DESIGN AND EVALUATION OF A LOGISTICS NETWORK FOR TIRE RECOVERY IN TURKEY

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Abstract

Tire remanufacturing, commonly known as tire retreading, and tire recycling are very profitable, yet many companies who reprocess used tires mostly conduct either only recycling or only retreading in Turkey. In this study, the profitability of adding a tire retreading facility into the logistics network for a company in Turkey who currently conducts recycling operations only is investigated.

The problem is formulated and solved as a mixed integer programming (MIP) model to find the optimal design that maximizes the overall profit. Numerical experimentations are conducted to see the effects of changing return parameters on the optimal design and profit.

Background Research and Introduction

Tires are highly structured rubber products which take a long time to decompose. Around 65%-70% of a tire consists of rubber and the remaining part is composed of steel wire and valuable outages.

The commonly used tire recovery options include energy recovery, recycling and retreading (Ferrao et al. 2008):

- Retreading is a process that basically consists of replacement of the worn-out tread, which extends the life of the used tire and is mainly applicable for truck and bus tires.
- Recycling is another commonly used end-of-life tire recovery option, which is an economic way of supplying various materials such as granule, steel wire and valuable outages or carbon black, oil and gas depending on whether mechanical or chemical recycling processes are used.
- Energy recovery is the combustion of tires, and it generates higher energy than coal combustion (Sienkiewicz et al., 2012).

Regarding to the literature survey conducted, no study exists in the literature that evaluates the profitability of having both tire retreading and tire recycling facilities in the same logistics network. In this study, the profitability of opening a tire retreading facility for a company who originally conducts recycling operation only is investigated using a multi-period mixed integer programming model that finds the optimal network design.

Objective and Methodology

Tire recovery can be done by three ways: tire retreading, recycling or combustion in cement facilities for energy recovery. In the existing logistics network model of the recycling companies in Turkey, shown in Exhibit 1, tires collected back from customers are directly sent to either recycling facility or cement facility without controlling whether the incoming tires are retreadable. After recycling, the main products obtained are granule and steel wire at respective rates of 65% and 25%.

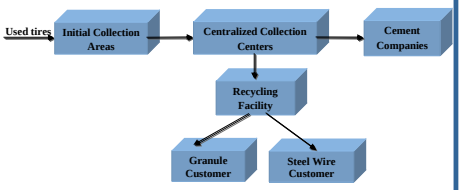

Exhibit 1. The existing logistics network of recycling company

The Proposed Logistics Network Model

The retreading option is added to the existing logistics network design of the recycling company. The integrated logistics network model for the collection and recovery of used tires is shown in Exhibit 2.

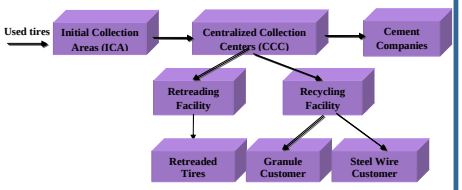

Exhibit 2. The proposed logistics network model

The aim of the model is to maximize the total profit over the planning horizon by determining the optimal locations of CCCs and the retreading facility. The problem is formulated as a multi-period multi-product mixed integer programming (MIP) model under these assumptions:

- All model parameters are known and deterministic.
- The recycling cost is included in the operating cost of the recycling facility.
- The candidate locations and capacities for CCCs and the retreading facilities are the same for every period.
- A certain proportion of the returns received at a CCC is retreadable. Due to the existence of significant demand for retread tires, all retreadable tires are retread and sold.
- All tires coming to the recycling facility are recycled or retreaded. Exceeding capacity of tires is sent to cement facilities.

Results

The profitability of launching a tire retreading business for a tire recycling company is investigated. The company is authorized to collect used tires only in Marmara Region. Here, 16 ICAs supply used tires to any open CCCs. CCCs then send the tires to open retreading facility, the recycling facility or to any of the 2 cement plants. Potential locations and corresponding capacities of each facility are provided in Exhibit 3.

CCCs		Retreading facilities	
Potential Locations	Capacity (tons)	Potential Locations	Capacity (tons)
Sakarya	15,000	Sakarya	72,000
Duzce	10,000	Kocaeli	48,000
Kocaeli	10,000	Duzce	24,000
Yalova	6,000		
Catalca	3,000		

Exhibit 3. Possible locations of CCCs and retreading facilities and the corresponding capacities*

*Due to privacy concerns, the identity of the firms is kept anonymous, and most numerical data corresponding to the model parameters (such as costs, selling prices, and supply and demand amounts) are not provided.

The model is solved for different scenarios corresponding to different values of retreadable tire ratio. The results indicate that tire retreading increases the profit by at least 16.7% compared to conducting only recycling when the retreadable tire ratio is at least 10%.

Exhibit 4. 16 ICAs and potential locations

Conclusion

In order to determine the profitability of tire recovery (both recycling and retreading), a logistics network design problem is defined and formulated as a mixed integer linear program. The model determines where to locate CCCs and retreading facilities to maximize the overall profit at optimal retreadable tire ratio.

References

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