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1 Introduction

Nowadays, there is an increasing interest in disassembly process research. The main objective is to obtain valuable components and separate those that may affect the environment. Actually, the disassembly process has become very vulnerable and far to be deterministic [1]. However, it involves a high degree of variability associated with disassembly lead time. This unpredictability may be caused by technical problems (absenteeism, limited disassembly capacity, etc.) and to economic condition (changes and increase in costs of end of life products, etc). Here, the disassembly lead time implies the total time required to receive the parts after placing an order of disassembling the parent item [2].

2 Problem description and formulation

In this work, we study the case of single-demand planning in a disassemble-to-order (DTO) environment. In order to fulfill demands for specific components $i = 1, ..., n$, we disassemble an end-of-life (EoL) product whose real disassembly lead time, denoted L, is a random discrete variable varying between L^- and L^+ and characterized by a cumulative distribution function $F(.)$. We assume that (i) the disassemble capacity is infinite, (ii) for each component-customer demand, the quantity is known, fixed to one and should be delivered at period T_i, and (iii) the unit backlogging (b_i) and holding (h_i) costs for components are known. The disassembly process starts at period X and all components are available at period $M = X + L$. If a given component i is available before T_i, we stored it until this period. Then the corresponding holding cost is equal to $h_i(T_i - T_i^-)$ with $T_i^- = min(M, T_i)$. If it is available after T_i, a backlogging cost is incurred and equals to $b_i(T_i^+ - T_i)$ with $T_i^+ = max(M, T_i)$.

The total cost $TC(X, L)$ is a random discrete variable depending on the variability of L. Its explicit form can be written as follows :

$$TC(X, L) = \sum_{i=1}^{n} \Big((b_i + h_i) T_i^+ - M h_i - b_i T_i \Big) \quad \forall X \in [\![\min_{\forall i \in [\![1,n]\!]} \{T_i - L^+\} \, ; \max_{\forall i \in [\![1,n]\!]} \{T_i - L^-\}]\!] \quad (1)$$

The objective is to find the best disassembly date, denoted X^*, that minimizes the expected total cost $\mathbb{E}(TC)$. In this preliminary work, we give only the explicit forms. Thus, the expression of $\mathbb{E}(TC)$ is in Equation 2 :

$$\mathbb{E}(TC) = \sum_{i=1}^{n} \left((b_i + h_i) \sum_{s \geq T_i} \Big(1 - F(s - X)\Big) + h_i T_i \right) - \Big(X + \mathbb{E}(L)\Big) \sum_{i=1}^{n} h_i \tag{2}$$

3 Optimization approach

The expected total cost expressed in Equation 2 constitutes a non-linear objective function to be minimized. Here, an exact method based on the well-known Newsboy formula is introduced to optimize the studied problem. In order to obtain the optimal disassembly date X^*, the computation of X is required to explore the set of all possible values of X^* and is stopped when we find a solution that checks Equation 3.

Proposition 1 *The Newsboy formula gives the optimal disassembly date X^* which satisfies the following optimality condition (Equation 3) :*

$$\sum_{i=1}^{n} (b_i + h_i) \times F(T_i - X^* - 1) \leq \sum_{i=1}^{n} b_i \leq \sum_{i=1}^{n} (b_i + h_i) \times F(T_i - X^*) \tag{3}$$

The full proof will be published soon elsewhere.
Note that for $n = 1$, i.e. for a single type of component, our model is equivalent to the one of [3]. Theoretically, the optimum X^* is not unique. In order to prove the uniqueness of the optimal solution, it can easily be proved that the objective function is convex.

4 Conclusions

In this work, we propose a mathematical model to study a single-demand planning and a two-level disassembly system in a DTO environment with stochastic lead time. In order to optimize the expected total cost which is composed of inventory and backlogging costs, we introduce an optimizing approach. In our knowledge, we are the first to propose a Newsboy approach to solve the disassembly scheduling problem under stochastic disassembly lead time.

Several perspectives to this work are identified. Firstly, to develop mathematical models for the case of multi-period planning with dependency between periods. Secondly, it will be interesting to investigate the case where each component is independently disassembled under uncertainty of lead time. Finally, the objective is to generalize the proposed approach for the case of multi-level disassembly systems.

Références

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