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Becoming More Profitable with Remanufacturing – Resolutions

As part of the ElevatoRe project, three theses have been performed for Husqvarna by students of Linköping University during this spring. These projects have investigated topics on the possibilities of remanufacturing robotic lawn mowers; the customer's purchase intention of remanufactured robotic lawn mowers, how to design the products for remanufacture, and the economic feasibility of a remanufacturing process.

Shifting towards a circular economy with remanufacturing is recognized as a beneficial way to act upon environmental issues and at the same time do profitable business. Remanufacturing is a process where a core (used product) is collected from the end user, and through industrial processes the quality is restored to "as good as new" functionality or up to a condition that satisfies the next customer.

Results of the first study concluded through structural equation modelling that the consumer's purchase intention is mainly influenced by the expected quality, price advantages and perceived risk. Within these three factors, product performance, durability, serviceability and price advantages are the four underlying factors that consumers value the most. Consumers were not knowledgeable about the product quality but knew more about environmental outcomes of a remanufactured robotic lawn mower. Consumers were equally willing to buy from or serve at retailers and original remanufacturers in conventional stores or on the internet with approval from original remanufacturers.

Results of the second study lead to general guidelines and possible design changes to facilitate a remanufacturing process for the Husqvarna Automower 310. This included the elimination of certain parts and simplification of assembly through design changes that were suggested. Suggestions were obtained by conducting an analysis of the product and the challenges that might occur during a remanufacturing process. A suggested process for remanufacturing of the product was finally defined and parts subjected to wear could be identified.

Results of the third study concluded through economic analysis that remanufacturing of robotic lawn mowers in the Swedish region could be profitable mainly with two different approaches. The first being a centralized remanufacturing process performed by Husqvarna in a facility nearby their spare parts warehouse in Torsvik, Sweden. Advantages of this approach are easy access to spare parts and the existing logistics network. The second option is a remanufacturing process performed in a decentralized setting at and by Husqvarna's dealers. Advantages of a decentralized approach would be the ease of acquiring cores from the end-customers and the ability to swiftly introduce the process.

The abstracts for all three theses are included in the following pages.

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Abstract 1

Consumer purchase intention of remanufactured EEE products: A study on robotic lawn mowers in Sweden

By Daan Kabel & Simon Ahlstedt

The study was conducted at Husqvarna and investigated the purchase intention of remanufactured robotic lawn mowers which later was generalized for remanufactured EEE products. The purpose was to study customer's purchase intention of remanufactured EEE products, and thereby identify factors and to what degree they influenced consumer's purchase intention. This study answered the following research questions:

- Which factors influence consumer's purchase intention of remanufactured EEE products in Sweden?
- How important are influencing factors to consumer's purchase intention for remanufactured EEE products in Sweden?

Theory of planned behavior and customer perceived value literatures helped to form the conceptual model, which was tested empirically using 118 survey responses. The sample mainly consisted of males between the age 36 and 45 and had a monthly household income over 60k SEK. Structural equation modelling was used to test the hypotheses.

The purchase intention was measured as a function of attitude, subjective norm and perceived behavioral control, among which attitude has the strongest effect on the purchase intention of remanufactured robotic lawn mowers. A consumer's attitude was significantly predicted by the expected product quality, price advantages, and perceived risk, among which product quality has the strongest effect on a consumer's attitude. Consumers expected information regarding the quality assurance and previous usage. Consumers were knowledgeable about the environmental benefits, but those benefits did not significantly contribute to more purchases. Consumers were equal willing to buy remanufactured robotic lawn mowers from retailers and original remanufacturers in conventional stores or on the internet with approval from original remanufacturers. The same applied for services.

Product performance, durability, serviceability and price advantages are the four dimensions that make up the consumer lens of remanufactured robotic lawn mowers products. Consumers are willing to buy remanufactured robotic lawn mowers if the price is low, the performance is as a new product, the life span is as promised, and it can easily be maintained and served to prolong the product's life.

Keywords: *Theory of planned behavior, structural equation model, expected product quality, price advantages and perceived risk*

Abstract 2

Analysis of the design of a robotic lawnmower from a remanufacturing perspective

By Oliver Bergstrand & Tobias Broman

This thesis has consisted of a design analysis of Husqvarna's Automower 310 with the goals of determining parts submitted to wear and therefore in need of replacement in a remanufacturing process, developing steps and proposing design changes that, in the future, might facilitate remanufacture.

Remanufacturing, briefly summarized, involves restoration of a used product to an as new condition where a guarantee can be given on sale. This process includes steps such as inspection, cleaning, disassembly, assembly and testing.

Theory studies in remanufacturing and product design have been carried out, as well as both practical and theoretical analyses of the design, remanufacturing, disassembly and assembly.

These studies and analyses led to the conclusion that there are several design changes that can be implemented to facilitate remanufacture. Components that were assessed as parts submitted to wear could be documented and steps for remanufacturing were proposed. Guidelines for a design suitable for remanufacturing were presented. Based on the results obtained from the analyses, a discussion on design changes could be carried out which, after discussions with Husqvarna, could lead to specific conclusions. These included proposals for structural changes such as integrated components and a change of fasteners to facilitate assembly but also steps to be able to carry out a remanufacturing process of Husqvarna's Automower 310. In accordance with the conclusions, recommendations of future studies for the work were given.

Abstract 3

Economic Potential for Remanufacturing of Robotic Lawn Mowers with an Existent Forward Supply Chain – A case study on Husqvarna

By Gustav Johansson & Johan Vogt Duberg

This project investigates how remanufacturing of robotic lawn mowers can be incorporated into an existent system with a forward supply chain. The project is conducted as a one case study on Husqvarna where an interview study and a literature study provide the data and theory respectively. Alternatives are proposed for potential remanufacturing cases at various locations, where different parties ranging from original equipment manufacturers to independent manufacturers perform the remanufacturing process. SWOT analyses are conducted to identify the most promising alternatives for an economic analysis. The economic evaluation is based on net present values and a sensitivity analysis which determine the feasibility of the alternatives.

The results of the project answers three research questions. The first concludes that out of seven defined production systems there are only two that are not suitable for remanufacturing in a general case mainly due to the low flexibility of these systems. The results of the second identifies labor, logistics, and operational prerequisite factors that must be considered when implementing remanufacturing for case specific alternatives. The conclusion of the third research question lists the feasibility of the alternatives from which the recommendations for Husqvarna are presented.

This project recommends Husqvarna to implement a remanufacturing process for their robotic lawn mowers either by enlisting their current dealers or by themselves at a location nearby the spare parts warehouse in Torsvik. What alternative that is the most profitable depends mainly on the expected quantity of the acquired cores, where Husqvarna as a centralized remanufacturer benefits more from higher quantities while the decentralized dealer alternative would comparably be more profitable if the quantities were lower. As it is perceived that initial collected quantities will be low, and possibly even somewhat higher for the dealers, a decentralized remanufacturing process could be the most profitable alternative. Using a third-party remanufacturer is also feasible but considered risky and therefore not recommended as they could have the same core acquisition problem as Husqvarna while having lower profitability.

Keywords: *remanufacturing; economic evaluation; production system; facility location; closed-loop supply chain*