Life cycle considerations in remanufacturing strategies – a framework for decision support

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Abstract. Remanufacturing is the most valuable product recovery option since here the value added to the product can be obtained. The goal of this contribution is to develop an instrument which supports decision makers in their considerations about implementing a remanufacturing strategy. The framework is built on a two-stage proceeding, where in the first step an approach for modeling this strategic decision process is presented. In the second step, the contribution aims to show how to evaluate alternative decisions economically by developing a life cycle model for remanufacturing and calculating the life cycle costs.

1 Introduction

Typically, legal reasons are the main driver for the take-back of products at the end of the use phase [11]. Regulations, e.g. on waste electrical and electronic equipment [4], define producers' responsibility for their products throughout the entire product life including the after-use phase. In addition to this, [7] identify business motives for product take-back like market forces and recapturing hidden economic value. Actually, these drivers contribute to the increasing significance of recovery strategies.

Two main types of recovery options can be identified in dependence of the object they refer to: product recovery and material recovery [13]. Remanufacturing is a high-grade product recovery option where the product is disassembled to part level, all modules and parts are inspected and repaired or replaced if necessary and the product is upgraded to an as new quality level. Another product recovery option is cannibalization, where a limited set of reusable parts are recovered and used as spare parts or for the production of new products.

Current literature on remanufacturing mainly covers specific operational [e.g. 10, 6] and process oriented [e.g. 8, 9] topics. Thus, the focus of this contribution is placed on the strategic decisions related to remanufacturing and aims at the development of a concept for decision support for choosing a recovery option.

2 Model of the decision situation

In order to realize legal demands and to pursue recovery options in an economically efficient way a number of strategic decisions have to be made by the producer in an insecure environment.

In order to be able to balance decision alternatives, external influencing factors which will develop in an unknown way have to be taken into consideration. Depending on the particular specification of these factors one decision alternative might be more promising under a business perspective than another. Relevant external factors that influence the internal decisions about the choice of the recovery option are:

- Market development
- Development of competitors
- Development of technology
- Development of legal regulations
- Return flow of discarded products
- State of returned products

For the given decision situation we assume that subjective probabilities for the development of these factors can be achieved by questioning experts about their expectation and to derive the needed data from their statements.

The characteristics of the decision process considered in our field of research can be subsumed as follows: The producer faces a multi-stage dynamic decision process under risk. An approach to model this type of decision situation is the decision tree, which shows the logical structure of the decision problem and contains all relevant elements of the decision situation as outlined in Fig. 1 [3].

t : Period, $t = 1,...,T$

j : Decision alternatives

i : States of nature

x_{tj} : Binary decision variable $x_{tj} = \begin{cases} 1, \textit{if alternative } j \textit{ is chosen} \\ 0, \textit{else} \end{cases}$

s_{ti} : State of nature in t which leads to decision node / result D_{ti}/R_{ti} $(i=1,...,I)$

D_{ti} : Decision node i in period t; $D_{ti} = \{d_{tj} \textit{ which are possible}\}$

S_{tj} : Chance node j in period t; $S_{tj} = \{s_{ti} \textit{ which are possible}\}$

p_{ti} : Probability that state of nature s_{ti} will occur

R_{ti} : Result node if the state of nature s_{ti} occurs in period t: $R_{ti} = R(s_{ti})$

Rtj : Result node of a decision alternative j in period t; $Rtj = Rti$ $\textit{if } i \in \{1,...,I\} \wedge s_{ti} \in S_{tj}$

$EV\{R_{tj}\}$: Expected value of result R_{tj}

μ^*t : Maximum expected value of all decision alternatives j in period t