A step-by-step guide to assist logistics managers in defining efficient re-shelving solutions for retail store deliveries

Structured abstract

Purpose

City logistics is a challenge in many cities. Literature works focus on the analysis of large or local-scale solutions to increase the efficiency of freight transport. However, store deliveries from the perspective of practitioners, particularly retail stores, is still an issue. In this context, a decision framework is proposed to assist logistics managers in defining efficient re-shelving solutions for store deliveries, according to the emplacement characteristics, city administration constraints and social issues.

Design/methodology/approach

An iterative step-by-step decision framework is developed, which allows taking decisions in a clear and structured way, including the preferences of key stakeholders. Moreover, a “what if” procedure is proposed, aiming to modify some initial conditions of the target store to achieve more efficient solutions.

Findings

The proposed decision framework is applicable in practice and helps users (mainly logistics managers) to identify solutions for efficient re-shelving in urban settings.

Research limitations/implications

The decision framework is applied by the logistics manager of two Spanish food retail stores, but it could be used in different logistics sectors and cities/regions, although adapting the decisions taken at each phase.

Practical implications

Logistics managers have a support tool when addressing re-shelving solutions for store deliveries.

Social implications

A balance can be found between company interests (minimise costs) and citizens quality of life (less contamination, noise, traffic, etc.).

Originality/value

This study simultaneously deals with large and local-scale decisions faced by logistics managers in their day-to-day activity, considering details about the store location, its surroundings and the company it belongs.

Keywords

Step-by-step guide; city logistics; re-shelving solutions; store delivery; social issues; case study

Introduction

City logistics is a challenge for many cities, aiming to achieve reliable and quick access to products and services (Rose *et al.*, 2016). Around 25% of urban traffic congestion and 25% of CO_2 emissions are caused by freight transport (Dablanc, 2007; ALICE/ERTRAC, 2014). Indeed, while cities' economic development grows rapidly, urban infrastructure grows slowly; so urban areas become saturated, negatively affecting population quality of life and companies' competitiveness (Rashidi and Samimi, 2012). In cities with historical centres the problem is even greater, due to the high population density, traffic congestion, and commercial areas in narrow streets. For that reason, many European cities have proposed solutions to reduce the negative impacts of freight transport (Gammelgaard, 2015; Nuzzolo *et al.*, 2016; Vierth *et al.*, 2017). The challenge when conceiving solutions for freight transport is to satisfy the interests of all stakeholders (Vieira *et al.*, 2015). City administrators, i.e. politicians and rulers, generally promote legislation benefiting citizens' quality of life: less noise, traffic, contamination, etc. However, these constraints are not always carefully studied and can cause unintended effects (Quak and Koster, 2009; Vieira and Fransoo, 2015). Consequently, private companies face the challenge of developing appropriate solutions that comply with city administration constraints, while maximising benefits and competitiveness.

In this context, this work focusses on re-shelving solutions that can be developed by companies and practitioners in order to improve the efficiency of store deliveries. The investigation on the topic can be classified depending on whether the emphasis is put on large or local-scale solutions, so the following literature review is presented accordingly. First, research analysing the impacts of global solutions on the activities of retail stores is examined. Then, papers focusing on the analysis of in-store logistics, aiming to improve the efficiency of retail store activities, are reviewed.

Concerning large-scale solutions, the BESTUFS (Best Urban Freight Solutions) initiative was developed in the European context to create an expert network to identify, follow-up and disseminate best practices, criteria and bottlenecks regarding freight transport solutions (BESTUFS, 2005; 2007). In addition, different works review solutions implemented in many contexts, highlighting their advantages and limitations (Muñuzuri *et al.*, 2005; van Duin and Quak, 2007; Kant *et al.*, 2016; Lagorio *et al.*, 2016). Other authors focus on a solution (or solutions), comparing expected and real results (Sathaye *et al.*, 2010; Russo and Comi, 2011a; Cantillo and Ortúzar, 2014; Johansson and Björklund, 2017). However, the need for ex-ante assessments to forecast the impacts of specific solutions on particular contexts has been reported (Ibeas *et al.*, 2012), as the results of the same solution in different situations can be completely dissimilar (Ambrosini *et al.*, 2013).

For instance, Filippi *et al.* (2010) propose a methodology for quantification of the impact of city access limitations and urban distribution centres, evaluating environmental externalities and the accomplishment of target goals. Russo and Comi (2011b) show that consumer behaviour can be influenced by infrastructures and governance, modifying travel costs between consumption and buying zones. Browne and Gomez (2011) study the impact of delivery constraints upstream the supply chain. Marcucci *et al.* (2011) rank innovative solutions according to policy makers, retailers and providers in Rome. Domínguez *et al.* (2012) review receiver response in front of off-peak delivery solutions and urban consolidation centres. Arvidsson *et al.* (2013) review the opinion of many stakeholders related to road hauliers about solutions affecting their activity. Ambrosini *et al.* (2013) propose a methodology for scenario construction and assessment of the impact of solutions on urban goods flows and land-use. Nuzzolo *et al.* (2013) review models to modify infrastructures, services and regulations in order to better adapt the solutions to each context. Nuzzolo and Comi (2014) present a multi-stage method to evaluate the impacts of freight transport solutions, considering practitioner behaviour, transport service, delivery time period and itinerary/vehicle type. Tadic *et al.* (2014) propose a multicriteria decision-making approach to select the most suitable city logistics concepts, including the opinion of many stakeholders with faced interests. Finally, Vieira *et al.* (2015) analyse the opinion of shippers, carriers and logistic providers over measures implemented in São Paulo.

Concerning local-scale solutions, Aastrup and Kotzab (2010) underline that, despite 40 years of research, out-of-stocks are still an issue. In particular, stores are seen as black-boxes by researchers, missing significant lacks to be improved in their activity. Indeed, the research on in-store logistics is noteworthy, although attention is mainly put on shelf space management according to the demand behaviour (Hübner and Kuhn, 2012). However, activities upstream the supply chain can have an impact on shelf availability and stock shortages. In this regard, Ettouzani *et al.* (2012) use semi-structured surveys to retail practitioners to identify the main reasons for on-shelf shortages, concluding about the causes affecting across the supply chain. Ehrenthal and Stölzle (2013) examine retail out-of-stocks, through field observations and practitioner interviews, highlighting the need to improve coordination between deliveries and shelf replenishment. Kuhn and Sternbeck (2013) focus on the interdependencies between in-store activities and upstream processes, analysing how store deliveries can influence on transport and distribution centres. Finally, Demir *et al.* (2015) review and quantify the cost of externalities of freight transport for society, depending on the transportation mode.

Under a different perspective, few works analyse the interdependencies between the in-store logistics and store deliveries; i.e. solutions to improve the process of making goods arrive from distribution centres into shelves. For instance, Reiner *et al.* (2013) use data envelopment analysis and simulation to compare and analyse the efficiency when handling dairy products from docks to shelves, for large retail stores. Sternbeck and Kuhn (2014) aim to select delivery patterns from distribution centres to in-store logistics using a binary model, achieving significant cost savings in European retailers. Limsirivallop *et al.* (2016) propose using the define-measure-analyse-improve-control method to improve the in-store logistics of a retailer, focusing on the pick area, in order to improve customer satisfaction. Gammelgaard *et al.* (2016) develop an analytical tool for value co-creation between retailers, particularly in-store processes, and city logistics service providers. Based on two case studies, the authors demonstrate how changes in delivery patterns can affect employees. Finally, some applications have been developed to improve the efficiency of store deliveries using real-time information (PVT Group, 2018; Wanko, 2018).

Dreyer *et al.* (2018) analyse grocery retailers in various countries, concluding about the benefits of integrating sales and operations planning to better balance supply and demand. However, although extensive literature has been written about city and in-store logistics, the perspective of practitioners and store deliveries is still an issue (Ettouzani *et al.*, 2012; Trautrims *et al.*, 2012). Reviewed works on large-scale solutions develop models to analyse the impacts of freight transport solutions. However, these solutions have a global scope and are generally imposed to stores, who have to adapt their activity accordingly. On the other hand, reviewed works on local-scale solutions analyse the in-store logistics not considering large-scale constraints or the impacts on upstream the supply chain. Consequently, there is a lack between the large and local scales, despite its usefulness for logistics managers, when defining re-shelving solutions for store deliveries, considering administration constraints (such as city access limitations), global supply chain conditions (such as urban distribution centres) and in-store issues (such as pallet jacks). In this context, this paper proposes a step-by-step guide to assist practitioners in such a decision. To do so, the store characteristics, its surroundings and the company it belongs are analysed, while considering the issues related to key stakeholders (citizens, city administrators and retailers) to ensure success of solutions (Domínguez *et al.*, 2012; Gatta and Marcucci, 2016). Hence, the contribution is threefold:

- Combination of local and large aspects. The proposed decision framework allows to easily analyse very specific features of the target store and its surroundings (seldom studied in the literature, Marcucci *et al.*, 2011), but also global limitations from the company supply chain and city constraints. Thus, a high degree of realism and accuracy is achieved, improving the usefulness for retail companies.
- Flexibility to adapt the decision process to several contexts. The proposed guide consists in a sequence of phases to be followed in order to reach an efficient re-shelving solution for store deliveries. Therefore, although the decisions taken in different situations may be different, the decision process itself is still the same.
- A clear structure in a three-stage division, in turn organised in seven phases. Hence, decisions are gradually taken, focusing on a specific part of the problem before dealing with the following steps. In addition, an iterative procedure allows decisions to be adjusted when studying the problem in-depth.

In order to validate the research and illustrate the decision-making process, the proposed framework is used by the logistics manager of two stores, located in high population density areas of Spanish cities, to define efficient prospective intervention design for re-shelving. In addition, an application as a “what if” procedure is suggested (Nuzzolo and Comi, 2014), aiming to study the possibility of amending some initial conditions, to recover solutions discarded across the decision process to finally find a better solution.

The remainder of the paper begins by clarifying the starting point and the research scope of this paper. Then, the step-by-step decision framework is explained in detail. Next, the application on two real stores is performed for validation purposes. Afterward, the “what if” procedure is presented. Finally, the main conclusions are summarised.

Problem definition

As mentioned above, city logistics is a challenge faced by many cities. From the perspective of practitioners, regarding retail store deliveries, the aim is to design the logistics system of a store, respecting city administration constraints and ensuring an adequate product supply at an affordable cost, to satisfy consumers. In order to show the dilemma faced by retailers, Table 1 represents the way as each of the three key stakeholders (citizens, city administrators and retailers) may create or destroy value (Ehrental *et al.*, 2014; Randall *et al.*, 2014; Gammelgaard *et al.*, 2016). The table must be read as: how the row influences on the column.

Table 1 – Value creation and destruction of key stakeholders in store deliveries

	Citizens	**City administrators**	**Retailers**
Citizens	-	CV: Vote periodically DV: Do not respect legislation (use of reserved spaces, etc.)	CV: Buy products and services DV: Look for alternative stores (less expensive, etc.)
City administrators	CV: Legislation for life quality (less traffic, noise, etc.) DV: Unintended effects (night activity, etc.)	-	CV: Legislation to ease activity (available spaces, etc.) DV: Legislation to limit activity (city access limitations, etc.)
Retailers	CV: Provide food and services DV: Cause traffic congestion, road occupation, noise, etc.	CV: Create jobs and population satisfaction DV: Do not respect legislation (noise, contamination, etc.)	-

CV: create value
DV: destroy value

As observed, the activity of retailers is interrelated with citizens and city administrators. Consequently, retail companies, and particularly logistics managers, must become active leaders to improve the efficiency of store deliveries, through the definition of appropriate re-shelving solutions. However, practitioners lack of methods to ease decision-making, so decisions are usually based on intuition, experience or economic interests. As a result, implemented solutions do not always solve the problem for which they were conceived and can cause unintended negative effects (Filippi *et al.*, 2010). In this context, the starting point of this research is a set of 38 solutions identified by Sanz *et al.* (2013), through a literature review on measures that can be used to improve the conditions of store re-shelving (Table 2). Note that “l/u” refers to “loading and unloading”. Afterwards, Sanz *et al.* (2015) defined 30 attributes to assess the advantages and limitations of each solution, regarding the interests of companies (lower distribution costs, high service level, etc.) and citizens (traffic flows, sustainable environment, social wellbeing, etc.). More specifically, they developed an ex-ante procedure, based on a multi-attribute decision-making perspective, to calculate a “goodness score” (Table 2), representing the quality and suitability of each solution. A positive value means benefits outweigh detriments, while negative values mean the opposite situation.

Table 2 – Solutions ranking (adapted from Sanz et al., 2015)

Solution		Goodness score
M01	Advanced systems for transport management	1.42
M02	Integration of reverse logistics	1.35
M03	Night delivery	1.23
M04	Time scheduling for freight reception	1.14
M05	Self-storage space for cargo unloading	1.12
M06	Suitable equipment for l/u activities	1.09
M07	Agreed sharing of l/u zones	1.08
M08	Communication equipment in vehicles	1.06
M09	Closing city centre to private vehicles	1.03
M10	Multiuse lane	1.00
M11	Centralise providers in distribution centres	0.99
M12	Exclusive l/u zones for UFD vehicles	0.81
M13	Sharing vehicles with other loaders	0.78
M14	Vehicles age restrictions for city access	0.68
M15	Logistics for home delivery	0.62
M16	Last mile with electric vehicles	0.61
M17	Use of controlled parking zones	0.57
M18	Special systems for vehicle positioning	0.56
M19	Use of reserved areas (disabled, motorbike, etc.)	0.52
M20	Combined use of l/u zones	0.51
M21	Cargo restrictions for city access	0.40
M22	Vigilance of l/u zones	0.36
M23	Licenses to temporarily close streets	0.33
M24	Urban tolls	0.13
M25	Time restrictions for city access	0.07
M26	Intelligent transport systems	0.04
M27	Logistics containers easy to manage	-0.03
M28	Time restrictions in l/u zones	-0.06
M29	Reservation of l/u zones	-0.16
M30	Out-of-town logistics platform	-0.55
M31	Weight restrictions for city access	-0.56
M32	Railway for freight transport	-0.62
M33	Urban terminal	-0.68
M34	Combined service for city logistics	-0.81
M35	Underground logistics platform	-0.84
M36	Shuttle areas	-0.89
M37	Use of public and private parking	-1.12
M38	External storage areas for deliveries	-1.78

In this paper, a comprehensive step-by-step decision framework is developed to assist companies in defining a suitable set of re-shelving solutions to efficiently organise store deliveries in complex urban environments, dealing with daily coexistence between commercial activities and citizens' quality of life. This investigation goes beyond the aforementioned papers, by proposing a structured and easy-to-use sequence of steps to be followed by logistics managers along the decision-making process of improving re-shelving efficiency of a store. The approach used aims to be very applicable, as illustrated by the case studies presented later, since it addresses the needs of store managers, not looking for a general assessment of each solution but on the decision-making process faced when deciding the solutions to be implemented in their store. Consequently, unlike many literature works that quantitatively evaluate the impacts of a limited set of solutions, a global and qualitative approach is here sought, considering the detail of the target store characteristics. Qualitative research is receiving increasing attention within the field of logistics and supply chain, as a means to bridge the gap between theory and practice (Trautrims *et al.*, 2012). Thus, the proposed framework guides along the whole decision process in a 3-stage structure: gathering information about the urban environment, and the target and nearby stores characteristics (Stage 1); defining re-shelving solutions (Stage 2); and assessing the combination of solutions to be implemented, though an iterative procedure to progressively adjust decisions while going in-depth into the problem (Stage 3).

The proposed step-by-step guide was developed under a qualitative research approach, using concepts from techniques such as the Gioia method (Gioia *et al.*, 2012), grounded theory (Rose *et al.*, 2016) and the documentary method (Trautrims *et al.*, 2012). Thus, despite the qualitative nature of this research, a scientific rigor was sought across the investigation in order to achieve results having a strong theoretical background while answering the practical requirements of logistics managers in their day-to-day activities. In this regard, a draft proposal of the step-by-step guide was initially developed, from authors' experience and literature review. This proposal was then presented to 26 experts through semi-structured interviews, to allow each one to lead the interview where he/she had more experience (Trautrims *et al.*, 2012). Afterwards, the guide was improved according to expert revisions, drawing up a new version (presented in the following section) which was validated by the experts. Therefore, this investigation can be aligned with design science research, which aims to develop knowledge for practitioners to implement solutions improving the design of operation systems (van Aken *et al.*, 2016). An example of design science research can be found in Kaipia *et al.* (2017), who examine the benefits and limitations of information sharing in sales and operations planning, for two product manufacturers and a retailer.

It must be noted that, according to the work scheme defined by Gioia *et al.* (2012), the research team got involved across the development of the investigation and the application on the case studies. In particular, the practical experience of the first author, as a practitioner on city logistics and supply chain, was combined with the academic experience of the second and third authors. This scheme enabled the research to include a strong applied approach, together with scientific soundness and rigor. In addition, the 26 experts surveyed included managers from food distribution companies, executives from the food industry, logistics operators, city administrators and researchers. The aim was to have a wide representation of city logistics in general, and the food distribution sector in particular (Lindholm and Behrends, 2012; Macharis and Bernardini, 2015).

The food industry is leading changes in city logistics, given the issue arising from managing perishable goods at three different temperatures (ambient, fresh and frozen), while including reverse logistics and recycling (Goldman *et al.*, 2002; Aung and Chang, 2014). Moreover, the work focuses on medium and large European cities (from 50,000 to 2 million inhabitants), whose morphology is very complex due to historical centres concentrating the core of commercial activity, having high traffic congestion and population density (Muñuzurri *et al.*, 2012). However, although the research arises from an analysis of the food sector and the European context, this paper proposes a general decision process which may be used in other sectors and contexts. Indeed, as it might be observed in the following section, the decisions to be taken across the decision-making have been standardised, not depending on the specific particularities of each case. In this way, the decision process is the same, although the decisions taken at each phase will logically be different in each case study.

Step-by-step decision framework to define a logistics system

In this section the step-by-step decision framework is described. Figure 1 shows the acting sequence, which systematises the logical decision-making process to be followed in obtaining adequate solutions for the supply chain of urban stores.

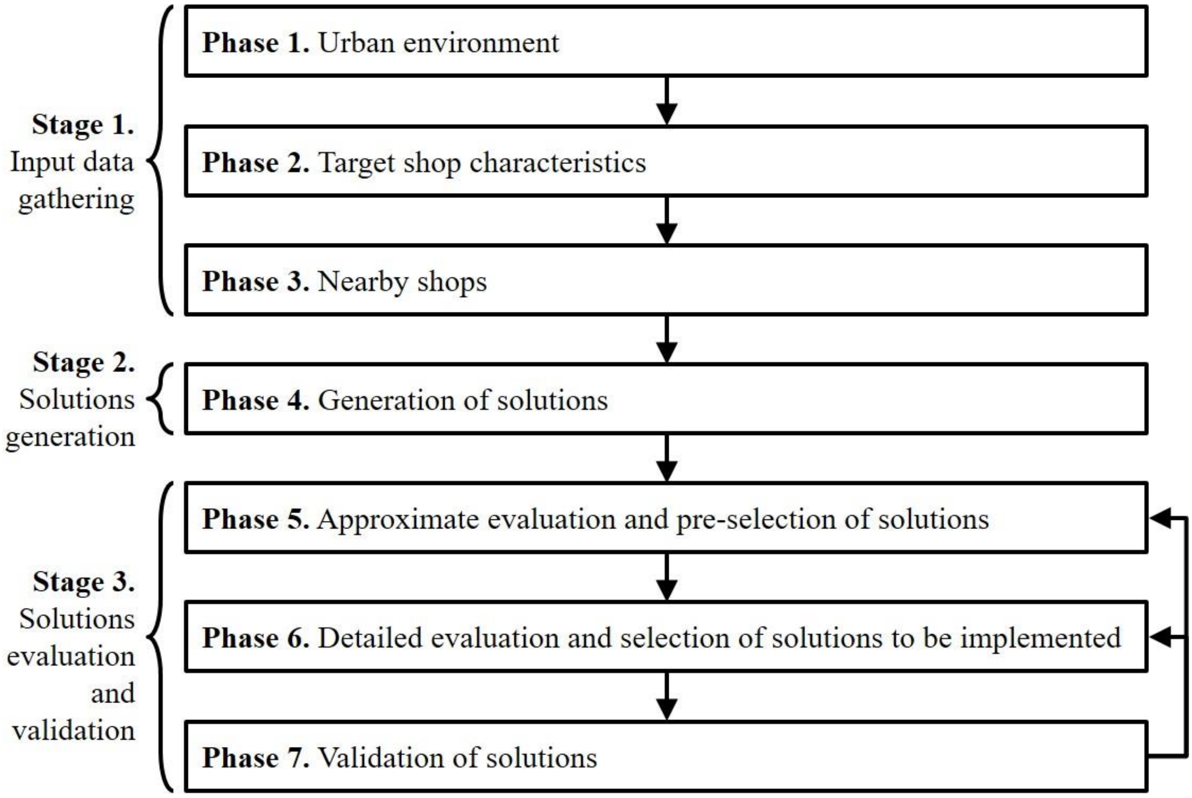

Figure 1 – Methodology to define efficient re-shelving solutions for retail store deliveries

In the business world, the most beneficial solution for companies usually consists in supplying stores using heavy vehicles at any moment of the day, making l/u operations in front of the establishment and serving goods in large containers. Despite its economical adequacy, the applicability is limited by physical, traffic or administrative issues. Therefore, a thorough analysis following the proposed 3 stages (Figure 1), detailed in next sections, assists decision-makers to select the solutions to be implemented, considering all issues involved.

Stage 1. Input data gathering

Stage 1 consists in gathering the information required for the following stages. First, an overview of the urban surrounding of the target store is examined. Then, the target store characteristics, in terms of l/u operations, are analysed. Finally, hypothetical collaborations with nearby stores are studied. As a result, a set of limitations on the solutions to be implemented are identified. The information is presented according to the elements directly affecting the target store activity. However, Stage 1 has been conceived so as data gathering can be performed in any context, without depending on the specific characteristics of each store. For instance, a nearby stadium itself is not an issue for the store. However, the high attendance of people on some particular days will probably have an influence on traffic congestion (Phase 1, *district* and *street*) and the demand behaviour (Phase 2, *commercial model*). Moreover, the way as the information is compiled is not detailed, since each company may have different means for data gathering. In contrast, focus is put on standardising the information to be gathered, which will then be useful to carry out the decision-making process in the following stages.

Stage 1. Phase 1. Urban environment

The first phase to determine a set of efficient logistics solutions for re-shelving activities is to examine the store surroundings, identifying the limitations from the city, the district and the street where the establishment is located, as well as the store outside.

- City:
    - *Number of inhabitants*, as an approximation of the amount of people shifts.
    - *Urbanised surface*, as an approximation of the distances to be covered.
    - *Population density*, as an approximation of city congestion.
    - *Routes from the distribution centre*, considering traffic congestion across the year, the week and the day, as well as the existence of tollbooths.
    - *City facilities*, such as logistics platforms, urban terminals, a combined service for city logistics or a real-time traffic information system.
    - *Other constraints*: access schedules; vehicles age, cargo or weight; etc.
- District:
    - *Typology*: residential, commercial, etc.; which affects the area congestion.
    - *Traffic congestion* across the year, the week and the day.
    - *Physical limitations* for vehicles: streets width, turning angles and type of roads.
    - *District facilities*, such as shuttle areas to transfer from large to small vehicles.
    - *Other constraints*: access schedules; vehicles age, cargo or weight; etc.
- Street:
    - *Typology*: free circulation or pedestrian (completely or at time slots).
    - *Traffic congestion* across the year, the week and the day.
    - *Physical limitations*: width, turning angles, surface, lanes and traffic direction.
    - *Other constraints*: access limitations; l/u zones; multiuse lanes; etc.
- Store outside:
    - *Municipality constraints* for l/u operations at the target store location.
    - *Facilities for l/u activities*: exclusive, shared or free l/u zones; enabled reserved spaces (motorcycles, taxis, disabled, etc.); underground parking; internal patios; etc. Their characteristics delimit the activity or vehicles used must be also gathered

(congestion, schedules, distance to the store, need for reservations, free or paid usage, minimum height and width, turning angles, etc.).
  - *Goods transportation*: limitations influencing the vehicle-store freight transport, thus affecting upstream the supply chain (pavement, ramps, storage area, etc.).
  - *Neighbours*: closeness of houses, which limits the solutions to be implemented.

Stage 1. Phase 2. Target store characteristics

The second phase consists in examining the internal facilities of the target store, the activity schedules and the service needs related to the products sold. Staff availability and ergonomics must be also taken into account. Thus, the appropriate equipment and procedures for l/u activities can be defined according to the requirements and limitations of the target store. As a result, a set of constraints is obtained, such as vehicles characteristics, delivery schedules, logistics containers to be used, etc.

- Internal facilities:
  - *Store surface*, which influences the space to move freight and the amount of products that can be replaced without storing.
  - *Entrance surface*, to check if it can be used to temporarily store freight or lockers.
  - *Storage surface*, distinguishing between ambient, cool and frozen temperatures.
  - *Physical limitations*: ramps or level changes needing from a lift or other devices, which may affect the logistics containers to be used.
  - *Mechanical devices* available for l/u operations and re-shelving activities.
- Activity schedules:
  - *Allowed activity schedule* for l/u operations and re-shelving activities.
  - *Commercial schedule*, which conditions l/u operations and re-shelving activities.
- Commercial model:
  - *Supermarket role* in terms of the customers focussed (wholesale, retailer, etc.) and the amount of brands managed.
  - *Fresh products sections* (fish, butcher and fruit), as they have a more stressed supply flow, both in self-service or counter formats, affecting schedules.
  - *Demand variations* across the year, the month, the week and the day.
  - *Customer attendance*, to disturb them as low as possible.
- Staff availability:
  - *Number of employees*.
  - *Polyvalence* for l/u operations and re-shelving activities.
  - *Flexibility*: staff schedules and adaptability for night or scheduled operations.
  - *Ergonomic limitations*, which can have an influence of freight supply.

Stage 1. Phase 3. Nearby stores

The aim of the third phase is to look for synergies in re-shelving operations with nearby stores, from the same company or the competition. Logistics collaboration between stores has proved beneficial to improve UFD efficiency, through occasional agreements (sharing l/u zones) or a more global cooperation (sharing vehicles).

- Company stores:
  - *Nearby supermarkets*: number and location of close supermarkets.
  - *Characteristics*: commercial model, schedule and market share, which has an influence on re-shelving frequency and volume.
  - *Flexibility* of supply operations and staff to adapt to collaborations.
- Competition stores:
  - *Nearby supermarkets*: number and location of close supermarkets.
  - *Flexibility* of supply operations and staff to adapt to collaborations.

Stage 2. Solutions generation

At this stage, the information about the target store and its surroundings has been gathered. Now, feasible solutions are proposed according to such information. Generally, well-known and documented solutions are used, such as the list from Table 2 (from now on called "basic solutions"). Additionally, the combination of basic solutions to form "aggregate solutions", counteracting each other's negative effects, is proposed as well as the generation of "novel solutions" to respond to the issues of each particular case study (Sanz *et al.*, 2013).
To perform the generation of solutions (Phase 4), the list of basic solutions is used as a starting point. All the solutions that respect the problem characteristics and constraints, identified in Stage 1, are considered, listing their main features. Before permanently discarding the remaining solutions, their combination to obtain feasible aggregate solutions is analysed. To do so, each constraint not satisfied by a non-feasible solution is studied, looking for another solution (or innovative idea) to combine and obtain an aggregate solution overcoming the limitation. Finally, innovative solutions that specifically respond to the target store are proposed, arising from logistics expertise, extrapolation from other sectors and novel developments from the literature or enabled by new technologies.

Stage 3. Solutions evaluation and validation

At this stage a set of feasible solutions, generated in Stage 2, is available. The aim is to select the appropriate one/s for the target store. For this purpose, a three-phase iterative procedure is carried out.

Stage 3. Phase 5. Approximate evaluation and pre-selection of solutions

To avoid spending excessive resources to evaluate in detail each solution generated in Phase 4, an approximate evaluate, discarding those having significant handicaps, is here proposed before the detailed evaluation of Phase 6. Thus, the set of solutions is reduced up to a manageable amount (around five) in three steps:

1. *Focus on UFD.* The advantages, inconveniences, approximate budget and viability of solutions from Phase 4 are analysed through the goodness score, shown in Table 2 for basic solutions. For aggregate and novel solutions, the goodness score must be calculated following the process shown in Sanz *et al.* (2015). Besides, the accomplishment of all the solutions with some feasibility thresholds that may arise from the problem analysis (budget limitations, etc.) must be ensured, as in Sanz *et al.* (2015). Thus, a list of feasible solutions is obtained, ranked from the highest to the lowest score.
2. *Impact of the upstream supply chain.* The same analysis than in (1) is carried out, but considering the whole supply chain. In particular, the effects of solutions on the company distribution system are analysed, as well as the adequacy of the available/acquirable vehicles, distribution centres, customers' requests and the respect for the company logistics policy. Solutions having limitations in the mentioned issues are discarded.
3. *Multicriteria decision-making procedure.* A set of feasible solutions is far obtained for the next phase. However, if the sample is too high, all of them with similar scores, a multicriteria decision procedure can be used. In most cases, solutions' analysis by a group of experts is enough to decide those deserving to be selected.

Stage 3. Phase 6. Detailed evaluation and selection of solutions to be implemented

In this phase a detailed analysis of solutions from Phase 5 is performed, regarding their economic, service and social impacts. At this point, solutions overcome the above filters and are adequate alternatives. However, to select the solution to be implemented, a detailed analysis of advantages and inconveniences is realised according to the involved stakeholders and the pursued objectives. The analysis is based on:

- Qualitative analysis of aspects beyond the quantitative evaluation from Phase 5.
- Specific conditions of the target store, intrinsic to each case and hardly analysable in previous phases (such as employees' experience and habits).
- Consistency with the company policy (such as electrical vehicles or reverse logistics for environment-committed companies or information systems for companies engaged in innovation).
- Decision makers' experience that could ease solutions applicability (such as sharing l/u zones for experienced decision-makers in negotiation).
- Accomplishment of expected business scopes (such as the condition of the store consolidation or the billing to justify the investment).
- Business plan to know investments needed, maintenance costs and predicted savings, using indicators such as NPV, IRR or the Pay-Back.

Additionally, the aggregation of solutions aiming to improving some inconveniences is proposed. In particular, the weaknesses of each solution (basic, aggregate or novel) must be analysed to find whether another feasible solution can be added without failing to fulfil any feasibility threshold. In this phase, the human factor has a significant value for a real applicability, since the sector experience and knowledge are key issues in taking correct decisions. As a result, the solution to be implemented in the target store is obtained.

Stage 3. Phase 7. Validation of solutions

The solution selected in Phase 6 has exceeded the abovementioned requirements and is, therefore, a suitable alternative. However, when applying theoretical ideas into the real world, unexpected events may arise. Thus, the solution must be validated by means of a pilot test to check its behaviour. To do so, qualitative and quantitative data must be controlled such as: route checking, timing measurements, unloading analysis, municipality constraints, stakeholders' satisfaction, real costs, etc. If satisfactory results are obtained, the solution is confirmed as valid and is definitely applied. Otherwise, the solution must be adapted to overcome its drawbacks. Only minor unforeseen deviations are modified, generally depending on the company itself. If the improved solution still has limitations, Phase 6 is executed again to select another solution and to check its real validity under similar conditions. This process is iteratively repeated until the final solution is found.

Validation of the step-by-step decision framework

In the previous section, the proposed decision framework was presented. For illustration and validation purposes, its use to design the re-shelving solutions for two supermarkets of a Spanish food retail company, located in Barcelona (large city, high urban density area and very congested traffic) and Santa Coloma de Gramanet (medium city, busiest commercial area). For clarity sake, Stages 1 and 2 are presented together for both supermarkets, while Stage 3 is presented separately. The validation was carried out by the Logistics Manager of the company, giving a very realistic approach to the validation.

Stage 1

Stage 1 includes the three phases where the input data is gathered: urban environment (Phase 1), target store characteristics (Phase 2) and nearby stores (Phase 3). The obtained information is presented in Table 3, which allows the data (by rows) from both stores (columns 4 and 5) to be compared.

Stage 2

In this stage, the generation of solutions (Phase 4) is carried out to obtain feasible solutions (basic, aggregate or novel). First, the basic 38 solutions from the literature (Table 2) are considered. After analysing the information from Stage 1 (Table 3), the set of feasible solutions is reduced up to 20 options in Barcelona and 18 in Santa Coloma de Gramanet (Table 4). For example, shuttle areas and external delivery zones are not possible since such infrastructures do not exist in the surroundings; the urban terminal is not available for foodstuffs; there is neither metro nor tramway adapted for goods transport; there is no space for vehicle positioning systems; etc.

Table 3 – Information gathered in Stage 1 for Barcelona and Santa Coloma de Gramanet

		Data	Barcelona	Santa Coloma de Gramanet
Phase 1	**City**	Number of inhabitants	1,608,746	117,153
		Urbanised surface	102 km²	7 km²
		Population density	15,687 inhabitants/km²	16,963 inhabitants/km²
		Routes from the distribution centre	3 options (shortest one 20.0 km) Traffic congestion: High: 6-10h and 17-21h Light: rest of the day	2 options (shortest one 18.3 km) Traffic congestion: High: 6-10h and 17-21h Light: rest of the day
		City facilities	Logistics Activities Zone, near Goods Integral Centre, 20km away Urban terminal not usable	–
		Other constraints	Not relevant for the target shop	Not relevant for the target shop
	District	Typology	Commercial and transited area	Shopping area of the city
		Traffic congestion	High except summer/weekends Especially high in rush hours	High except summer/weekends Especially high in rush hours
		Physical limitations	Good streets width, steering angles and roadways	Good streets width, steering angles and roadways
		District facilities	–	–
		Other constraints	Not relevant for the target shop	Not relevant for the target shop
	Street	Typology	Circulation free	Circulation free
		Traffic congestion	High except summer/weekends Especially high in rush hours	High except summer/weekends Especially high in rush hours
		Physical limitations	Small access steering angle Narrow street 1 lane, single direction flow Inability to block street for l/u	Small access steering angle Wide street 2 lanes, double direction flow Inability to block street for l/u
		Other constraints	Not relevant for the target shop	Not relevant for the target shop
	Shop outside	Municipality constraints	Non-existing for l/u operations	Non-existing for l/u operations
		Facilities for l/u activities	Very congested zone 9m away Less congested zone 3 streets away Night zone 15m away	Not very congested zone 15m away (other street side)
		Goods transportation	Adequate road surface and access ramps for l/u operations Goods must cross the shop from l/u zones to storage zone	Adequate road surface and access ramps for l/u operations Direct access from l/u zone to storage zone
		Neighbours	Above shop	Adjacent building
Phase 2	**Internal facilities**	Shop surface	604 m^2	499 m^2
		Entrance surface	30 m^2	25 m^2
		Ambient/Cool/Frozen storage	20/15/small m^2	50/20/small m^2
		Physical limitations	–	–
		Mechanical devices	2 manual pallet jacks	2 manual pallet jacks
	Activity schedules	Allowed activity schedule	8-21h, except 24h licences for neighbour-respectful activities	8-21h
		Commercial schedule	9-21h	9-21h
	Commercial model	Supermarket role	Retailer and medium assortment	Retailer and medium assortment
		Fresh products sections	Counter and self-service for: fruits/ veg, butchery, charcuterie and frozen. Counter for fish products.	Counter and self-service for: fruits/ veg, butchery, charcuterie and frozen. Counter for fish products.
		Demand variations	Yearly: slight decrease in summer big increase in Christmas Monthly: slight increase first week Weekly: slight increase Mo/Fr/Sa Daily: tops 10-13h and 18-21h	Slight decrease in summer
		Customer attendance	10-14h and 17-21h	11-14h and 17-21h
	Staff availability	No. employees	15	14
		Polyvalence	100% except 5 fresh prod. specialists	100% except 5 fresh prod. specialists
		Flexibility	2 shifts of 6.5 hours Mon to Sat 8-21h	2 shifts of 6.5 hours Mon to Sat 8-21h
		Ergonomic limitations	Shelf height	Shelf height
Phase 3	**Company shops**	Nearby supermarkets	1 (same district) / 1 (same street)	1 (another district)
		Characteristics	Similar commercial model Slightly lower sales Less crowded l/u zones	Similar commercial model Slightly higher sales
		Flexibility	Exclusive staff for each shop Flexible supply conditions	Exclusive staff for each shop Flexible supply conditions
	Competition shops	Nearby supermarkets	13 (3 same street)	0
		Flexibility	Not studied since there are nearby shops from the same company	–

Table 4 – Solutions generated in Stage 2 for Barcelona and Santa Coloma de Gramanet

Barcelona			Santa Coloma de Gramanet		
Policies		Score	Policies		Score
M01	Advanced systems for transport manag.	1.42	M01	Advanced systems for transport manag.	1.42
M02	Integration of reverse logistics	1.35	M02	Integration of reverse logistics	1.35
M03	Night delivery	1.23	M03	Night delivery	N.A.
M04	Time scheduling for freight reception	N.A.*	M04	Time scheduling for freight reception	1.14
M05	Self-storage space for cargo unloading	N.A.	M05	Self-storage space for cargo unloading	N.A.
M06	Suitable equipment for l/u activities	1.09	M06	Suitable equipment for l/u activities	1.09
M07	Agreed sharing of l/u zones	N.A.	M07	Agreed sharing of l/u zones	N.A.
M08	Communication equipment in vehicles	1.06	M08	Communication equip. in vehicles	1.06
M09	Closing city centre to private vehicles	N.A.	M09	Closing city centre to private vehicles	N.A.
M10	Multiuse lane	N.A.	M10	Multiuse lane	N.A.
M11	Centralise providers in dist. centres	0.99	M11	Centralise providers in dist. centres	0.99
M12	Exclusive l/u zones for UFD vehicles	0.81	M12	Exclusive l/u zones for UFD vehicles	0.81
M13	Sharing vehicles with other loaders	N.A.	M13	Sharing vehicles with other loaders	N.A.
M14	Vehicles age restrictions for city access	0.68	M14	Vehicles age restrict. for city access	0.68
M15	Logistics for home delivery	0.62	M15	Logistics for home delivery	0.62
M16	Last mile with electric vehicles	N.A.	M16	Last mile with electric vehicles	N.A.
M17	Use of controlled parking zones	0.57	M17	Use of controlled parking zones	N.A.
M18	Special systems for vehicle positioning	N.A.	M18	Special systems for vehicle positioning	N.A.
M19	Use of reserved areas	N.A.	M19	Use of reserved areas	N.A.
M20	Combined use of l/u zones	0.51	M20	Combined use of l/u zones	0.51
M21	Cargo restrictions for city access	0.40	M21	Cargo restrictions for city access	0.40
M22	Vigilance of l/u zones	0.36	M22	Vigilance of l/u zones	0.36
M23	Licenses to temporarily close streets	0.33	M23	Licenses to temporarily close streets	N.A.
M24	Urban tolls	0.13	M24	Urban tolls	0.13
M25	Time restrictions for city access	0.07	M25	Time restrictions for city access	0.07
M26	Intelligent transport systems	N.A.	M26	Intelligent transport systems	N.A.
M27	Logistics containers easy to manage	-0.03	M27	Logistics containers easy to manage	-0.03
M28	Time restrictions in l/u zones	N.A.	M28	Time restrictions in l/u zones	N.A.
M29	Reservation of l/u zones	-0.16	M29	Reservation of l/u zones	-0.16
M30	Out-of-town logistics platform	N.A.	M30	Out-of-town logistics platform	N.A.
M31	Weight restrictions for city access	-0.56	M31	Weight restrictions for city access	-0.56
M32	Railway for freight transport	N.A.	M32	Railway for freight transport	N.A.
M33	Urban terminal	N.A.	M33	Urban terminal	N.A.
M34	Combined service for city logistics	N.A.	M34	Combined service for city logistics	N.A.
M35	Underground logistics platform	N.A.	M35	Underground logistics platform	N.A.
M36	Shuttle areas	N.A.	M36	Shuttle areas	N.A.
M37	Use of public and private parking	-1.12	M37	Use of public and private parking	-1.12
M38	External storage areas for deliveries	N.A.	M38	External storage areas for deliveries	N.A.

*N.A.: not applicable

Afterwards, the combination of discarded solutions and the inclusion of new solutions are tested aiming to obtain feasible aggregate or novel solutions. However, no additional feasible solutions are obtained in both supermarkets.

Stage 3 (Barcelona)

Once the list of feasible solutions has been obtained, an appropriate option is selected by means of an iterative procedure, which is presented next for the supermarket of Barcelona, following the three phases (5, 6 and 7) of this stage.

Stage 3. Phase 5 (Barcelona)

This phase consists of an approximate evaluation of previously generated solutions and a selection of a reduced group among them, from the point of view of UFD itself and the impacts of the upstream supply chain. Where necessary, this can be complemented by a multicriteria decision-making procedure to assist in the definitive selection.

Regarding UFD itself, the solution M37 is directly discarded, since it never complies with feasibility thresholds. In fact, this solution has many obstacles, such as the opposition of parking space owners and the need for adequate goods transport facilities, especially in underground parking, which is the common case in Barcelona. To complete the analysis, an approximate budget is calculated for the remaining 19 solutions, determining that all of them are acceptable, and the goodness scores from Sanz *et al.* (2015) are considered (Table 4). Regarding the impacts of the upstream supply chain, M27 is discarded since the automation rigidity of the distribution centre allows using pallets, but not other types of containers. Therefore, 18 feasible solutions are still available. However, it is noted that the goodness scores of the 6 top-ranked solutions clearly stand out above the others: M01 (1.42), M02 (1.35), M03 (1.23), M06 (1.09), M08 (1.06) and M11 (0.99); so these solutions are selected for Phase 6.

Stage 3. Phase 6 (Barcelona)

In this phase a detailed evaluation of the 6 pre-selected solutions is realised. Next, the most relevant features of each solution are described with regard to the supermarket:

- **Advanced systems for transport management (M01).** Since the company already has a system of this kind, the main drawbacks of this solution (high investment cost and complex use) disappear. Therefore, this is a very good option for route optimisation and vehicles load, but traffic congestion and occupation of l/u zones cannot be avoided.
- **Integration of reverse logistics (M02).** The company already uses this solution in most stores. Therefore, this is a very good option, although it never provides as many benefits as other options for this particular case study.
- **Night delivery (M03).** Barcelona's municipality has already implemented night delivery projects, so the requirements to avoid the negative impact of this solution are clearly defined and can be assumed by the company. Consequently, this is a very good solution for solving traffic congestion and high l/u zones occupation problems.
- **Suitable equipment for l/u activities (M06).** To carry out more efficient l/u operations, more sophisticated equipment with capacity for lifting would be necessary. Forklift trucks are discarded due to their high cost, but pallet jacks are considered.
- **Communication equipment in vehicles (M08).** The application of this solution is very simple, since carriers already have such devices. However, these devices do not provide great benefits, especially for citizens.

- **Centralise providers in distribution centres (M11).** This solution is usually has high investment and operation costs, but the company already has distribution centres. Therefore, this is a good solution since only adapting and expanding centres would be necessary, while synergies and economies of scale are expected.

Finally, some solutions are combined to obtain suitable aggregate solutions. Starting from M03, and based on previous experiences of the company, M02 and M11 are added to multiply the benefits of the combination. Besides, M06 (pallet jacks) and M23 (*Licenses to temporarily close streets*), discarded in Phase 5, are re-considered to improve the efficiency of this option. Thus, an aggregate solution, where limitations of each basic solution are balanced out between each other, is selected.

Stage 3. Phase 7 (Barcelona)

Finally, the selected aggregate solution is validated through its implementation into the real supermarket. This process is driven by the store logistics manager, in collaboration with the staff involved in l/u activities. The aim is to check whether the solutions' behaviour turns out to be as expected. To do so, the logistics manager gathers information about re-shelving activities before and after the implementation.

As night delivery (M03) is implemented, providers are centralised in distribution centres (M11) to allow their supply during daytime. In addition, the negative effects of night activities (M03) are minimised using adequate equipment (M06) and closing streets during l/u activities (M23). In this way, re-shelving activities can be carried out faster so as reverse logistics (M02) can be easily integrated. In this regard, measures were taken by the logistics manager about the time for trucks l/u and from the distribution centre, obtaining an average reduction of 25 and 20 minutes, respectively. This time saving also implies a reduction on greenhouse gas emissions. Moreover, as re-shelving activities are moved into night-time, customers and pedestrians are not disturbed during daytime. In contrast, the implementation implies a global cost of around 10,000 €, including 2 noiseless manual pallet jacks, rubber rugs to pull pallet jacks across the road, noiseless lifting platforms and engine adaptations of the trucks, and a drivers' training to increase driving efficiency.

It must be noted that the main drawback across the pilot project was the opposition of some employees to working at night, which was solved after agreeing a night-time bonus and staff rotation. Additionally, after the first week, one of the vehicles was sent to the garage for repairs to reduce the engine noise. After the second week, instructions were given to employees to realise l/u operations silently, to avoid disturbing neighbours. Finally, due to a medical emergency one night, l/u activities were partially interrupted. Therefore, this solution was finally implemented in the store as well as in nearby stores.

Stage 3 (Santa Coloma de Gramanet)

Next, Stage 3 is presented for the supermarket of Santa Coloma de Gramanet.

Stage 3. Phase 5 (Santa Coloma de Gramanet)

As in Barcelona, solutions M37 and M27 were discarded since they never accomplish with feasibility thresholds. For the remaining 16 solutions, an approximate budget is calculated, determining that all of them are acceptable, and the goodness scores from Sanz *et al.* (2015) are considered (Table 4). Among the 16 solutions, the goodness scores of the 6 top-ranked ones clearly stand out above the others: M01 (1.42), M02 (1.35), M04 (1.14), M06 (1.09), M08 (1.06) and M11 (0.99); so these solutions are selected for Phase 6.

Stage 3. Phase 6 (Santa Coloma de Gramanet)

Next, the most relevant features of such solutions are described with regard to the case study (considering most of the comments made for the supermarket of Barcelona):

- **Advanced systems for transport management (M01).** Very good solution for vehicles load and route optimisation, but cannot avoid traffic congestion and l/u zones occupation.
- **Integration of reverse logistics (M02).** Very good solution, although it never provides as many benefits as other options for the target store.
- **Time scheduling for freight reception (M04).** The main drawback of this solution is its operational management difficulty, having to arrange delivery schedules with all suppliers. Even so, this is considered a good solution for the target store.
- **Suitable equipment for l/u activities (M06).** Pallet jacks are considered a good option.
- **Communication equipment in vehicles (M08).** This is a very simple solution, although these devices do not provide great benefits for citizens.
- **Centralise providers in distribution centres (M11).** This is a good solution, just requiring a small investment to adapt and expand the centres, while synergies and economies of scale are expected to reduce the operation costs.

Finally, 5 of the 6 basic solutions are combined to obtain a more suitable aggregate solution for the target store: M01, M02, M04, M08 and M11. Thus, the limitations of each basic solution are balanced out without incompatibilities, and this is the option selected for Phase 7.

Stage 3. Phase 7 (Santa Coloma de Gramanet)

Finally, the selected aggregate solution is implemented into the real supermarket by the store's logistics manager and staff. In this case, the use of a Transport Management System (M01) together with the centralisation of providers in distribution centres (M11) enables to efficiently organise re-shelving activities and eases the integration of reverse logistics (M02). This whole solution is facilitated by including communication equipment in the vehicles (M08) and schedules for freight reception (M02). Unfortunately, the solution does not lead to the expected benefits due to the illegal occupation of l/u zones, so a greater Municipal control would be necessary. In contrast, the cost for this solution is very low since the company already has a Transport Management Systems license and communication equipment in most vehicles, so any improvement in the efficiency becomes globally positive.

“What if” procedure

Thus far, the proposed decision framework has been described and validated. Now, a complementary “what if” approach is suggested to evaluate the impact caused by changes in the initial conditions, assessed in Stage 1, to achieve more efficient solutions. These modifications can be obtained, for example, in exchange for an additional cost and will presumably be leaded by the own company, either on the target store (products’ assortment or facilities), its surroundings (ramps or l/u zones) or the upstream supply chain (smaller vehicles or unloading systems). Modifications in municipality constraints could also be achieved, after the corresponding negotiations, such as the allowed activity schedules or vehicles weight.

The “what if” analysis is proposed for: (1) unfeasible solutions discarded in Phase 4 (case I), due to their non-adaptability to the environment and/or the target store; (2) unfeasible solutions discarded in Phase 5 (case II), since they do not overcome the feasibility thresholds; and (3) feasible solutions pre-selected in Phase 5 and evaluated in Phase 6 (case III), for their improvement. The starting point is the input data gathered in Stage 1: urban environment, target store characteristics, and nearby stores. With this information, the aim is to check whether initial conditions can be modified to obtain new and more efficient solutions. To do so, the next procedure is applied to each solution from cases I, II and III:

1. Enumeration of inputs causing non-feasibility (cases I and II) or limiting goodness (case III).
2. Examination of inputs to be modified (and how) or removed to achieve feasibility (cases I and II) or improvement (case III).
3. Evaluation of the modifications viability.
4. Evaluation of viable modifications’ cost.
5. Selection of modifications having acceptable cost and viability.

Logically, solutions recovered or improved there should pursue the decision process. Besides, this procedure must be carried out before the solution validation (Phase 7), to avoid implementing a pilot project before analysing all the possibilities.

Conclusions

In this work, a step-by-step decision framework to define efficient re-shelving solutions for store deliveries in complex urban contexts is proposed. More specifically, the scheme and acting sequence are presented, organised in seven phases grouped into three stages. First, the urban environment and characteristics of the target store and nearby ones are analysed, gathering the input data for the following stages. Second, several feasible solutions are generated and evaluated, while satisfying the problem constraints. Third, the solution (or set of solutions) to be implemented is selected by means of an iterative procedure that includes a pilot test to ensure validity of solutions when implemented. The proposed scheme represents the logical decision-making process to be followed when improving store deliveries in urban stores of large retail companies. This thoroughness is needed to justify the decisions taken and to ease understanding of the implications of selected solutions.

Next, the decision framework is used by the logistics manager of a Spanish food retail company to design an adequate re-shelving solution for two supermarkets located in areas with high population density, commercial activities and traffic congestion: a big and a medium city; which represent the scope of cities focused in this work. Both applications allow, on the one hand, the functioning of the decision framework to be illustrated and, on the other hand, its performance and usefulness to be validated. Results show how a combination of solutions, different for each supermarket, is selected. Finally, an application as a "what if" procedure is introduced to study modifications of some initial conditions to rescue discarded solutions and make them feasible or improve already feasible ones.

The proposed decision framework has been developed on the basis of the food sector and the European context. However, it could be used in other sectors or contexts, since it does not depend on the specific characteristics of each case. In fact, the same decision process by the same logistics manager for the two case studies, leads to different solutions since the context is not the same. In order to support such a statement, new applications could be developed, for instance at the informatics or textile sectors, or Asian or American cities. In this regard, the decision taken along the process should be logically revised. In particular, the goodness score (Table 2) should be adapted to represent the suitability of solutions in a new context, or if new technologies appear leading to novel solutions to be examined. In line with Golicic and Davis (2012), a combination of qualitative and quantitative methods to evaluate the impacts over citizens and practitioners of each solution could be developed to strengthen the proposed decision-making process. These methods could be used both in the calculation of the goodness score and the measure of the impacts of the pilot projects in Phase 7. In this sense, not only the perspective of retailers, but also of other stakeholders involved should be assessed to evaluate the global suitability of solutions for the society. Finally, as mentioned before, this research is work-in-process investigation and can be linked to early design science research (van Aken *et al.*, 2016). The research methodology used in this paper has had the intention of iteratively improving the performance of the proposed step-by-step guide, to evaluate suitable solutions for re-shelving at an early stage intervention. However, further evaluation could be developed to analyse perceptions of logistics practitioners about the benefits and limitations of the proposed re-shelving solutions.

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