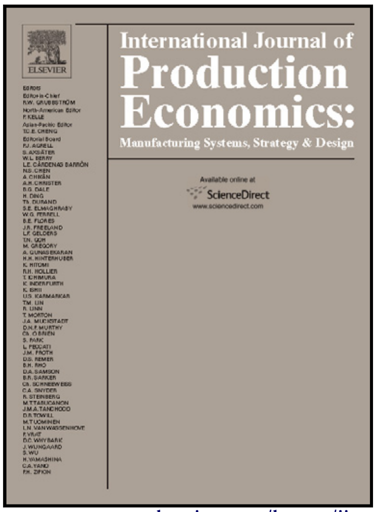
Author's Accepted Manuscript



www.elsevier.com/locate/ijpe

Rail car fleet design: optimization of structure and size

S.T. Klosterhalfen, J. Kallrath, G. Fischer

PII: S0925-5273(13)00234-X
DOI: http://dx.doi.org/10.1016/j.ijpe.2013.05.008
Reference: PROECO5456

To appear in: *Int. J. Production Economics*

Received date: 3 September 2012
Revised date: 22 April 2013
Accepted date: 1 May 2013

Cite this article as: S.T. Klosterhalfen, J. Kallrath, G. Fischer, Rail car fleet design: optimization of structure and size, *Int. J. Production Economics,* http://dx.doi.org/10.1016/j.ijpe.2013.05.008

Rail car fleet design: Optimization of structure and size

Abstract

We develop a model to determine the optimal structure and size of a rail car fleet at a chemical company under uncertainty in demand and travel times as well as substitution between rail car types. First, we formulate an MILP model that accounts for the substitution relations between the types and minimizes the total direct rail car cost under given rail car availability constraints and a predefined maximum number of types. Second, based on the fleet structure obtained by the MILP model, the fleet size is computed by using an approximation from inventory theory that considers the existing uncertainties. Compared to the current approach of the rail car fleet management team, the model produces a reduction in safety stock of 120 rail cars and thus direct cost savings of 8% as well as further indirect cost savings due to a smaller number of rail car types, which reduces the switching effort of the rail cars on the storage tracks.

Keywords:
fleet management, fleet structure, inventory, safety stock

1. Introduction

In the chemical industry, rail cars represent an important means of transportation. Due to safety regulations many products are not allowed to be transported on the road. Moreover, rail cars can carry larger volumes than trucks. The product poses minimum requirements on a rail car with respect to material, valve model, heating, etc. The combination of these characteristics specifies a certain rail car type and determines its cost. Types with higher quality characteristics can be used as substitutes for lower ones and thus are more flexible.

At the company, which motivated this research, the task of the rail car fleet management team is to secure the supply with rail cars of an appropriate type while at the same time solve the trade-off between (i) minimizing the direct cost for rail cars and (ii) minimizing the number of different rail car types. The latter aspect is relevant because the smaller the set of rail car types, the easier it is to access a requested type on the storage tracks due to a sorted parking strategy. As the number grows, space limitations require a chaotic parking strategy, which increases the switching effort and thus causes higher indirect costs. Further, the smaller the set of types, the lower the required safety stock due to a larger risk pooling effect. These benefits have to be traded off against the higher costs for more flexible types.

Over the last decade, the fleet management team has invested considerable effort to reduce the overall cost and free up storage space on the site. In a first analysis of the rail car fleet, old and seldomly used types that could be easily replaced by others have been discarded. Thus, the number of so-called standard rail cars (which we will be focusing on in

Preprint submitted to Elsevier *May 20, 2013*