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Collaborative distribution: strategies to generate efficiencies in urban distribution - Results of two pilot tests in the city of Bogotá

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Abstract
The urban freight distribution (UFD) processes represent externalities and inefficiencies to the community and the private actors involved. The enterprise collaborative approach has been implemented during the last decades as a solution to the referred problems. The aim of this study is to present the results of two pilot tests for collaborative logistics strategies carried out in Bogotá, Colombia. The tests were conducted to assess the collaborative logistics strategies' efficacy in the reduction of congestion and contamination as well as their impact on companies' efficiency. The initiatives evaluated were: (a) freight consolidation and (b) unload scheduling at retailers. In both cases, benefits were evidenced for the companies (-26% on average freight and + 83% on vehicles occupancy) as well as the community (-23.5% parked trucks on roads and -7% emissions). Nonetheless, the results do not possess statistical sufficiency. Further research could complement the factors and methodologies that facilitate organizational collaboration.

Keywords: urban freight distribution; logistics pooling; collaborative distribution; horizontal collaboration; vertical collaboration; pilot test.

Distribución colaborativa: estrategias para generar eficiencias en la distribución urbana - Resultados de dos pilotos en la ciudad de Bogotá

Resumen
Las actividades de distribución urbana de mercancías generan externalidades y constituyen ineficiencias para los actores privados involucrados. Para mitigar dichos problemas, durante los últimos años, las empresas han direccionado sus esfuerzos hacia la obtención de mejores resultados vía procesos colaborativos. El objetivo de este trabajo es presentar los resultados de dos pruebas piloto ejecutadas en la ciudad de Bogotá, las cuales evaluaban la efectividad de estrategias de logística colaborativa tanto en la reducción de congestión y contaminación ambiental, como en el aumento de la eficiencia empresarial. Las iniciativas evaluadas fueron: (a) consolidación urbana de mercancías y (b) programación de citas para descargue. En ambos casos, se obtuvieron beneficios empresariales (26% de reducción en flete promedio y 83% de aumento utilización vehicular) y sociales (23.5% menos vehículos en vías y 7% menos Emisiones GEI), aunque sin suficiencia estadística. Futura investigación podría profundizar en factores y metodologías que facilitan la colaboración organizacional.

Palabras clave: distribución urbana de mercancías; pooling; distribución colaborativa; colaboración horizontal; colaboración vertical; prueba piloto.

1. Introduction

Despite being essential, urban freight distribution processes (UFD) have traditionally come along with negative externalities. As a result, societies have contemplated this kind of activity as a problem rather than as a crucial component of the economic systems [1].

First, it is widely accepted that the urban freight transport shares between 30 and 50% of the total distribution activities contaminants' generation. Moreover, it has been established

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that UFD accounts for 25% of the total urban carbon dioxide emissions (CO_2) in a worldwide view [2]. In the case of Bogotá, the figures in this matter have been assessed as well, and it is widely accepted that this kind of activity accounts for 33% of the total environmental impact related to particulate matter in the city [3].

Secondly, the impacts caused by the operation of freight vehicles on congestion and traffic in urban areas have been broadly reported by [4-8]. In regard to the Colombian context, [9] presents an analysis on the overall traffic cost in the country, stating that approximately \$3.9 trillion COPs (almost 1.27 USD billion) are lost in the economy as a result of the congestion.

The participation of freight transport vehicles in urban accidents has also been evaluated. [10-13] established that these kinds of vehicles are highly involved in casualties and, accordingly, cause considerable social costs. For the Colombian case, it was reported that 69.2% of the accidents that involved freight transport took place in urban areas [14].

In order to provide solutions to the referred problems, the UFD has been steadily addressed within the activities of the public and private sector. The former has striven for increasing the overall transport efficiency, while parallelly minimizing the impacts. On the other hand, the enterprises have tangentially sought solutions that increase their profitability and/or conduct their processes to comply with the regulations [15].

Regarding public programs, scholars state and highlight that: a) there is lack of integration of the urban freight distribution concept when designing and enacting public policies [16]; b) urban passenger transport is the common center of the solutions regarding congestion, pollution, and accidents in cities [17]; c) there is a shortage of human capital, tools and knowledge on logistics and distribution processes in the related public institutions [18-21]; and, lastly, d) there is no clear identification and / or integration of the main stakeholders in the development of policies related to freight flows in urban contexts [22].

Accordingly, ineffective regulative approaches that even hinder have been enacted by the local authorities on the UFD processes. [19,23-27]. The normative framework of the Colombian capital has been labeled as being inappropriate for the holistic logistics performance as well [28].

On the other hand, regarding the private tier, interenterprise collaboration in the supply chain has been positioned as an effective way to reach higher efficiency levels as well as processes with smaller level of externalities [24]. This kind of paradigm can be understood as the model at which two or more autonomous companies work together to plan and execute activities of their respective chains [31,36].

In this sense, research questions that originated this study are: 1) What are the opportunities for the private sector to generate collaborative solutions on the mentioned problems? 2) To what extent should those alternatives be promoted by the local authorities? and 3) What is the potential impact of collaborative solutions?

With that operational framework, and with the support of the Bogotá's Secretariat of Mobility, two collaborative strategies were selected to be subsequently deployed by some private actors. To analyze the impacts and difficulties of those initiatives, two pilot tests were carried out respectively. The execution of this type of tests provides valuable information for researchers, in addition to granting a warning to possible failures in the strategies and / or methodologies to be implemented [44]. In the field of logistics, particularly the one of UFD, [45] used this methodology, and [46] presents cases of pilot test applications at the international level.

The first initiative that took place was that of scheduling appointments to download freight at retailer reception points. For the second one, instead, an urban consolidation or collaborative distribution strategy was instituted. It is worth mentioning that the approaches were chosen by applying a multiactor-multicriteria (MAMCA) evaluation and decision model. For that end, workshops were established with the participation of private and public sectors' representatives.

Public authorities' participation was included into the procedure as a way to obtain valuable inputs for the design of public policies in the UFD field. In this way, this study contributes not only to the private interests also includes the public sector and generates knowledge for it.

2. Literature review

In the context of urban distribution, three approaches have been established to take action towards the efficiency increase and sustainability of the UFD processes: the enacting of logistics policies, the technological developments, and the innovations in distribution practices [16].

In terms of supply chain performance, several approaches and models have been proposed by scholars as innovative solutions to make supply chain activities more efficient and, therefore, more competitive. Among those developments, companies' collaboration practices have been steadily implemented during the past recent years in the field of UFD [29-31]. Due to advantages and benefits such as efficiency increases, asset productivity enhancement, emissions reduction and improvements in service and market position, this paradigm has gained position among the main stakeholders [24,32-35].

On the supply chain management theoretical framework, [31,36] define collaboration as the operational model by which two or more autonomous companies work together to plan and execute activities specific to their chains. [37] state that collaboration requires a certain degree of involvement of the participant tiers. The authors also highlight that resource sharing is crucial to satisfy each independent supply chain customer.

Companies collaboration has conventionally been classified into two main categories by scholars: horizontal and vertical collaboration, respectively. The former refers to the mutual agreement between agents such as suppliers, manufacturers, distributors (or any logistics operator) and finally customers, all along the value chain of the same industry or sector. On the other hand, the latter classification corresponds to strategies undertaken by entities that operate at the same supply chain level. This approach involves, therefore, direct competitors' relationship in some cases [29].

However, the implementation and appropriation of such models is still limited in the Latin-American private sector. There are some developments in the Brazilian context [38-40], but neither the scientific production related to collaboration benefits and results nor the factual processes among companies have reached a mature level in the region.

Understanding that urban freight distribution processes take place in a multiactor environment, diverse approaches have been broadly proposed to reach better UFD performance either by local authorities or by private actors.

[18,24,41] present a compilation of the most relevant strategies deployed in this regard mainly by the public institutions at a local level. According to these studies, efforts and developments can be categorized into: a) infrastructure measures: that comprise all the tools and assets guaranteed by the government (e.g., development of transshipment and/or intermodal centers, urban consolidation centers (UCC), line divisions, creation of delivery docks and zones); b) traffic management measures: that encompass approaches intended to establish access and time restrictions, as well as control the traffic and routes (e.g., low emission zones, prioritized lines, multifunctional ways, vehicle restrictions, enacting of time-frame restrictions); c) market-based measures: which are alternatives that seek to determine fiscal control through taxation, incentives and collection (e.g., creation of urban tolls, acknowledgment programs for privates, operational and fiscal incentives); d) decisions and public policies related to the urban land planning and use, which are, thereby, long-term modifications (e.g., development of sustainable urban logistics plans (SULP), relocation of big freight generators and receptors); and, finally, e) support and sponsorship of new technologies' development (utilization of global positioning systems (GPS) and freight transport management systems (FTMS), implementation of parking booking systems, and support in the development of vehicular technologies).

As stated by [18], "Good practices can be projects, initiatives or activities which directly change freight transport and distribution. This measures are planned or implemented by private sector, by public sector or in public-private agreements". It is possible to find, within these categories, a well-positioned segment that comprises behavioral and organizational changes that eventually include interenterprise collaboration schemes. These initiatives might represent the interaction and intervention of the local authorities at some point. However, their burst and leadership are completely dependent on private determination.

The basic concept of collaboration within the UFD systems is that a group of generators, shippers, and receiver companies cooperate and organize their own goods distribution in pursue of a faster and more efficient delivery [18].

One initiative is that of establishing local or regional coordinated goods delivery systems, for example, by structuring "city goods terminals". [47] reported decrement in the number of total deliveries and higher satisfaction levels when this strategy was implemented this approach in Uppsala, Sweden.

[39] evaluates a vertical collaboration scheme deployed by a Brazilian wholesaler with its suppliers. Basically, they implemented a coordination and standardization model. Within the most remarkable results are the reduction of non-conformities in invoicing processes, the positive evolution of load unification and occupation indexes, and the reduction of merchandise damages in both the inbound and outbound logistics processes.

Other strategies encompassed by this approach are parking shared-time campaigns, loading associations, consolidation and truck-pooling measures, alignment of processes (loading and unloading, off-hour deliveries, night-time deliveries), promotion of driver training courses, modal switch programs (cross-docking) [24,41].

3. Methodology

3.1. *Selection of strategies*

For the selection of the two strategies, a multi-actor multicriteria analysis (MAMCA) was structured; following the work of [20]. This approach is widely used given its capacity for including the objectives of different actors involved in the decision-making process. Fig. 1 gives an overview of the basic scheme followed for this purpose.

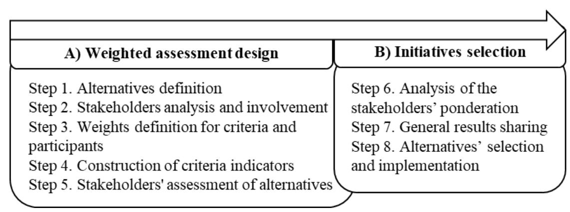

Figure 1. MACMA general scheme followed.
Source: The authors based on [20].

Table 1.
Selection of strategies final ponderation results

Strategy	Final Scoring Results			
	Private Sector (50%)	*Public Sector (40%)*	*Research Team (10%)*	*Aggregated*
Unloading scheduling in retail stores	3,42	3,91	5	3,78
Urban freight consolidation	2,96	4,35	5	3,72
Shared freight systems	3	4,29	5	3,72
Freight load/unload areas design	4,56	2,78	1	3,49
Parking booking schemes	3,53	3,39	3	3,42
Urban logistics platforms	3,35	3,95	1	3,36
Driver training programs	4,05	2,91	1	3,29
Time-windows schemes	2,68	3,49	5	3,24
Circulation restrictions	2,26	3,13	3	2,68
Parking and load/unload restrictions	2,26	2,96	3	2,61
Exclusive lanes for freight trucks	2	2,77	1	2,21

Source: The Authors.

Workshops were held with different actors from the public sector, private associations, freight generators, logistics operators, and freight receptors from step 3 to 5. Regarding the classification of the strategies, a ponderation model with specific scores (between 1 and 5) was used to assign weights to each criteria and actor. This exercise also required further workshops, complemented with virtual surveys for non-attendees.

Finally, according to the directive of the DSM, a weight of 50%, 40%, and 10% was given to the evaluations of the private sector, the public sector, and the research team, respectively. These weight factors were established in workshops led by the DSM during the study.

As a result of the evaluation, the strategies with the highest scores, which thereby were deployed in the pilot tests, turned out to be: 1) Unloading scheduling at large receptors, and 2) Freight consolidation (Collaborative transportation). Table 1 presents a breakdown of the overall ponderation results.

3.2. *Pilot tests*

The pilot tests were conducted with the collaboration of the Municipal Secretariat of Mobility, considering the results of the MAMCA analysis. The objective of this collaboration was to understand the challenges and complexities in the implementation of efficient logistic practices, and the impacts for the city with a proper policy making.

3.2.1. Urban freight consolidation

This horizontal collaborative initiative seeks to promote the shared use of vehicles within companies for the distribution of goods. It is intended to increase the vehicle (truck) capacity utilization while parallelly improving the mobility by reducing the number of vehicles on the streets. For this implementation, the private firms that participated in the workshops were called upon. Two of these firms manifested interest in participating in the pilot test; they are described below:

- Company type: Freight generator and logistic operator
- Distribution channel: Presales
- Merchandise: Refrigerated meat
- Departing point: Parque Empresarial Potrero Chico
- Vehicle capacity: 2,2 tons (for both companies)

Fig. 2 below illustrates the operation model without collaboration (independent distribution).

During the pilot test deployment, the freight was consolidated in the vehicle fleet of company A. This implied for company B, picking the merchandise at its production plant and delivering it to company A distribution center.

In order to control risks of potential cross contamination in the reverse logistics of food in poor conditions (due to expiration, meat in poor conditions, etc.), the companies isolated these products with expanded polystyrene coolers during the pilot test. The characteristics of the test are described in Fig. 3 below.

As company B's distribution points totally coincided with company A's clients, company B's route disappeared completely. That is, the total route coincidence represented a great similarity with the operation characteristics of company A without collaboration.

Table 2.
Operative characteristics of companies A and B.

Characteristic	Company A	Company B
Company type (economic activity)	Food logistics operator	Food production and commercialization
Delivery points in Bogotá	18	4 (included within the 18 points of company A)
Average utilization of vehicle capacity	75%	36%
Operation time on route	5,5 hr. (from 6:30 a.m. to 12:00 m)	5,5 hr. (from 6:30 a.m. to 12:00 m)
Route length	69 km	38 km
Estimated transport cost of route	COP $400.000	COP $140.000
Estimated fuel consumption on route	4 gal	1.4 gal

Source: The Authors.

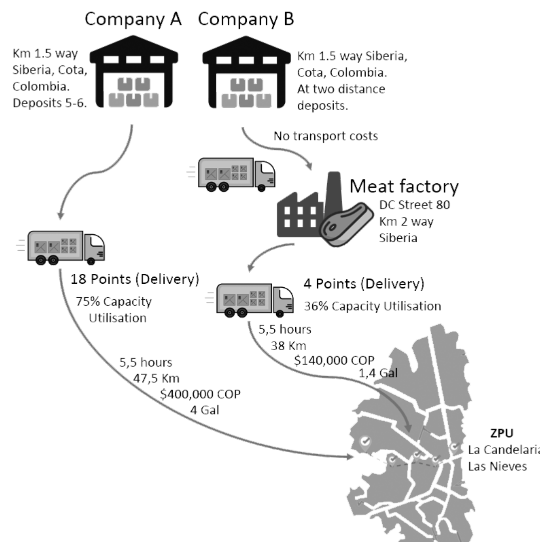

Figure 2. Distribution model without collaboration.
Source: The Authors.

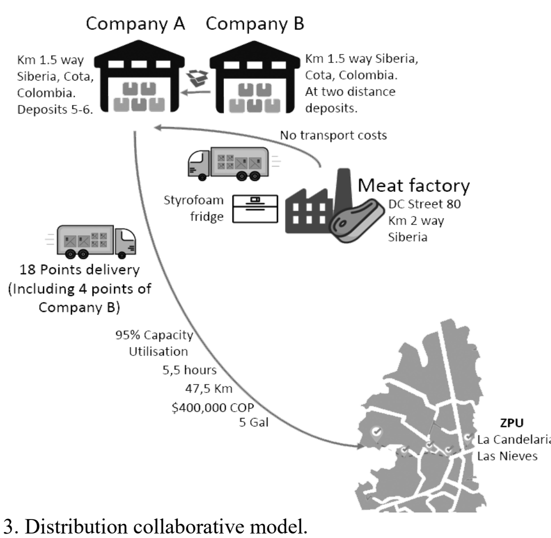

Figure 3. Distribution collaborative model.
Source: The Authors.

Besides modifying the logistics operation per se, there was a clear need for the participants to structure an information sharing model. This model was necessary to define some operational protocols and responsibilities regarding the exchange of data related to: 1) the kind of merchandise that would be consolidated; 2) the physical dispatch points; 3) the clients (delivery points) that could be covered by the scheme; 4) the main logistics indicators (costs, occupation rates, vehicles features); 5) risks and safety problems. It is worth mentioning that the vehicle utilized during the deployment had no intervention or modification.

Additionally, the companies structured agreements to specify some relational factors. These agreements, consolidated as letters, were essentially signed by the two parties involved. The points encompassed were a) the fleet to be utilized; b) the traceability of the process; c) the costs distribution scheme; d) payment and invoicing; and e) the procedure to transfer the information. However, a deeper description on this matter is out of the scope of this study.

3.2.2. Unloading scheduling in retail stores

This vertical collaboration initiative is sought to be implemented in retail stores with lack of or poor infrastructure conditions for the reception of merchandise. This initiative seeks to reduce the probability of simultaneous arrival of distribution vehicles to a given retail store.

- Description of cargo receptors (retail stores)
  The selected retail store for this trial lacked the proper infrastructure conditions for the reception of freight distribution vehicles. This retail store had the following characteristics: Supermarket, located in the residential and commercial area of El Restrepo (Bogotá), in the intersection of a main and a secondary street, equipped with an unloading dock with a reception capacity of maximum two vehicles. The distribution vehicles usually delivered their goods to the selected store, mostly parking on the secondary street. The Fig. 4 illustrates the common delivery parking spots.
- Baseline (prior reception model)
  For the observed scenario, the baseline distribution system consisted of freight vehicles that delivered goods directly to the retail sector. In a lower proportion, the goods were distributed through a hub and spoke system, using the retail company's main distribution center in Bogotá. Fig. 5 illustrates this operative model.

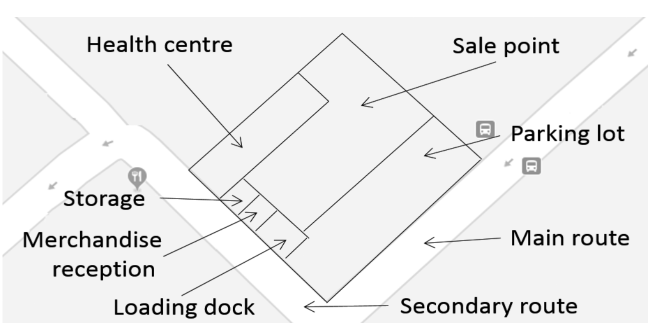

Figure 4. Physical characteristics of the studied retail store.
Source: The Authors.

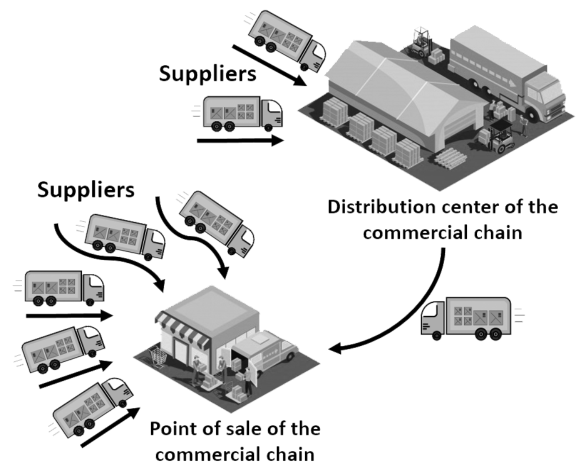

Figure 5. Reception model with a low degree of vertical coordination.
Source: The Authors.

In order to determine the baseline of this case, observations of the goods reception process were conducted in August, September and October 2017, from Monday to Friday from 6 AM to 12. This observation schedule was determined by the participating retail company due to the fact that the delivery process was normally conducted only during these hours. These observations included the registry of the time-length and the parking place of the vehicles during the unloading procedure. A total of 221 vehicles were observed in the studied store.

- Pilot test (coordination vehicles arrival)
  With the purpose of improving the pattern of vehicle arrival to the store, an adjustment in the distribution scheme was implemented in the beginning of 2018. This adjustment consisted in migrating to a distribution model which incremented the participation of the central distribution center of the retail company. Fig. 6 depicts this adjusted model.

87 vehicles were observed during the adjusted delivery process (from February to March 2018). The same observation methodology was implemented as the one used during the baseline.

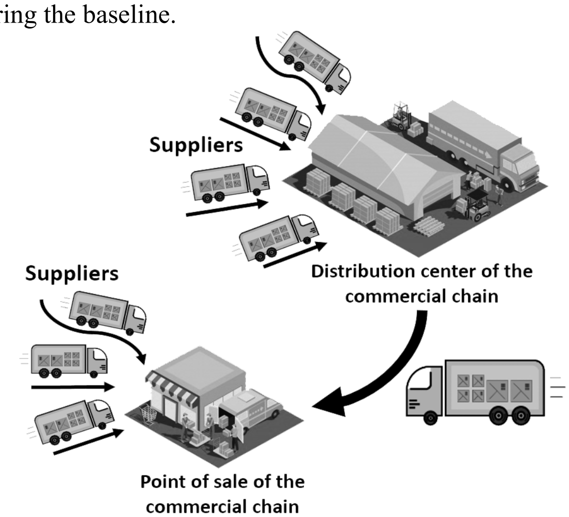

Figure 6. Reception model with increased degree of vertical coordination.
Source: The Authors.

Table 3.
Operative indicators in the “as is” and at the consolidation pilot test

Indicator (1 day)	Baseline[1]	Pilot test	Variation
Number of trips	2	1	**-50%**
Number of deliveries	22	18	**-18%**
Journey’s total time (hour)	11	6	**-50%**
Distance travelled (km)	107	69	**-36%**
Vehicle occupation capacity utilization	52%[2]	95%	**+83%**
Cost (COP $ millions)	$ 0,540	$ 0,400	**-26%**
Fuel consumption (Gal)	5,4	5,0	**-7%**
Emissions level (kgCO2eq)	55,5	51,4	**-7%**

Source: The Authors.

4. Results

4.1. Urban Freight consolidation

Table 3 gives a breakdown of the indicators assessed in the “as is” and the pilot test scenarios.

4.2. Unloading scheduling in retail stores

4.2.1. Base-line

The bar chart in Fig. 7 illustrates the vehicles reception scheme followed before the pilot test deployment. As depicted, there was a high vehicular concentration at the facility between 7:00 and 9:30 am. It was even possible to find an average of 6 vehicles parked at the same time. The most common parking slot turned out to be the secondary route.

The maximum quantity of vehicles present at the same moment was the first variable to be analyzed. For the complete system, the figure took the value of 16. This scenario was evidenced in one observation during the 8:00 - 9:00 am time period. The unloading dock, the main route, and the secondary route presented values of 6, 8, and 11 agents / hour respectively for the same figure.

In terms of areas utilization, the secondary route was the logistics zone with the highest average occupation rate, with 4 vehicles per hour. The dock and the main route reported averages of 1.8 and 1.4 vehicles per hour respectively. As for the complete perspective, there were 2.4 agents / hour on average in the system.

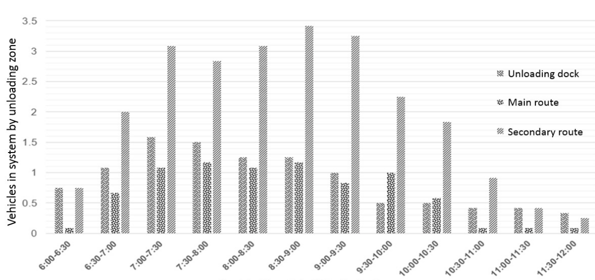

Figure 7. Distribution of freight vehicles reception with low coordination.
Source: The Authors.

Regarding the timing analysis, the zone where the vehicles remained the highest amount of time was that of the unloading dock, with 64.7 minutes per vehicle. Additionally, the secondary and the primary route evidenced an average of 43.8 and 27.8 minutes / entity respectively. In this scenario, freight vehicles spent 43.9 minutes on average throughout the complete system processing.

This model represented a high discoordination level among the suppliers, whose vehicles arrived in an inefficient and non-tiered way. As a result, the trucks frequently parked on the public routes and, consequently, externalities as well as delays on the suppliers’ delivery processes were common.

With this situation as the basis scenario, the alternatives for collaboration were evaluated as a tentative solution. The expectation was that, by increasing coordination, both the total processing vehicle time in the system and the average number of vehicles per hour would decrease, assuming that everything else remained constant.

4.2.2. Pilot test deployment

Fig. 8 gives an overview of the accommodation behavior of the freight vehicles in 2018. Compared to the model in 2017, there was an increase in the unloading dock utilization. Accordingly, reductions in the average quantity of trucks parked on both the primary and the secondary routes were evidenced. The maximum quantity of entities in the system decreased to 13 vehicles (occurring between 7-8 am).

The configuration of the trucks in the predefined logistics zones was reorganized. The unloading dock thus cushioned the vehicles reception from the other two areas. The former came to host 2 vehicles per hour on average, whereas the main and the secondary route evidenced 1.1 and 2.9 vehicles/hour respectively, thus reducing their figures of 2017.

With the pilot test deployment, the unloading dock became the zone with the highest number of vehicles, followed by the secondary and the primary route with values of 8, 7 and 6 vehicles per hour respectively. The secondary route continued to have the highest occupation level, with an average of 2.9 vehicles per hour. The loading dock (2 v/h)

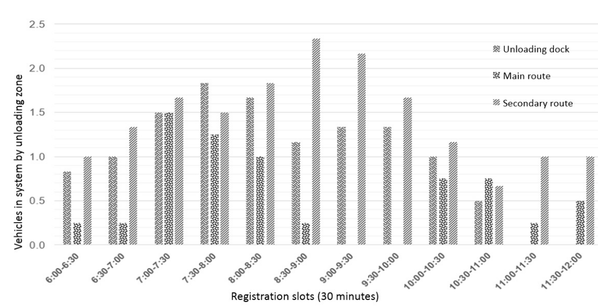

Figure 8. Distribution of freight vehicles reception at the salespoint during the pilot test.
Source: The Authors.

[1] These figures correspond to the sum (or average, depending on the indicator) of the indicators reported by each company in the individual distribution.

[2] This figure corresponds to an average vehicle occupancy of both companies in independent distribution.

and the main route (1 v/h) also kept the order in terms of this figure. Finally, the average number of agents in the system was 2.4 entities per hour.

4.2.3. Contrast

In order to analyze the statistical significance of the described changes, each variable was assessed separately. Firstly, it was corroborated that the probability distribution of the variables did not followed a normal behavior. Accordingly, the Wilcoxon rank-sum test, a nonparametric alternative to the two-sample t-test for non-normal experiments[3], was applied to assess the significance. The procedure was carried out with software R, version 3.5.1 for Windows. The respective results are presented in Table 4.

Despite the fact that the variations were important for both the retailer and the congestion level at the zone, the only variable with a statistically significant change (at a significance level of 95%) was that of the vehicular average time in the system.

In terms of percentual change, increases were experienced only in the unloading dock variables. In this zone, the average time trucks were parked, and the average number of vehicles housed showed a growth of 23 and 15% respectively. It is worth saying that, for the other areas (e.g. the complete system, and the primary and secondary routes), both figures had a negative trend. These results corroborate that it was possible to increase the loading dock's average occupation to its maximum capacity (2 freight transport vehicles), which was indeed the aim of the project, to, on the one hand, cushion the number of vehicles that congested the public routes; and, on the other, to boost the utilization of the supermarket infrastructure assets.

However, the fact that the parking and unloading average time increased in the loading dock was completely opposite to the expectations of the pilot test. In order to analyze the influence of this result on the pilot proficiency, further analysis was undertaken to understand whether this unexpected result indicated a failure of the pilot or whether there was any factor, non-related to the coordination scheme, that caused the situation. Therefore, the time that it took for the supermarket to process and receive the just delivered items was assessed. With a more introspective eye, the data showed that, while the pilot successfully reduced the average hourly number of parked vehicles as a result of the more uniformly and coordinated distribution of the trucks arrival schedules, the administrative receiving and processing time of the supermarket did indeed double. That figure was, at the baseline, 22 minutes on average, whereas during the pilot test deployment it rose up to 50 minutes per delivery.

Within the design of this pilot test, it was assumed that all the variables would remain constant except for the arrival time of the trucks, determined by the coordination scheme. It can be supposed, therefore, that the items were not immediately received, and that situation possibly added a second waiting time inside the supermarket. However, although the different processes outside and inside the warehouse could have been susceptible to improvement, this particular study focused on enhancement based on the proposal to coordinate the arrival of vehicles.

The freight capacity of the vehicles could have affected these figures as well. Even though [47] found no significant correlations between amount of goods and delivery duration in their study, it is acceptable that, nominally, the unloading, reception, and administrative services times would increase as the vehicle capacity does [15]. Unfortunately, this variable was not contemplated within the data compilation as the investigation was intended only to analyze the effects of the new coordination scheme, that is, the number of trucks on each zone, and the respective processing times.

For the authors, this complexity is the most remarkable insight of the research due to the fact that it could indicate that coordination and velocity of urban freight distribution (UFD) processes can be determined, and even affected, by the efficiency of the inbound logistics of the involved companies. In this sense, the actors present in this collaborative initiative (scheduling appointments) should not only modify their external operations but they must make a commitment to enhance their internal independent procedures as well.

It is clear that, unfortunately, the data of this study is limited. And as a result, statistical results on this new variable (the internal processes of the organizations) cannot be provided. In order to better understand this relationship,

Table 4.
Comparison of indicators at baseline and pilot test.

Variable	**2017 - Baseline**				**2018 - Pilot test deployment**				**Avg. variation**		**Wilcoxon rank-sum test**	
Number of vehicles	**[Vehicles / hour]**											
Unloading zone	Avg.	Min	Max	DST	Avg.	Min	Max	DST	#	%	Ranks sum (w)	P - value
Dock loading	1.8	0	6	1.2	2.0	0	8	1.5	0.3	15%	29	0.538
Main route	1.4	0	8	1.3	1.1	0	6	1.2	-0.3	-20%	32.5	0.4934
Secondary route	4.0	0	11	2.6	2.9	0	7	1.5	-1.1	-27%	55	0.1721
Systematic view	2.4	0	16	1.7	2.1	0	13	1.4	-0.3	-11%	326	0.6831
System's times	**[Minutes / Vehicle]**											
Dock loading	64.7	6	160	24.4	79.5	16	198	22.5	14.8	23%	352.533	0.1576
Main route	27.8	0	171	17.7	25.2	5	59	10.3	-2.6	-9%	419.5	0.9171
Secondary route	43.8	1	196	28.1	43.3	3	125	22.7	-0.5	-1%	2729	0.7855
Systematic view	43.9	0	196	23.4	48.8	3	198	19.5	4.9	11%	8252.5	0.05***
Sample (observations)	(n) = 221				(n) = 87							

Source: The Authors.

[3]https://www.stat.auckland.ac.nz/Ch10.wi lcoxon.pdf

further research and studies should be conducted to include data following this new approach.

In this way, the previously described situation indicates that urban logistics and distribution problems must be addressed by the enterprises not only for external alignment collaboration schemes but also for internal improvement commitments. Even though this supplier-retailer coordination on the arrival times, and its respective frequency agreement, certainly reduced the average hourly number of vehicles on the primary and the secondary routes on 20 and 27% respectively, externalities were certainly extant throughout the pilot test.

5. Conclusions

The observed tendency of a globalized and accelerated urbanization imposes pressure upon municipality administrations and the private sector to increase coordination for the implementation of better urban logistic practices. In this sense, collaborative logistic strategies have been gaining popularity within the private sector, given the proven benefits for increasing competitiveness and reducing negative externalities to the community.

In this matter, the present research was conducted in order to solve the following questions: 1) What are the opportunities for the privates to generate collaborative solutions on the externalities and other mentioned problems? 2) To what extent should those alternatives be promoted by the local authorities? and 3) What is the potential impact of collaborative solutions?

Questions number one and three were answered in the analysis of the pilot tests results. As means to answer the second question, a couple of collaborative logistic strategies were identified by means of implementing the MAMCA methodology, in order to better understand the priorities of the private sector. According to the prioritization results, the strategies were tested in a controlled environment.

The private sector understands that the urgent matters to be solved by the municipality are: 1) the coordination and enforcement of good practices in cargo loading and unloading, and 2) the promotion of collaborative distribution.

This research has identified great optimization potential in collaborative distribution, but it has also revealed the necessity for companies to create solutions to improve compatibility issues among themselves. Even though great potential benefits were also identified in the case of coordinated merchandise reception, further research must be conducted in order to improve vertical coordination between companies.

Latin America, and more specifically Colombia, still have a great space for improvement in vertical and horizontal collaboration. Even though the private sector has been leading these types of strategies, its documentation is still in infancy.

Despite the limited statistical evidence of the pilot tests, the results showed positive impacts in mobility and operational efficiency for the participating companies; evidence that motivates further efforts from the private and public sector in the designing of sustainable logistic policies.

The observed results for the vertical collaborative test were opposite to the initial expectations, which opens new interesting research questions regarding internal retail logistic efficiency, which could contribute positively to the current academic literature. This matter was not found in the literature by the research team.

Even though the horizontal collaborative practice revealed greater benefits for the companies, it is necessary to conduct research with a broader sample in order to guarantee statistical significance. To increase the impact and the coordination between companies in the studied case, combined implementation strategies should be deployed, such as selective arrival scheduling for specific suppliers in order to better balancing the number of vehicles arriving simultaneously at the store.

In general, although both pilot tests evidenced benefits for the participating companies, the underlying difficulties in company collaboration limit the achievement potential (both horizontal and vertical). To facilitate this collaboration, further research in the development of compatibility models should be conducted. In addition, the municipalities should explore mechanisms to encourage these types of strategies in urban logistics.

Finally, the results of this research served as a basis for the creation of an institutional program led by the Municipal Secretariat of Mobility of Bogotá to encourage the implementation of better urban logistic operations. And, even though this research contributes to the theory related with the benefits of these strategies, future studies should be focused on identifying the key factors that facilitate or hinder their implementation within companies. Furthermore, theory regarding this matter should be complemented in the country and the region.

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