Considering environmental aspects in the multi-item multi-site capacitated lot-sizing problems

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Mots-clés : *Lot-sizing, multi-item, multi-site, resource capacity, carbon emission*

1 Introduction

In the ever growing manufacturing industry, environmental considerations have become a persistent challenge for companies who aim to reduce their carbon footprint. The environmental aspects can be evaluated at the tactical level of production planning. This level is represented by lot-sizing problems. The goal of this problem is to minimize the overall cost of the manufacturing process while respecting the capacity constraints and the material flow constraints. We propose a mathematical modelling of this problem and the carbon emission constraints in order to compare their influences. We also develop an algorithm for the upper and lower bound search in the case of a non linear constraint.

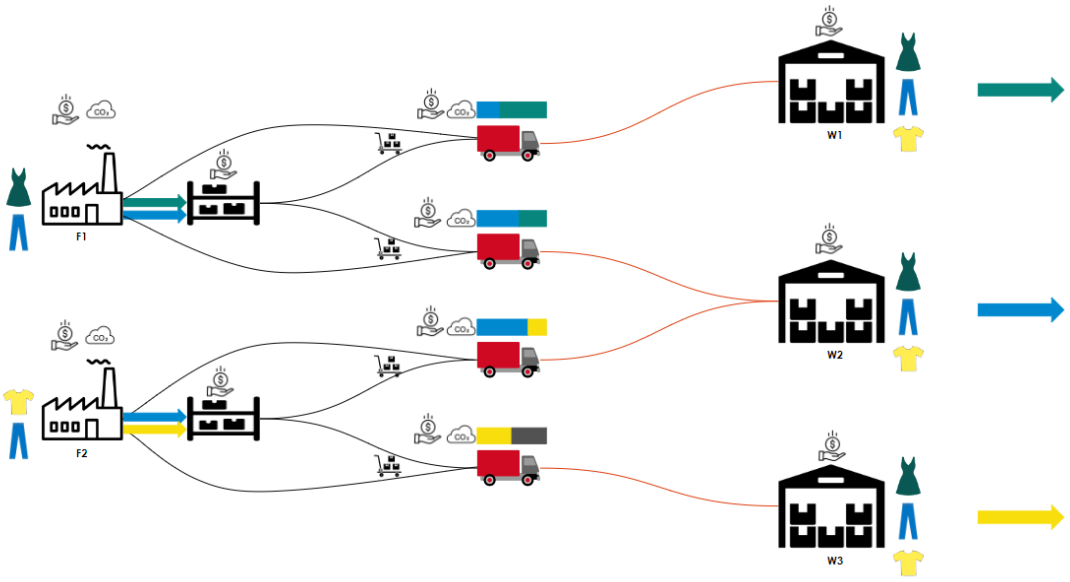

FIG. 1 – Example of the multi-item multi-site capacitated lot-sizing problem with carbon emission constraints

2 Contributions and challenges

In this work, we consider the lot-sizing problem with multiple products, multiple sites separated into factories and warehouses and multiple resources with limited capacities. This problem is NP-hard [2].

We also take into consideration the transportation processes alongside the production processes. The environmental aspects studied are the carbon emission from the different processes and are represented by periodic carbon emission constraints as defined by Absi et al., 2013[1]. An example of the problem is illustrated in Figure 1.

In order to evaluate the environmental aspects in a lot-sizing problem, we start by defining a mathematical model for the optimization problem. Then, we consider the different evaluations of the carbon emissions on the production level as well as the transportation level. We present two versions for each evaluation : total and averaged. Given the practical aspect of this work, it is required to generate instances as realistically as possible. These instances are used to compare the influence of the different carbon emission constraints presented on the feasibility of the problem. At this point, we present the carbon emission constraint combining production and transportation. This constraint is non linear which requires either a linearization method or an upper and lower bounds search. Given the nature of the variables and the constraints, we opt for developing an algorithm for the bounds search. The execution of this algorithm on the instances generated provided optimality results in regards to the minimal transport capacity.

3 Conclusions and perspectives

During this work, we provide a method to accurately evaluate the carbon emissions of manufacturing processes. We also model these evaluation and explore their aspects on the solutions of the lot-sizing problem. Finally, we provide an algorithm that finds an upper and lower bound in the case of the non-linear carbon emission constraint combining production and transportation. The perspective of this work is threefold : Possible relaxations of the lot-sizing problem with carbon emission constraints ; explore linearization techniques or different formulations for the non-linear constraints ; and, develop an efficient algorithm to improve the upper and lower bounds of the optimal value of the lot-sizing problem with non linear carbon emission constraints.

Références

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