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Global Supply Chain Management

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Abstract: The basis for an ecological economy structure is primarily the process of recycling. Especially in only partially closed recycling cycles the challenge to decide between the options recycling, new production, and waste disposal arises. A special challenge of this complex problem exists in the consideration of more periodical dependencies and the creation of amounts based on quick costs. Based on a circulation model often used in literature, this paper as result of a three year research study closes the methodical gap between the up to now examined dynamical approaches without fixed costs and the static approaches with fixed costs. This can be achieved by developing different heuristics having a high efficiency of their low calculation effort and their ability to adjust fast. For that the differences between models with and without disposal options will be shown and the individual approaches indicated. The developed methods were examined in a software that allows a good comparison of the solutions. A critical discussion about the functionality of the different approaches explains the different quality of the heuristics.

Heuristics On Reverse Logistics

Abstract

Apart from waste avoidance, product recycling mainly constitutes the basic building block for an ecological business culture. Particularly in only partly closed recycling cycles, the problem arises of having to simultaneously decide between the options of recycling, new production and old parts disposal.

A particular difficulty of this complex task is taking dependencies of multiple periods and the formation of lot sizes on the basis of fixed costs into account.

Building upon a cycle model frequently employed in the literature, this essay closes the methodological gap between previously researched dynamic approaches without fixed costs and static approaches with fixed costs. This succeeds by developing various heuristics, which, in view of the low effort for accounting and their quick adaptability, additionally have great practical suitability. Building upon classical single product lot size heuristics, systematic adaptations of the basic principles applied there are derived. To do this, the models with and without an option for disposal are additionally differentiated and various theoretical approaches are each presented. The methods developed are brought together in one software, which permits a good comparability of the results. A critical discussion about the function of the approaches explains the different achievable quality of the heuristics.

Problems

In a standard model of the closed loop materials economy, a single product is produced in order to satisfy demand. These products return again after use by consumers. Owing to unforeseeable customer behavior, there is no direct dependence between demand and return. The latter can be temporarily stored before a decision is made whether the actual recycling process should take place or the parts which have returned should be disposed of.

In most cases the return of used parts and their recycling is not sufficient to satisfy current demand. For this state of affairs, new production of products is available as a further option. Both manufactured and recycled parts flow into a service warehouse in which they can no longer be differentiated in terms of quality.

For the problem described here, several theoretical approaches already exist which can be differentiated in models using

Continuous or periodic inventory control, [1]

Stochastic or deterministic information relating to demand, return and lead time, [3] [6]

Finite or infinite rate of production and recycling, [4]

Returns of used parts, internal or external to the model [2].

In the following, attention will be turned to a deterministic system in which periodic demand and returns are estimated for a definite time period and thus are assumed to be known. For reasons of simplicity, an infinite rate of production and recycling as well as decoupling of return and demand (thus returns external to the model) will be assumed. In the now completely defined model, the three decisions

Production

Recycling

Disposal

must thus be made simultaneously in every period in order to achieve the primary objective of satisfying demand. Each of these decisions however has different consequences in view of the freedom of decision-making of future periods and the costs incurred. Following the dynamic single product lot size problem, these costs will be differentiated in

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Storage costs per period and part in the recycling and service warehouse,
Variable costs which accrue per part for production, recycling and disposal,
Fixed costs which accure in every period in which there is production or recycling.
This study thus attempts to take up preceding studies [2] and to expand these by the aspect of fixed costs. This expansion makes the problem to be solved previously richer by a dimension, since the optimal strategy without fixed costs of lot for lot production is expanded by the strategic decision to form lot size. This means bringing together several periods of demand to a production or recycling lot with the goal of fixed cost savings.

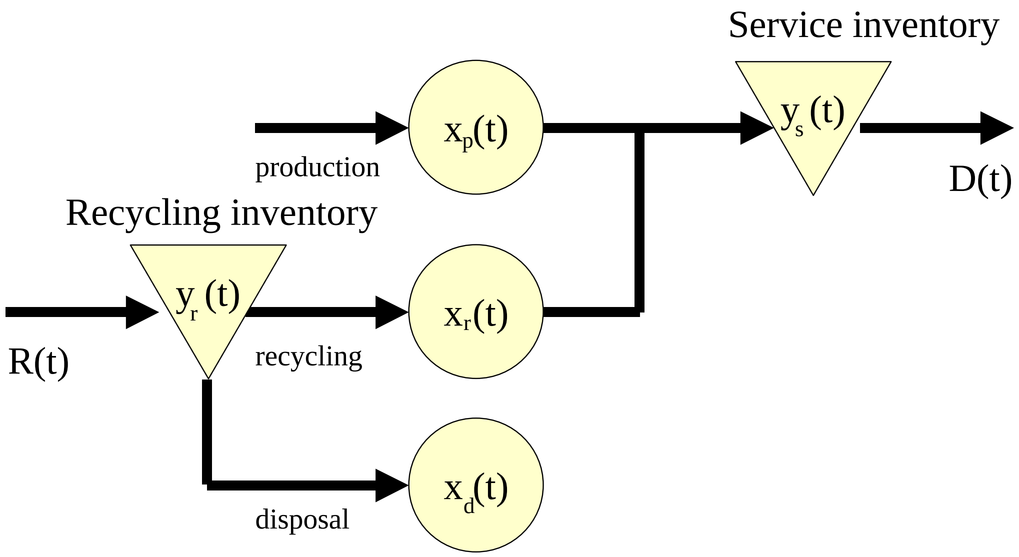

figure 1: model for reverse logistics

A methodologically simpler theoretical approach for this problem is formulating and solving a linear optimization program. However it quickly turns out that, despite skilful formulation of the program, the solution time behavior already becomes poor for relatively small problems from approximately 25 periods onward. Hence in this essay, heuristics are to be developed which can be flexibly applied and are not very arithmetically intensive.

Theoretical Approach

The following will attempt to analyze the classical dynamic single product inventory model and to adapt it to the conditions of the cycle model. At the same time, a fundamental differentiation of the process will be made regarding the rules of decision making used as its basis [5].
Abort criterias
gradually increase the range of a lot to be made until a defined limit value is exceeded.
Algorithms
successively include more and more information about the decisions to be made and, through comparative calculation, attempt to constantly improve an initial solution.
An important limitation of the dynamic lot size models is based upon the fact that several decisions must be made simultaneously in the cycle model. It then proves difficult to define an objective criterion of the disposal decision which could be meaningfully implemented into one of the existing dynamic single product lot size models. Therefore the assumption is made in the studies of this phase that the disposal decision is of strategic nature and will be made in advance of the study. This step either completely rules out the disposal option or makes a decision that all returns are immediately disposed of. The second possibility reduces the decisions to be made to a simple single product lot size model which can be resolved with the known process of dynamic lot size formation.
The simplification of the problem as a result of the strategic disposal decision becomes tenable

when the empirical research of this study is looked at. Parameter variations then show that the disposal option are usually used completely or not at all. Corresponding statements from the literature support this thesis.

Algorithms
The saving process represents a typical algorithm of the single product lot size problem. Assuming there is a valid starting solution, the attempt is made to systematically uncover potentials for saving and to implement these in the solution.

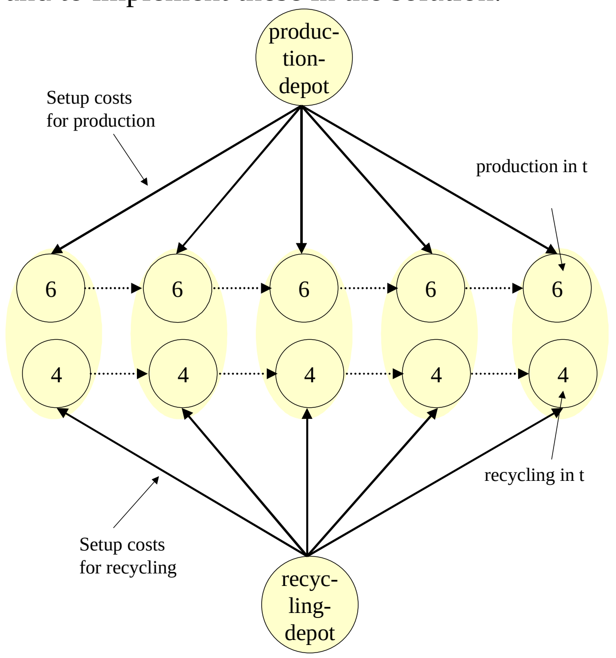

figure 2: recycling adapted saving model

The new solution resulting in this way has a saving value which expresses the cost difference for the initial solution. In the adaptation of the saving process to the cycle model, this is based upon
The savings of fixed costs of recycling;
The savings of fixed costs of production;
Additional storage costs of the production lot;
Additional storage costs in the recycling warehouse.
The process is represented in sequence and further refinements are developed. The achievable solutions are compared with the optimal solution.

Abort criterias
In the classical single product lot size problem, the static optimal condition of EOQ serves as the starting point for the derivation of the various heuristic algorithms. Varying the problem for the cycle model leads to heuristics which are based on the principles of the processes of
Groff
Least Unit Costs
Silver Meal

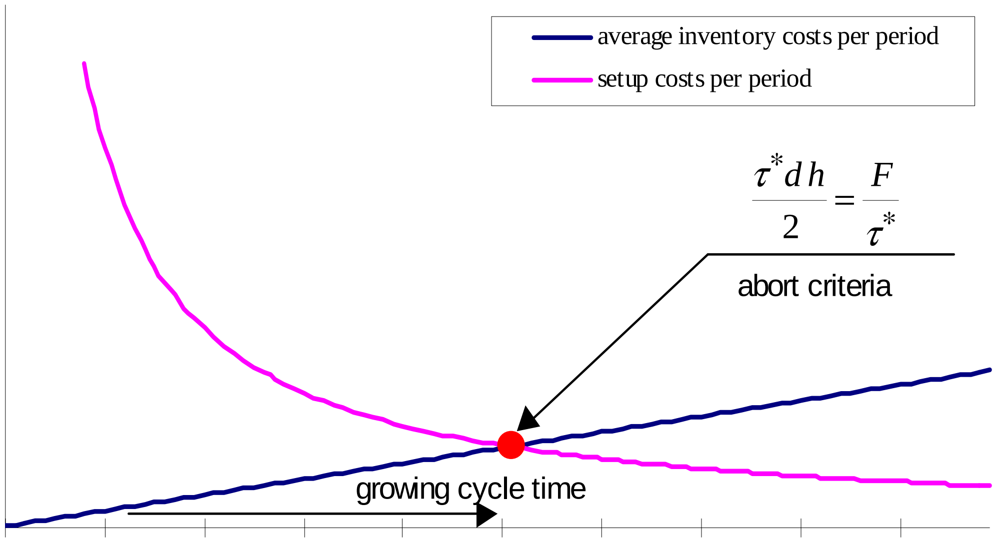

figure 3: abort criteria in the EOQ model

In view of the multi-dimensionality of the problems of the cycle model, not all processes of the single product lot size problem are equally suited for adaptation. Hence comparing the achievable solutions with the optimum systematically uncovers and documents weaknesses of some algorithms.

In addition, improvement calculations are introduced which compensate for unavoidable end effects of the optimal solution.

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