Guidelines for extended abstracts to be submitted to the 2017 BIVEC Transport Research Days

Inventory routings problems for the management of Returnable Transportation Items (RTI) with durability constraints

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1. Problem and research questions

Reducing environmental impact, related regulations and potential for operational benefits are the main reasons why companies share their returnable transport items (RTIs) among the different partners of a closed-loop supply chain. A returnable transportation item is a particular type of reusable packaging material, aimed and designed to be used several times in the same form (Glock & Kim, 2015). It consists of every manner to gather products for handling, transportation, storage and protection in a supply chain that returns these items for further use. Pallets, railcars, crates, containers, boxes can be different sorts of RTIs and are used in various industries today (IC-RTI, 2003). The use of RTIs avoids repeated purchase of new transportation materials, reducing this way the waste and disposal cost. RTIs can also be designed to improve transportation and storage efficiency, as well as handling (Kärkkäinen et al., 2004).

RTIs managements are quite diverse. Research efforts are thus needed in the areas of RTI acquisition; warehouse layout, inventory routing problem; production planning and control; tracking and scheduling. In this paper, the inventory-routing problem for the management of RTIs developed in Iassinovskaia et al. (2017) has been enriched by adding constraints referring to specificities that can be encountered in real life, such as minimum threshold or a maximum ceiling of RTIs to be returned or durability. Durability can be characterized by the number of times an RTI can be used which is called maximum number of lives *n*. For instances, glass bottle can be used 25 times, wooden pallet 50 times and Crates for bottles 120 times (Geyer et al., 2007).

2. Methodology, research strategy

In their paper Iassinovskaia et al. (2017) consider a producer, located at a depot, who has to distribute his products packed in RTIs to a set of customers. Customers define a time window wherein the service can begin. The producer is also in charge of the collection of empty RTIs for reuse in the next production cycle. Each partner has a storage area composed of both empty and loaded RTI, characterized by initial levels and maximum storage capacity. As deliveries and returns are performed by a homogeneous fleet of vehicles that can carry simultaneously empty and loaded RTIs, this research addresses a pickup and delivery inventory-routing problem within time windows over a planning horizon. A mixed-integer linear program is developed and tested on small-scale instances.

First, a set of constraints is added to the formulation presented in Iassinovskaia et al. (2017) in order to consider a minimum threshold of RTIs or a maximum ceiling to be returned. This new formulation is straightforward but it allows computing gains that companies may have if this threshold or ceiling is dropped.

Second, to take durability into account, the maximum number of lives *n* has to be known. For our analysis, it is assumed, as in Geyer et al. (2007), that *n* is constant for all RTIs and that all collected RTIs can be brought back to a like-new condition until their components have been used *n* times. The producer collects a certain percentage *c*, the collection rate, of the empty RTIs. In most cases, the collection rate *c* will be smaller than one because, for instance, the customer does not return RTIs, loses them, or there are third parties collecting RTIs for other networks. The non-collected RTIs are thus supposed to be lost. Moreover, it is also assumed that RTIs reaching their end of live can be sold as raw material. To describe the number of time an RTI has been used, a new index $k \in \{0, \ldots, n\}$ is added to variables denoted RTIs.

As our approach is based on a mixed integer linear program and tested on small-scale instances, it can be handled by a standard optimization library. We rely here on IBM ILOG CPLEX 12.5 with the default parameters.

3. Major findings

We enriched the model formulated in Iassinovskaia et al. (2016) to include some real life constraints such as minimum threshold or a maximum ceiling of RTIs to be returned or durability.

4. Takeaway

Different cost policies and collection rate linked to the RTIs management are compared. The output of the developed models can contribute to improve the management of RTIs and results provide help with the decision-making process.

5. Keywords

Returnable Transport Item (RTI), closed-loop supply chain, pickups and deliveries, durability constraints.

References

Glock, C H 2016, ‘Decision support models for managing returnable transport items in supply chains: A systematic literature review’, *International Journal of Production Economics.*

Glock, C H, Kim, T 2015, ‘A joint economic lot size model with returnable transport items’, *International Journal of Integrated Supply Management,* vol. 9, No. 3.

Geyer, Roland; Van Wassenhove, Luk N; Atasu, Atalay; ,The economics of remanufacturing under limited component durability and finite product life cycles, *Management science*, 53, 1, 88-100, 2007, INFORMS

Hariga, M, Glock, C H, Kim, T 2015, Integrated product and container inventory model for a single-vendor single-buyer supply chain with owned and rented returnable transport items', *International Journal of Production Research.*

Iassinovskaia, G., Limbourg, S., & Riane, F. (2017). The inventory-routing problem of returnable transport items with time windows and simultaneous pickup and delivery in closed-loop supply chains. *International Journal of Production Economics*, (183), 570-582.

IC-RTI (2003). Reusable Transport Items (RTI) – Organizational Recommendations. Retrieved from http://ecr-all.org/wp-content/uploads/pub_2003_RTI_organizational_recommendations.pdf.

Kärkkäinen, M., Ala-Risku, T., Herold, M. (2004, February). Managing the rotation of reusable transport packaging – a multiple case study. Proceedings of the 13th International Working Seminar on Production Economics, Igls/Innsbruck.

Martin, A 2016, 'An analysis of the management of returnable transport items'.