A supply chain network design problem for the RENAULT vehicle distribution

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1 Introduction

We describe a case study of the RENAULT outbound supply chain and model the problem as a deterministic multi-period, multi-commodity Supply Chain Network Design Problem (SCNDP) model. Related reviews of the literature are [4] and [2][1] for the distribution case. Our problem aims to find the less costly way to transport vehicles from plants to dealers, through a complex supply chain network. We hence need to determine the facilities and the routes through which the products will transit. Costs include road and sea transportation costs, facility passage costs, and facility inventory costs.

Figure (1) describes the transport flow of the distribution network. Vehicles leave plants and go through a nearby dispatch center. Then they reach their dealers (customers) either by direct flow or through intermediate centers by an indirect flow. The last center of an indirect flow is a capillary distribution center. There exists two different product management strategies : build-to-order or build-to-stock. This problem is not multi-modal as transport between two facilities represents either a road or a sea transport.

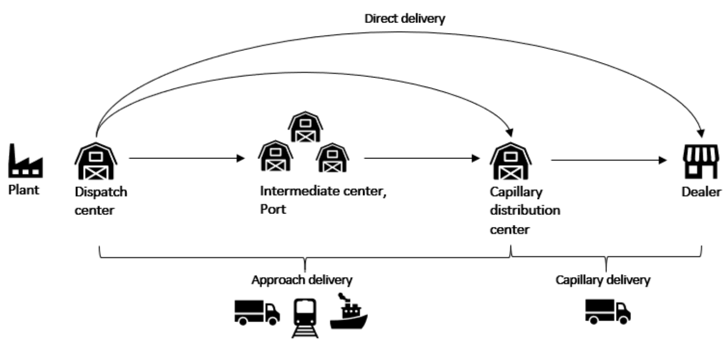

FIG. 1 – Outbound supply chain network

2 Problem description

Due to the outsourcing of the transport management, our transport unit (trucks and boats) flow are viewed as direct round trips. Consequently, we chose to represent this problem into a multi-flow graph, where a node represents a center or a dealer and a period and arcs represent the flow of the products. The flow is pushed at definite periods in the nodes representing

dispatch centers. The exact demanded products quantity must reach the dealers before the end of the time horizon.
The resulting graph is almost a complete graph with the following exceptions :
- Only arcs with their corresponding transport cost mentioned in the input data exist
- There exists no outflow from dealers (dealers do not behave like centers)
- Transport arcs by boat do not exist for every period
- Built-to-stock products arcs do not exist between a node and a dealer node from different countries (for fiscal reasons)

One originality lies in the way we construct the road transport costs. Road transport costs are charged for each truck unit, and the truck unit cost differs on each arc. Truck quantities are estimated thanks to a truck filling rate information per product type. To our knowledge [3] developed a multi-commodity problem with a comparable product flow management, but under the form of a capacity constraint instead of a non-linear cost. Sea transport costs, passage costs, and inventory costs are simple linear costs per product unit.

Due to the complexity of dealing with multi-period problems with non-linear transport costs and industrial-sized instances, an intuitive heuristic is proposed, and a performance comparison with our mixed-integer problem (MIP) model is presented. This heuristic consists in solving the equivalent single-period problem. As the single-period problem is relatively close to our original problem, it seems interesting to keep the arcs from the best solution found by the single-period problem and run the original multi-period problem with the additional constraint of using only these promising arcs available for all periods.

3 Computational experiments

The industrial case study concerns all dealers in Italy supplied by all plants in Europe and around the Mediterranean sea. We consider several planning horizons from 10 days to 1 month, based on demand data in January 2019. We compare the performances of our MIP and heuristic. On average, the heuristic solutions are 3.78% less costly, and the gap with the best lower bound is reduced by 46%, after one hour of computation.

To motivate the choice of modeling road transport costs per truck unit, we compare the results of our problem with the same problem considering linear road transport costs. This simpler model runs indeed much faster and gives optimal solutions in 7 to 244 minutes. However, the total costs induced by the solutions are, on average, 11% higher than those found by our heuristic.

To conclude, the proposed heuristics offer better solutions than the MIP in one hour of CPU. In addition, although employing non-linear road transport costs increases the complexity of the problem, it seems promising to obtain satisfying solutions.

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