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Topic(s) Covered:
Optimization

Groceries need to be stored and transported at different temperatures depending on the nature of each product – so why not rationalize the distribution of these items by accommodating different temperature zones in the same truck?

This is the basic rationale of multi-compartment vehicle (MCV) distribution, which is gaining ground in Europe. But adding complexity to vehicles comes at a cost. The Luxembourg Centre for Logistics and Supply Chain Management (LCL) has analyzed this tradeoff to shed light on the cost-effectiveness of MCV distribution.

In Europe, distribution can account for as much as 20% of total logistics costs in the grocery supply chain. Since margins are generally thin, there is an obvious imperative to maximize the efficiency of supply chain operations.

Grocery products come in deep-frozen, cold or ambient temperature segments, that are subject to strict regulation. The majority of product is shipped to stores from distribution centers. European discounters and most full-line supermarkets operate several regional DCs. These facilities are organized according to temperature-specific segments, and typically serve 50 to 400 retail outlets.

Traditionally, delivery trucks are equipped to carry one temperature category of grocery product, which restricts the number of outlets they can serve. Hence, the introduction of MCVs that deliver all product segments and provide much more route planning flexibility.

However, these versatile vehicles also add complexity to supply chains. At DCs, the trucks visit multiple doors to pick up different temperature category products. Traditional, single-compartment (SCVs) trucks can usually complete loading operations at a single bay. In addition, loading and unloading MCVs is more complicated, in that the vehicles are partitioned into different compartments for each temperature zone.

There are three substantial process and cost differences between the MCV and SCV models.

- MCV distribution requires additional operational processes. The extra stops required to pick up a mix of product segments at the DC generates more travel and set-up time. Reopening the compartments when unloading at retail outlets also adds time to this option.
- MCV distribution reduces operational process time. Since trucks carry multiple product segments, they can serve customers with more than one product type at each stop. Thus, the number of stops and unloading set-ups at retail outlets can be reduced. These advantages also lower the time required for the stores for the goods reception (e.g. checking orders, completing shipping documents).
- MCV distribution reduces travel costs. There is more flexibility when assigning orders to trucks and building delivery routes, and this reduces driving distances significantly.

Given these differences, the LCL researchers considered several variables when analyzing the cost implications of MCV versus SCV distribution. These variables include the number of compartments on each truck and each tour, which orders are assigned to which compartments and truck, and which outlets and outlet orders are combined on each tour.

The ability to customize vehicles was also considered. For instance, the number and size of compartments can be altered for each tour, and it is possible to deactivate individual compartments if necessary. Orders of one temperature zone can be combined in the same compartment; others must be transported separately.

The researchers built a mathematical decision model and solution approach for minimizing loading/unloading and transportation costs associated with the routing of MCVs, for different compartment configurations. The order assignment and routing needed to obey compartment and capacity targets. A further constraint built into the model pertained to the sequencing of locations in each delivery run.

For retailers, a key question is whether MCV distribution is superior to the more traditional SCV option in terms of cost. The model analyzed the performance of a distribution system with MCVs only, alongside one served solely by SCVs. Different average order sizes (low, med, high) were tested with simulated data to obtain general insights. The approach enabled researchers to simulate a broad set of distribution scenarios that included up to 200 customers and five product segments.

MCV outperformed SCV for each average order size. The smaller the order, the wider the gap. For example, transporting small orders in MCV trucks achieved a cost saving of 23.6%. The analysis suggests that the advantages yielded by MCV distribution increase significantly as average order size decreases.

These findings were benchmarked against data from an actual distribution operation of a large German retailer. The data set covered one week of movements from a distribution center in a region of Germany to more than 400 customers. The savings achieved by using MCV trucks as opposed to SCVs were in line with those indicated by the model. The switch to MCV distribution yielded a cost saving of 6.3% for the week.

The researchers also used the model to explore other possible advantages of an MCV-based distribution system. The model confirmed that this versatile system can achieve more efficient vehicle routing as well as greater operational flexibility.

Clearly, these results will vary for different distribution systems. However, the model provides a valuable decision support tool for the grocery industry in Europe when assessing the pros and cons of MCV distribution.

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Back to Supply Chain Frontiers issue #64