the product design, which most often does not favour remanufacturing [34]; (4) the lead time of remanufacturing operations is not standardized and it becomes almost impossible to estimate accurately [31]; (5) quite often there is a lack of transparency and detailed information on the technical parameters of the original product from the Original Equipment Manufacturer (OEM) [35]; (6) user acceptance of remanufactured products [36]; (7) legislative barriers, particularly pertaining to intellectual property rights and waste [37–39]; (8) OEMs resistance to remanufacturing, since the motivation is not always clear, especially when remanufacturing may affect negatively the sales of new products [40]—a phenomenon also called “cannibalization of new product sales by remanufactured products” [41]; (9) lack of systematic knowledge on planning and performing remanufacturing as a viable business model configuration [42].

The benefits of remanufacturing include a lower price of products, saving of material and energy resources, and the creation of new jobs as remanufacturing is generally a labour-intensive process [36]. Additionally, remanufacturing contributes to waste prevention and a higher environmental consciousness among consumers [43]. A study by Kim et al. [44] illustrated the multiple benefits of remanufacturing, which in the case of a remanufactured alternator can reduce material and energy consumption by one fifth and one seventh, respectively, in comparison to a newly manufactured alternator. Sakao and Sundin [42] developed a theoretical analysis of the remanufacturing system and its constituent components, namely, the core acquisition process, the remanufacturing process, and the sales process, by using the methods of cause and effect analysis and means-ends analysis to derive to a concrete set of practical success factors for remanufacturing. Their findings indicate that success factors include (1) addressing product and component value, (2) having a customer-oriented operation,

(3) having an efficient core acquisition, (4) obtaining the correct information, and (5) having the right staff competence.

As illustrated above, a key aspect of improving the remanufacturing system as a whole lies in the investigation of the sales segment of remanufacturing and more specifically on the interface of customer-oriented operations and the configuration of an appropriate business model to respond to customer needs [42,45]. To achieve that, a more nuanced insight on the consumer perception of remanufactured components is considered beneficial [29]. Therefore, the objective of the present study is to investigate consumers' perceptions in Sweden regarding remanufactured automotive parts. Despite the wide outreach of remanufacturing operations in a global scale, research on consumers' perceptions of remanufactured products has been limited [46–50]. Researchers have recognised that consumers' perceptions of remanufactured products can have a significant effect on their behaviour and can influence their purchasing decisions. Perception is the way people can understand their surroundings. Peoples' attitudes and preferences towards an object are highly affected by the way they perceive things [29]. This contribution follows closely the extensive investigation of consumers' perceptions of remanufactured auto parts by Matsumoto et al. [29,30], and applies their established methodology in an effort to uncover relevant findings in a European context. Previous studies by Matsumoto et al. [28–30] have focused in US and Asian markets, but the European perspective is still missing from similar literature regarding remanufactured auto parts.

The choice to focus on remanufactured automotive parts is considered for a variety of reasons. The focus on the automotive industry in this research is due to its long history in remanufacturing, which accounts roughly for two-thirds of global remanufacturing operations [51]. Moreover, automobiles contain several high value and durable components, which can easily be redistributed and re-used among consumers due to the wide co-existence of first- and second-hand markets for auto parts. Many automotive components have high potential for remanufacturing [52], and therefore a great potential for resource efficiency and energy savings exists in the process of auto parts remanufacturing. Previous studies on remanufactured automotive parts have focused on the operational challenges and drivers of OEMs [42] and small- and medium-sized independent remanufacturers [35]. Very few studies have focused on consumer perceptions of remanufactured parts, mostly in the US and Asian markets [28–30], while a European perspective is still missing from literature regarding this topic.

Sweden is selected as a case study due to its clustered remanufacturing industry, mainly connected to major OEMs in the automotive sector. The largest car manufacturer in Sweden reports that their remanufacturing operations currently covers 15 percent of vehicle spare parts supply. Due to decreased raw material extraction and energy used for remanufacturing compared to new production, the remanufacturing of spare parts saved 542 tonnes of steel and 265 tonnes of aluminium in 2017; this corresponds to nearly 3,000 tonnes of carbon dioxide emission reduction [53]. Due to these reported benefits, OEMs in Sweden are keen to expand their operations and increase remanufacturing activities; however, an important aspect that needs to be taken into consideration is the consumers' perception.

This contribution aims to generate new knowledge that responds to industry concerns over consumers' acceptance and purchase intention of remanufactured auto parts and propose ways to increase confidence and potentially market share of remanufactured over new components. The remainder of this article is organised as follows. In Section 2, the theoretical underpinnings of this investigation are fleshed out, briefly determining the factors that affect consumers' purchase intentions and the influence of information provision and quality certification. Section 3 details the applied methodology and Section 4 presents the results and discusses the findings. Finally, Section 5 contains the conclusions of this study with a number of recommendations for future research.

## 2. Consumer Perceptions of Remanufactured Products

Although, remanufacturing has the potential to induce higher resource efficiency in the manufacturing sector [9], especially within the circular economy paradigm [7], there is still an apparent consumer aversion to buying remanufactured products [46,54]. There is a widespread

perception among consumers that remanufactured products might be of lower quality than their respective newly manufactured equivalents [54–56]. The lower price of second-hand products has been traditionally associated with making up for their perceived substandard quality and thus increasing the desirability of remanufactured goods in the market [57]. This, in turn, led to extensive research for the optimal pricing of such products [58]. However, significantly less research has been dedicated to the actual knowledge and characteristics of such products by consumers to ameliorate their purchasing decision, other than optimal pricing. Knowledgeable consumers would relatively easily distinguish the quality and level of performance of remanufactured goods, which can be equal to new products [59], while consumers who are unaware of remanufacturing are more likely to prefer to buy new products [23].

### *2.1. Product Knowledge*

Consumers' product knowledge influences their evaluation criteria for a given product [60], thus further influencing their purchasing behaviour [28]. In a previous study, Matsumoto et al. [28] found that 80% of US consumers have heard about the existence of remanufactured auto parts, whereas only 20% of Japanese consumers have been familiar with the term "remanufactured auto parts". Hazen et al. [61] found a link between consumers' "tolerance for ambiguity" (the level of tolerance related to a situation, in case of complete absence of information, e.g., the process of remanufacturing or product-related properties) and their willingness to pay for a product, which indicates that knowledge of the product or process leads to higher purchase intention of a remanufactured product. Additionally, the tolerance for ambiguity is related to the consumer's perception of quality, which is ultimately related to their willingness to pay [61].

### *2.2. Perceived Risks and Benefits of Remanufactured Products*

The willingness to pay for remanufactured goods changes according to the consumer's perceived risk of lower product quality, either functional or cosmetic [55]. Abbey et al. [55] indicate that the most common factors affecting perceived quality of remanufactured goods are related to the lifespan, performance, and standard features of a remanufactured product, as well as its serviceability. Second-hand goods, such as household appliances, computers, and televisions, are perceived as high-risk purchases by consumers, mainly due to inconsistent claims on product properties by the sellers [56]. Therefore, Guiot and Roux [56] highlight the need of warranties and technical documentation to accompany this type of sales in order to boost consumer confidence and lower their perceived risk. Wang et al. [50], in a case study of remanufactured auto parts, identified five common factors of risk perception among Chinese consumers: performance, financial, social, resource, and time risk. Consumers' concerns about the low quality of remanufactured products is one reason leading to lower acceptance and willingness to buy such products and ultimately constitutes a major barrier in increasing their market share [49,62,63]. Therefore, it becomes apparent that uncertainty constitutes an inhibiting factor in the purchase of remanufactured goods [64].

On the other hand, several perceived benefits of buying remanufactured products could turn consumers into adjusting their purchase preferences. Among the benefits of remanufacturing, there are significant material and energy savings, shorter production lead times, additional market capture opportunities, and a socially positive impact, not least by creating new job opportunities. [29]. Table 1 summarises the perceived risks and benefits that consumers are facing when having to decide whether to buy remanufactured spare parts or not.

**Table 1.** Consumers' perceived risks and benefits of remanufactured auto parts.

	Benefits	Risks
Consumer perception	<ul style="list-style-type: none"> <li>• Cost savings in the purchase of a “like-new” fully functional spare part. The cost of remanufacturing is typically 40% to 60% of the cost to manufacture new products [65].</li> <li>• Positive social impact by the creation of skilled jobs and the contribution to a healthy job market at all educational levels [66].</li> <li>• Potential resource savings impact, since remanufacturing conserves energy [43] and primary raw materials [49].</li> <li>• Positive environmental impacts, since remanufacturing prevents waste, and reduces the need for space and energy to treat end-of-life products, and its associated pollution problems [36].</li> </ul>	<ul style="list-style-type: none"> <li>• Financial risk, as the initial low purchase price might be offset by future financial investment to maintain or replace the part ahead of time [50,67].</li> <li>• Performance risk, due to potential product malfunction or substandard performance, failing to deliver the desired outcome [50,67].</li> <li>• Time risk when the purchasing decision results to a product that needs to be fixed or replaced if it does not perform according to expectations [50].</li> <li>• Probability that a purchased product results in actual physical threat to human life due to substandard quality [50].</li> <li>• Social risk may result in losing status among one's peers due to the purchase of a used—not brand new—product [50,67].</li> <li>• Ambiguity intolerance because consumers are not familiar with remanufacturing processes and cannot assess the extent to which a product's components have been treated [28].</li> </ul>

### 2.3. Purchase Intention

In this study, we investigate the underlying factors, such as knowledge, benefit, and risk perceptions of remanufactured auto parts, which have the potential to affect the purchasing behaviour of consumers in Sweden. Previous studies have concluded that purchase intention is directly linked to consumers' perceived risk, perceived benefit, and knowledge of remanufactured products [28,29,50]. Knowledgeable consumers, regarding the benefits of remanufactured products, are more likely to interpret the cost-benefit of purchasing remanufactured goods, rather than those that are less knowledgeable [68]. Therefore, we are testing the following three hypotheses:

**Hypothesis 1 (H1).** *Product knowledge positively influences the purchase intention of remanufactured auto parts.*

**Hypothesis 2 (H2).** *Perceived benefits positively influence the purchase intention of remanufactured auto parts.*

**Hypothesis 3 (H3).** *Perceived risks negatively influence the purchase intention of remanufactured auto parts.*

### 2.4. Quality Certification

Product eco-labelling, quality certifications, standards, and other relevant information instruments can potentially assist consumers in their decision-making process [69]. Despite the documented potential of labelling and certification schemes to inform consumers, multiple studies within sociology and environmental research have showed that just the provision of information is not enough to lead changes in consumers' attitudes, and even when incremental changes happen, these do not always relate to deeper or consistent behavioural changes [70]. However, in the case of remanufactured auto parts, a reliable quality certification constitutes a critical factor in decision-making since consumers are usually not able to verify the quality of remanufactured products by themselves, which contributes to a higher risk perception [49]. Credible certification schemes have the potential to provide direct

signals of product quality, and thus help consumers to reduce their risk perception of remanufactured products [49,50]. Therefore, in this study, we additionally explore the influence that information provision and quality certification of remanufactured auto parts exerts on the purchase intention of Swedish consumers. Furthermore, we identify which certification issuing agency consumers would be more likely to trust for making better informed purchasing decisions.

### 3. Method

This study investigates factors such as knowledge of remanufactured auto parts, as well as benefit and risk perceptions that may affect the purchasing intentions of consumers. The method used in this article follows closely the methodology outlined in previous studies by Matsumoto et al. [28–30], exploring similar aspects of consumers' perceptions in the markets of U.S.A., Japan, Malaysia, Thailand, and Vietnam. The method is constituted by an on-line survey and the statistical analysis of the results. For the current study, we chose to perform a survey about the knowledge, benefit, and risk perceptions of a remanufactured gearbox. The selection of this remanufactured auto part, in contrast to the previous studies where alternators and starters have been investigated, is due to the existing remanufacturing operations and market share of this part in the Swedish market—directly in connection with operations by the leading OEM in Sweden. Since the remanufacturing and marketing of this spare part is already taking place in the domestic market, it was selected as an appropriate case, since the probability of consumer knowledge might be significant in relation to other non-wide-spread auto parts. This poses a limitation in the study, since the sample entails non-probability aspects. However, the sample would be more representative for the purpose of this specific study.

#### 3.1. Survey

The survey consisted of three sections. The first section asked for general characteristics of the sample population, including three introductory questions on their relative knowledge of repairing and the option of remanufacturing alternatives. The second section consisted of 11 questions about knowledge, benefits, and risks of purchasing a remanufactured gearbox. The third section included questions about the influence of product information and quality certification of a remanufactured gearbox in consumers' purchase intention. The sample was between 18 and 74 years old. The selection criteria of the sample population included that each respondent must be the owner of at least one car and be its main driver. Full profile information of the respondents is provided in the Appendix A (Table A1).

#### 3.2. Dependent and Independent Variables

The dependent variable in this study is the 'Purchase Intention'. We use the same definition of purchase intention as it is defined by Wang et al. [50], which is "(the) individual assessment of future willingness to buy". Consumer perception about a remanufactured gearbox is measured in this study by responses to 11 questions on a seven-point Likert scale (1-'strongly disagree' to 7-'strongly agree'). The questions cover three constructs: product knowledge, perceived benefits, and perceived risk of a remanufactured gearbox. The detailed list of questions can be found in the supplementary material of this article.

#### 3.3. Statistical Analysis

The statistical analysis constituted an ordinary least squares estimation (OLS) of the variables. The regression model we used can be presented as:

$$PI_i = \alpha + C_i\beta + X_i\gamma + e_i \quad (1)$$

where  $PI_i$  is the purchase intention index of a respondent  $i$ ,  $C_i$  is the vector of perceptions concerning the remanufactured gearbox surveyed in this study,  $X_i$  is the vector of the respondent  $i$  personal

characteristics adopted as control variables, and  $ei$  is the error term.  $Ci$  consists of three composite indices: the index of product knowledge (PK), perceived benefit (PB), and perceived risk (PR). The composite indices are derived from the quantitative responses to the questions found in the Supplementary Materials, for each theme respectively.

For the statistical analysis of the survey results, the statistical package for the social sciences (SPSS) software was used, specifically the IBM SPSS Statistics software version 25.

#### 4. Results and Discussion

In this section, the results of the survey will be presented and discussed. The presentation of the results follows the three parts of the survey, starting with the general characteristics and the relative knowledge of the sample population about repairing their car and the option of remanufacture auto parts, continuing with the purchase intention and the analysis of the composite index of perceptions, and finishing with the analysis of the influence of product information and quality certification on consumers' purchase intention.

##### 4.1. Acquaintance and Purchase Experience of the Survey Sample

The general characteristics of the sample population are summarised in Table A1. The sample is well balanced between male and female respondents (50/50), coming roughly equally from all the regions of the country. There is a slightly higher representation of people aged over 40 years old in the sample, while the general self-assessment of repair skills was low with 71.4% of the sample indicating that they do not have any car repair skills at all.

Regarding the respondents' acquaintance and purchase experience of remanufactured auto parts, the results are presented in Table 2. Nearly 6 out of 10 respondents (58.6%) have never heard of the existence of remanufactured auto parts, and an even higher percentage of the sample (76.4%) has never actually bought remanufactured parts for their own use. Moreover, the personal engagement of the respondents with replacing faulty car parts with the equivalent remanufactured parts is remarkably low (14.8%) and can be compared with the experience of Japanese drivers, who rather seldom would engage in such operations [28] as it is common in Japan for car parts to be replaced in periodic mandatory inspections, usually before a problem occurs. Similar conditions apply also in Sweden, with Swedish consumers relying on car services provided by OEMs that take care of decisions such as replacing parts.

**Table 2.** Respondents' acquaintance and purchase experiences of remanufactured auto parts.

Question	Yes N (%)	No N (%)
Have you ever heard of remanufactured auto parts?	84 (41.4)	119 (58.6)
Have you ever bought remanufactured auto parts?	48 (23.6)	155 (76.4)
Have you ever repaired or replaced the gearbox of your car, including that of your current car and/or your previous cars?	30 (14.8)	173 (85.2)

##### 4.2. Purchase Intention and Composite Index of Perceptions of Remanufactured Auto Parts

The composite index of purchase intention comprises of the three constituent elements ("constructs") of product knowledge and perceived benefits and risks of remanufactured auto parts. The statistical method of combining the constructs into the aggregate purchase intention index can identify linear combinations of multiple elements and can decompose them to principal components not correlated with each other. In Table 3, the loadings of the principal components of each construct are presented. In the case that the Cronbach's  $\alpha$  for each set of elements is higher than 0.75, the elements in each construct have internal consistency. The composite index of each construct is estimated from the loadings in Table 3. For instance, the composite index of product knowledge (PK) is derived as:

$$PK = 0.862 \times Q1 + 0.861 \times Q2 + 0.889 \times Q3 + 0.914 \times Q4 \quad (2)$$

The values of Q1–Q4 are standardized. The other indices of perceived benefit (PB) and perceived risk (PR) follow the same procedure, except in the case of PB in which the index comprises of three questions (Q1–Q3).

**Table 3.** Composite index by principal component analysis.

Construct	Element	Principal Component	Statistic
Product Knowledge	PK1	0.862	
	PK2	0.861	
	PK3	0.889	
	PK4	0.914	
	Eigenvalue		3.111
	Contribution ratio		0.78
	Cronbach $\alpha$		0.904
Perceived Benefits	PB1	0.781	
	PB2	0.886	
	PB3	0.889	
	Eigenvalue		2.185
	Contribution ratio		0.73
	Cronbach $\alpha$		0.812
	Perceived Risks	PR1	0.631
PR2		0.872	
PR3		0.721	
PR4		0.826	
Eigenvalue			2.361
Contribution ratio			0.59
Cronbach $\alpha$			0.763

Table 4 outlines the regression analysis of the purchase intention (PI) index, following the statistical analysis method presented in Section 3.3. The F statistic with 7 and 195 degrees of freedom is 11.303 which means that we reject the null hypothesis, in which all coefficients are equal to zero. The effects on PI related to gender, age, income and the self-assessed repair skill of respondents are statistically insignificant.

Analysing the three constituent elements of the PI index, it becomes apparent that product knowledge (PK) and perceived benefit (PB) affect PI at a statistical level of significance. Consumers which exhibit higher product knowledge, also show a higher purchase intention of remanufactured auto parts, thus H1 is supported. Similarly, consumers that perceived benefits of remanufactured parts would exhibit positive purchase intention, resulting in the support of H2 as well. However, the perceived risk (PR) element, although marginally negative, does not appear to be statistically significant, and therefore, it does not influence the PI of Swedish consumers, resulting in the rejection of H3. Such insignificant results of the perceived risk index have not been observed widely in literature, since the majority of existing studies suggest that a high perceived risk of remanufactured products is a major reason for consumers' low acceptance of such products [28,50,57,61,71,72].

Only recently, a study by Matsumoto et al. [30] in the context of developing and transition (D&T) countries in South East Asia revealed similar results concerning the relevance of perceived risk to the purchase intention of remanufactured auto parts. In that case, the deviance from previous literature evidence was attributed to the fact that the risk of product inferiority actually exists in those markets and does not constitute a consumer perception. This means that consumers in these countries may anticipate the quality of remanufactured auto parts to be lower than their new equivalents and therefore internalise the risk in their purchasing decision. In other words, they take for granted that the remanufactured part will not be equal to "like new" quality, a fact which then does not influence negatively their purchase intention—irrespective of whether the actual quality of the remanufactured part would be "like new" or not.

**Table 4.** Regression analysis of dependent variable Purchase Intention (PI) index.

Predictor	B Coefficient	S.E	Beta Coefficient	Significance
Gender (Female = 1)	0.184	0.117	0.108	
Age	0.007	0.004	0.113	
Income	0.046	0.004	0.099	
Self-rated repair skill (Yes = 1)	−0.116	0.161	−0.061	
Product knowledge	0.117	0.022	0.424	***
Perceived benefits	0.116	0.025	0.295	***
Perceived risk	−0.001	0.023	−0.003	
Constant	2.445	0.266		***
Number of observations	203			
F (7, 195)	11.303			
Adjusted R2	0.263			

\*\*\*  $p < 0.001$ .

In the case of Sweden, it is not possible to verify similar consumer behaviour as in the D&T countries. However, a possible explanation would have to do rather with the high level of trust in Swedish society and the expectation of an honest and trustworthy transaction between parties. Research consistently shows a high level of trust in Sweden between individuals and to a lesser degree in institutions and big companies [73], and therefore, it could be argued that this level of trust would expand to transactions between individuals. In the case of car repairs, either at local garages or OEM filial shops, the level of interpersonal transaction is closer to the individual (person-to-person), compared to the dynamics of an international OEM and a single customer. Thus, it is assumed that the customer would trust the repair shop on their claims of product quality and guarantees, even without an official certification to prove it. This means, that the level of perceived risk minimises and the influence in the purchase intention becomes less critical, as shown by the statistical analysis of the results. Although this is just one possible explanation of the insignificant effect or risk perception of remanufactured auto parts in Swedish consumers' purchase intention, it would be necessary to further research the causes behind this phenomenon.

Concluding, the mean (M) and standard deviation (SD) of the purchase intention of Swedish consumers, as indicated by the PI index, are  $M = 3.07$  and  $SD = 0.86$ . These values can be partially compared with previous studies by Matsumoto et al. [28,29] concerning the purchase intention of US and Japanese consumers. In comparison to these studies, the Swedish consumers exhibit purchasing behaviour similar to Japanese consumers, having lower PI index than the US consumers ( $M = 4.15$  and  $SD = 1.59$ ) and a comparable PI index with the Japanese consumers ( $M = 3.19$  and  $SD = 1.56$ ). However, the results between the past and the present studies cannot be compared in absolute terms, since the PI index in this study lacks the additional element of price consciousness (PC). Therefore, the PI index results in lower values, since it is constituted by three instead of four elements. By roughly taking into account the potential effect of price consciousness in the PI index, we expect the purchase intention of Swedish consumers to be similar or relatively higher than that of the Japanese but still lower than the purchase intention of remanufactured auto parts of the US consumers.

#### 4.3. Quality Certification and Product Information Influence

The final part of the survey measured the influence of product quality certification on the purchase intention of remanufactured auto parts of Swedish consumers. Additionally, the survey measured the willingness of consumers to accept remanufactured auto parts in the case this would become a mandatory requirement by direct policy intervention. The results are presented in Table 5.

The results indicate that Swedish consumers are more willing to purchase quality certified remanufactured auto parts than uncertified ones. Despite the results of perceived risk (PR) of remanufactured auto parts, which showed no significance in influencing the purchase intention of Swedish consumers, in the follow-up questions about quality certification, a high percentage of the

sample (72.9%) responded that a quality certification for remanufactured parts would positively affect their purchase intention. In this, we identify a credibility booster rather than a credibility determinant, since the level of perceived quality risk was already low. Additionally, despite the high percentage of positive responds in the need for quality certification, the share of Swedish consumers willing to buy remanufactured auto parts appeared to be lower, 64.5% in contrast to 72.9% of positively inclined consumers to quality certification. By combining the results, we observe that low perceived risk of remanufactured auto parts and the provision of information on quality have moderate influence in the overall acceptance and purchase intention of Swedish consumers. Moreover, the Swedish consumer becomes even more averse to remanufactured auto parts in the case of a mandatory policy intervention for repairing older cars exclusively with remanufactured parts. The results in Table 5 show a slightly negative response and the shares of the sample population being roughly equally divided between neutral and positive reactions. A consumer choice mandate is seen negatively by the Swedish consumers in the case of automotive parts.

**Table 5.** Response to policy interventions and perception of influence to purchase decision.

Statement	Positive N (%)	Neutral N (%)	Negative N (%)
A quality certification for remanufactured auto parts would affect my purchase decision.	148 (72.9)	36 (17.7)	19 (9.4)
I am willing to buy remanufactured auto parts if they are quality certified.	131 (64.5)	48 (23.7)	24 (11.8)
Repairs of vehicles over 5 years old are done exclusively with remanufactured parts.	64 (31.5)	62 (30.6)	77 (37.9)

Finally, consumers exhibit a higher level of trust in a remanufacturing industry association to develop a quality certification for remanufactured auto parts (Table 6). Further, it seems that they would trust more an OEM (car manufacturer) than a governmental or public organisation. These answers reveal the high trust of consumers to the domestic automotive industry to set standards of quality for remanufacturing. Thus, the industry, having a widely accepted and generally positive reputation, it has the potential to lower perceived risks and act as a guarantor of product quality [68]. Similarly, validation of a retailer or service provider by OEMs and a general positive reputation may increase the confidence of consumers and enhance their willingness to pay for remanufactured products [74]. This may lead OEMs and industry remanufacturing associations to develop appropriate certification schemes and provide certified remanufactured auto parts, contributing to raising consumers' acceptance.

**Table 6.** Most trusted organisation as certifier of remanufactures auto parts.

Type of Organisation	N (%)
Government or Public organisation	39 (19.5)
Remanufacturing association	63 (31.0)
Car manufacturer	47 (23.0)
Remanufacturer	23 (11.2)
(Inter-)national standards organisation	31 (15.3)

## 5. Conclusions and Recommendations

The consumption of material resources is constantly increasing, despite efforts to increase resource efficiency in industry, especially in emerging economies. In Europe, the EU has adopted several strategic plans towards the direction of reducing resources consumption, aiming at higher resource security and economic sustainability of its manufacturing industries. Diffusion of remanufacturing is important for mitigating the increased resource consumption and for easing the pressures on the natural environment. However, to scale up remanufacturing operations, it is critical for consumers to accept and demand remanufactured products.

This article presented the results of a survey of Swedish consumers, analysing their knowledge of remanufactured auto parts and their perception on associated benefits and risks, which are factors contributing to their overall purchase intention. The results revealed that Swedish consumers have limited knowledge about remanufactured auto parts. Nevertheless, they do recognise the benefits of using remanufactured auto parts without showing a significant risk aversion in their purchase decision, being less preoccupied by the risks entailed in buying a remanufactured product. This last result comes into conflict with much of the existing literature that identifies consumers' perceived risks about remanufactured products to be the defining reason for the lack of diffusion of remanufacturing [28,50,57,61,71,72]. Therefore, further studies on this topic are needed to identify the underlying reasons for this behaviour of the Swedish consumer. In the current study, the sample of the survey consisted of 203 individuals, which might be a limitation in the representativeness of the results. A larger sample, therefore, might be needed to extract statistically safer conclusions.

Based on the previous literature which identified lack of information and perceived risks as major barriers for the upscale of remanufacturing operations, the survey was designed to include also consumers' opinion on potential measures to bridge the identified gap in knowledge, by providing information and quality certification of remanufactured auto parts. The results showed that although the Swedish consumers trust a quality certification scheme for remanufactured auto parts—preferably set up by an industry association—that would not be the most critical factor in their purchase decision. High trust in the information of the certification label did not translate into equally high purchase intention of certified remanufactured auto parts in the survey results.

Therefore, it becomes obvious that the introduction of quality certification for remanufactured auto parts has the potential to increase the uptake of remanufactured products, but it is not sufficient. Making quality related information visible to consumers does not always translate directly to altered consumer behaviour [70,75,76]. Therefore, to capitalise on the information contained in a certification instrument, it is recommended that a combination of policy interventions can be introduced, as for instance the linking of the quality certification to public procurement requirements for a specific product group [77]. Public or private (business) procurement has the potential to influence the demand of remanufactured auto parts and send a clear signal in the market, by setting specific requirements on market actors. A comprehensive policy mix that could influence the upscale of remanufacturing operations would include: (a) a constant quota of available remanufactured auto parts vs. new parts in the stock of spare parts of OEMs (as for instance 15% in the case of Volvo Cars [53]) with a gradual increase, thus incentivising not only remanufacturing operations but also the effective collection of cores; (b) a quality certification scheme of remanufactured auto parts, ideally by a remanufacturing industry association; (c) clear criteria in procurement administrative processes that prioritise the use of remanufactured auto parts, which coupled with the lower pricing of remanufactured products would become the obvious choice for any procuring authority; and (d) an optional eco-label documenting the environmental benefits of each remanufactured auto part.

Although this article measures the factors influencing the purchase intention of individuals, it is inexorably connected with action at administrative or business level as well. Municipalities or business entities can be expected not to have negative preconceptions towards quality or reliability of remanufactured products as private individuals may have. However, a recent study by Wasserbaur and Milios [78] in Swedish municipalities revealed that it is not uncommon that selection bias and user preferences of the procurement officers occur during the drafting of tender specifications, as procurers are more likely to prioritise/prescribe the utility or the product they are familiar with. This is also reflected in research by Sporrang and Bröchner [79] suggesting that procurement officers hold individual preferences, which are mirrored in their procedures for procurement. Therefore, the study of individuals' perceptions of remanufactured products is of the highest importance, and further studies would be beneficial for understanding consumers' attitudes and influencing consumer's acceptance towards remanufactured products.

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## Appendix A

**Table A1.** Descriptive statistics for socio-demographic variables.

Variable	N (%)
Gender	Male: 101 (49.8) Female: 102 (50.2)
Age M = 50.20, SD = 14.60	
Age 20–29	22 (10.8)
Age 30–39	30 (14.8)
Age 40–49	41 (20.2)
Age 50–59	48 (23.6)
Age 60–69	43 (21.2)
Age 70–74	19 (9.4)
Income	
Under 100,000 SEK	7 (3.4)
100,000 SEK–249,999 SEK	17 (8.4)
250,000 SEK–349,999 SEK	30 (14.8)
350,000 SEK–449,999 SEK	22 (10.8)
450,000 SEK–599,999 SEK	36 (17.7)
600,000 SEK–749,999 SEK	45 (22.2)
750,000 SEK–999,999 SEK	37 (18.2)
Over 1,000,000 SEK	9 (4.4)
Self-rated repair skill	Yes: 58 (28.6) No: 145 (71.4)
Place of residence	
Capital region (Stockholm)	29 (14.4)
East Sweden	30 (14.8)
South Sweden	52 (25.6)
West Sweden	48 (23.6)
North Sweden	44 (21.6)

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