Original Research

Understanding coordination drivers to Align last-mile logistics with supply chain objectives: A case in the retail sector

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Abstract
With the boom of e-commerce, urbanization and population growth, the complexity of the last mile in the SC has increased, forcing companies to evaluate new distribution strategies and face new logistical challenges. Coordination mechanisms appear as a solution to cope with the challenges of the last mile. However, without considering the general supply chain strategy coordination mechanisms could generate a conflict in logistics operations. Studies related to coordination mechanisms in the last mile of the supply chain have been influenced by the absence of practical applications, reflecting a need for considering the supply chain actors and their roles... And to avoid inefficient diagnosis in the application of coordination in the supply chain.
A three-phase methodology is proposed to diagnose the needs of last-mile logistics. In the first phase, coordination drivers are identified through a literature review and subsequently validated by industry and academia. In the second phase, the level of incidence of each driver is measured in the particular context of the company. Finally, in the third phase, coordination mechanisms are proposed to improve the performance of the supply chain according to the levels of incidence found. The proposed methodology s validated in a case in the city of Bogotá. This research highlights the need to identify coordination drivers existing within the company and how well they adjust to the supply chain strategy. The results of our study are helpful for logistics practitioners to evaluate the fitting of a coordination mechanism and their logistics needs. Additionally, for scholars, it shows how coordination can be applied in industries in a developing economy and what are the challenges to fit coordination with the context of these companies

Keywords - Coordination; Coordination mechanisms; Last Mile; Logistics; Supply Chain

INTRODUCTION

Last-mile logistics is the final stage of a supply chain (SC) where products are taken from a warehouse or a logistics facility to the customer [1]. Last-mile highly contributes to the carbon footprint of supply chains, especially in urban contexts [2]. This relatively recent concept responds to the need of finding sustainable last-mile solutions that contribute not only to cost reduction but congestion and environmental effects, particularly in cities with a high density of people [3]

Additionally, an SC aims to maximize the total value generated, where that value corresponds to the difference between the revenues of the final product and the cost incurred within the chain to meet the request of different points of demand [4]

Last-mile logistics is known to be the most expensive, inefficient, and polluting section of the SC [5] As population grows in the world's major cities and the expansion of traditional trade channels such as e-commerce [6] had put pressure on the construction of more complex city systems where mobility patterns and services based on shared resources such as last-mile logistics have appeared [7]. The increase in urbanization and the concern for efficient freight transport highlight the importance of urban logistics and the last mile.

As the last-mile is a leg of an extended SC, the solutions to the last-mile problem must be aligned with the objectives of SC. As exposed in the literature review, different authors claim that this can only be achieved via the coordination of the different stages in the SC. Within the coordination mechanisms, contracts, pricing, and ordering strategies[8], and the use of data techniques have been found as solutions[9], [10]. Despite the participation of coordination mechanisms in the literature and the increasing interest in improving indicators within supply chains, not all actors may want to coordinate properly their operations. Therefore, it is necessary to identify which actors within the logistics chain want to coordinate and agree on what to coordinate and why coordinate? As well as evaluating the different situations that can be possible [11]

Coordination mechanisms balance individual gain and global gain in decentralized schemes. These are schemes where each role and actor seek its own benefit and a coordinated scheme where the need to share information is highlighted[12], the use of information technologies to improve coordination performance [13]–[15]negotiation strategies to strengthen coordination performance [16]–[18] and contracts as coordination mechanisms[19].

Thus, the different mechanisms identified in the literature are based on the handling of different assumptions and neglect specific conditions of the context of a SC such as the existence of power structures, the characteristics of the demand, the context of the environment where the SC operates or the specific conditions in the logistics operation [9], [20], [21]. These characteristics are not considered in all the mechanisms of coordination leading to a lack of adequate identification of the different drivers that may affect the application of a coordination mechanism. Because of a weak or non-existent identification of the appropriate drivers, a low real application of coordination mechanisms can be observed in the industry [22].

In this article we propose a methodology to identify the drivers that enable coordination mechanisms, this methodology includes a validation in a case study in a large company producing and distributing backpacks in Bogota, a central metropolitan area of a country in process of economic development. Past research has shown that the context of developing countries imposes additional challenges to logistics coordination and urban last mile. The object of study will focus on the last mile mainly on the distribution activities of the company.

The structure of this paper is organized as follows: Section 2 develops a literature review about coordination in last mile. Section 3 presents the proposed DEA Methodology for the driver's identification. Section 4 validates the methodology within a case study. Section 5 creates a discussion about the presented methodology. Finally, Section 6 ends with conclusions

COORDINATION IN THE LAST MILE OF SUPPLY CHAIN -LITERATURE REVIEW

Coordination opposed to local optimization, is a mean to improve the performance of all actors involved in the chain. It has also been defined as the relationship between the different actors involved in the logistics chain to obtain a common benefit[23], [24]. In other words, the role of coordination is the management of dependencies between the roles and the joint effort of these to achieve mutually defined objectives.

SC coordination is a process built from a gradual trust in combination with proper design, financing, monitored collaboration and information-sharing tools. Academic papers touching the topic of coordination, have identified shortcomings when it comes to applications in practice. Reasons for failure have been lacked of trust, fear of external competition, inadequate infrastructure, and financial barriers to sharing resources and income [25], [26]

Coordination mechanisms have been considered to improve the coordination performance by focusing on the need for all actors to derive benefits either vertically or horizontally. Research related to the mechanisms applicable in horizontal coordination has focused on cost optimization as a starting point and has subsequently focused on evaluating and optimizing the efficiency of the chain [27]–[30]. However, to improve the efficiency of the chain using horizontal coordination, it is necessary to manage alternatives that allow gains sharing between the roles involved [31], [32], and managing the information in the chain due to its influence on coordination performance [33], [34] and know the objectives that are intended to be obtained with the coordination to manage relationships in which the gain of each of the actors is win-win [35]

Research focused on mechanisms applicable in vertical coordination on the other hand, has included analysis of supplier-producer relationships [25], [36], [37], Producer-Retailer [38]–[40], supplier-retailer[41], [42], supplier-producer-retailer [43],

[44], and supplier-carrier [45]. In the single-supplier-single-vendor scheme in the supply chain, much of the wholesale price contract and revenue-sharing contract mechanisms have been focused on achieving coordination [46].

However, the last mile represents the most complex stretch within urban distribution systems since it is considered the most expensive and complex task to manage within the supply chain. Shipping from a distribution center to a customer typically takes up to 28% of the total cost of transportation where last-mile operations are primarily responsible for polluting emissions from cities [47]

Urban logistics seek to increase supply chain efficiency in terms of costs, time and resources by changing methods and means of transportation while maintaining sustainability [48]. These initiatives consider a variety of measures including driving behavior education programs, improved public information provision, vehicle grouping, standardization of charging units, fuel technology advances, cargo consolidation facilities, and policy measures to regulate vehicle traffic [49].

Several solutions have been proposed to reduce coordination problems in the last mile such as time constraints, weight, and size of loads, as well as after-hours deliveries, urban consolidation centres[50] and networks of collection points. Improve transport infrastructure, mass transit systems, priority measures for buses, bicycle sharing and public bicycles, government involvement and policies to promote solutions and other means, among others [51] These works attending the big incidence of having an adequate coordination in the SC Performance. Last-mile coordination should therefore consider the main issues faced by the different roles and actors and should be seen to adequate the aligning of last-mile objectives with the SC and in general with any enterprise objectives.

Full coordination is recurrently impractical because it is very expensive or risky. Making information available to other companies and information management requires investment in information technologies that result in a negative cost-benefit analysis [52].

In the literature, scholars have identified drivers that can influence the implementation of coordination mechanisms [1], [15], [49], [53], [54]. On Table I are presented the main drivers found in the literature review where the authors [55] consider that the level of incidence of drivers is positive towards coordination. In addition, it is possible that the drivers have a degree of impact on the supply chain. Ssignificant differences regarding the level of impact of the drivers that affect coordination that may be due to characteristics such as the context, type of coordination or even the sector where a mechanism is being applied. In some cases, the authors agreed on the definition of the impact of a driver on the implementation of coordination mechanisms.

The same happens with investigations where the drivers are more implicit, such as when the author assumes that all actors want to coordinate or when he assumes that the relationship of trust between all actors is the same, which in turn is limiting practical application.

TABLE I
DRIVER IDENTIFICATION FROM LITERATURE REVIEW

Driver	Description
D1	Market changes
D2	Resources & infrastructure capacity
D3	Sector capacity
D4	High level Management Commitment
D5	Financial Costs
D6	Incentives
D7	Economic uncertainty
D8	Indicators
D9	National and regional politics and regulations
D10	Maturity level
D11	Governmental entities support
D12	Information management and traceability
D13	Information sharing ability
D14	Members commitment
D15	Members trust

D16	Socioeconomic
D17	Leadership capabilities
D18	Power distributions
D19	Relationship and strategic alignment

Source: Authors.

This information will be useful as a starting point for knowing the initial state of a supply chain in terms of its existing coordination mechanisms, whether it has previously been coordinated, coordinated, identified as likely to limit, impede or facilitate coordination.

On the one hand, authors who worked on coordination mechanisms have not visualized the complexity required to build a coordination mechanism without understanding the needs of the stretch of the chain they are going to evaluate [25], [53], [56]. It is clear that there are a series of drivers that according to the type of industry, sector, context or type of coordination, the application of a mechanism manifests different qualities, which again leads us to the question of how to identify those drivers that affect the coordination of actors taking as an object of study the last mile of the supply chain. To solve this concern, the following chapter proposes the construction of the methodological proposal to identify the drivers that affect coordination.

PROPOSED METHODOLOGY

The implications of the drivers that are previously identified have considered from different perspectives the effects that the coordination mechanisms that exist in the literature may have and have sought to mitigate them. [27], [29], [38], [40], [46], [48], [49]. However, the identification of these drivers in a particular role or stretch of the supply chain influences the future design of horizontal and vertical coordination mechanisms where it is intended to evaluate the effect of role-specific barriers and enablers on coordination. Although the identification of these drivers may increase the level of complexity of the coordination mechanisms, it will be possible to have closer approximations to the real behavior of the supply chain horizontally and vertically. [47]. Likewise, a correct measurement and identification of these drivers can help measure more accurate coordination indicators.

Despite the efforts of different authors in identifying barriers and enablers that influences coordination [32], [50], [51] There are similar and different approaches to the identified drivers. Similarly, some of these studies are based on a classification in the literature for the identification of the drivers [38], [44], [47] But there is no measurement of coordination levels and even a methodology to identify the needs of coordination.

A methodology is needed to identify the main drivers that enable the coordination of actors. It consists of three main phases to Diagnosis, Evaluation and Analysis. Each phase consists on a series of steps whose central objective is to identify the drivers that could enable coordination in the last mile. After their identification, the level of incidence of each driver is measured to understand the current state of a SC in terms of coordination and to propose a mechanism that fits the current behaviour of the drivers.

The drivers that enable coordination can greatly facilitate the application of the mechanisms in practical cases. Identifying these drivers and standardizing their identification through a methodology can give supply chain actors a tool to identify appropriately and in context the drivers before applying or proposing a coordination mechanism in a case study. In chapter three of the research, it was evident that the manifestation of some drivers, as well as their incidence may vary according to geographical contexts, sectors of the economy, types of coordination or even coordination mechanisms.

TABLE II
COMPOSITION OF DEA METHODOLOGY

Phase	Description	Step	Tickets	Outputs
Diagnose	Identification of the main characteristics of coordination and actors in the last mile	Step 1	- Identification of the sector - Identification of the type of supply chain - Identification of the chain section - Identification of actors - Identification of the type of coordination - Identification and understanding of the process to be coordinated	Supply chain characterization and scope of coordination
		Step 2	- Selection of the drivers to measure the level of incidence through a panel of experts	List of selected drivers
Evaluate	Measurement of the level of incidence of each of the drivers	Step 1	- Determination of measurement indicators - Sample size determination - Determination of measurement scales - Determination of statistical techniques - Selection of guide measuring instruments	Measuring Instrument and Sample Size
		Step 2	- Application of the measuring instrument	Incidence levels by Driver
Analyze	Analysis of incidence levels and suggestion of a coordination mechanism	Step 1	- Diagramming of results and construction of scenarios of incidence levels	Evaluation of the level of incidence of each driver
		Step 2	- Proposal of alternative based on the results	Proposal for a coordination mechanism

FIGURE 1
DEA METHODOLOGY.
SOURCE: AUTHORS.

The concepts of the four pillars of the SCOR model (Supply Chain Council of North America, 2010) were used in order to build the methodology. The four pillars of the SCOR model focus on modeling the supply chain to know, categorize and classify processes to later measure the level of supply chain performance. Once the relevant indicators have been measured and the results obtained, it is expected to make use of the best practices of similar chains or even roles within the chain in order to start acting on improving performance. All the processing of the SCOR model concludes in the last pillar where the positive effects on the operational processes are reflected.

To make a transition to a broader characterization process that considers not only the actors traditionally found in the literature but those that are not commonly considered as logistics service companies, carriers, groups or market alliances.

It is not only enough to know who is going to carry out the coordination, but it is also necessary to understand why to coordinate, and what is the objective of considering that coordination within a vector of alternatives to improve efficiency and costs.

After understanding why to coordinate and who will coordinate it is necessary to establish what to coordinate, processes, inventories, and information to establish the appropriate mechanism to meet that need.

Finally, considering the sector to be evaluated can make a difference. For example, supply chains in the food sector has influential elements such as care, and storage time required by a product to one dedicated to the production of goods with a longer shelf life

To identify which of the 19 drivers affect the coordination mechanisms found in the state of the art apply for the last mile, a validation was carried out by experts from academia and industries. A calculation of the weights of the drivers is proposed from comparisons of two to two, asking if the Driver Di has more incidence than the Dj (or vice versa) and how much more, using the following scale [57]

- Dij = 1: driver i is considered to have an equal impact on coordination mechanisms as driver j
- Dij = 3: driver i is considered slightly more incidences than driver j
- Dij = 5: driver i is considered to be much more relevant than driver j
- Dij = 7: driver i is considered with much more incidence than driver j
- Dij = 9: driver i is considered to be absolutely more influential than driver j

2. Evaluate

A relevant aspect of the research methodology is the estimation or calculation of the number of participants that should be included in a study [58]. In this case, the study population once the variables have been identified corresponds to the total number of positions and people involved in the processes of the roles identified in phase one of the proposed methodology. The sample size varies according to the number of roles and the type of coordination defined in it scope. Finally, to obtain the result of each driver and because the questions used to measure the level of incidence do not correspond to numerical values but categorical ordinals between 1 and 4 for each question, a sum of the value of each category obtained in the questions corresponding to each driver was made. Those questions were designed in a single questionary in order to obtain data for each driver.

3. Analyze

For this research, the object of study is the last mile and therefore the alternatives of coordination mechanisms will be focused on activities of the last mile that correspond to the distribution processes. The alternatives that will be considered for the distribution processes in the last mile should consider an important stage of information collection. The information required for the construction of the coordination mechanisms does not necessarily imply that the sales data and data relevant to the data processing policy with the client will be made public. Importantly, there may be different types of coordination mechanisms for the last mile of the supply chain that should be considered according to the role, type of industry and context, we present the main one for the study:

-Coordination mechanisms in storage: These are focused on infrastructures designed to store products belonging to third parties, shared inventory policies, joint demand planning, increased levels of inventory security are terms investigated in these mechanisms [59], [60].

-Coordination mechanisms in distribution: Focusing on strategic decision-making, the authors have investigated coordination mechanisms to improve the decision-making process on supply chain strategy and distribution processes [61]

-Coordination mechanisms in transport: Collaborative transport activities, as well as the use of shared fleets helps to improve capacity performance and decrease costs as it is the most expensive activity [47].

STUDY CASE

1. Diagnose

After applying step 1 of the Diagnose phase, it was found that specialized warehouses for online order preparation have an independent inventory exclusive for digital channels, similar to the concept of dark store. While the other warehouses satisfy the physical orders of the stores. Of the warehouse about 15% corresponds to inventory that is lent to third parties and of which the inventory is used in case for filling shortages to satisfy orders from digital channels.
The company has been influenced by the boom in the use of digital media for product purchases, from which arises an interest in evaluating coordination alternatives and their drivers within its SC where initially improving vertical-type coordination levels could be a good starting point to subsequently evaluate alternatives with different horizontal type roles and actors.

TABLE III
SUPPLY CHAIN CHARACTERIZATION

Purpose of the context	Example
Economic activity	Distribution of backpacks and clothing
String Type	Consumer Goods Distribution Chain
Sector	Distribution
What will be coordinated?	Last mile distribution
Who will coordinate?	Distribution Centers
Type of coordination	Vertical
Why coordinate?	Growing demand for e-commerce
Product	Backpacks and Bags
Roles	Planning, Distribution, Commercial

To make the validation with five experts in processes of the last mile of the SC comprised of academics from the National University of Colombia and experts from the distribution sector. AHP was used to make the respective comparisons between the different drivers for each actor. The result of this first phase ranges from the identification of the coordination objectives of the SC section to the selection of the drivers that will be evaluated. Those drivers that exceed the weight of 10% were selected after calculating the average of the comparisons of experts. The results showed that D10: Level of maturity, D12: Information management and traceability management and D16: Socioeconomics have the major level of incidence for the last mile of this SC. In Annex A the results of AHP processes are presented considering the constraint of the Consistent Ratio CR<0.10.

2. Evaluate

Within the designing of a measurement instrument is contemplated to know the level of incidence of each of the drivers, through the coordination mechanisms.

This phase used the selected drivers and then the measurement instrument was applied to 86 samples assigned to positions of heads and managers, when applying the equation of determination of sample size contained in the methodology it was obtained that the expected number of surveys for a confidence level of 97% and an error margin of 7% is 54. The final version of the measuring instrument was applied to a sample of 50 people from whom a Cronbach's Alpha of 0.8327 is obtained, indicating that the consistency in the measuring instrument is High.

3. Analyze

This phase presents the results obtained from the implementation of the instrument and proceeds to consider the objective of the SC to identify the appropriate coordination mechanism.

For the selected drivers, incidence levels were high and very high when considering the application of a coordination mechanism. Likewise, the company can apply several coordination mechanisms given the result presented in Table IV.

TABLE IV
DRIVERS INCIDENCE

Driver	Assessment	Incidence
Maturity Level	3	High
Information management and traceability systems	4	Very high
Socioeconomic	3	High

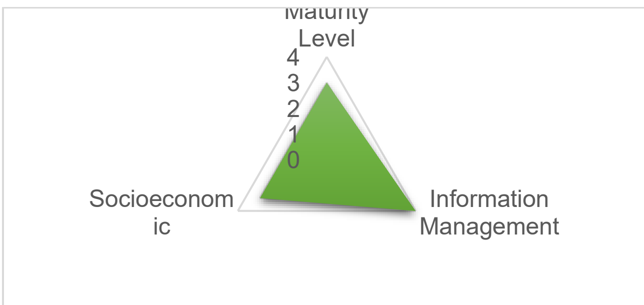

FIGURE 2
DRIVERS INCIDENCE RADAR.
SOURCE: AUTHORS.

To select a coordination mechanism, different kinds were evaluated: Coordination mechanisms on storage, coordination mechanisms on distribution and coordination mechanisms on transportation. According to Table III distribution is the main goal, VMI Vendor Managed Inventory then is considered a good option to attend the current state.

The results show high and very high levels of incidence to apply a coordination mechanism; an alternative was chosen that considers the distribution processes in the last mile according to the scope defined in the "diagnosis" phase. Knowing the level of incidence of each of the drivers in the distribution activities in this section of the supply chain for the backpack manufacturing sector, an appropriate alternative would be to evaluate the different types of delivery that are made, as well as their respective implications of the level of incidence of each driver.

During the construction of the proposal, comments are made regarding the relationship with the level of incidence of the drivers and how that result affects the selection of the mechanism Within the scope of inventory managed by the supplier, distribution activities are considered as an opportunity to align supply chain objectives with the current state of the last mile in terms of coordination. In the selected mechanism, the separation of Global demand D_i must be processed, from which a percentage of online sales share was identified $OLpct_i$, with this the online demand of the product D_{oi} was obtained. In addition, to determine the earnings that are obtained from deliveries on lines sent from the distribution center under the following definition, $pcow_{ij} = p - Cwl_j - Csowl_{ij}$ (1) the profits per unit in the stores under $pcr_s = p - Crh_s$ (2) the earnings from deliveries made from the stores $pcos_{is} = p - Crl_s - Cso_{is}$ (3) and the determination of the cost of returning products from the store to the Distribution Center $Cb_s = Crh_s - Csb_s$ (4).

Three types of deliveries are considered according to the work proposed by Millstein et al. Deliveries are made from Stores (SFS), From Warehouses o Distribution Center (SFW), and a Hybrid version SFS+W.
In the proposed mechanism, different percentages of online sales share are considered. For the case study, the data of three main products sold online were considered, evaluating variations in the share of online sales and the percentage of profits obtained by each of the percentages.

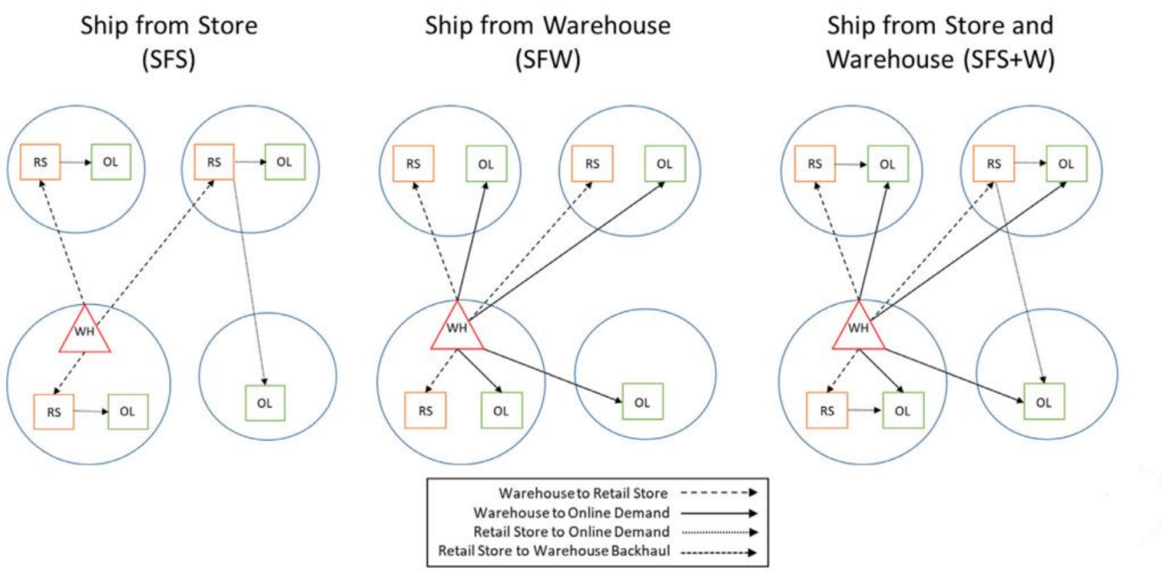

FIGURE 3
TYPES OF DELIVERIES.
SOURCE: (MILLSTEIN ET AL., 2022).

Index
i = Nodes representing products
j = Distribution Center location
s = Store Locations Arrangement
k = Distribution Center Capacity

Parameters
Y_j^k= DC capacity in k units
T_{ij}= Delivery time for the product i from node j in days
D_i= Total market demand
$OLpct_i$= Online demand as a percentage of total market demand
D_{oi} = Online product demand
$Csow_{ij}$ = Cost of shipping product i from DC
$Csos_{is}$= Cost of shipping product i from the store
$Csrw_{sj}$ = Cost of shipping from DC j to store s
Csb_s = Cost of returning from store s to DC j
Cwh_j^k = Costs of maintaining inventory for a CD size k
Cwo_j^k = Operating costs of the CD of size k located in j

Cwl_j = Inventory management costs for demand products met from the CD
Crh_s = Costs of maintaining inventory of units shipped to the customer from store s
Crl_s = Inventory management costs for demand products met from the store s
p = Gross revenue per order
g_i = Binary indicator of whether returns are allowed in that store
$pcow_{ij}$ = Unit profit for orders satisfied by the CD
pcr_s = Profit per unit for the store in s
$pcos_{is}$ = Unit profit for orders fulfilled by the store s
Cb_s = Return cost per unit in store s

Decision Variables
ST_s = 1 if a store is open at location s,0 otherwise
Z_{ij} = Total units shipped online from CD
V_{sj} = Total units shipped to stores from the CD
B_s = Total units returned from store to CD
Q_s = Total units sold in stores to customers
U_{is} = Total units shipped online from stores

Shipping from the main Warehouse (SFW): This delivery alternative suggests that all shipments of online orders must be satisfied from the main Distribution Center (DC). Using this alternative requires in terms of coordination and involves very high levels of centralized information in the DC, thus the DC assumes an important position in making decisions regarding how the merchandise is delivered and handled, it is the duty of the DC to meet the demand for online orders while in turn satisfying the demand of the stores for sales at the points of sale. Considering this alternative results in aiming for an efficient strategy. On the other hand, the maturity that the supply chain must have must be high enough to determine the ease of the flow of logistics operations and, finally; Congestion, infrastructure capacity, transport costs have a high impact on the decisions taken in the coordination mechanism. To consider this alternative is to aim at the Efficiency strategy [61]

Objective function case 1 – Shipping from DC

$$Max = \sum_s pcr_s Q_s + \sum_i \sum_j pcow_{ij} Z_{ij} - \sum_j \sum_k Cwo_j^k Y_j^k - \sum_s \sum_j Csrw_{sj} V_{sj} - \sum_s Cb_s B_s \quad (5)$$

This first objective function conforms to the following constraints

$$Z_{ij} \leq Do_{ij} \; for \; all \; i, j \quad (6)$$

$$\sum_k Y_j^k \leq 1 \; for \; all \; j \quad (7)$$

$$\sum_i Z_{ij} + \sum_s V_{sj} \leq \sum_k Y_j^k + 2B_s \; for \; all \; j \quad (8)$$

$$Q_s \leq Dr_s \; for \; all \; s \quad (9)$$

Shipping from the Store: This alternative suggests that all orders be shipped directly from the store to customers. Resorting to this alternative has coordination implications in terms of inventory management, in this case, it is the store that has the position to decide under what inventory levels it will work according to the behaviour of the demand of online sales. The flow of balance information should be available from stores in order to determine available inventories and closer distances. By considering this alternative we approach the responsiveness strategy where in some cases the customer is willing to pay a little more to get a product faster.[61]

Objective Function Case 2 – Shipping from Stores

$$Max = \sum_s pcr_s Q_s + \sum_s \sum_i pcos_{is} U_{is} - \sum_j \sum_k Cwo_j^k Y_j^k - \sum_s \sum_j Csrw_{sj} V_{sj} \quad (10)$$

This second objective function conforms to the following constraints

$$Z_{ij} \leq Do_{ij} \; for \; all \; i, j \quad (11)$$

$$\sum_k Y_j^k \leq 1 \; for \; all \; j \quad (12)$$

$$\sum_i Z_{ij} + \sum_s V_{sj} \leq \sum_k Y_j^k + 2B_s \; for \; all \; j \quad (13)$$

$$Q_s \leq Dr_s \; for \; all \; s \quad (14)$$

Shipments from the Distribution Center and Stores: This alternative implies in terms of coordination a greater complexity because the decisions made must consider the capacities and demands of all the actors involved in the distribution process [61]

Objective function case 3 – Shipping from Stores and CDs

$$Max = \sum_s pcr_s Q_s + \sum_s \sum_i pcos_{is} U_{is} + \sum_i \sum_j pcow_{ij} Z_{ij} - \sum_j \sum_k Cwo_j^k Y_j^k - \sum_s \sum_j Csrw_{sj} V_{sj} \quad (15)$$

This third objective function conforms to the following constraints

$$Z_{ij} \leq Do_{ij} \text{ for all } i, j \quad (16)$$

$$\sum_k Y_j^k \leq 1 \text{ for all } j \quad (17)$$

$$\sum_i Z_{ij} + \sum_s V_{sj} \leq \sum_k Y_j^k + 2B_s \text{ for all } j \quad (18)$$

$$Q_s \leq Dr_s \text{ for all } s \quad (19)$$

The results for each of the three products (See Table V) show that the best delivery alternative varies according to the type of product and the percentage of participation of each product in online demand According to the variation of the percentage of online demand, some products suggest one or more different delivery alternatives. In addition, as the percentage of online sales increases, the results that present a better percentage of profit is the combined SFS+W delivery.

For the product two and three, the combined distribution offers the higher profit when the participation of online sales OPTC is 10%, 75% and 90%. When the online sales participation is 25% and 50% for the product two the best delivery option is SFW-SFS and SFW correspond. For the product three only when the online sales participation is 25% the best option is using SFS, in any other case SFW+SFS.

The product one represents a variation in the results, only when the online sales participations is over 75% the best distribution option is SFW+SFS. In any other case for product one the distribution option varies between SFW and SFS.

TABLE V
REVENUE PERCENTAGE BY ONLINE SALES PARTICIPATION IN PERCENTAGE

OPTC = 10%			
Product	***1***	***2***	***3***
SFS	1,20%	1,30%	1,50%
SFW	1,50%	1,40%	1,30%
SFW+SFS	1,30%	1,50%	1,60%
OPTC = 25%			
Product	***1***	***2***	***3***
SFS	1,80%	1,60%	1,30%
SFW	1,50%	1,40%	1,20%
SFW+SFS	1,40%	1,80%	1,20%
OPTC = 50%			
Product	***1***	***2***	***3***
SFS	1,70%	1,70%	1,80%
SFW	1,80%	1,80%	1,40%
SFW+SFS	1,30%	1,30%	2,30%
OPTC = 75%			
Product	***1***	***2***	***3***
SFS	2,00%	1,70%	2,10%
SFW	1,90%	1,60%	1,70%
SFW+SFS	2,20%	1,90%	2,10%
OPTC = 90%			
Product	***1***	***2***	***3***
SFS	2,00%	2,20%	2,40%
SFW	2,30%	1,80%	1,90%
SFS	2,40%	2,20%	2,40%

Having only deliveries from the DC implies high levels of information centralized in this role. A position of power over the Distribution Center over when and how to ship to customers is manifested. While when deliveries are made from stores or a combination, it denotes the decentralization of information and positions of power disappear from this stretch of the supply chain because depending on the product the behavior varies.

It is important to consider the capabilities of each of the stores to consider delivery alternatives from the stores where shipping costs are shifted to the costs of storing in the store. It is also necessary to consider demand planning mechanisms that consider the storage capacities of stores.

The values in Table V show that as the percentages of online sales share increase, the maximum percentages of profits increase, additionally the maximum percentages of profits may vary depending on the quantity of product and does not imply that the greater the quantity of products, the lower the percentage of profits.

DISCUSSION

Despite the existence of proposals related to coordination mechanisms, implementation has been affected by a series of drivers that so far have not been identified in supply chains. These drivers may vary from sector to sector, geographical context or part of the supply chain.

Because the existence of these drivers is so specific it is necessary to identify which driver are present on each situation and what is their incidence on coordination mechanisms. In the specific case presented on this paper we applied a structured methodology consisting in three different phases. This methodology and the documentation produced by it can be re-used for other last mile analyses.

The specific case where we applied the methodology produced a set of alternatives. It is important again to consider the implications in terms of coordination of each of the alternatives. Since the groupings of the drivers obtained values between High and Very High, it can be considered a driver to apply on any mechanism. Going into the detail of each of the drivers within the groupings and the different behaviors of each of the products, it is necessary to consider the implications in terms of coordination for each distribution alternative.

As these new designs emerge in the alternatives of coordination mechanisms considering the proposed methodology and the different drivers with their respective incidences, it is possible that new drivers that have not been considered in this document will be identified, denoting an advance in scientific terms to begin to change the perspective in the design of proposals for coordination mechanisms.

CONCLUSIONS

The use of the methodology proposed in this paper has been helpful at the strategic level to evaluate coordination mechanisms. Coordination within the supply chain is an issue that still has potential to be developed within the supply chain to improve performance according to its objectives, achieving interaction between the different roles involved in logistics processes to achieve a common goal.

The methodology is an effective tool to enable coordination by aligning the objectives of the last mile which is typically a ill in the company, with the objectives of the whole SC. The result of this case proved the benefits of the methodology and in future investigations it is interesting to see how the results may vary according to the context, sector, and type of coordination, as well as the selection of a coordination mechanism.

This methodology is open to the inclusion of new drivers, or new or redesigned coordination mechanisms whose scope considers the appropriation of the drivers that affect coordination within them. In fact, our methodology is consistent and valid for future applications.

The measurement of the level of influence of the drivers within the proposed methodology focuses on the use of questions with categorical values so that many statistical analyses cannot be considered within the scope of the analysis of results. Future research could rethink the type of data to be used if it manages to respond to the measurement of the level of incidence of each driver and its statistical operability. Understanding the drivers to align supply chain objectives with the last mile in terms of coordination obeys a series of drivers that must be identified, evaluated, and analyzed to achieve that alignment.

A future avenue is also considering new technological developments in the last mile enhancing its sustainability. Developments such as drones, cargo bikes or crowdshipping provide an interesting perspective because they coordinate not only industrial actors but also the public sector itself. How this type of coordination has an effect on mechanisms and which drivers can enable this coordination open relevant questions for future research.

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A. Annex A: AHP Results of Expert Comparisons:

Driver		Waver	A*Waver	Nmax	CI	ACI	CR
D1	Market changes	0,0322	0,6491				
D2	Resources & infrastructure capacity	0,0297	0,5960				
D3	Sector capacity	0,0307	0,6205				
D4	High level Management Commitment	0,0345	0,6946				
D05	Financial Costs	0,0308	0,6248				
D6	Incentives	0,0326	0,6553				
D7	Economic uncertainty	0,0340	0,6868				
D8	Indicators	0,0314	0,6410				
D9	National and regional politics and regulations	0,0348	0,6946				
D10	Maturity level	0,1032	2,1806	22,0898	0,1717	1,7716	0,0969
D11	Governmental entities support	0,0385	0,8287				
D12	Information management and traceability	0,1091	2,5710				
D13	Information sharing ability	0,0473	1,1455				
D14	Members commitment	0,0479	1,0937				
D15	Members trust	0,0515	1,1686				
D16	Socioeconomic	0,1424	3,3890				
D17	Leadership capabilities	0,0573	1,3397				
D18	Power distributions	0,0592	1,2846				
D19	Relationship and strategic alignment	0,0527	1,2258				