

Digital Transformation in Urban Mobility and Logistics: An Integrative Framework and Umbrella Review

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Abstract

Digitalization is transforming urban mobility and logistics, changing behaviors and the way demand is anticipated and managed. This paper frames both research and practice in this area. Through a systematic review of reviews in Scopus and Web of Science, following PRISMA 2020, a corpus of 21 documents was compiled. The analysis organizes findings into five interrelated dimensions: technology; operation and service design; society, user, and equity; institution, regulation, and governance; and economics and scalability. These are interpreted through two cross-cutting axes: behavioral change among users and operators, and the anticipation and management of demand supported by big data and predictive models. By integrating urban mobility and logistics, usually analyzed separately, this study compares barriers and enablers. The two axes help identify gaps: limited coverage of medium-sized cities, low-density environments, and developing countries; fragmented treatment of user diversity; weak integration between mobility and logistics data; and the lag between the sophistication of predictive models and the institutional capacity to incorporate them into planning. This paper proposes an integrative framework for analyzing the digitalization of urban mobility and logistics as part of a single urban transition.

Keywords: digital transformation; urban mobility; urban logistics; behavioral change; demand forecasting; Mobility as a Service; smart mobility; last mile; systematic review of reviews; barriers and enablers

1. Introduction

Digital transformation has profoundly altered the way urban passenger and freight transport is planned, operated, and experienced. Its most visible manifestations are integrated platforms, real-time information systems, digital payments, data analytics, and shared mobility applications [1–3], but the process also affects the relationships between operators, users, and public authorities and alters the behavioral patterns upon which the urban transportation system relies. On the mobility side, this transition manifests itself in Mobility as a Service (MaaS), shared micromobility, flexible on-demand transport, and smart mobility ecosystems [1,4,5]. In urban logistics, it is expressed, primarily, in the digitization of the last mile, the algorithmic optimization of routes and fleets, real-time traceability, and the progressive integration of electric vehicles into distribution [6–8]. That digitalization supports organizational issues such as choice, collaboration, and optimization, in both passenger and freight transport systems [9].



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Beyond these visible manifestations, the process has an equally decisive aspect. Behaviors themselves change, as does the way the associated demand is anticipated and managed. Users adopt routines that combine transport modes and services in ways that would be unfeasible without intermediary applications. Operators adjust their supply to time series that their legacy systems could not process. Public authorities, for their part, are beginning to base their planning decisions on data whose coverage, granularity, and frequency were unimaginable just a few years ago. Behavior and demand forecasting evolve together in digitalized urban services because forecasts guide operational decisions that, in turn, reshape observed practices [2,10].

The available literature addresses both aspects in a fragmented manner. Review research has proliferated in recent years, but in doing so, it has reproduced disciplinary and sectoral boundaries: there are reviews on MaaS adoption, on gender and digital mobility, on micromobility, on smart mobility, on demand-responsive transport, on carpooling, on the last mile, on artificial intelligence applied to delivery, and on platform-based delivery work. What is lacking are analyses that frame the urban digital transition as a single process. The separation between passenger mobility and freight logistics is the most visible, but not the only one. The technological, social, institutional, and economic aspects of the transition are often treated in isolation, and the link between the development of predictive models and their actual implementation conditions is rarely examined systematically. The result is an expanding field in which syntheses accumulate without fully communicating with one another. A structured field, however, would give current and future research a basis on which to develop new concepts, along with a unified view of barriers, enablers, and gaps that would help both researchers and practitioners advance the digitalization of urban transportation.

In light of this fragmentation, this study adopts an umbrella review approach to examine existing syntheses on urban mobility and logistics as a single body of evidence. Its main novelty lies in bringing together two fields that have largely developed separately and analyzing them as part of the same process of urban digital transformation. This makes it possible to identify convergences, contrasts, and gaps across both fields and to propose an integrative framework for analyzing barriers, enablers, and research gaps.

To fulfill this function, this study is organized around three objectives. The first is to critically synthesize the evidence from previous reviews on the digitalization of urban mobility and logistics, identifying barriers, enablers, and research gaps. The second is to develop the proposed framework, based on five interdependent dimensions (technology; operation and service design; society, user, and equity; institution, regulation, and governance; and economics and scalability) and two cross-cutting axes (behavioral change and demand forecasting). The third is to translate these findings into directions for future research, identifying priorities for empirical work and for evaluation across different contexts.

From these objectives, five research questions are derived:

- RQ1. What types of barriers appear most frequently in reviews on digitalization and urban mobility or logistics?
- RQ2. What enablers are identified for the implementation and consolidation of digital solutions in these areas?
- RQ3. What structural similarities and differences do urban mobility and logistics present in relation to these barriers and enablers?
- RQ4. What does the review literature say about behavioral change and demand forecasting, and what gaps remain in their treatment?
- RQ5. What knowledge gaps should guide the future research agenda in this field?

The main contribution of this work is to provide an analytical framework that allows for a systematic examination of the digitalization of urban mobility and logistics, identifying barriers and enablers, comparing both fields, and deriving knowledge gaps to guide future research. More specifically, the framework enables both fields to be examined through the same five dimensions and two cross-cutting axes, thereby revealing shared mechanisms and interdependencies that sector-specific approaches may overlook. Section 2 develops the conceptual framework. Section 3 describes the methodology. Section 4 presents the results, organized first by dimension and then by cross-cutting axes, highlighting similarities and differences between urban mobility and logistics. Section 5 discusses the implications, revisits the research questions, and acknowledges the study's limitations. Finally, Section 6 concludes with the findings and identifies future research directions derived from the identified gaps.

2. Conceptual Framework

2.1. Digital Transformation in Urban Mobility

The digital transformation in urban mobility goes far beyond the introduction of new technical tools. It involves a reconfiguration of how transportation services are planned, provided, managed, and used in the urban space. Integrated platforms, real-time information systems, digital payments, data analytics, and shared mobility applications are its most visible manifestations [1–3], but the process also affects the relationships between operators, users, and public authorities and alters the behavioral patterns upon which the urban transportation system relies.

Within this field, MaaS has attracted much of the research attention. Its central proposition is the integration of different modes of transport through a single digital interface that allows for the unified planning, booking, and payment of trips [1,11]. But, MaaS is not the only driver of change; digitalization has fueled the expansion of shared micromobility [12], flexible on-demand transportation [13], and carpooling platforms [10], as well as, in a broader sense, smart mobility ecosystems aimed at increasing the responsiveness and operational coordination of urban systems. The literature agrees that the actual scope of these changes cannot be explained by technology alone: it depends on decisions regarding service design, modal integration, user acceptance, accessibility, regulation, and financial sustainability [4,14,15].

2.2. Digital Transformation in Urban Logistics

Urban logistics has followed its own trajectory, accelerated by the growth of e-commerce and pressure on last-mile distribution. The incorporation of digital tools, smart systems, and analytical capabilities has responded both to the pursuit of operational efficiency and to the need to reconcile it with urban sustainability goals and increasingly demanding regulatory frameworks [7,8]. This agenda coexists with a less visible but critical labor dimension: the digitization of delivery, centered on platforms and algorithmic work management, has generated new psychosocial and safety risks for the workers who sustain it [6].

The most concrete manifestations of this transition range from digitized fleet management and route optimization (tactical planning) to delivery coordination and operational traceability (operational planning). The recent incorporation of artificial intelligence and machine learning has opened up a specific avenue focused on demand forecasting, dynamic resource allocation, and improving last-mile performance [7]. As in the case of mobility, technical efficiency does not exhaust the analysis; digital tools are deployed in complex urban settings involving private operators; public administrations; legacy infrastructure; spatial constraints; and recurring tensions between business profitability, environmental

sustainability, and collective urban goals. The literature review on digital urban logistics is, moreover, much less established than that on mobility. This asymmetry is one of the field's starting points, and this work treats it as such.

2.3. Analytical Framework: Five Dimensions and Two Cross-Cutting Axes

The two previous sections suggest that mobility and urban logistics share the same digital transition but navigate it unevenly. To analyze them in a comparable manner, a framework is required that does not depend on a specific technology or service but rather allows for situating different digital solutions in relation to conditions that the literature identifies as relevant to their implementation, scaling, or stagnation. In this regard, approaches to sociotechnical transitions and complex urban systems [16,17] emphasize that an innovation's performance is not explained solely by the technological artifact but also by its coupling with a broader ecosystem of actors, institutions, infrastructures, and practices. When this coupling is incomplete or fragile, adoption tends to remain fragmented or in the pilot phase. This multidimensional logic is well established in the Information Systems literature on technology adoption and digital transformation. The technology–organization–environment (TOE) framework holds that the adoption and implementation of a technological innovation depend not on the artifact alone but on the joint configuration of technological, organizational, and environmental contexts [18]. Vial [19], in turn, characterizes digital transformation as a process in which digital technologies create disruptions that trigger strategic responses from organizations seeking to reconfigure their value-creation paths, while managing the structural changes and organizational barriers that condition the outcomes. Existing frameworks in smart mobility and MaaS generally focus on passenger transport, particularly on technology adoption, modal integration, service design, and user acceptance [1,4,5]. Frameworks developed in urban logistics tend instead to emphasize last-mile efficiency, routing, fleet technologies, and environmental performance [7,8]. Sociotechnical transition and digital transformation approaches provide a broader explanation of systemic change, but they do not usually offer a common structure for comparing passenger mobility and urban freight logistics. The framework proposed here differs by applying the same technological, operational, social, institutional, and economic dimensions to both fields and by treating behavioral change and demand forecasting as cross-cutting axes (Figure 1).

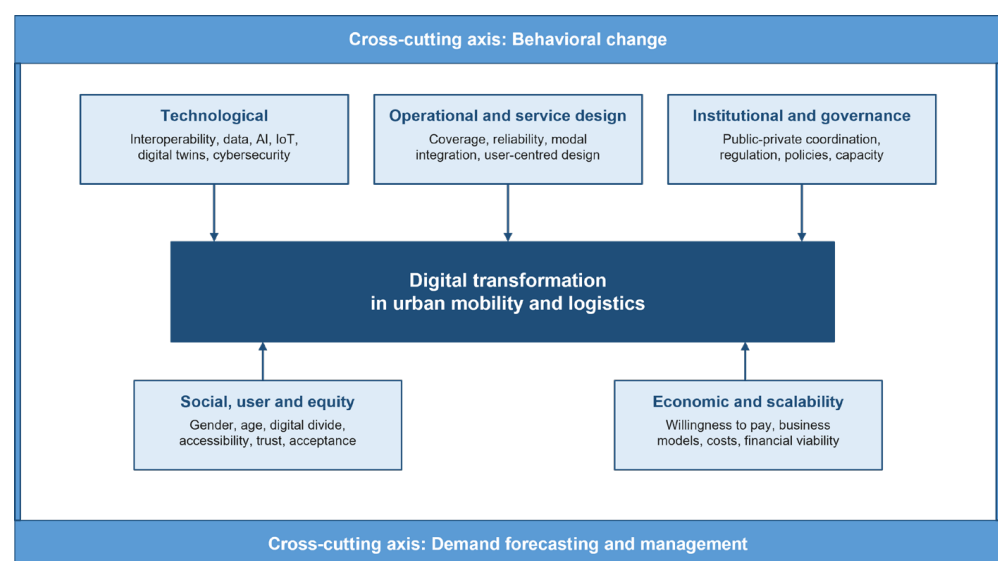


Figure 1. Integrative framework of the five dimensions and the two cross-cutting axes.

The five dimensions are as follows. The technological dimension encompasses platforms, data, connectivity, artificial intelligence, and digital infrastructure. The operational and service design dimension brings together decisions regarding coverage, reliability, modal integration, pricing structure, ease of use, and adaptation to heterogeneous usage contexts. The social, user, and equity dimension includes acceptance; accessibility; the digital divide; and differences based on gender, age, income, or ability, as well as the distributional consequences of digitalization on both end users and the workers who support the services. The institutional, regulatory, and governance dimension encompasses coordination between public and private actors, regulatory frameworks, alignment with urban policies, and institutional capacity to sustain the transition. Finally, the economic and scalability dimension considers business models, financial viability, implementation costs, willingness to pay, and the ability to replicate solutions in diverse contexts. All five are interdependent; misalignments in any of them can prevent a technically sound solution from becoming established.

In addition to these five dimensions, the analysis considers two cross-cutting axes. The first is behavioral change: the way in which digitalization alters the decisions, routines, and practices of both service users and operators. In the field of mobility, behavior has been addressed primarily in terms of the adoption and acceptance of digitized services [1,10,14]; in logistics, when it has been addressed, it has been analyzed in terms of labor practices and the organization of delivery work [6]. In both cases, design decisions and regulatory frameworks determine which changes occur and who benefits from them. The second axis is demand forecasting: the emerging capability, supported by big data and artificial intelligence, to anticipate behaviors and adjust supply. This capability cuts across all dimensions (it is technological in origin, operational in use, social in its distributive effects, institutional in its governance, and economic in its viability) and constitutes one of the areas where the gap between technical sophistication and implementation maturity is most pronounced [2,7,8].

The two axes are not merely another dimension but rather a way of interpreting the previous five. Each manifests itself differently depending on whether it is viewed from the perspective of behavioral change (what people do, how they do it, and why they change) or from that of forecasting (what can be anticipated, with what precision, and with what practical consequences). The Results section first develops the five dimensions separately and then synthesizes the specific findings regarding the two cross-cutting axes. Taken together, the framework integrates scattered evidence and facilitates a comparative analysis of barriers, enablers, and cross-cutting patterns, with implications for research and for the design and governance of solutions. This synthesis allows for the identification of knowledge gaps and research opportunities.

3. Methodology

3.1. Design and Search Strategy

This study adopted an umbrella review design, appropriate for fields in which the primary literature has already been synthesized by multiple studies but those syntheses remain isolated from one another [20]. The review was conducted and reported in accordance with the PRISMA 2020 guidelines [21], with the usual adaptations for an umbrella review, covering the identification, screening, eligibility assessment, and inclusion of sources. The review protocol was not prospectively registered before the screening and data extraction stages. To enhance transparency, the review was subsequently registered retrospectively on the Open Science Framework (OSF; DOI: 10.17605/OSF.IO/ESFHX). This retrospective registration should not be interpreted as a preregistration. To enhance transparency and reproducibility, the methodology is reported in full in this section.

The search was conducted on 16 March 2026, in Scopus and Web of Science, which were selected for their multidisciplinary coverage and established relevance in transportation, logistics, and urban planning. The search was structured into four blocks: type of synthesis document (systematic review, literature review, scoping review, review of reviews, overview of reviews, and bibliometric review), thematic scope (urban mobility; MaaS; shared mobility; micromobility; demand-responsive transport; and their equivalents, along with urban logistics, city logistics, urban freight, and last-mile delivery), digital transformation (digitalization, digital transformation, smart mobility, digital platform*, and digital logistics), and analytical dimensions (barrier*, enabler*, challenge*, driver*, research gap*, and implementation). In Scopus, the search was conducted in the “Article title, Abstract, Keywords” field and in Web of Science, in the “Topic” field, which covers title, abstract, author keywords, and Keywords Plus. The complete search queries are provided in Appendix A.

3.2. Eligibility Criteria and Screening Process

To be included, a document had to meet all five of the following conditions: (i) be a systematic review, scoping review, structured literature review, bibliometric review, overview of reviews, or environmental scan; (ii) focus primarily on digital transformation in urban mobility, urban logistics, or both; (iii) analyze identifiable digital services, technologies, or processes, such as MaaS, smart mobility, micromobility, DRT, shared mobility, city logistics, or digital tools for urban logistics; (iv) identify, explicitly or implicitly, barriers, enablers, implementation challenges, or research gaps; and (v) be published in English.

We excluded empirical or conceptual studies with merely introductory literature reviews, works with a tangential focus on the subject, those centered on non-urban contexts or sectors unrelated to urban transportation, and document types not comparable to established academic reviews (conference papers, book chapters, and proceedings). Records that were objectively ineligible due to document type or language were removed prior to screening by title and abstract, so as not to distort the exclusion figures in subsequent phases.

The initial search retrieved 54 records in Scopus and 40 in Web of Science. A preliminary screening based on bibliographic metadata eliminated 37 ineligible records (26 from Scopus and 11 from Web of Science), corresponding mainly to conference papers, conference reviews, proceedings papers, book chapters, and documents not published in English. Of the remaining 57 records, 21 were identified as duplicates, leaving 36 unique records for screening by title and abstract. In this phase, 14 studies were excluded because they were not structured reviews or syntheses, presented a tangential approach to digitization, focused on excessively broad or non-urban contexts, or fell outside the study’s thematic scope. The remaining 22 documents were evaluated in full text, and one was excluded because it constituted a conceptual and mathematical model, not a review per se. The final sample consisted of 21 documents. Screening was carried out by one reviewer and verified by a second, with any disagreements resolved by discussion until consensus was reached. Figure 2 presents the complete flowchart of the selection process.

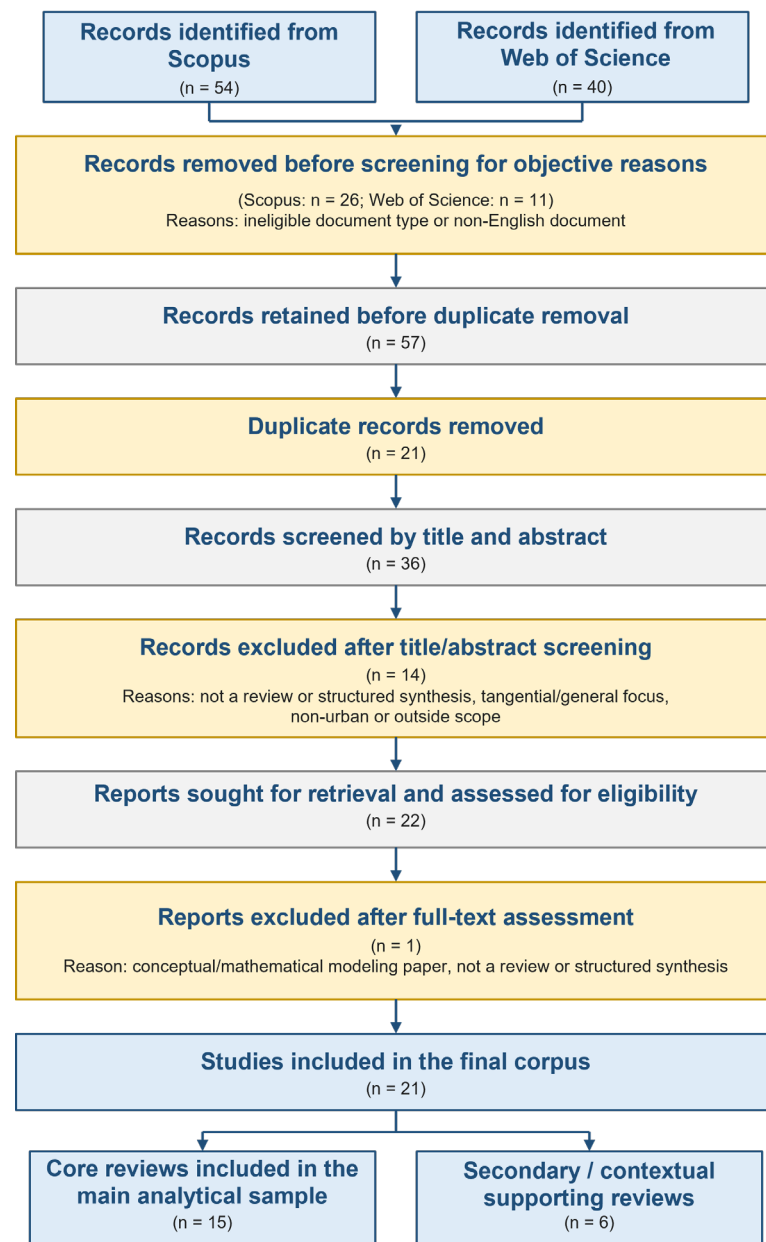


Figure 2. PRISMA flowchart of the process of identification, screening, eligibility assessment, and inclusion of documents.

3.3. Data Extraction, Coding, and Synthesis

Each included document was systematized using an extraction table with bibliographic variables (authorship and year), methodological variables (type of review and focus), thematic variables (main scope, subtopic, and dominant digital dimension), and analytical variables (barriers, enablers, gaps, and specific contribution to the study's objective). The analysis followed an inductive–deductive coding approach. The deductive categories corresponded to the five dimensions of the framework proposed in Section 2; the inductive categories emerged during the reading process itself and included aspects such as user-centered design; the digital divide; organizational sustainability; and, specifically, the two cross-cutting themes of behavior and demand forecasting. Data extraction and coding were performed by one reviewer and checked by a second, with discrepancies resolved by discussion.

To provide a descriptive characterization of the corpus's thematic focus, each review was also assigned a binary code for each dimension: a 1 was assigned to dimensions

addressed substantively, defined as those that appear as an explicit category of analysis, are the subject of specific findings or recommendations, or are included in the review's keywords or research questions. The identification of a gap in a dimension was not counted as coverage. This coding is used solely to characterize the analyzed material, not as a metric for the field as a whole. The complete coding matrix is provided in Appendix B, and its aggregated results are presented in Section 4.8.

The eligibility assessment and the analytical classification of the included reviews were conducted in two stages. First, all documents in the final corpus were required to meet the five predefined eligibility criteria concerning document type; thematic focus; the presence of identifiable digital content; analytical relevance to barriers, enablers, implementation challenges, or research gaps; and publication language. Full-text reading was used to confirm eligibility in potentially borderline cases, particularly when the review component was combined with a conceptual framework, a bibliometric analysis, or an empirical application. Once the final corpus had been established, the included reviews were classified according to the function they could perform within the synthesis. This additional classification was considered necessary because of the asymmetry between the relatively mature literature on digital urban mobility and the more limited body of review literature on digital urban logistics. Accordingly, a review was classified as core when the digital transformation of urban mobility or logistics constituted its central object of analysis; when barriers, enablers, risks, implementation conditions, or research gaps were examined sufficiently directly; and when its findings could be transferred and coded within the five-dimensional comparative framework. Reviews were classified as secondary/contextual when they met all eligibility criteria but their main contribution consisted of bibliometric mapping, a conceptual or research agenda, a highly specialized technological focus, or a broader contextual interpretation. Their findings were used to complement the analysis of specific technologies, dimensions, or emerging research directions, but they did not constitute the main basis of the cross-cutting taxonomy of barriers and enablers. The distinction between core and secondary/contextual reviews does not constitute a formal assessment of methodological quality or risk of bias. Rather, it reflects the degree of analytical alignment of each review with the specific objectives of this umbrella review and the function that its findings could perform within the synthesis. Of the 21 included reviews, 15 were classified as core and 6 as secondary/contextual. The resulting classification is presented in Table 1, while Supplementary Table S1 presents the classification of the included reviews by analytical role and provides the corresponding justification for each study.

Table 1. General characteristics of the included reviews.

Reference	Type of Review	Main Scope	Subtopic/Focus	Main Contribution	Role
Aguiléra & Pigalle (2021) [10]	Systematic review	Urban mobility	Carpooling/shared mobility	Research challenges and the future sustainability of carpooling	Core
An (2024) [22]	Systematic literature review	Urban mobility	Smart mobility, ICT, and older adults	Accessibility, aging, and the digital divide	Core
Anthony Jnr (2025) [15]	Scoping review	Urban mobility	Sustainable mobility governance	Conceptual model of governance and KPIs for smart cities	Core
Baier et al. (2024) [13]	Review	Urban mobility	DRT/flexible public transport	Performance evaluation and implementation of DRT	Core
Butler et al. (2021) [1]	Systematic literature review	Urban mobility	MaaS	Barriers and risks to MaaS adoption	Core

Table 1. Cont.

Reference	Type of Review	Main Scope	Subtopic/Focus	Main Contribution	Role
Chmiel & Wierzbowski (2025) [11]	Systematic literature review	Urban mobility	MaaS	General overview of MaaS as a direction for urban mobility	Core
Ferreira & Esperança (2025) [8]	Structured review + framework + case	Urban logistics	Electric vehicles, AI, and last-mile delivery	Integration of EVs and AI in the sustainable optimization of the last mile	Secondary
Firzan et al. (2025) [23]	Comparative Systematic Review	Urban mobility	Paratransit in the digital age	Transferability, efficiency, and accessibility in diverse contexts	Core
Li et al. (2024) [4]	Review	Urban mobility	MaaS and Service design	User-centered design and supply–demand alignment	Secondary
Liyanage et al. (2019) [24]	Environmental scan	Urban mobility	Flexible on-demand mobility	Evolution, characteristics, and challenges of on-demand mobility	Core
McIlroy (2023) [14]	Review	Urban mobility	MaaS and Gender	Gender perspective, Equity, and MaaS use	Core
Mitieka et al. (2023) [5]	Bibliometric review	Urban mobility	Smart mobility	Integrated conceptualization of the field and future agenda	Secondary
Munhoz et al. (2020) [3]	Systematic review	Urban mobility	Smart mobility	Key drivers of urban mobility intelligence	Core
Nalluri et al. (2025) [7]	SLR + bibliometric analysis	Urban logistics	AI/ML in last-mile optimization	Emerging technology in digital urban logistics	Secondary
Orozco-Fontalvo et al. (2023) [12]	Systematic review	Urban mobility	Micromobility /e-scooters	Regulation, user profile, impacts, and modal integration	Core
Porru et al. (2020) [25]	Review	Urban mobility	Smart mobility and public transportation	Opportunities and challenges in urban and rural areas	Core
Shaik et al. (2026) [26]	Systematic review	Urban mobility	Smart mobility and urban planning	Implementation barriers and pathways in Saudi cities	Core
Son et al. (2025) [2]	Systematic review	Urban mobility	Advanced technologies/smart transportation planning	IoT, AI, digital twins, and optimization in smart planning	Core
Szpilko et al. (2023) [27]	SLR + bibliometric analysis	Urban mobility	Sustainable and smart mobility	Field classification and future directions	Secondary
Tubis & Sadowski (2025) [28]	Systematic + narrative review	Urban mobility	Smart, sustainable, and resilient transport	The triple imperative of urban public transport	Secondary
Useche et al. (2025) [6]	Systematic literature review	Urban logistics	Last-mile delivery/work and safety	Occupational risks and human costs of the digitization of delivery	Core

4. Results

4.1. General Characterization of the Corpus

The final sample reflects the current state of the field, which is expanding yet heterogeneous. Of the 21 documents included, 18 primarily address digitalized urban mobility and

3 focus on digital urban logistics, the latter concentrated on specific subfields such as the last mile, working conditions in delivery, and artificial intelligence applied to operational optimization [6–8]. This asymmetry is not a bias in the search, which applied equivalent descriptors in both areas but rather corresponds to the actual state of the literature, and constitutes a finding of the study in itself. Table 1 lists the included documents and distinguishes between core reviews and secondary or contextual reviews, in accordance with the criteria outlined in Section 3.3.

Three features of the corpus shape the interpretation of the results. The first is the thematic concentration in MaaS, smart mobility, micromobility, demand-responsive transport, and shared mobility, which reflects that review research has advanced most in areas where digitalization has produced visible services oriented directly toward the end user. The second is methodological diversity: systematic reviews, scoping reviews, environmental scans, bibliometric analyses, and framework-based structured reviews coexist, making direct comparison between studies difficult. The third is geographic and population heterogeneity. Some reviews adopt a broad international perspective, while others are anchored in specific contexts, whether due to territorial density, level of development, or demographic characteristics of the user population [22,23,25,26]. This variety has a direct consequence: the barriers and enablers identified are not universal, and what works in a well-funded city with high digital penetration may prove irrelevant, or counterproductive, in other settings.

Before turning to the analysis by dimension, it is worth noting a cross-cutting feature of the sample. The corpus shows a clear imbalance in favor of the technological dimension over the attention given to social, institutional, and economic factors. Although the search strategy, centered on digitalization descriptors, predisposes the retrieval of technology-anchored studies, several of the reviews themselves acknowledge that this imbalance is a feature of the field and not a mere artifact of the search [4,5].

4.2. Technological Dimension

Digital platforms, data integration, artificial intelligence, the Internet of Things, digital twins, and advanced optimization models make up the technological toolkit that runs throughout the corpus [1,2,5]. The recurring message, however, is not that technology is lacking but rather that having it is rarely enough. The difficulties most frequently identified in the reviews do not stem from technical shortcomings but from problems of system integration, coordination deficits among stakeholders, security vulnerabilities, or a failure to adapt to the actual context of use.

In MaaS, the tension between technological capacity and implementation conditions is especially visible. Butler et al. [1] show that the system's viability depends not only on a digital interface integrating planning, booking, and payment but also on resolving cybersecurity issues and building cooperative ecosystems between public and private operators. Li et al. [4] dig deeper into the academic origin of the problem and argue that the MaaS literature itself has prioritized the development of enabling technologies and platform logic over an understanding of users' actual needs.

Munhoz et al. [3] contribute a revealing finding to the debate on smart mobility. Although technology occupies a central place in the field's discourse, the factors that industry professionals consider priorities for increasing the intelligence of urban mobility are mostly governance-related, not technological. Mitioka et al. [5] document, in parallel, a recent evolution strongly driven by advances in big data, artificial intelligence, and real-time technologies and warn that the literature continues to place a disproportionate weight on the technological dimension. Taken together, these findings point to a distance between what professional practice demands and what academic research prioritizes.

The case of micromobility is illustrative. Orozco-Fontalvo et al. [12], in their review of dockless shared e-scooters, show that the actual performance of these systems depends not on the vehicle or the mobile app but on factors that are seemingly secondary yet decisive. These include redistribution and collection logistics, the lifespan of the vehicles, and the regulatory framework each city sets for their deployment. A technologically mature solution can fail or produce unintended consequences if it is not coordinated with urban management, local regulation, and integration with other transport modes.

In flexible mobility and demand-responsive transport, an additional concern arises: the difficulty of evaluating and comparing experiences. Liyanage et al. [24] show that the deployment of on-demand mobility is conditioned by a combination of social, technological, and economic factors that vary by context, which makes it difficult to draw generalizable conclusions. Along the same lines, Baier et al. [13] argue that digitalization has fostered a proliferation of demand-responsive transport systems with highly diverse configurations and that this diversity complicates comparing experiences and identifying what actually works and under what conditions.

In urban logistics, the evidence is more fragmented but points in the same direction. Nalluri et al. [7], from a technical and bibliometric approach, show that artificial intelligence and machine learning are establishing themselves as an emerging trend in last-mile optimization, with promising results in routing, capacity, and first-time delivery. Ferreira and Esperança [8] reinforce this interpretation through the integration of electric vehicles and artificial intelligence. Even so, the focus on technical performance leaves equally relevant issues less explored, such as how to implement these solutions in real urban environments, the governance frameworks required, the necessary infrastructure, or the systemic effects they generate beyond immediate operational efficiency.

Technology is, ultimately, the starting point of digitalization, but it is rarely enough to explain it. The most recent literature appears to be shifting from an instrumental view toward approaches that conceive of technology as part of complex urban systems, where sustainability, intelligence, and the capacity to adapt to disruptions are articulated as interdependent dimensions [27,28]. That same complexity justifies the subsequent analysis of operational and service design factors, where many of the most decisive barriers have their real origin.

4.3. Operational and Service Design Dimension

While the previous section showed that technology is a necessary but not sufficient condition, this one focuses on the design and operational decisions that determine how that technology translates into a service for the user. At this level, coverage, flexibility, reliability, modal integration, fare structure, ease of use, and the ability to adapt to diverse contexts and user profiles are, according to the reviewed literature, factors at least as decisive for the success of a digital solution as the sophistication of the platform that supports it [1,4,13].

The most critical assessment comes from MaaS. Li et al. [4] argue that its development has been overly guided by a provider-oriented approach, in which the platform's capabilities dictate the service offering rather than travelers' actual needs. This orientation produces persistent mismatches between what the system offers and what users demand and leaves more innovative approaches to capturing complex mobility preferences and designing personalized experiences relatively unexplored. Butler et al. [1] complement this analysis with a practical implication: integrated packages and subscriptions simplify ticketing and payment, which increases acceptance. That said, a low price alone is not enough to trigger behavioral change. The determining factor is the perception of value, which depends on how the user experience is structured, which modal combinations are offered, and how simple it is to access the service.

The literature on demand-responsive transport examines these issues with a notable degree of operational detail. Baier et al. [13] observe that digitalization has driven a wide variety of configurations but that many fail to establish themselves as a permanent transport option. The reviewed evidence attributes their success to a specific combination of context; stakeholder objectives; and concrete operational decisions, such as fleet size, stop patterns, level of service, ride sharing, and integration with the public transit network. To handle this complexity, the authors propose a four-step evaluation framework that integrates objectives, external and internal conditions, and the weighting of results. They conclude that there is still no standardized way to evaluate the performance of these systems that simultaneously incorporates operational efficiency, environmental impacts, social benefits, and regional differences.

Liyanage et al. [24] offer a useful historical perspective. Demand-responsive transport is not a radically new phenomenon, but an evolution of traditional forms of on-demand transport that digitalization has profoundly reshaped. The shift to mobile app-based services and real-time tracking has blurred the line between conventional public transit and shared mobility, creating a hybrid space whose operating rules are not yet established. The operational attributes that define success are very specific: reliability; affordability; accessibility; route flexibility; and the ability to plan, book, and pay from a single interface.

Orozco-Fontalvo et al. [12] reinforce this argument from micromobility. Their review of e-scooters shows that the variables determining the system's actual performance are not the most visible ones, the vehicle or the app, but the most operational ones, such as redistribution and collection logistics, vehicle lifespan, pricing structure, and the local regulatory framework. The review also identifies integration with public transport and MaaS as one of the potentially most valuable contributions of micromobility, though it stresses that such integration requires very specific operational and regulatory decisions that most cities have not yet satisfactorily resolved.

In urban logistics, the pattern is similar, though with an important nuance. Nalluri et al. [7] and Ferreira and Esperança [8] show that artificial intelligence, machine learning, electric vehicles, and optimization tools are reshaping the organization of the last mile, but research remains focused on operational efficiency metrics. Studies on routing, capacity, emissions reduction, and delivery performance predominate. The least developed area is the design decisions that allow the move from proof of concept to stable implementation. Among these, the coordination of heterogeneous fleets, integration with urban regulation, the allocation of implementation costs, and the measurement of performance beyond immediate technical efficiency stand out. In logistics, as in mobility, turning a digital infrastructure into a viable, sustainable, and coordinated urban operation requires much more than implementing the right technology.

4.4. Social, User, and Equity Dimension

The reviews analyzed show that digitalization does not affect all users equally. Age, gender, income level, digital skills, prior mobility habits, and trust in platforms influence both adoption and the benefit each person derives from the new services [1,12,14,22,29]. This heterogeneity is not only a matter of equity. It is also a design challenge because a service that fails to incorporate the actual diversity of its users is unlikely to take hold.

The case of micromobility illustrates this with concrete evidence. Orozco-Fontalvo et al. [12] show that the user profile for shared e-scooters is predominantly male, young, and relatively high-income. This pattern contrasts with the common narrative that presents these systems as accessible and sustainable solutions. The review also reports an important finding: a significant share of the trips captured replace journeys previously made on

foot, by bicycle, or by public transit. This substitution effect calls into question the net contribution of micromobility to equity and to the sustainability of the urban system.

In MaaS, McIlroy [14] conducts a gender-focused review. Although a growing number of studies mention this dimension, the available evidence remains fragmented and does not allow robust conclusions about differences in adoption, use, or preferences. What does emerge consistently is that the effects of MaaS on gender equity depend on specific design decisions, such as the structure of service packages, perceived safety across modes, travel patterns associated with caregiving roles, and the explicit consideration of diverse needs. Without addressing that diversity, systems tend to reproduce preexisting inequalities in access.

An [22] addresses the digital divide from the perspective of aging, a population segment that the smart mobility literature has tended to underrepresent despite its growing demographic weight. The very technologies that could improve older adults' autonomy and accessibility create new barriers when their design requires digital skills that many do not have or do not wish to acquire. Usability, design adaptation, and tailoring to specific needs are conditions, not optional improvements, without which digitalization widens exclusion rather than reducing it.

Li et al. [4] add a more cognitive argument. They note that the MaaS literature has paid insufficient attention to users' psychological needs, such as how they perceive the value of the service, what builds their trust, and what frictions deter them from using it. This omission partly explains why technically sound systems fail to reach expected adoption rates. A service can be robust, integrated, and well-priced and still fail to take hold if it is not understandable or trustworthy to the users it targets.

In demand-responsive transport and flexible mobility, the social dimension appears less explicitly but is no less relevant for it. Liyanage et al. [24] link the success of deployment to public acceptance and to the systems' ability to offer services perceived as reliable, accessible, and affordable, attributes that depend as much on technical design as on social and cultural factors that are hard to standardize. Baier et al. [13] add that these systems serve stakeholders with very different objectives and expectations, which means their evaluation cannot be limited to operational efficiency indicators.

Aguiléra and Pigalle [10] round out the picture on carpooling with a broader observation. Their review identifies three key factors for understanding the future of this form of shared mobility: the digitalization of platforms, the spread of collaborative consumption, and changes in work routines associated with remote work. None of them alone explains the trajectory of carpooling, and the empirical evidence on the interaction between technological and behavioral transformations remains limited.

In urban logistics, equity emerges from a different angle. Useche et al. [6] show that the digitalization of the last mile, centered on delivery platforms and algorithmic work management, has generated new psychosocial and safety risks for delivery workers. This is a social dimension of digital change that does not appear in the debate on passenger mobility, and it is a reminder that equity affects those who sustain the service from the labor side, not only end users.

Taken together, these findings show that equity in digitalized urban transport goes beyond access and differences in adoption. It also concerns how benefits, costs, and risks are distributed among users, workers, firms, and urban areas; whose needs are reflected in service design and data; and who participates in implementation decisions. Digitalization may reproduce existing inequalities when services concentrate on profitable markets, when some groups are poorly represented in the data, or when efficiency gains depend on transferring pressure and risk to platform workers. Equity should therefore be understood as having distributive, procedural, territorial, and labor-related dimensions.

4.5. Institutional, Regulatory, and Governance Dimension

Some of the most persistent obstacles to implementing digital solutions are not technical but institutional. This dimension is especially relevant in contexts with public and private operators that have different objectives, incentives, and capabilities, which covers most real urban environments [1,12,15,26].

Anthony Jnr [15] offers the most articulate argument on this matter in his review of sustainable mobility governance in smart cities. His central thesis is that no digital innovation translates into real improvements in accessibility, sustainability, and inclusion without governance models capable of coordinating policies, infrastructure, operators, and social needs in an integrated way. The proposal of a conceptual model with key indicators reflects that the field still lacks the tools needed to govern the digital transition coherently, which limits both the evaluation of services and accountability for their results.

In MaaS, Butler et al. [1] identify public–private cooperation as one of the most significant supply-side barriers. The integration of modes, operators, and payment systems is not a technical interoperability problem. It requires agreements among actors with often divergent interests; a shared vision of the service's role in the urban ecosystem; and clear mechanisms for sharing responsibilities, data, and risks. Without that framework, even technically advanced platforms may struggle to attract operators willing to integrate.

Micromobility shows the shaping role of regulation with particular clarity. Orozco-Fontalvo et al. [12] show that differences between cities in how they regulate e-scooter systems are not mere administrative details but determine whether deployment is orderly or chaotic, whether the service integrates with public transit or competes with it, and whether it generates conflicts in public space or coexists with other uses. The same technology produces very different outcomes depending on the regulatory framework. Regulation does not merely accompany digitalization, it shapes it.

In demand-responsive transport and flexible mobility, governance determines not only how the service is regulated but how its success is defined. Baier et al. [13] show that these systems simultaneously serve frequently divergent objectives, such as operational efficiency for the operator, accessibility for the user, cost reduction for the administration, and environmental sustainability for the city. There is no neutral metric that weighs them all equally, so evaluating one of these systems involves prior decisions about priorities. Liyanage et al. [24] reinforce this interpretation by showing that the deployment of on-demand mobility depends as much on appropriate organizational and commercial frameworks as on public acceptance.

In urban logistics, the institutional dimension manifests itself differently. Nalluri et al. [7], despite their markedly technical approach, show that research on artificial intelligence in the last mile has advanced more in optimization than in implementation, coordination, and systemic effects. Ferreira and Esperança [8] situate the integration of electric vehicles and artificial intelligence within a framework that requires operational coordination, viable economic conditions, and adaptation to the urban environment. Logistics digitalization requires governance frameworks capable of connecting operational efficiency, environmental sustainability, urban regulation, and real infrastructure constraints.

Governance operates, in short, as a precondition. Many innovations fail not for lack of technology but for lack of coordination among actors, the absence of adapted regulatory frameworks, and the difficulty of aligning public and private objectives [1,15].

4.6. Economic and Scalability Dimension

Economic viability is a condition that the literature on urban digitalization has been slow to place at the center of its analysis. Many digitalized services have proven technologically viable, well-designed, and institutionally supported yet have failed to take hold

because their economic models were not sustainable without exceptional conditions or subsidies difficult to maintain over time [1,7,8,13,24]. Willingness to pay, pricing structure, implementation costs, and scalability determine whether a solution survives beyond the pilot phase.

Butler et al. [1] show that, in MaaS, willingness to pay is a more complex barrier than it appears. It is not simply that users are price-sensitive; the perception of added value is hard to build when the service integrates modes the user already knows separately and whose combined cost may be opaque. Integrated packages help simplify that perception, but reducing the price is not enough on its own to change behavior. What drives adoption is clarity about what the user gains by using MaaS instead of existing alternatives, and that clarity depends as much on pricing design as on the ability to communicate value credibly to very different user profiles.

The argument by Li et al. [4] about the mismatch between MaaS supply and actual user needs also lends itself to an economic reading. A service that does not address real needs is unlikely to generate sustained demand, and without sustained demand, it is hard to establish a viable business model. Investing in more user-centered design methods is not an incidental expense but a requirement for the system's economic scalability.

In demand-responsive transport and flexible mobility, the economic tension takes a particular form. These systems are not justified by direct profitability alone because in many cases, they have been designed to address accessibility and territorial cohesion needs that the market alone does not satisfy. Baier et al. [13] note that this multiplicity of objectives makes them hard to evaluate with a single metric, which complicates demonstrating their viability to funders and administrations. Liyanage et al. [24] add that the reduction in technology costs and the improvement of algorithms have markedly lowered the cost of deploying these services, but the balance among flexibility, reliability, accessibility, and operating costs remains hard to achieve without some form of public support.

In micromobility, Orozco-Fontalvo et al. [12] focus on the actual cost structure. The logistics of redistributing and collecting e-scooters, the accelerated wear of the vehicles, and differences in regulatory frameworks between cities generate very different cost structures that directly determine the economic viability of the service. Integration with public transit and MaaS could reinforce its systemic value and distribute those costs better, but the available literature does not yet offer sufficient evidence on the conditions under which such integration is truly viable.

In urban logistics, the economic dimension revolves around a tension specific to the sector: the simultaneous pressure to improve operational efficiency, reduce environmental externalities, and sustain viable deployment models. Nalluri et al. [7] show where the most immediate economic promise lies, with advances in capacity optimization, dynamic routing, and improved first-attempt delivery rates. Ferreira and Esperança [8] add that the combination of electric vehicles and artificial intelligence can improve the environmental, operational, and economic performance of the last mile. Its scalability, however, is limited by adoption costs, infrastructure availability, fleet coordination, and regulatory alignment.

Scalability warrants a final clarification. It is not merely quantitative growth but the ability to replicate, adapt, and sustain a digitalized service under territorial, institutional, and economic conditions very different from those of the original implementation context. Mitieka et al. [5] note that the literature has tended to assume that digital innovation generates value almost automatically and has paid less analytical attention to the conditions under which models are economically viable and to the actual capacity to scale beyond major cities in developed countries. The summary of barriers, enablers, and illustrative implementation mechanisms across the five dimensions is presented in Table 2.

Table 2. Summary of barriers, enablers, and implementation mechanisms in the digital transformation of urban mobility and logistics.

Dimension	Main Barriers	Key Enablers	Emphasis on Mobility	Emphasis on Logistics	Illustrative Implementation Mechanism/Outcome
Technology	Lack of interoperability, limited data integration, cybersecurity issues, technocentric bias	Integrated platforms, advanced analytics, AI, IoT, digital twins, real-time information	MaaS, smart mobility, micromobility, DRT	AI/ML in last-mile delivery, electric vehicles, operational optimization	Poor interoperability limits data exchange and service integration, whereas shared standards and integrated platforms support coordinated operations and more reliable real-time services.
Operation and service design	Insufficient coverage, low reliability, limited modal integration, inconsistent metrics, supply–demand mismatch	Flexibility, multimodal integration, ease of use, user-centered design, comparable metrics	MaaS, DRT, flexible mobility, micromobility, carpooling	Route optimization, fleet coordination, traceability, first-time delivery	Low reliability and weak alignment between supply and demand reduce trust and continued use; flexible, user-centered services can improve adoption, retention, and operational performance.
Society, user, and equity	Digital divide; biases by gender, age, and income; low acceptance among certain groups; fragmented attention to diversity	Inclusive design, accessibility, personalization, trust, perceived usefulness	MaaS and gender, older adults, e-scooters, acceptance of smart mobility	Appears primarily in working conditions and psychosocial risks of delivery	Digital exclusion narrows the potential user base and may weaken demand and financial viability, while inclusive design broadens access and supports more stable adoption.
Institution, regulation, and governance	Weak public–private coordination, fragmented regulation, lack of a shared vision, poorly adapted institutional frameworks	Integrated governance, policy alignment, clear regulation, KPIs, monitoring frameworks	MaaS, smart mobility, urban planning, e-scooters, DRT	Last-mile regulation, charging infrastructure, operational coordination	Weak coordination and unclear responsibilities delay data sharing, integration, and scaling; aligned regulation and governance arrangements facilitate implementation and institutional continuity.

Table 2. Cont.

Dimension	Main Barriers	Key Enablers	Emphasis on Mobility	Emphasis on Logistics	Illustrative Implementation Mechanism/Outcome
Economics and scalability	Low willingness to pay, implementation costs, fragile business models, scaling difficulties	Clear value propositions, subscriptions and packages, operational efficiency, context-adapted scalability	MaaS, DRT, flexible mobility, carpooling, smart mobility	AI/ML, electric vehicles, implementation costs, operational scalability	High costs and weak demand can keep services dependent on pilots or subsidies, whereas clear value propositions and efficiency gains support long-term viability and replication.

Note: The final column provides illustrative mechanisms derived from the synthesis and shows how barriers and enablers may influence implementation outcomes. These mechanisms should not be interpreted as universal causal relationships, as their effects depend on the service and urban context.

The mechanisms summarized in Table 2 also illustrate the interdependence of the five dimensions. Weak governance can restrict data sharing and service integration, thereby limiting operational performance and scalability. Similarly, digital exclusion can reduce the potential user base, weaken sustained demand, and undermine the economic viability of services such as MaaS. These interactions show that implementation outcomes rarely arise from a single dimension and should instead be understood as the result of cross-dimensional alignments or misalignments.

4.7. Cross-Cutting Themes: Behavioral Change and Demand Forecasting

The five dimensions analyzed so far provide a map of barriers and enablers, but they do not exhaust the analysis. Two questions cut across all five dimensions and deserve specific attention. The first is how the behavior of those who use and operate digitalized urban services is changing, including operational and labor practices. The second is what tools are currently used to anticipate the demand associated with these services and to respond to it. This section summarizes what the review literature says on the matter and, above all, what it does not yet say.

In mobility, the evidence converges on recurring determinants linked to perceived value and cost, prior mobility habits, and sociodemographic heterogeneity (gender, age, and digital divide), along with changes in routines associated with remote work and the sharing economy [1,10,14,22]. What the reviews address less, and which is key to interpreting impacts, are the behavioral changes that emerge beyond initial adoption: on one hand, mode substitution and its net effects on the system, especially when new services displace trips previously made by active modes or public transit [12]; on the other, the stability of use over time, which depends less on price as an incentive and more on an accumulated perception of value and service experience [1]; and, beyond the end user, labor practices in digitalized services, where algorithmic work management introduces frictions and risks that condition the social sustainability of the service [6]. Behavioral change is therefore not limited to acceptance; it includes substitution patterns, dynamics of sustained use, and transformations in operational and labor practices. Even so, the reviews agree on three gaps: a lack of longitudinal evidence on post-adoption effects, limited integration of social heterogeneity (gender, age, and digital divide) into comparable evaluations, and a weak empirical link between behavioral changes and system performance at the urban scale.

Regarding demand forecasting, the literature shows a clear asymmetry between technical sophistication and application maturity. In logistics, Nalluri et al. [7] document that artificial intelligence and machine learning are establishing themselves as an emerging trend in last-mile optimization, with promising results in routing, capacity allocation, and first-time delivery. Ferreira and Esperança [8] reinforce this perspective through the integration of electric vehicles and predictive models. In mobility, Son et al. [2] summarize how the Internet of Things, artificial intelligence, digital twins, and optimization techniques are being incorporated into smart transportation planning to anticipate flows, adjust supply, and simulate scenarios. The sophistication of available models has grown quickly, but their actual degree of integration into urban planning has not kept pace. Five gaps emerge from the reviews. Most of the evidence relies on short-term pilot studies, not on longitudinal deployments that would allow observation of how models behave when demand changes. The data feeding them come mostly from large cities in developed countries, which limits their ability to anticipate behaviors in peripheral, low-density, or developing contexts [23,25,26]. To this, we add that most are built on assumptions of user homogeneity that the equity literature itself challenges [4,14,22], so they often predict aggregate demand that obscures relevant heterogeneities. Mobility and logistics data also remain largely separate, which prevents the joint modeling of urban land use by people and goods. And, there persists, perhaps as the underlying limitation, a distance between the sophistication of the models and the institutional frameworks capable of incorporating them into operational and planning decisions [5,15]. Having a predictive model is not the same as being able to incorporate it into governance.

This gap also involves issues that go beyond institutional capacity. The practical value of predictive models depends on the quality, coverage, timeliness, and representativeness of the data on which they are trained. Their use in public decision-making also requires uncertainty to be made explicit, responsibilities for model-supported decisions to be clearly assigned, and outputs to be sufficiently understandable and auditable. Without these conditions, technically accurate models may reproduce existing biases, obscure the needs of underrepresented groups, or face limited acceptance among public officials and citizens. Data quality, accountability, transparency, and public legitimacy should therefore be treated as implementation conditions rather than as secondary technical concerns.

The link between behavioral change and demand forecasting is, in reality, the same issue seen from two sides, and this parallelism is observed in both mobility and urban logistics. Predictive models serve to anticipate behaviors and, when integrated into decision-making, also help modify them by reorganizing supply and operations on the basis of those models. The review literature has not yet addressed this feedback loop systematically, although it is one of the most fertile areas for future research.

4.8. Research Gaps and Future Directions

The dimensions and cross-cutting axes analyzed make it possible to map not only what the literature has established but also what is not yet well understood. The gaps identified are not mere thematic absences. They reveal unquestioned assumptions, underrepresented populations, excluded contexts, and methodological limitations that constrain the practical usefulness of accumulated knowledge [5]. Table 3 summarizes the main gaps, and the following paragraphs develop the most relevant ones.

The technocentric bias is the most widespread gap. Many reviews identify it [4,5], and the composition of the corpus itself confirms it. The dimensional coding described in Section 3.3 shows that 81% of the reviews substantively address the technological dimension and 71% the operational one, compared to 57% for the institutional dimension and only 31% for the social and 29% for the economic dimensions (Figure 3). The weight of the literature

continues to fall on platforms, artificial intelligence, the Internet of Things, and data integration, while the social, institutional, and economic dimensions receive comparatively less attention. Correcting this imbalance does not mean abandoning technology, but ceasing to treat it as the main explanatory variable and placing it as one component, important but not the only one, of the sociotechnical assemblage that underpins the transition.

Table 3. Major research gaps and future directions.

Identified Gap	Most Affected Area	Implications for Future Research
The prevalence of technocentric approaches	Urban mobility and logistics	Develop analytical frameworks that combine technology, governance, equity, and economic sustainability
Fragmented attention to equity and user diversity	Primarily urban mobility	Incorporate gender, age, digital capabilities, and heterogeneous needs more deeply
Lack of standardized evaluation frameworks	Urban mobility and, to a lesser extent, logistics	Design indicators and comparative frameworks that go beyond technical efficiency
Lack of longitudinal studies	Urban mobility and logistics	Promote research on consolidation, institutional learning, and systemic effects
Weak coverage of peripheral contexts and developing countries	Urban mobility and logistics	Expand research to mid-sized cities, low-density areas, and developing countries
Fragmentation between urban mobility and urban logistics	Especially urban logistics	Promote research that treats them as interdependent dimensions of the same transition
Little attention to service design as a strategic variable	Primarily urban mobility	Delve deeper into design; user experience; and the interplay between design, adoption, and feasibility
Insufficient analysis of governance and implementation	Urban mobility and logistics	Conduct studies on multilevel governance, comparative regulation, and coordination among stakeholders
Limited consideration of behavioral change beyond adoption	Urban mobility	Investigate substitution effects, changes in routines, and post-adoption dynamics
Gap between the sophistication of predictive models and the maturity of implementation	Urban mobility and logistics	Explore institutional and data frameworks capable of incorporating forecasting into planning

Alongside this, attention to user diversity remains fragmented. Reviews on gender, aging, accessibility, and the digital divide show that this dimension is critical to the success of digitalized services [12,14,22], but its treatment in the general literature remains limited. This has practical implications: predictive models and service designs that ignore this diversity tend to reproduce preexisting inequalities.

From a methodological standpoint, standardized evaluation frameworks are lacking. Baier et al. [13] illustrate this for demand-responsive transport, Liyanage et al. [24] for flexible mobility, and Nalluri et al. [7] for the last mile. The field accumulates experience but draws comparable lessons from it less than would be desirable. Developing shared indicators and frameworks that go beyond technical performance and incorpo-

rate accessibility, equity, sustainability, and social acceptance emerges repeatedly as a methodological priority.

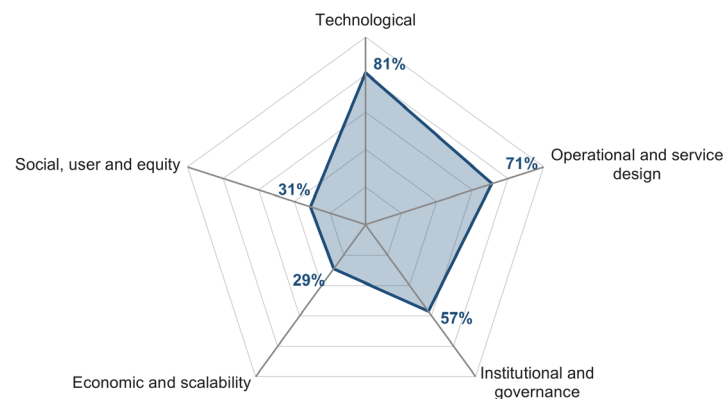


Figure 3. Distribution of the thematic focus of the corpus. Percentage of reviews ($n = 21$) that substantively address each dimension of the analytical framework. This characterization describes the focus of the analyzed corpus, not a metric of the field as a whole.

A geographic bias with conceptual implications also stands out. The concentration of studies in large cities and developed countries is not only a problem of sample representativeness. It also affects the validity of the conclusions [23,25,26]. Solutions generated in contexts with high urban density, solid institutional infrastructure, and users with high digital literacy are implicitly calibrated for those conditions. Their application in medium-sized cities, peripheral environments, or developing countries requires adaptations that the current literature does not always allow to be identified precisely.

Another gap concerns the architecture of the field itself. The separation of urban mobility and urban logistics as largely independent fields of study limits understanding of the systemic effects of the urban digital transition and hinders the design of integrated policies. People and goods share the same urban space, the same infrastructure, and many of the same pressures toward digitalization, yet the review literature mostly treats them as distinct domains. Connecting the two fields is more than a methodological choice. Their integration is emerging as a line of research with the potential to shape the field in the coming years.

Finally, two gaps align with the cross-cutting axes analyzed. Behavioral change has been studied mainly as initial adoption, leaving the substitution effects, the evolution of routines, and post-adoption dynamics less explored. And, demand forecasting reveals a persistent distance between the sophistication of available models and the maturity of the institutional and data frameworks that would need to incorporate them. This gap appears with particular frequency in the reviews and hinders the translation of technical advances into operational and planning decisions.

5. Discussion

Taken together, these reviews point to a central argument. The digitalization of urban mobility and logistics is not explained by technology alone [1,7,8,15,24]. Although research on smart mobility, MaaS, and digital logistics has advanced considerably, the technological focus remains dominant, something reflected both in what is studied and in how planning is done.

Viewed through the lens of the literature on sociotechnical transitions [16,17], the picture these works paint is recognizable. Digital innovation takes hold when it is integrated with the regulatory framework, the practices of use, and the economic models in which it is embedded, and when those elements are reorganized at the same time. What the reviews

add to that general framework is a concrete map of where this articulation breaks down in urban mobility and logistics, such as coordination between public and private operators, the alignment of supply with users' actual needs, attention to heterogeneous user profiles, and economic sustainability beyond the pilot phase.

There are signs, however, that the literature is beginning to correct this bias. In MaaS, the most mature field in the corpus, the shift is clearly visible. Butler et al. [1] place social equity and public–private cooperation at the center of their analysis, and Li et al. [4] question whether the development of MaaS has been overly guided by platform logic and call for a shift toward genuinely user-centered design methods. The fact that these approaches now appear in well-established reviews points to a maturing field, although the gap between academic analysis and design practice remains wide.

Another implication concerns the structure of the field. Urban mobility and logistics share the same digital transition, but not the same level of academic maturity. Mobility already has a relatively well-established conceptual framework, with recognizable taxonomies; numerous reviews on adoption, gender, micromobility, demand-responsive transport, and carpooling; and an increasingly sophisticated theoretical debate. Digital urban logistics is still a field under construction, more dispersed and dependent on specific technical subfields. This asymmetry has direct methodological consequences, and comparisons between the two fields (Table 4) should be read with that underlying difference in mind. It is not that urban logistics matters less but that the available corpus still offers a smaller critical mass of comparable syntheses; moving toward broader and more integrative reviews in digital urban logistics could reduce this asymmetry in the coming years.

Table 4. Comparison between urban mobility and digital urban logistics in the reviewed literature.

Dimension	Digital Urban Mobility	Digital Urban Logistics	Key Difference
Maturity of the literature	More established (MaaS, smart mobility, DRT, micromobility)	Less established and focused on specific subfields	Broader review base in mobility
Dominant approach	Adoption, acceptance, modal integration, user experience	Operational efficiency, optimization, traceability, last mile	More focus on the user vs. more focus on operations
Social factors and equity	Visible issue: gender, age, digital divide	Less developed; appears in working conditions	Equity much more studied in mobility
Governance and regulation	Public–private coordination, integration of services	Urban regulation, infrastructure, environmental sustainability	Different but equally crucial approaches
Behavior	Studied in terms of adoption and acceptance	Studied in delivery work practices	Different sides of the same change
Demand forecasting	Intelligent planning, smart cities, simulation	Routing, capacity, first-time delivery with AI/ML	More mature application in logistics, broader framework in mobility

The importance of the five dimensions varies across contexts. In rural and low-density areas, such as those examined in the RUMOBIL initiatives discussed by Porru et al. [25], dispersed demand, population aging, limited familiarity with digital tools, and dependence on public support may be more decisive than the technology itself. In developing-country contexts, the cases reviewed by Firzan et al. [23], including Jakarta, show that integrating and formalizing existing shared or flexible transport services may be a more immediate priority than introducing advanced optimization solutions. In Saudi cities such as Riyadh and Jeddah, Shaik et al. [26] identify high car dependence, limited public transport development, and fragmented governance as major barriers. These examples show that the framework should be applied with close attention to context, since the relative weight of technological, operational, social, institutional, and economic barriers differs across territories.

Finally, the two cross-cutting axes reveal their own limits. Behavioral change has been studied mainly as initial adoption, with less attention to what happens afterward, including substitution effects, the consolidation or abandonment of use, the evolution of routines, and user learning. For demand forecasting, the diagnosis is parallel. Models are increasingly sophisticated, yet they operate on non-representative data and within institutional frameworks that rarely incorporate them into planning. Their interaction is where the most promise lies. Neither axis advances fully without the other, a connection the review literature has not yet exploited.

5.1. Practical Implications

In mobility, the evidence suggests that launching a digital service requires preconditions that are not technological, such as a governance framework able to align public and private operators, a service design centered on the actual diversity of users, and an understandable fare structure that helps build a perception of value. In logistics, the pattern is similar. The adoption of digital or artificial intelligence tools, unless integrated into a broader urban strategy that incorporates sustainability, working conditions, and social responsibility, tends to produce local efficiency gains but not a transformation of the system. In both fields, the main bottleneck is not technological availability but the institutional capacity to translate innovation into a stable and equitable urban service.

For local authorities, this means using digital and predictive tools to support specific decisions, such as adjusting service frequencies, identifying areas with poorer coverage, allocating vehicles, or improving the management of urban deliveries. Before these tools are introduced, it is necessary to define who manages the data, how data quality and privacy are ensured, who updates the models, and who holds final responsibility for the decisions made. Pilot projects should not be assessed only in terms of accuracy or operational improvements but also in terms of cost, ease of use, effects on different groups, and their actual usefulness for planning. In addition, when model outputs affect public services or the allocation of resources, human oversight and regular monitoring should always be maintained.

Transport operators and logistics firms should also focus on service reliability, interoperability, the needs of users and customers, working conditions, and the medium- and long-term viability of the proposed solutions. For researchers, the framework makes it possible to examine not only whether a technology works but also why the same solution may produce different results depending on the urban, institutional, and economic context. In this sense, digital transformation should be understood as a process of organizational and governance change, rather than simply as the introduction of new technologies.

The framework can also guide future empirical research. In case studies, the five dimensions can be used to organize interviews, document analysis, user surveys, and

operational indicators. In comparative studies, the same structure can be applied across cities or services to explain why similar digital solutions produce different results. It can also support policy evaluation before, during, and after implementation by considering not only technical performance but also user response, institutional coordination, equity effects, and economic viability. The two cross-cutting axes add a temporal and decision-oriented perspective by examining how behavior changes and how predictive tools are incorporated into practice.

5.2. Answers to the Research Questions

To conclude the analysis, we revisit the five questions that guided this study.

- RQ1. The most frequent barriers are not technical but institutional (weak coordination between public and private actors, and fragmented regulation), operational (coverage, reliability, modal integration, and heterogeneous metrics), social (digital divide; biases by gender, age, and income), and economic (willingness to pay, fragile business models, and scaling difficulties). Technological barriers appear, but rarely as the most decisive.
- RQ2. Enablers converge on five conditions, namely effective interoperability between systems, service design centered on user diversity, integrated governance able to align policies and operators, viable economic models beyond the pilot phase, and sensitivity to the local context. None of them works in isolation.
- RQ3. Urban mobility and logistics share the same digital transition but navigate it unevenly. Mobility has a more mature review literature and prioritizes the user perspective. Logistics focuses more on operational efficiency, shows less comparative development, and addresses equity mainly through the working conditions of delivery.
- RQ4. For behavioral change, the literature prioritizes initial adoption and pays less attention to substitution effects, the consolidation of use, and post-adoption dynamics. For demand forecasting, the sophistication of models grows faster than the institutional maturity needed to incorporate them into operational and planning decisions.
- RQ5. The cross-cutting gaps fall into seven areas, namely technocentric bias, fragmented attention to user diversity, the absence of comparable evaluation frameworks, a scarcity of longitudinal studies, reliance on evidence from large cities in developed countries, a lack of integration between mobility and logistics, and the dual gap in behavior and forecasting described in RQ4.

5.3. Study Limitations

This study has limitations that should be explicitly acknowledged. The search was restricted to Scopus and Web of Science and to publications in English. This may have excluded relevant studies published in Spanish, Portuguese, French, or other languages, as well as local or regional evidence that is not indexed in these databases. This limitation may be especially important in urban logistics, where municipal initiatives, operational experiences, and regulatory analyses are often published in national-language journals or institutional reports. As a result, the review may underrepresent evidence from Latin America, Southern Europe, and other non-English-speaking contexts. This language restriction may also have contributed to the imbalance between mobility and logistics, although it does not fully explain it. The search was conducted in March 2026 and therefore does not include works published after that date; given the pace of change in the field, this temporal restriction may affect the comprehensiveness of the synthesis. The exclusion of document types such as conference papers, book chapters, and proceedings ensures methodological homogeneity but may omit useful empirical evidence. The final corpus of 21 documents is sufficient for a review of reviews but reflects the actual asymmetry between mobility and logistics, with only three reviews on the logistics side, of which only one plays a core role.

Comparisons between the two fields should be read with that asymmetry in mind. Finally, the classification into core and secondary reviews, although guided by explicit criteria, retains an interpretive component that other teams might assess differently.

6. Conclusions and Directions for Future Research

This study has synthesized the review literature on the digitalization of urban mobility and logistics through a systematic review of reviews. The field shows notable expansion, growing thematic diversification, and persistent fragmentation across subfields, methodological approaches, and application contexts. The asymmetry between the relative maturity of the mobility literature and the less consolidated body of work on digital urban logistics is one of the features that define the current state of the field. This article proposes treating it as a substantive finding and a priority research direction, not only as a limitation. The framework is therefore integrative at the conceptual level, but its current empirical basis is stronger for passenger mobility than for urban logistics, since only three of the 21 included reviews focus primarily on the latter.

The results support three conclusions. Digitalization cannot be interpreted as an exclusively technological process. The effectiveness of platforms, smart systems, and artificial intelligence depends on their integration with operational, regulatory, social, and economic factors that no technology resolves on its own. The proposed taxonomy of barriers and enablers, organized into five dimensions and two cross-cutting axes, shows that barriers and enablers are not symmetrical. Overcoming a barrier does not automatically generate the corresponding enabler because they operate on different levels and with different actors. And, the technocentric bias of the literature affects not only the knowledge produced but also the solutions designed, the populations considered, and the questions prioritized. Equity and governance, together with the two axes of the framework, therefore require greater analytical attention.

As a framework article, this work offers a reusable lens for organizing the evidence and guiding future research. The analysis identifies lines of work on behavioral change that go beyond initial adoption and incorporate substitution effects, sustained use, and operational frictions. In parallel, it outlines challenges and opportunities in data- and AI-driven demand forecasting, for both passenger mobility and urban logistics, including how to integrate these capabilities into planning and management decisions. It also points to cross-cutting priorities, namely strengthening equity and accessibility, generating implementation evidence in diverse contexts, and advancing data integration approaches that allow impacts to be assessed at the system level.

Taken together, the findings show that decisions on urban digitalization should consider technology, service design, equity, governance, and economic viability jointly. For public authorities and operators, this means moving beyond isolated pilot projects and embedding digital tools in stable planning, monitoring, and decision-making processes. For researchers, the framework provides a common basis for comparing mobility and logistics across different urban contexts and for testing how the five dimensions interact in practice.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/futuretransp6040137/s1>, Table S1: Classification of the included reviews by analytical role.

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Appendix A. Search Equations

The following search equations were used to identify relevant review-based documents in Scopus and Web of Science. The queries were designed to combine four blocks of terms: type of review; thematic scope related to urban mobility and urban logistics; digital transformation; and analytical terms related to barriers, enablers, challenges, drivers, implementation, and research gaps.

Appendix A.1. Scopus

TITLE-ABS-KEY (("systematic review" OR "literature review" OR "scoping review" OR "review of reviews" OR "overview of reviews" OR "bibliometric review") AND ("urban mobility" OR "mobility as a service" OR MaaS OR "shared mobility" OR micromobility OR "micro-mobility" OR "demand-responsive transport" OR DRT OR "urban logistics" OR "city logistics" OR "urban freight" OR "last-mile delivery" OR "last-mile logistics") AND (digitalization OR digitization OR "digital transformation" OR "digital platform*" OR "smart mobility" OR "digital logistics") AND (barrier* OR enabler* OR challenge* OR driver* OR "research gap*" OR implementation)).

Appendix A.2. Web of Science

TS = (("systematic review" OR "literature review" OR "scoping review" OR "review of reviews" OR "overview of reviews" OR "bibliometric review") AND ("urban mobility" OR "mobility as a service" OR MaaS OR "shared mobility" OR micromobility OR "micro-mobility" OR "demand-responsive transport" OR DRT OR "urban logistics" OR "city logistics" OR "urban freight" OR "last-mile delivery" OR "last-mile logistics") AND (digitalization OR digitization OR "digital transformation" OR "digital platform*" OR "smart mobility" OR "digital logistics") AND (barrier* OR enabler* OR challenge* OR driver* OR "research gap*" OR implementation)).

Appendix B. Dimensional Coding Matrix of the Corpus

Each review was coded as 1 for dimensions addressed substantively (explicit category of analysis, specific findings or recommendations, or presence in keywords or research questions) and as 0 for the remaining dimensions. The identification of a gap was not counted as an address.

Table A1. Dimensional coding of the 21 reviews.

Reference	Technology	Operation and Service Design	Society, User, and Equity	Institution and Governance	Economics and Scalability
Aguilera & Pigalle (2021) [10]	1	0	0	0	0
An (2024) [22]	1	1	1	0	0
Anthony Jnr (2025) [15]	0	0	0	1	0
Baier et al. (2024) [13]	0	1	1	1	1
Butler et al. (2021) [1]	1	1	1	1	1
Chmiel & Wierzbowski (2025) [11]	1	1	0	1	1
Ferreira & Esperança (2025) [8]	1	1	0	0	1
Firzan et al. (2025) [23]	1	1	1	1	0
Li et al. (2024) [4]	1	1	1	0	0
Liyanage et al. (2019) [24]	1	1	0	1	1
McIlroy (2023) [14]	0	1	1	0	0
Mitieka et al. (2023) [5]	1	0	0	1	0
Munhoz et al. (2020) [3]	1	0	0	1	0
Nalluri et al. (2025) [7]	1	0	0	0	0
Orozco-Fontalvo et al. (2023) [12]	1	1	1	1	1
Porru et al. (2020) [25]	1	1	0	1	0
Shaik et al. (2026) [26]	1	1	0	1	0
Son et al. (2025) [2]	1	1	0	0	0
Szpilko et al. (2023) [27]	1	0	0	0	0
Tubis & Sadowski (2025) [28]	1	1	0	1	0
Useche et al. (2025) [6]	0	1	1	0	0
Total	17	15	8	12	6
%	81%	71%	38%	57%	29%

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