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From pilot to policy: Examining the transition towards institutionalized practices in freight curbside management

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ABSTRACT

Streets are contested urban public spaces due to their limited availability. While they serve various functions, the needs of certain uses—such as freight—often have been overlooked in space allocation policies affecting urban livability. Recently, freight curbside management has emerged to address these conflicts, allowing service and delivery vehicles to better use street space, contributing to cities' sustainability targets. Although pilots testing freight curbside interventions are a first step for policymakers to evaluate the effectiveness of these interventions, the transition from pilot to established practices remains underexplored. Therefore, the aim of this research is to understand the success and failure factors that influence the institutionalization process of interventions tested in freight curbside pilots. To achieve this, this paper analyses cases from various cities worldwide that have implemented such pilots, using the lens of institutional theory. Case selection criteria were based on the maturity level of freight curbside pilots. Specifically, the paper focused on those cases that had already implemented pilots, undergone monitoring, evaluation, and possible continuation processes. Data collection and analysis revealed coercive, normative, and mimetic forces driving change towards institutionalized practices. The data analysis identified 23 themes across four content domains, i.e., organizational, economic, technological, and regulatory. Successful institutionalization process relies on strategically selecting high demand loading zones and demonstrating public benefits. Enhancing user experience is also crucial. However, some interventions fail to become institutionalized due to regulatory constraints, business model issues, and land use regulations. This highlights the need for flexible, context-specific approaches. The analysis of institutional pressures revealed that coercive pressures influence transitions from themes related to the legal mandate of public agencies, pilot scope definition, and user experience, while normative pressures shape transition regarding public benefit, business models, stakeholder involvement, and data management themes. Mimetic forces guided early-stage pilots through lessons learned from cities with prior experience in curbside pilots. The findings provide recommendations and guidelines for the development of future pilots, useful for planners aiming at generating long-term curbside policies that solve freight-related street space conflicts.

1. Introduction

In an urbanized world, improving quality of life necessarily entails actions towards making cities better places to live in. This implies developing conditions for environmentally sustainable, economically prosperous, and socially equitable and just cities (UN-Habitat, 2023). Although the United Nations (UN) has delineated a path for motivating countries' commitment to actions with that purpose, i.e., the Sustainable Development Goal 11 (SDG11) – Sustainable Cities and Communities, global results are far behind the target, for instance, due to the inadequate management of public space (UN-Habitat, 2023).

Upgrading public space quality and access conditions requires understanding and addressing space-sharing conflicts experienced by the multiple users claiming the same urban space (Allen and Piecyk, 2022). Despite the efforts in the implementation of inclusive designs prioritizing active travel and micro-mobility, unintended results have come up due to the limited attention paid to space requirements for freight deliveries (Williams and Carroll, 2015). Last-mile deliveries support cities'

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economic vibrancy and the satisfaction of daily citizens' needs for supplies. Besides economic and environmental negative consequences, the lack of urban space allocated to last-mile deliveries make driving through urban areas harder for freight operators, leading to congestion, sidewalk encroachment, pavement damages and crashes (Castrellon et al., 2024). For instance, time restrictions in the access to central streets have increased vehicle rounds, total distance traveled and occupation of public space at adjacent zones, leading to negative consequences in congestion and emissions (Anderson et al., 2005; Holguín-Veras et al., 2013). Thus, curbside regulations have become an issue for freight deliveries in a contested urban public space, threatening cities' sustainability (Allen and Piecyk, 2022).

Allocation of curbside space for freight deliveries, e.g., loading zones (LZ), is one of the most promising interventions policymakers have for including freight needs into urban planning (Comi et al., 2022; Holguín-Veras et al., 2018). Studies highlight this solution as one of the most extensively explored and implemented in Europe (De Marco et al., 2017) and the US (Maxner et al., 2024). A review on the effects of LZ showed the benefits reported from several cities worldwide in last-mile efficiency (i.e., 29% delivery time reduction), emissions (i.e., 32% reduction) and curbside regulation compliance (i.e., 44% less parking violations) (Castrellon and Sanchez-Diaz, 2024). Most of these outcomes are based on simulations or estimates from transport modelling. Only a few results come from actual evaluations conducted after implementing pilots or tests in cities to determine the effectiveness of LZs in resolving curbside conflicts over specific periods of time. The instances of well-established practices were even fewer.

Running pilots presents its own set of challenges and has been the focus of research in urban freight (Quak et al., 2023). Previous contributions have uncovered the technical, managerial, and operational aspects for successfully executing urban freight pilots. These studies have approached the subject from various angles—some through the lens of freight companies (Cowie and Fisken, 2023; Ranjbari et al., 2023), others via public sector viewpoints (Butrina et al., 2020; Castrellon et al., 2024) or a combination thereof (Diehl et al., 2021). Concerning freight companies' perspective, key findings underscored the importance of selecting optimal locations for pilots' implementation—such as parcel lockers, cargo bikes, parking apps, and micro-hubs—and establishing collaborative frameworks among stakeholders (Ranjbari et al., 2023). This also includes engagement with local authorities and crafting appropriate regulations (Cowie and Fisken, 2023). From the standpoint of the public sector—especially regarding curbside pilots—experiences in both U.S. and European contexts have highlighted critical factors for pilots' success. These include strict enforcement of LZs, dedicating spaces for freight activities, implementing data-sharing agreements, and introducing automated systems for payment collection (Butrina et al., 2020; Castrellon et al., 2024; Diehl et al., 2021).

Despite the insights provided by urban freight pilots regarding their impact on city sustainability, expanding these initiatives beyond their initial scope has been limited (Quak et al., 2016). Some projects faced difficulties when trying to extend to other parts of the city or turn pilot learnings into permanent practices. Research has identified several barriers to scaling up these pilots, including a mismatch of stakeholders' interests and perspectives, lack of supportive laws or policies, unclear business models, inadequate resources like staff and expertise, as well as inconsistent monitoring and evaluation (Nesterova and Quak, 2016). However, there is still limited understanding of what drives freight curbside interventions from pilot stages to sustained implementations. Moreover, research on factors that help transition from temporary pilots to permanent regulations is scarce in studies comprising multiple cities.

Therefore, this research aims at understanding the success and failure factors that influence the institutionalization process of practices tested in freight curbside pilots. In essence, authors studied how freight curbside pilots are influenced by their structure and the environmental forces, meaning rules, heuristics or values from the social context (Hoffman, 1999), in either their evolution to established practices or non-adoption. Institutional theory provided the foundations for understanding forces influencing the process that led to institutionalized practices derived from freight curbside pilots.

The paper is structured as follows: Section 2 describes the conceptual framework that guided the research approach and analysis of collected data. Section 3 addresses the methodology including the cases selection and the research design. Section 4 presents the results along with corresponding discussions. Section 5 concludes the paper with final remarks and outlines future research directions.

2. Conceptual framework

2.1. Theoretical approach: institutional theory (INT)

The theoretical lenses of institutional theory (INT) served for identifying factors influencing the transition from loosely organized freight curbside management to structured practices properly adopted by the organizations involved in freight curbside pilots (i.e., the organizational field). INT provided the analytical grid to understand how policymaking develops previous, during and after pilots, i.e., pre pilot, pilot and post pilot phases, by studying changes in the organizational field in terms of power relationships, involved organizations and their interactions (Thoenig, 2011).

In freight curbside management, the institutionalization process refers to the change in rules, norms and routines that curbside users experience when adopting generally accepted practices for deconflicting the access to curb space. Thus, success factors refer to those factors that facilitate the institutionalization process, making the organizational field adopt structures considered rational and legitimate in the external environment, i.e., culturally sensitive (Thoenig, 2011). Conversely, failure factors are those hindering the process of adopting learnings from pilots, impeding, for instance, their scaling up.

Fig. 1 presents the conceptual approach that guided this research that focuses on examining the factors contributing to the success (+) or failure (−) of the institutionalization process for interventions tested during freight curbside pilots. According to INT, practices adopted and deemed legitimate within the organizational field are considered institutionalized practices—orderly, stable, and socially integrating patterns that evolve from initially unstable, loosely organized, or narrowly technical activities (Selznick, 1996).

Based on INT postulates, changes in the organizational field are driven by three types of forces that organizations experience and make them adapt to contextual characteristics, i.e., coercive, normative, and mimetic isomorphism (DiMaggio and Powell, 1983). Coercive isomorphism refers to the changes driven from influences exerted by those in power, e.g., government mandate or cultural expectations in society. Normative isomorphism denotes drivers causing organizations to conform to be perceived as having legitimate organizational activities. Lastly, mimetic isomorphism indicates that changes occur when organizations imitate the actions of successful competitors in the industry, to replicate the path of their success.

2.2. Change forces driving institutionalization processes in urban freight

In urban freight, previous research has investigated change forces influencing isomorphism in private UFT companies (Rose et al., 2016), and local public authorities designing UFT policies (Akgün and Monios, 2018). For instance, limitations in the access to public space, national transport regulations, growing demand for goods due to urbanization, and scarcity of places to park and deliver have been identified as coercive forces that influence practices in last-mile deliveries (Rose et al., 2016). Previous research has also analyzed the influence of neighborhood organizations in urban communities in the implementation and scaling-up of pilots and street experiments (Smeds and Papa, 2023). However, these latter evaluations consider predominantly passengers' mobility, overlooking freight initiatives.

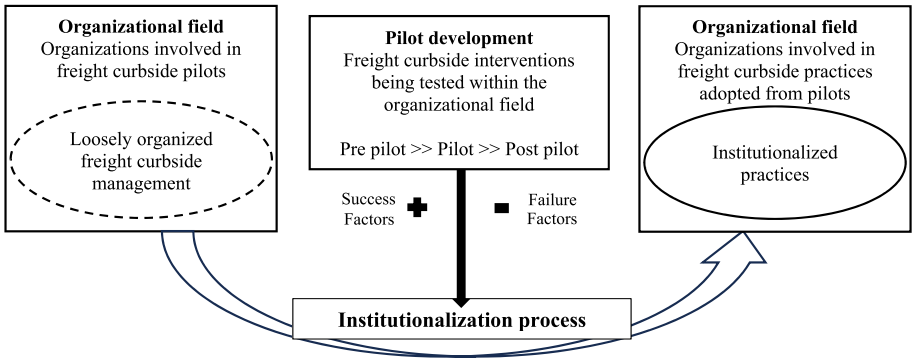

Fig. 1. Theoretical framework based on INT constructs.

As for normative forces, previous contributions have identified pressures from public opinion and non-governmental organizations requesting actions in terms of freight regulations to mitigate impacts on society and environment (Akgün and Monios, 2018) or to prioritize active transport modes. While in mimetic forces, authors reported the practice of articulating freight regulations with mobility and land use policies, particularly regarding the urban space allocation under situations of space scarcity and high demand from other users (Akgün and Monios, 2018). Also, transferring learnings between cities has been an example of mimetic forces driving change in urban freight (Janjevic and Ndiaye, 2014).

Pilots have served as a vehicle for institutionalizing interventions in UFT (Nesterova and Quak, 2016). The organizational field impacted during the implementation of pilots in urban freight is described in the section below.

2.3. Organizational field in freight curbside pilots

According to the central constructs of INT (Hoffman, 1999), an organizational field comprises a group of organizations that share an interest in a particular issue, even if their purposes and natures are diverse. The field members are mainly those that exert coercive, normative or mimetic influences on one or multiple organizations within the field.

In this study, organizations participating in freight curbside pilots represent the organizational field under consideration. Public and private actors make up temporary organizational arrangements to test freight curbside practices through pilots (Letnik et al., 2020). Pilots provide a realistic setting, revealing both predictable and unforeseeable obstacles and benefits of the practices (Ranjbari et al., 2023). The involved organizations vary by location but typically include local/regional authorities, freight receivers/generators, transport companies, technology companies, transport infrastructure providers/managers, and academia.

Organizations participating in pilots share the interest of improving freight access to curbside space for (un)loading, while mitigating conflicts between freight and other uses of the curbside space. The pilots aim to assess potential interventions for permanent adoption within the organizational field and their implications for curbside policies, including technology, regulatory frameworks, infrastructure, and economic, social and environmental impacts.

Freight curbside pilots are extensively documented in the literature (Letnik et al., 2020). The pilots differ in terms of duration, leading organization–whether academia, local government, tech company, national government, NGO, or private retail/transport company–, project origination–such as research projects, public tenders, or supranational project calls–, and the technology implemented–including cameras, ground sensors, mobile apps, parking meters–.

For example, in Lisbon (Portugal), city authorities installed parking meters and loop vehicle detection sensors on loading zone floors to monitor occupancy levels and enforce curbside regulations. A similar trial in Seattle aimed to provide real-time and forecasted parking information to freight operators (Dalla Chiara and Goodchild, 2020). In Lyon (France), the 'Loading Bay of the Future' pilot assessed the effectiveness of booking systems in reducing double-parking, congestion, and emissions. Vienna (Austria) implemented 'i-Ladezone' for loading zones monitoring and control to prevent unauthorized curbside use (BESTFACT, 2013). In Vic (Spain), an app-based solution, i.e., Parkunload, was introduced, providing a tool for curbside access control by requiring truck drivers to notify the beginning and end of their operations at loading zones (Kalahasthi et al., 2022). These and several other initiatives have examined the impacts of practices at strategic, tactical and operational levels (Castrellon et al., 2024), using relevant indicators for the involved organizations and the city.

2.4. Scaling-up of pilots in urban freight curbside

For analyzing the institutionalization process in freight curbside management, this paper studies the evidence from pilot's scaling-up experiences, meaning that tested interventions are institutionalized when pilots successfully scaled-up in any of the scaling forms, i.e., roll-out, expansion, and replicability (Hartmann and Linn, 2008). Roll-out means that the intervention was successfully tested during the pilot phase and made available to more organizations (i.e., change in the organization field). Expansion involves scaling up the pilot within the organization(s) that developed it, which can be done in terms of geographic area (i.e., geographic expansion), recruitment of new partners (i.e., quantitative expansion), and addition of functionality (i.e., functional expansion). Replicability refers to the reproduction of the pilot in a different context, such as a new city or different zones of the same city or different environment, characterized by different regulations and partners.

In the UFT literature, previous contributions have identified challenges stakeholders face when testing city logistics solutions and factors influencing the scaling-up of pilots (see Table 1).The references are organized based on themes, mentioning the identified factors that could either enabled or hindered pilot scalability.

According to (Sista and De Giovanni, 2021), among the requirements for performing a successful scaling-up are: the prospect of reaching economies-of-scale, the presence of knowledge transfer mechanisms and incentives, the management of ambidexterity in exploration–exploitation activities, the presence of enabling regulatory, legal, and policy frameworks, the interoperability between systems, data and standards, and the inclusion of standards to measure returns on an investment. Since most of the studies focused on urban consolidation centers (UCC) or smart cities' technologies, research opportunities emerged regarding the identification of success and failure factors in another important urban freight initiative: freight curbside management. This gap motivates the following research question guiding the current paper: What are the success and failure factors influencing the

Table 1
Factors influencing the scaling up of urban freight pilot projects.

Theme	Factors influencing scalability	References
Organizational	– Effective management – Knowledge transfer – Coordination among stakeholders – Risk management – Stakeholder involvement	Cleophas et al. (2019) van Winden and van den Buuse (2017) König and Spinler (2016) Gonzalez-Feliu and Morana (2014) Söderström et al. (2014)
Economic	– Profitability – Financial constraints – Business model	Sista and De Giovanni (2021) Quak et al. (2014) Sigrist et al. (2016)
Regulation	– Enabling regulatory, legal and policy frameworks – Adapting and updating regulations and policies – Demand and land use management and policy	Holguín-Veras et al. (2020) van Winden and van den Buuse (2017) Sigrist et al. (2016)
Technological	– Existing infrastructure – Modularity – Data interoperability – Data collection and sharing – Data management and analytics – User experience – Implementation easiness	Sista and De Giovanni (2021) Sigrist et al. (2016) Zahra et al. (2021) (van Winden and van den Buuse, 2017; Sigrist et al., 2016) Kogan and Lee (2014) Walravens and Ballon (2013) Walravens and Ballon (2013)

institutionalization process of interventions tested in freight curbside pilots?

3. Methodology

The methodology applied is a within-case and cross-case analysis of cities with pilots on freight curbside management worldwide. Fig. 2 summarizes the methodological steps and the main activities at each step. Semi-structural interviews together with a review of existing literature and pilot reports provided empirical evidence from cases in North/South America, Europe and Asia. An initial set of 35 cases were identified through website screening, then stakeholders of the pilots were contacted for interviews to obtain detailed information. Cases selection led to 17 pilots based on the maturity level of pilot developments, i.e., pilots already implemented and went through monitoring, evaluation, and possible continuation processes. Most of the selected cases involved digitalization pilots that tested technologies' adoption in freight curbside management. For instance, cameras and sensors providing real-time data about parking occupancy, or mobile app systems used by freight operators, enforcement agents and infrastructure managers, that registered data on vehicles' arrival, departure among other attributes.

The interviews were conducted with stakeholders that were leading or having an active participation during all the pilot phases. The sample design method and research quality approach used is adopted from (Bryman and Bell, 2015). The interviews were performed to understand the challenges faced before, during and after the pilot that could give insights into factors influencing the institutionalization process of interventions tested in freight curbside pilots.

The interview guide was developed to obtain new information or verify the secondary data previously collected (see Appendix A). The interviews were conducted during summer 2023 and spring 2024. Each interview lasted between 25 and 105 min and was conducted either in English or Spanish, according to the interviewee's convenience to avoid communication barriers in addressing the questions. In total 19 interviews were conducted, having for some cases more than one participant providing information about the same pilot, e.g., academic partner and technology provider. An overview of the interviews can be found in Table 2.

All interviews were performed online, and each interview was recorded with permission of the interviewees and transcribed. To increase trustworthiness, secondary data were read prior to the interviews (e.g. technical reports, technology description, conference presentations, news articles, among other grey literature). This was done to reduce the possible misunderstanding between interviewers and interviewees. The secondary data was also used to validate and complete the information collected during the interviews to ensure data triangulation of evidence (Eisenhardt, 1989). Appendix B shows descriptive information of the cases selected.

Table 2
Cases selection: description of the interviewees.

Case	Pilot location	Respondent	Interview language	Duration of the interview (min)
1	Belo Horizonte, Brazil	Academic project leader	English	47
2	Bilbao, Spain	Project manager	English	45
3	Bogotá, Colombia	Municipality project leader	Spanish	67
4	Groningen, Netherlands	Company project leader	English	62
5	Guadalajara, Mexico	Academic project leader	Spanish	105
6	Hamburg, Germany	Municipality project leader	English	38
7	LA, USA	Company project leader	English	25
8	Lyon, France	Project manager	English	45
9	Miraflores, Peru	Academic project leader	Spanish	36
10	Paris, France	Company project leader Academic project leader	English English	25 25
11	Patras, Greece	Company project leader	English	45
12	Pittsburg, USA	Company project leader	English	25
13	Santiago, Chile	Company project leader	Spanish	55
14	Seattle, USA	Academic project leader	English	52
15	Singapore	Academic project leader	English	38
16	Vic, Spain	Company project leader Municipality project leader	English Spanish	61 74
17	Zapopan, Mexico	Academic project leader	Spanish	105

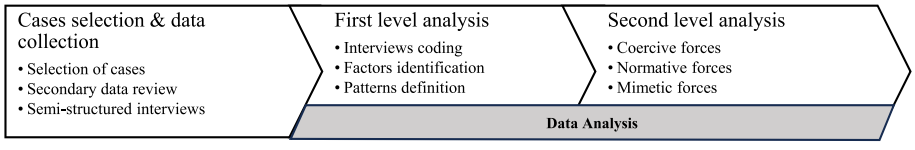

Fig. 2. Methodological steps.

3.1. Data analysis

Structural coding was employed to identify the relevant codes provided by the data analysis (Saldaña, 2021). Codification shown in Appendix C was validated by an external researcher.

The identified 23 codes, labeled in Appendix C as themes, were then arranged in four content domains: organizational, economic, regulation, and technological. These content domains come from the literature on UFT pilots' scaling up shown in Table 1. The content domain refers to aspects that feature pilot's development and are linked to success and failure factors influencing the institutionalization process of freight curbside practices from pilot's learnings. These contents were compared with the findings in the secondary data collection to understand what aspects were most mentioned during the interviews.

The *organizational content* domain intends to explain how the involved actors were organized to plan and develop the pilot. It integrates themes such as: scope definition, stakeholders' involvement, and leadership definition, but also how they communicate and resolve the conflicts during the pilot, being aware of the risk management and the public sector capabilities, this last one understood as the resources and knowledge available in public agencies to address urban freight projects.

The *economic and social content* domain describes themes such as: funding and business model defined by the stakeholders involved, implementation cost, economic risk, and the public benefit achieved through the pilot implementation.

The *regulation content* domain aims to understand the regulatory factors defined during the pilot planning, such as: loading and unloading zone definition, legal framework for pilots contained in cities' legislation, land use regulations, enforcement rules defined for the pilot, and the legal mandate of public agencies involved.

The *technological content* domain integrates themes such as: data management through the pilot phases, feedback about users' experience and the implementation easiness considering interoperability and modularity of the implemented technologies.

During the data analysis, Nvivo coding was used to capture the interviewees' language, experiences, and perspectives through their direct quotes. A parallel and independent coding process was performed by two members of the research team to ensure reliability, obtaining 94% of intercode agreement. First the information related to case context was coded, including the location and duration of the pilot, type of zone (i.e. commercial, industrial, residential, mixed), the phase of the pilot (pre-pilot, during pilot and post-pilot), the leading organization (i.e. local authority, academy, company), project origin (i.e. European project, public tender, research project), type of funding (i.e. European, local, private), technology implemented during the pilot (booking system, cameras, sensors, check-in and check-out), and in the cases where pilot interventions turned into institutionalized practices, their continuation was classified according to the scaling-up typologies (rolling out, expansion, replication, not scaled). Then, the connection elements and themes were coded.

After completing the first-level coding, a set of patterns was identified based on code frequency, focusing on those with the highest occurrences across the pre pilot, pilot and post pilot phases. These patterns went through a second-level coding to determine the nature of the driving forces for change, i.e., coercive, normative, and mimetic. The analysis of these forces informed recommendations for policymakers and highlighted potential directions for future research.

4. Results and discussion

This section outlines the factors that either facilitated or hindered the institutionalization process of pilot interventions, and the nature of the forces driving the shift toward institutionalized practices. The first-level analysis presents the results of the interview data, categorized by content domain across the pre-pilot, pilot, and post-pilot phases. It also includes an examination of how themes evolved from one phase to the next. The second-level analysis focuses on the institutionalization process, highlighting the forces that shaped the institutionalized practices.

4.1. First-level analysis: factors influencing the institutionalization process

Appendix D-G present the success (+) and failure (−) factors identified during the interviews, coded by content domains and themes. The results highlight the factors associated with the most frequently occurring themes in the data across each phase of the pilot. Each theme includes factors that can either facilitate or hinder the institutionalization of curbside interventions. Consequently, success and failure factors arise within the same theme, reflecting different practices. This distinction helps identify effective practices for addressing the selected themes, e.g., data management, which while present, sometimes required specific focus to support the institutionalization process of curbside interventions–otherwise, it could lead to the opposite outcomes.

4.1.1. Patterns description

The most frequently coded themes in the data, consistently present across the pilot phases, were identified as patterns, i.e., legal mandate of public agencies (legal competence), public benefit, scope definition, stakeholders' involvement, business model, data management, and user experience. As the interventions tested in the pilots were institutionalized, this research identified the factors that supported and hindered their institutionalization process. Fig. 3 illustrates the patterns and the identified interactions that influenced this process.

Initially, pilot's originators, e.g., public agencies, involve those stakeholders whose competence to implement freight curbside pilots is given in regulations, and motivate the pilot based on the hypothesized public benefit of an initiative. Once this foundation is established, the pilot is designed in terms of its scope, business model and the involvement of relevant stakeholders. While data management and user experience are considered during the planning phase, they are often subject to adjustments during the pilot implementation in a back-and-forth loop that aligns the plan, scope and business model with the actual conditions. The analytics of data collected during pilots and users' feedback then serve as input to reassess the public benefit, ultimately determining whether to reinforce or discontinue the tested interventions.

The institutionalization process, influenced by the seven patterns shown in Fig. 3, leads to the adoption of tested interventions into established practices if certain factors are given, i.e., success factors. However, failure factors can impede this process, hindering the institutionalization of pilot interventions. Since the goal of this paper is to identify these factors, a detailed description of both success and failure factors for each pattern is provided below, addressing the list of factors included in Appendix D-G.

a. Legal mandate of public agencies

According to the collected data regarding legal mandate of public agencies, the institutionalization of curbside interventions largely

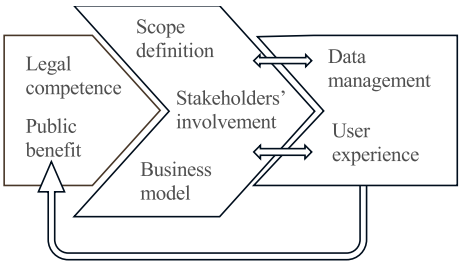

Fig. 3. Patterns and their interactions in the institutionalization process of freight curbside interventions.

depends on the ability to adapt local bylaws, effective collaboration of stakeholders within the public sector, and the use of digital tools for enforcement. However, challenges such as the lack of national legislation or independence of local governments in designing freight curbside regulations need to be addressed.

Regarding success factors, the ability to adapt local bylaws to support new technologies enabled the implementation of pilots and their scalability. For instance, in some countries in Europe, "*the mayor has the power to make bylaws, which facilitated the mandatory use of an app for managing loading zones.*" This local legislative flexibility allowed for smoother implementation and enforcement of new rules.

Once the legislation is in place, the use of digital tools to enforce regulations also played an important role in permanently adopting interventions tested during pilots. For instance, the adaptation of enforcement mechanisms to include digital tools helped in better managing curbside activities in some of the included cases. Nonetheless, these developments were not possible in contexts where there was a lack of independence for local governments to define freight transport regulations, coupled with non-existent national legislation supporting curbside management.

Additionally, respondents identified the high fragmentation of local traffic regulations and the lack of coordination among public agencies with overlapping responsibilities in curbside management decision-making as significant failure factors. An interviewee explained, "*You have the traffic department, the maintenance department, and the mobility or logistic department, and that delayed all.*" This fragmentation led to inefficiencies and hindered pilots' development.

b. Public benefit

In terms of public benefit, the improvement in space utilization and turnover was one the main aspects highlighted by the interviewees, confirming findings from previous research regarding the benefits of efficient management and enforcement of the curbside space, from the city perspective. For instance, in one pilot, the results were described as "*spectacular in terms of the improvement of the turnover of the space, the availability of the spaces, and the number of fines that they were able to issue with a small number of enforcement agents.*"

Also, evidence about reductions in double parking and emissions was noted as a relevant factor for motivating the continuation of freight curbside interventions after trials. These reductions not only improved traffic flow but also contributed to environmental benefits, making the city more livable. "(…) *we've been able to significantly reduce double parking across cities in North America, reducing emissions from circling the block by about 12 metric tons per zone.*"

The adaptability of curbside spaces also emerged as a success factor. Having loading zones that adapt to different needs throughout the day, such as serving freight deliveries in the morning and al-fresco dining in the afternoon, maximized the public utility of the curbside space. Making the public aware of the benefits that technology offers in leveraging dynamic urban space encourages the acceptance and adoption of tested practices during and after pilots.

Among the identified failure factors, interviewees mentioned the lack of thorough evaluation and data collection. One interviewee mentioned, "*they could have been a bit more thorough or careful in evaluating these schemes to see the effectiveness,*" highlighting that without systematic and recurrent data collection, it becomes difficult to identify ongoing issues and make necessary adjustments.

The resistance to change and civic culture also poses a challenge. As one interviewee noted, "*there is always someone who continues to park where it is not allowed … this is already a matter of civic culture.*" Changing long-standing behaviors and attitudes towards parking and space utilization requires continuous effort and engagement with the community.

c. Scope definition

For scope definition, the strategic selection of locations was mentioned as success factor for pilot's development and institutionalizing its interventions. Interviewees highlighted that zones were chosen based on high demand areas, particularly those where double parking was a significant issue. One participant noted, "*They chose … the zones next to the pedestrian center … because the demand on the parking spaces is concentrated due to the pedestrianization policy and that's where the problem was located.*" This strategic approach ensured that the most problematic areas were addressed first, thereby maximizing the impact of the pilot and with it the stakeholders' interest in adopting tested interventions.

Data-driven decision-making was also highlighted as a success factor. The use of indicators such as (un)loading times and delivery schedules to determine the ideal locations for loading zones was crucial. An interviewee mentioned, "*We came to process the data and determined indicators such as loading and unloading time … and based on that we determined which were the possible loading and unloading bays.*" This evidence-based approach ensured that decisions were grounded in actual usage patterns and needs, providing the required legitimacy of practices in the institutionalization process.

During post pilot phases, the incremental deployment of loading zones also emerged as a success factor. Starting with a small number of zones and gradually increasing them allowed for manageable implementation and adjustments based on initial learnings. For instance, one interviewee described, "*They made a trial with eight zones. In two more phases, they went up to 22 and now to 50 zones in two more stages of deployment.*" This incremental approach facilitated continuous improvement and adaptation to emerging challenges.

However, the analysis also revealed failure factors. Funding constraints were a significant challenge, limiting the number of zones that could be implemented initially and potentially slowing down overall progress and impact. One interviewee remarked, "*For budgetary reasons and also to learn how it works, we're going to start with maybe one or two delivery one or two areas.*"

Considering the conflicts among curbside users when allocating space for freight was also a challenge. The selection of loading zones had to include the impact assessment on traffic and congestion, as well as the demands of other users for the same curbside space. An interviewee highlighted, "*The city has a set of loading zones to study but finally the 180 ULZ were selected based on the impact on traffic and congestion, conflict among the curbside users.*" Overlooking competing interests in the access to public space represented a failure factor during pilot and post pilot phases.

After having analyzed scope definition as a relevant pattern on the transition from pilot to established practices, results confirmed that a successful transition is not only positive influenced by structured process of loading zones' location and monitoring, but also by shaping pilot implementation easiness during the scope definition. Consequently, technology adoption must be carefully considered, as interviews highlighted the significant challenges of adapting technology to new use cases.

> "We had a very different use case, so never before we had tried to apply the technology to a wholesale market."
>
> "I think in terms of being able to deploy a solution our work in City X was definitely a good case of comparing how good it is with a Bluetooth mobile solution compared to other solutions"
>
> "Well, if the app is mandatory, they agree with that and they are quite happy with the solution because they find more easily free parking spots in the loading zones. They have adapted the solution quite well"

This highlights the importance of considering aspects of flexibility and adaptability in technology deployment during the pilot scope definition.

d. Stakeholders' involvement

According to the collected data, the institutionalization process of interventions from freight curbside pilots is heavily influenced by the level and quality of stakeholders' involvement. Early engagement, clear communication, and alignment of interests leveraged success across the pre, during and post pilot phases, while lack of coordination, and insufficient end-user engagement led to failures in pilot's implementation and scaling up.

Regarding early engagement, responses suggested that a proactive approach helped in addressing potential issues early on and facilitated smoother project execution. For instance, in one case, the traffic department led the project and ensured that enforcement personnel, the technology provider and transport companies were involved from the very beginning. Engaging with logistics companies and drivers ensured that the locations of the loading zones met actual needs, thereby increasing the likelihood of success. One interviewee explained, "*We consult different logistic companies and drivers, and we asked them where they need additional loading zones.*" This collaborative approach helped in identifying the most effective locations for the loading zones. The involvement of academics was also found to be as a positive influence for building trust, facilitating interaction between the public and private sectors, and providing the reliability of the pilot results.

However, the data also reveals failure factors related to stakeholder involvement. One significant issue is the lack of coordination and conflicting interests among public agencies, as mentioned in the legal mandate of public agencies pattern. In one instance, the project faced delays due to the involvement of multiple public agencies with differing priorities.

Additionally, the insufficient engagement of end-users, such as delivery drivers and local businesses, e.g., shop owners, is the reason for the lack of awareness and understanding of the project's benefits, leading to resistance or non-participation. For example, in one of the revised cases, delivery drivers were skeptical about using the new system because it was not mandatory, and enforcement of existing regulations was lax.

e. Business model

A business model benefiting the city, the users and the solution providers, was viewed as a success factor for institutionalizing pilot interventions. In this regard, the business model integration to the existing traffic and enforcement systems eased pilots' implementation and built the foundations for a successful scaling up. Thus, the benefits for users were in the form of improved space management at high demand zones, available data for better routing decisions, and cost savings due to less congested streets, even if they had to pay for the use of on-street spaces, as reported in some of the cases. For instance, in the US, the implementation of smart loading zones with automated payment systems significantly reduced double parking and emissions while increasing turnover and revenue for the city. The interviewee explained, "*We typically deploy our smart loading zones where we fully automate payments like a toll road using cameras at the curb.*"

However, the business case for freight curbside management varies depending on local regulations. For example, in most European countries, loading operations are free of charge, making the implementation of freight curbside pilots reliant on funding from international or national agencies and NGOs. Consequently, business models must remain flexible and adaptable, with strong collaboration between private companies and public agencies. A successful example from South America demonstrated the effectiveness of such partnerships. In this case, a technology company developed an application at no cost to prove its viability, which subsequently facilitated broader adoption. As one interviewee noted, "*We asked this company to develop it for free to demonstrate its effectiveness. This underscores the potential of public-private partnerships to drive innovation and reduce costs.*"

Data from interviews also revealed failure factors related to business models. One significant issue was the lack of alignment between the business model and the needs of end-users. For instance, an inhibitor to the continuation of practices like booking systems was the resistance from freight operators, who were reluctant to adopt new technologies due to the additional workload they imposed.

Another common challenge was the complexity of public procurement processes. In some instances, the success of a pilot was hindered by the lengthy and bureaucratic process of contracting with the private sector, making more attractive funding options with external funds. The interviewee explained, "*when you do business to governance, it is a long process, and it can definitely ease things if you can use* funds. *So, if there is an option for* funds*, we do it because it makes it more attractive for the cities to work on a pilot.*" Although the scalability could be challenged by future availability of grants.

f. Data management

Data management together with user experience were the most frequent themes found in the data under the technological content domain. In data management, the success factors were related to the ability to collect, visualize and analyze curbside data. Commonly, curbside data allowed for the identification of the most used loading zones and the times during which these zones were most active. These data provided relevant insights for improving freight decisions after identifying high-utilization areas and peak delivery times.

Data integration was also mentioned as a success factor. In some cases, the data collected from the implemented devises, e.g., mobile apps, cameras, ground sensors, among others, were directly accessible to city officials, enabling them to monitor and manage curbside activities more effectively. Data dashboards were developed to provide real-time information on the use of loading zones, including occupancy rates, booking distributions, and user statistics. "*The data is very good, and it's collected directly by the city, allowing for detailed analysis of delivery patterns and enforcement activities.*"

Several challenges and failure factors were also identified. One major issue is the lack of comprehensive data collection and planning. In some pilots, the data collection process was not well planned, leading to gaps in the data and difficulties in analyzing the freight needs for curbside space. Furthermore, resistance to data sharing and privacy concerns hindered the progress of some pilots, leading to extended planning times or limited participation of companies due to the administrative burden of NDA signings. *"(…) there was a process of signing NDAs. Then, out of 15 interested companies, we finally signed NDAs with 5, the others were left in legal limbo to allow access to certain company data.*"

g. User experience

Given that most of the curbside pilots involved any sort of technology, success factors referred mainly to the smooth interaction between users and the adopted technology, comprising visual and user-friendly apps and devices, effective communication about their proper use and on-the-ground support. For instance, in one of the pilots, the app provided a visual indication of time limits, changing from green to amber to red as the time approached its limit. This feature was described as "*very visual, making it easier for drivers to manage their parking time effectively.*"

Regarding communication, authorities in some cities were proactive in communicating with users and providing necessary support on-the-ground, "*the municipality did all the communication towards the users, which helped in onboarding and educating drivers about the new system.*"

However, one major issue still was the resistance from drivers to adopt new technologies. In many cases, drivers were reluctant to use the app, either due to a lack of familiarity with the technology or because they found it cumbersome. For instance, in some cases, drivers found the process of booking a loading zone too complicated or time-consuming highlighting the need for more intuitive and streamlined solutions. Additionally, the lack of clear and consistent enforcement led to low compliance rates. "*There was no active deployment because there was no*

enforcement, making it difficult to ensure that drivers adhered to the new rules."

4.1.2. Institutionalization process of pilot interventions

The transition from trials to institutionalized practices, i.e., the institutionalization process, was shaped by different patterns and interactions across the pre-pilot, pilot, and post-pilot as illustrated in Fig. 4. In the pre-pilot phase, the emphasis (indicated by shadowed shapes) was on patterns that ensured the pilot's successful setup. During the pilot phase, the main emphasis shifted to data collection and analysis, user experience assessment, and the back-and-forth loop to adjust aspects in the business model, scope, and stakeholders' involvement. In the post-pilot phase, the harmonic flow/interaction among all the different patterns influenced the institutionalization process.

The successful scaling up of freight curbside pilots, particularly in terms of expansion or roll-out, was based on several factors as mentioned in the section above. Among all, the strategic and data driven selection of loading and unloading zones in high-demand areas is essential to address freight curbside challenges effectively. Enforcement and demonstrating public benefits, also provides support for institutionalizing pilots' practices.

> "Everybody will say our city is unique, our city is different, and that's true in a lot of cases. But the principles hold true, and so generally, there are different phases that we see where cities can start with collecting data, small scale automation, and then they can expand, but generally, just capturing the data producing case studies, we find is the most helpful way to scale these types of projects up."

However, challenges like managing exemptions, optimizing times, and integrating dynamic control technology require continuous adaptation and investment. Starting with a few zones and expanding based on feedback ensures smoother scaling up process. User experience, enhanced by tools like apps showing available zones, is also relevant to ensure acceptance from curbside stakeholders. Despite these advantages, regulatory constraints, business model adaptation issues, and land use regulations can hinder scalability, emphasizing the need for flexible, context-specific approaches.

4.2. Second level analysis: driving forces of change towards institutionalized practices

Forces driving the transitions across pilot phases shown in Fig. 4 are explained in this section based on the coercive, normative, and mimetic isomorphism of INT.

4.2.1. Coercive drivers

Local authorities' mandate for regulating the curbside space coupled with national government bylaws for parking management were found to be a coercive driver of change to enable the institutionalization of pilot interventions. This force is featured by legal instruments for allocating right-of-way and providing loading zones with the corresponding traffic signs. Enforcement is key in the institutionalization of interventions, having technological deployments to increase the effectiveness of curbside control, e.g., automated fines using cameras. This force hinders the institutionalization process only when local authorities lack autonomy to define rules, there is no interest in regulating the use of space or when there is a misalignment between enforcement practices/regulations and freight curbside pilot interventions. "*The hard part again was getting the internal departments motivated to help and get the right permits*".

The allocation of loading zones drove change in curbside practices, confirming the results from (Rose et al., 2016), about the coercive pressure-built environment poses on freight curbside practices. Trucks navigating throughout narrow streets and not finding parking spots influence driving behavior that often leads to illegal parking or driving on the pavement, generating rejection from the general community. Furthermore, the implementation of smart signs and enforcement technologies results unfeasible when the availability of energy services is limited, e.g., electric utilities and suitable outlets to plug curbside technologies. This latter aspect is also part of the built environment that determine the institutionalization of monitoring and enforcement practices. "(…) *there is no source of energy. And then, (…) the company owning the streetlights and electric utilities in the city, they were really not friendly. They didn't allow us to plug anything in. So, there was a huge issue.*"

The institutionalization of pilot interventions was also influenced by the implementation of freight curbside initiatives together with other mobility initiatives to maximize the benefits of data collected and the control scheme in place. For instance, digital loading zones available for only electric vehicles was found to be a coercive force for ensuring an appropriate use of curbside space while leveraging low emission zones policies simultaneously.

Additionally, the interest of funding agencies in developing curbside interventions influences change towards institutionalization of learnings from projects funded by these agencies. Thus, grant applications scope and requirements from the funding agencies for funding cities' projects represent a coercive force also identified in (Akgün and Monios, 2018). If the funding comes directly from the government and a tender process was required for the pilot continuation, then the legal framework for contracting technology firms become also a manifestation of coercive forces. "*One of the huge things is contracting the company, so they had to say the pilot had been successful and that they were interested in having it as a permanent scheme. That required setting up a new contract*"

Finally, the influence of neighborhoods was a coercive force evidenced in freight curbside pilots as it was in other trials reported in (Smeds and Papa, 2023). "*We had two families, two houses next to each other that made an official complaint about the location of the loading zones. (…) their main complaint was that they were afraid that this new smart loading zone would lead to more logistic companies parking in front of their house*". Also, landowners and shop owners had influence in the definition of (un)loading rules constituting a coercive force. This evidence reinforce research gaps reported in (Castrellon and Sanchez-Diaz, 2024) related to the involvement of local communities in the definition of

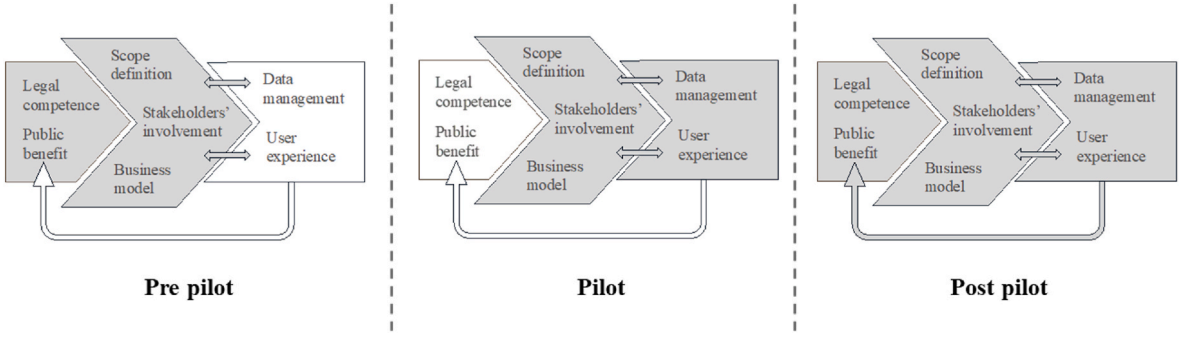

Fig. 4. Transitions driven by patterns emphasis.

curbside practices.

4.2.2. Normative drivers

Successful pilots' scaling-up occurred when analyzed data was properly communicated regarding the demonstrated efficiency gains for companies and the benefits for the city in terms of congestion reduction, and cleaner environment. Pricing schemes to encourage parking turnover and prevent other users to occupy freight zones act as a normative driver in contexts where paying for the curbside access is an institutionalized practice. Thus, legitimating practices tested in pilots and adopting them later within the organizational field heavily depended on how different users of the curbside and other stakeholders realized about the benefits of certain practices from their own perspectives. Additionally, the business models orchestrating the implementation of pilots influences the institutionalization process by prioritizing the fair equilibrium of interests among the involved actors.

> "Our goal and all of the projects that we work on with cities is to tackle any combination of these three categories, i.e., emissions, congestion and safety hazards, as well as to also ideally, have the project be sustainable from a financial perspective, and so for us what that means is to automate operations at the curb to help companies (…) pay compliantly for parking at the curb versus getting tickets, which is how they're generally managed today."

These benefits were tangible when the implementations took place in areas with urgent needs of balancing supply-demand mismatches, confirmed by the organizations involved. "*We consult different logistic companies and drivers, and we asked them where they need additional loading zones and at the end, we had a list with around 160 different loading zones*." This identification of zones also gained legitimacy when robust methods supported the allocation of loading zones based on demand estimations, traffic modelling and impacts' assessment. These aspects of pilot project design are crucial, as they influence the institutional process of curbside practices and their scaling-up as also found in (Sista and De Giovanni, 2021).

Legitimating the practice of data sharing between enforcement agencies, urban planning officers and freight operators to improve decision-making was possible only under trustworthy conditions of GDPR compliance and responsible use of data to avoid privacy violations. Academia can articulate these efforts by providing expert knowledge and unbiased position in the public-private interaction. "*Just by saying that it comes with the backing of the University, it opened many doors and generated more confidence among members of the private sector.*"

Training programs were normative forces of change required to illustrate the benefits of using technologies in curbside operations. However, operators' reluctance to new interventions and technology in parking can hamper the institutionalization process of these interventions.

4.2.3. Mimetic drivers

Multi-city projects encouraged knowledge sharing as mimetic forces of change. "*It was a call for innovation, and we teamed up with the three cities, it was all organized through EIT, so we had a matchmaking event solution.*" However, mimetic forces related to replication of pilots from city to city require an a priori assessment about the suitability of the transferability process (Janjevic and Ndiaye, 2014). City aspects like demography, innovation willingness and experience in pilot's implementation can determine if mimetic forces result in an effective vehicle for enabling the institutionalization process of freight curbside interventions. Additionally, transferability challenges, for instance between US and Europe, remain due to differences in regulations and conception about public space management.

5. Conclusions and future research

To ensure the successful transition from freight curbside pilots to institutionalized practices, it is crucial to follow a structured approach across all pilot phases. In the pre-pilot phase, thorough planning to ensure successful setup and stakeholder engagement are essential. During the pilot phase, robust data collection and user experience feedback should be prioritized, allowing for iterative adjustments based on real-time data to the business model. Post-pilot, a comprehensive interaction of these patterns should be developed to assess the pilot's success and identify areas for improvement. For instance, our data shows that 47% of pilots that followed a structured pre-pilot phase successfully transitioned to institutionalized practices.

The successful institutionalization of pilot practices relies on the strategic selection of loading and unloading zones in high-demand areas, addressing freight curbside challenges effectively. Enforcement and demonstrating public benefits can leverage the institutionalization of tested interventions in pilots. Starting with a few zones and expanding based on feedback ensures a smoother scaling process. User experience, enhanced by tools like apps showing available zones are also relevant to the legitimation of curbside interventions. In general, American cities under study, the introduction of a curbside management app started with the inclusion of strategic set of loading zones, test and after receiving feedback and make the adjustments, then expand to more loading zones, ensuring a smoother scaling process.

Nevertheless, this paper also highlights cases where curbside interventions fail to become institutionalized after pilot development. Challenges such as managing exemptions, optimizing times, and integrating dynamic control technology require continuous adaptation and investment. Similarly, regulatory constraints, business model adaptation issues, and land use regulations can hinder scalability, emphasizing the need for flexible, context-specific approaches. For instance, during the interviews 100% of the people interviewed mentioned regulatory constrains as the most important challenge faced.

The analysis of institutional pressures revealed that coercive pressures have an evident influence in transitions driven by patterns related to legal mandate of public agencies, scope definition and user experience, while normative pressures are present in patterns such as public benefit, business model, stakeholders' involvement, and data management. Although mimetic forces were not determinant in driving change towards institutionalized practices, evidence showed that they influenced the initial stages of pilots' development by learning from experiences of cities that had previously implemented curbside pilots.

This paper offers practical implications by identifying key factors that facilitate the transition from freight curbside pilots to institutionalized practices. Key recommendations include designing plans for scaling up since the pre-pilot phase, ensuring that the gradual implementation occurs in zones with urgent needs of intervention due to the intense conflicts in the access to the curbside space. These plans should be supported by strong public and private partnerships to enhance resource sharing and expertise for institutionalizing freight curbside management practices. During the pilot phase, regular communication focusing on pilots' impacts should be encouraged to legitimize practices among the stakeholders and the general community. This action would smooth the change process of regulations needed to the institutionalization of pilot interventions. During the post-pilot phase, cities should ensure effective mechanisms for stakeholders' engagement and funding of interventions. With these recommendations, decision-makers will then gain a better understanding of the curbside pilots through these collaborations and develop a set of best practices by providing more guidance on freight curbside management requirements for long-term policy implementations.

The results also support a set of policy recommendations such as: incentivizing the adoption of digital tools and technologies to enhance curbside management efficiency; development of enforcement mechanisms, such as fines for non-compliance and rewards for best practices, to ensure adherence and correct use of the curbsides for loading operations; allocation of resources for curbside pilot projects and subsequent scaling efforts, encouraging public-private partnerships that enable

access to additional resources and; encouraging continuous improvement through research and development and establishing a feedback loop where stakeholders can share insights and update practices based on new findings.

Moreover, the insights from this paper enhance the existing body of knowledge regarding applications of institutional theory in the field of urban freight by identifying factors that influence the transition from loosely organized freight curbside management to systematically adopted, structured practices within organizations involved in pilot testing these initiatives. Additionally, the empirical evidence drawn from seventeen pilot projects supports and validates existing theoretical constructs, providing concrete examples of how these theories are applied in real-world scenarios.

While this study provides insights into the success and failure factors in transitions from freight curbside pilots to institutionalized practices, several limitations should be acknowledged. First, the study's scope is limited to seventeen pilot projects, which may not fully capture the diversity of contexts and variables present in broader freight curbside management practices. Second, it is necessary to consider that the freight curbside management is dynamic, which means that factors influencing transitions may evolve over time, necessitating ongoing research to keep the findings relevant. Lastly, future research should explore whether the institutionalization process observed in this study is consistent across other initiatives within urban freight. This would help to identify any initiative-specific factors influencing the success or failure of institutionalizing urban freight management practices and broaden the applicability of the findings.

In conclusion, this study sheds light on the critical factors that influence the successful transition from freight curbside pilot projects to institutionalized practices. By identifying and understanding these factors, stakeholders can enhance their decision-making processes, foster stronger collaborations, and implement more effective strategies. Ultimately, the practical implications of this research offer a pathway for decision-makers to achieve institutionalized practices to improve the freight curbside management. As these practices continue to innovate, the lessons learned from this study will serve as a foundation for future advancements and effective freight curbside management.

CRediT authorship contribution statement

Laura Palacios-Argüello: Writing – original draft, Methodology, Funding acquisition, Formal analysis, Conceptualization. **Juan Pablo Castrellon:** Writing – original draft, Methodology, Formal analysis, Conceptualization. **Ivan Sanchez-Diaz:** Writing – review & editing, Supervision, Funding acquisition, Conceptualization.

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Declaration of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.tranpol.2025.02.005.

Data availability

Data will be made available on request.

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