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Note on "The economic lot-sizing problem with remanufacturing and one-way substitution"

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ABSTRACT

In Piñeyro and Viera (2010) (Int. J. Prod. Econ. 124 (2), 2010, 482–488) we investigate a lot-sizing problem with different demand streams for new and remanufactured items, in which remanufactured products can be substituted by new products, but not vice versa. In this note we correct some typos that appear in that paper and review the analysis carried out about the problem decomposition into easier subproblems of production, remanufacturing and final disposing.

1. Introduction

In Piñeyro and Viera (2010) we consider an extension of the economic lot-sizing problem (ELSP) in which there are different demand streams for new and remanufactured items, and the demand for remanufactured items can be also satisfied by new products, but not vice versa. We refer to this problem as the economic lot-sizing problem with remanufacturing and final disposal options and one-way substitution (ELSR-S). In that paper we provide a mathematical formulation for the problem and show it is NP-hard, even under particular cost structures. Considering this last complexity result, we suggest a Tabu-Search-based on procedure for solving the ELSR-S. The procedure is an extension of that provided in Piñeyro and Viera (2009) for the traditional ELSR, i.e., new and remanufactured products are identical from the customer's viewpoint. The procedure takes advantage of the key role that remanufacturing plays in the problem resolution. The divide and conquer principle is used for determining the plans for the different activities, i.e., production, remanufacturing and final disposing.

In this note we correct typos that appear in some mathematical expressions of Piñeyro and Viera (2010). Besides, we provide a further analysis about the ELSR-S decomposition into easier subproblems. We note that according to the mathematical formulation of the ELSR-S given in Piñeyro and Viera (2010), the decomposition depends not only on the remanufacturing quantities but also on the substitution quantities. However, we note that the decomposition depends only on the remanufacturing quantities if we add certain constraints on the mathematical formulation of the ELSR-S in order to allow only one feasible substitution plan.

2. Typos correction

In this section we provide the correction of the following mathematical expressions of Piñeyro and Viera (2010).

- The production plan of the numerical example provided in Section 3.1 for the case that substitution is allowed should be replaced by $\{p_1=30,\ p_3=20\}$.
- Expression (10) should be replaced by

$$r_t = \min(DR_{t(j-1)}, y^u_{t-1}+R_t) \quad 1 \le t < j \le T$$

- Expression (11) should be replaced by

$$\begin{cases} s_t = \max\{(DR_{1t} - r_{1t} - s_{1(t-1)}), 0\}, & 1 \le t \le T \\ s_{1,0} = 0 \end{cases}$$

- Expression (12) should be replaced by

$$\begin{cases} \Delta_t = \max\{(R_{tT} - r_{tT} - \Delta_{(t+1)T}), 0\}, & 1 \le t \le T \\ \Delta_{(T+1)} = 0 \end{cases}$$

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3. Problem decomposition analysis

We review here the analysis carried out in Section 3.1 of Piñeyro and Viera (2010) about the connections among the problem activities. In that section of Piñeyro and Viera (2010) it is suggested that if the remanufacturing plan is known in advance (periods and quantities), then the optimal production plan and the optimal final disposing plan can be obtained by solving separate ELSP subproblems. Nevertheless, we must point out that this analysis is not entirely true. The reason is that according to the constraint (4) of the mathematical formulation of the ELSR-S in Piñeyro and Viera (2010), there may be more than one solution of substitution for the same remanufacturing plan rather than only one. Therefore, the problem decomposition into the activities of production and final disposing depends on both the remanufacturing plan and also on the substitution plan. We show this last observation in the numerical example of below.

Let us consider an ELSR-S instance of two periods, demand values for new and remanufactured products $DP=(0, 0)$ and $DR=(2, 2)$ respectively, return values $R=(1, 0)$, and a feasible remanufacturing plan $r=(1, 0)$. Considering constraint (4) of Piñeyro and Viera (2010), there are two feasible substitution solutions $s=(1, 2)$ and $s=(2, 1)$. Then, the optimal production plan may depend on the substitution plan chosen. By means of expression (11) of Piñeyro and Viera (2010) (corrected in Section 2 of this note) the substitution solution chosen is $s=(1, 2)$. For this solution the substitution quantity at each period is exactly the required quantity, i.e., the portion of the demand in the period that cannot be covered by the remanufactured products.

Considering the observations in the example of above, we want to note that the decomposition analysis of Piñeyro and Viera (2010) is valid if there is only one feasible substitution plan. In order to achieve this goal, we can add to the mathematical formulation of the ELSR-S the following constraints:

$$M\delta_t^r \geq r_t, \quad \forall t = 1, ..., T \tag{1}$$

$$M\delta_t^{yr} \geq y_t^r, \quad \forall t = 1, ..., T \tag{2}$$

$$\delta_t^r + \delta_t^{yr} = 1, \quad \forall t = 1, ..., T \tag{3}$$

$$\delta_t^r, \delta_t^{yr} \in \{0, 1\}, \quad \forall t = 1, ..., T \tag{4}$$

where M is a sufficient big number. Constraints (1)–(4) state that in a certain period either the substitution quantity or the inventory of remanufactured products is positive but not both, i.e., substitution only occurs if the remanufactured products are not sufficient for fulfilling the demand requirements. We consider that an ELSR-S formulation with constraints (1)–(4) is more accurate for the substitution activity (Inderfurth, 2004; Bayindir et al., 2007). However, we note that the original mathematical formulation of Piñeyro and Viera (2010) is more general than that with constraints (1)–(4).

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