

Submission for 20th CEMS Research Seminar on Supply Chain Management

Category of submission

CAT 1 (early research stage):

Problem definition and literature review

CAT 2 (intermediate research stage):

Modelling, methodology, experimentation and/or empirical study

CAT 3 (mature research stage):

Completed research or conceptual topic

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“A Novel Multi-Objective Model for Data-Driven Scattered Storage Assignment in Warehouses”

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A Novel Multi-Objective Model for Data-Driven Scattered Storage Assignment in Warehouses

Today's competitive retail market is faced with high expectations from customers on both delivery (time) and price (cost). This situation has led retailers such as Amazon and Zalando to improve their replenishment and picking strategies at their distribution centres to achieve a higher degree of efficiency [1]. One of these replenishment strategies is Scattered Storage Assignment (SSA). The underlying idea behind SSA is to unbundle each received Stock-Keeping Unit (SKU) and spread it within different positions in the warehouse. As the distance travelled by pickers to retrieve items is a crucial issue in warehouse operations management, SSA increases the average adjacency of pickers to SKUs, irrespective of his/her actual position, which leads to less travel distance in the warehouse [2].

To the extent of our review, the prevalent definition and measure used in literature for scatteredness is based on [3]. We present a new data-driven scatteredness measure which extends the concept of scatteredness to include more real-world requirements and takes customer order data into account. To do so, a novel multi-objective mathematical model is proposed in this study. This model aims to (a) maximize the scatteredness; (b) minimize splitting order-lines by aiming to collect all items of an order-line from the same location; (c) maximize order correlation of items close to each other by reducing the distance between items which are frequently ordered together and (d) maximize adjacency of frequently-ordered items to the depot. This proposed model has several benefits.

Firstly, as order frequency of items is not identical, their degree of scatteredness is weighted differently. Therefore, association rules which describe customer order behaviour, are included in the proposed scatteredness measure. Secondly, as mentioned by [4], balanced dispersion of each SKU through the warehouse is important. In other words, if 18 units of an SKU are located in three different locations with the inventory of (6, 6, 6), it is more balanced than (5, 1, 12). Consequently, this characteristic is also embedded in the proposed measure. Thirdly, pairwise distance between various locations of an SKU is taken into account. Namely, if 2 units of an SKU are located in two different locations where their pairwise distance is 30 meters, they are more scattered than the situation where their pairwise distance is 5 meters. Fourthly, in contrast to existing SSA measures that allow a single SKU in each position, the proposed measure in this study allows multiple SKUs in a position which can have different spatial capacities. Fifthly, previous research requires a pre-defined degree of scatteredness [5], while our proposed multi-objective SSA model determines the optimal storage location without needing pre-calculation of a fitted scatteredness degree. Like this, the provided approach in this study not only scatters the inventory fit to the context of corresponding business but also tries to keep the inventory level of each SKU in each location in a way that minimizes splitting order-lines.

In order to avoid having to find the Pareto frontier, which is complex and may require long computation times, lower and upper bounds for each of the four objectives are calculated. These bounds are then applied to re-scale each objective, such that they can be used in a weighted-sum

approach. Next, a data-driven method for assigning the weight of each objective is introduced in this study. Finally, as the proposed model is both non-linear and non-differentiable, a meta-heuristic solution algorithm based on Differential Evolution [6] is developed. It is notable that the authors are working on testing the model and the algorithm on problems of different scale.

References

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