Micro-freight Systematic Literature Review: Preliminary Findings

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Abstract
Micro-freight, the transportation of goods using micro-mobility modes, has gained significance as online activities and remote work surged during the pandemic. This paper presents a preliminary systematic literature review on micro-freight, examining both freight-specific and micro-mobility-specific aspects. Preliminary findings highlight its potential benefits, challenges, and trends while identifying gaps in current knowledge. Insights from a workshop with stakeholders further inform planning, policy, and deployment strategies. By combining the literature review and workshop insights, this paper provides a comprehensive understanding of micro-freight and emphasises the need for further research and collaboration in this emerging field.

1. Introduction

The global shift towards online activities and remote work during the pandemic has not only transformed our daily routines but also accelerated the demand for efficient and timely delivery of small parcels and food items (Patella et al., 2021). In response to this demand, the concept of 'micro-freight' has emerged as a promising solution for the transportation of goods using micro-mobility modes. Micro-freight focuses specifically on harnessing the potential of smaller, lightweight vehicles such as bicycles, e-bicycles, e-scooters, and e-tricycles, whether powered by humans or 'clean' energy sources (Narayanan & Antoniou, 2022). These micro-mobility modes offer distinct advantages in terms of cost-effectiveness, environmental friendliness, and the ability to facilitate efficient last-mile deliveries (Golinska-Dawson & Sethanan, 2023).

However, the rise of micro-freight has introduced challenges within the context of urban transport. The lack of comprehensive regulations and norms surrounding micro-modes of transport has raised concerns regarding safety and their compatibility with existing transportation options. The acceptance, legislation, and provision for micro-freight vary across different regions and cities, with some locations being more advanced in mainstreaming these modes than others (Narayanan & Antoniou, 2022).

To address the need for comprehensive strategies in micro-freight, this paper conducts a systematic literature review encompassing freight-specific and micro-mobility-specific aspects. It aims to contribute to the field by providing an overview and capturing diverse perspectives. By gaining a deeper understanding through the ongoing full-text review, this study seeks to advance the knowledge and inform planning, policy-making, regulation, and deployment strategies for micro-freight.

This paper incorporates findings from a Sydney workshop that engaged stakeholders from academia, government, and industry. The workshop addressed critical micro-freight issues and explored planning, policy, regulation, and deployment strategies. Additionally, an upcoming London workshop will facilitate comparative analysis and global knowledge exchange, promoting valuable insights and best practices sharing.

The paper is structured as follows: In Section 2, the methodology of the systematic literature review is described. Section 3 presents preliminary findings from quantitative and qualitative analyses of filtered papers. Section 4 discusses insights from the Sydney workshop, highlighting stakeholder perspectives. Section 5 compares the literature review and workshop findings, providing a comprehensive overview of micro-freight. Finally, Section 6 concludes the paper by summarising key insights and outlining future research directions.

2. Methodology

The systematic literature review method was selected as the approach for this study due to its ability to present a comprehensive, objective, and reproducible overview of the existing knowledge and research within a specific field. This method enables researchers to demonstrate in a clear and

organised manner what is known or has been studied about a particular field of knowledge. By employing systematic procedures, such as well-defined protocols for locating, selecting, and evaluating papers, the systematic literature review ensures data reliability. Also, it allows for rigorous analysis and synthesis to present the main findings (Tranfield, Denyer & Smart, 2003). This approach provides valuable insights for stakeholders involved in planning, policy-making, and deployment strategies, as well as guiding future research endeavours.

The methodology employed in this study consists of several stages to ensure a thorough and rigorous systematic literature review on micro-freight. Figure 1 presents an overview of the six steps involved in the systematic literature review process adapted from Golinska-Dawson & Sethanan (2023): problem identification, preparatory analysis, formulation of research questions, the definition of search strategy, paper selection and data extraction, and reporting.

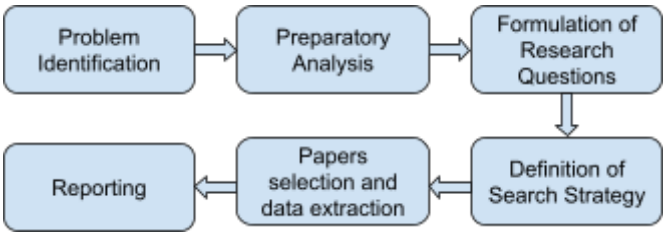

Figure 1: Steps of systematic literature review

During the problem identification step, the unsustainability of conventional transport methods, the potential benefits of micro-mobility, and the challenges posed by unregulated micro-mobility modes in freight delivery were recognized. These challenges encompassed safety, regulation, and integration with existing transport systems. The absence of comprehensive regulations and guidelines for micro-freight presented significant obstacles that required attention. As a result, thorough research and analysis of micro-freight were deemed necessary to inform the development of policies, regulations, and sustainable development strategies in an informed manner.

The subsequent step involved preparatory analysis, where previous literature review papers on micro-mobility and sustainable freight were reviewed. This step aimed to familiarise ourselves with the existing body of knowledge and identify research gaps. It provided a foundation for formulating research questions that addressed key aspects such as definitions, benefits, challenges, trends, and gaps in the literature related to micro-freight. These research questions guided the subsequent steps of the study:

RQ1: What are the key definitions and characteristics of micro-freight in the existing literature, and how have these definitions and characteristics evolved?

RQ2: What are the main benefits and key factors that influence the adoption and success of micro-freight solutions?

RQ3: What are the key challenges in implementing and gaining approval for micro-freight solutions?

RQ4: What are the current trends and future directions in micro-freight research and practice?

RQ5: What are the gaps and limitations in the existing literature on micro-freight, and how can these gaps be addressed in future research?

The search strategy for this systematic literature review was conducted using the Scopus database. To ensure a consistent and high-quality review process, only journal papers were included in the search. The time range for the search was limited from 2000 to 2023, encompassing a significant period of relevant literature. There were no language restrictions imposed, although the inclusion of journal papers ensured that the publications predominantly used English as the language of publication.

The specific search strategy employed in this study is outlined in the string "TITLE-ABS-KEY("micro-freight") OR (TITLE-ABS-KEY(“micro-mobility” OR “e-scooter” OR “electric-scooter” OR “bicycle” OR “bike” OR “tricycle” OR “trike”) AND TITLE-ABS-KEY(“freight” OR “cargo” OR “e-commerce” OR “parcel” OR “courier” OR {logistics}))", which was used to identify papers related to micro-mobility and freight or delivery. The search string was designed to be comprehensive, capturing as many relevant papers as possible. A total of 276 papers were retrieved from the Scopus database on 15 April 2023.

The paper selection and data extraction step of this systematic literature review consists of two phases: titles and abstracts screening, and full-text review. The titles and abstracts screening phase has been completed, while the full-text review is currently ongoing.

During the titles and abstracts screening phase, 105 papers were excluded from the initial set of retrieved papers. The main exclusion reasons included studies focusing on cyclists' health indicators, bike and electric bike sales, relationships between cyclists and freight trucks/vans, logistics for bicycle tourism, and evaluation of sustainability indicators with specific equipment on cargo bikes. These exclusion criteria were applied to ensure that the selected papers closely aligned with the research objectives and scope of the systematic literature review on micro-freight.

After completing the title and abstract screening phase and filtering the papers accordingly, an additional step was taken to identify relevant papers through cross-referencing. This involved examining the main references cited in the selected papers from the initial screening phase, particularly focusing on the references within the most highly cited papers. This cross-referencing approach aimed to ensure a comprehensive inclusion of relevant literature and to capture additional sources that may have been missed during the initial search. Out of the 22 additional papers identified, 11 were duplicates and excluded, while the remaining 11 unique papers were included in the systematic literature review, further enriching the analysis of micro-freight.

A total of 276 papers were initially retrieved through the search strategy. After screening the titles and abstracts, 105 papers were excluded based on predefined criteria. Additionally, 11 papers were included through cross-referencing, bringing the current number of papers for the ongoing full-text review phase to 182. This phase entails a thorough evaluation of the selected papers, extracting relevant data, and refining the findings and conclusions of the literature review. The paper selection process leading up to the ongoing full-text review phase is depicted in Figure 2.

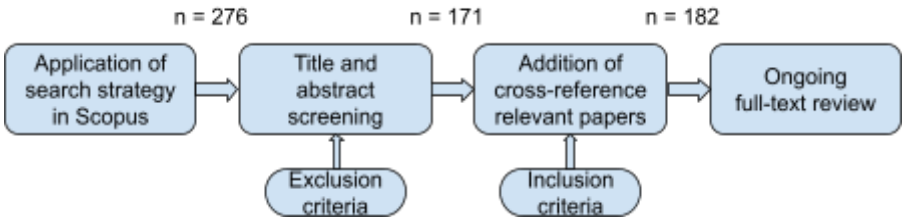

Figure 2: Process of paper selection

This preliminary paper serves as the initial step in the reporting phase of our systematic literature review on micro-freight by providing an overview of the methodology employed. While the full-text review phase is still ongoing, we have reached a significant milestone in gathering a comprehensive set of papers for analysis. In the next section, we will present a quantitative analysis of the papers collected thus far, examining various characteristics and trends within the dataset. Additionally, we will discuss the preliminary findings derived from the literature review papers in the current set. This combination of quantitative and qualitative analyses aims to provide a comprehensive understanding of the existing body of literature on micro-freight and contribute valuable insights to the field.

3. Literature review

This section provides a preliminary analysis of the literature review conducted on micro-freight. Through the process of title and abstract screening, a set of relevant papers has been identified for our review. The analysis presented here represents the main findings obtained thus far, combining both quantitative and qualitative approaches. While the quantitative analysis examines numerical data and statistical findings, the qualitative analysis explores conceptual and practical insights from the literature. These initial findings shed light on the current state of micro-freight research, identifying key themes, trends, and research gaps. It is important to note that the selection procedure is still ongoing, and further insights will be incorporated into the final review.

3.1. Quantitative Analysis

Our search strategy allowed for the inclusion of papers covering the period from 2000 to 2023. Figure 3 illustrates this distribution of the papers included after the title and abstract screening process, highlighting an increasing trend. Before 2015, the number of papers on micro-freight was relatively scarce, with few or no papers meeting our inclusion criteria. However, since 2015, there has been a

noticeable surge in research output, indicating a growing interest in the field. This upward trend is evident, with over 20 papers identified in 2019-2020 and approximately 40 papers in 2021-2022. It is important to note that the relatively lower number of papers identified in 2023 is attributed to the fact that our search was conducted in April of this year. This observation suggests an increasing focus on micro-freight research, providing a robust foundation for our literature review.

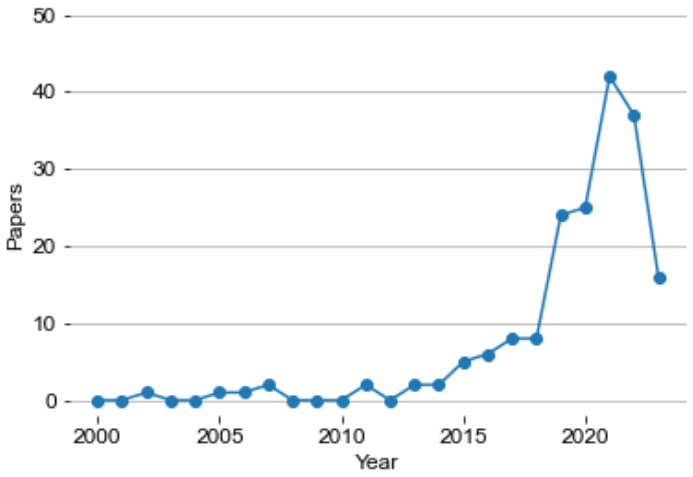

Figure 3: Papers by year

Figure 4 reveals the countries with the highest number of first authors among the selected papers from the title and abstract screening stage. Germany and the United States stand out as the most frequent contributors, demonstrating their significant involvement in micro-freight research. Additionally, authors from 23 other countries also contributed to the literature, indicating a global interest in studying micro-freight and providing diverse regional perspectives.

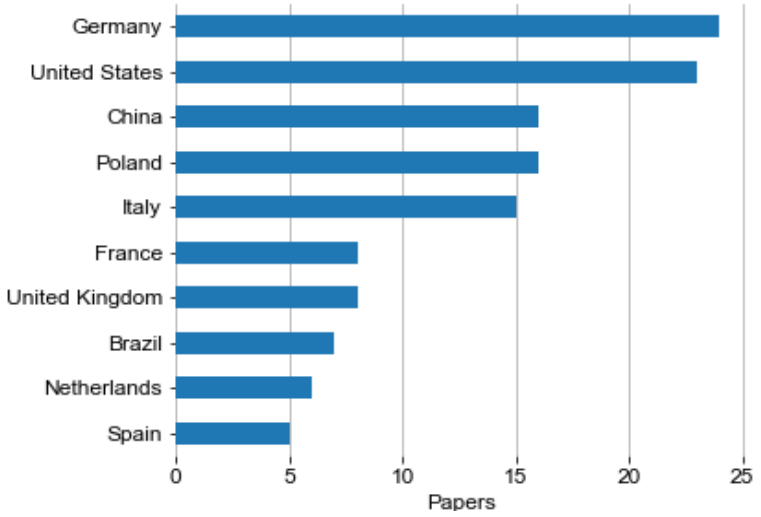

Figure 4: Papers by country

Figure 5 highlights the authors who have made the most frequent appearances in the selected papers from our title and abstract screening stage. Notably, Assmann, T., Faulin, J., Goes, G.V., and Gruber, J., all tied with four appearances, have significantly contributed to the field.

Additionally, Table 1 presents the distribution of papers among the journals with the highest number of publications within the approved set. Sustainability and Energies emerge as the prominent journals in this regard, with Sustainability alone featuring nearly 30 papers.

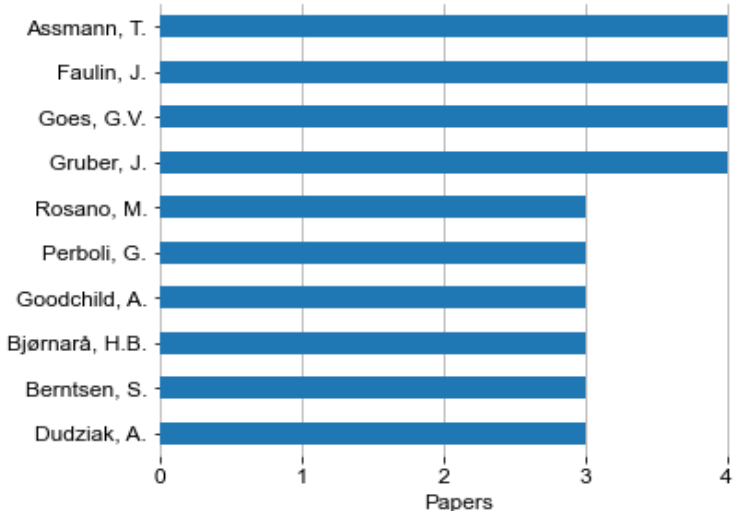

Figure 5: Papers by authors

Table 1: Papers by journals

Journal	Number of papers
Sustainability (Switzerland)	28
Energies	10
Transportation Research Interdisciplinary Perspectives	7
Research in Transportation Business and Management	6
Transportation Research Part D: Transport and Environment	6

Figures 6 and 7, generated using VOSViewer software, provide visual representations of bibliometric data analysis. These figures depict the co-occurrence of keywords within the set of approved papers thus far. Specifically, the figures illustrate keywords that have appeared together at least five times in these papers, revealing meaningful associations and trends.

Figure 6 showcases the co-occurrence of keywords and provides insights into the average year of publication for papers in which these keywords appear. This analysis allows us to observe the usage of recent keywords such as covid-19, shared mobility, and public transport, indicating their relevance and prominence in the latest research.

Figure 7 utilises clustering techniques to identify five distinct clusters of keywords with strong connections and co-occurrence patterns. These clusters provide insights into thematic relationships and common research areas within the literature. Detailed information on the keywords within each cluster is provided below:

- Cluster 1: benchmarking, carbon dioxide, city logistics, cost, cycle logistics, electric vehicles, energy efficiency, environmental impact, fleet operations, last mile, sustainable development, trucks, urban delivery, vehicle routing, vehicle routing problem, vehicles
- Cluster 2: crowdsourcing, logistics, mobility, optimization, parcel delivery, shared mobility, strategic approach, sustainability, transportation planning, transportation policy, transportation system, urban area, urban freight, urban logistics, urban planning
- Cluster 3: bicycles, cargo bikes, covid-19, cycling, electric bikes, gig economy, human, sporting goods, surveys, sustainable transport, transportation, urban mobility
- Cluster 4: cargo, cycle transport, freight transport, gas emissions, greenhouse gases, public transport, traffic congestion, traffic emission, urban freight transport, urban transport, urban transportation
- Cluster 5: decision making, last-mile delivery

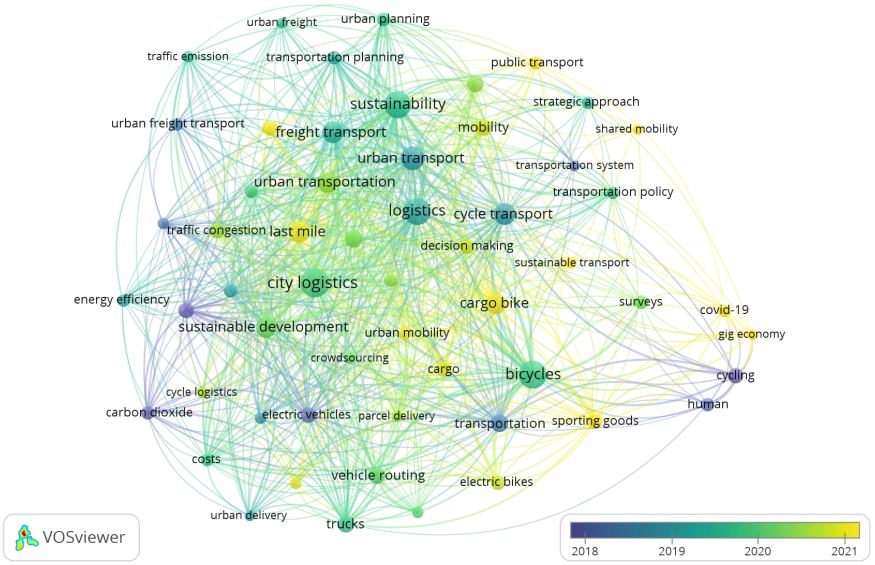

Figure 6: Co-occurrence of keywords per average year

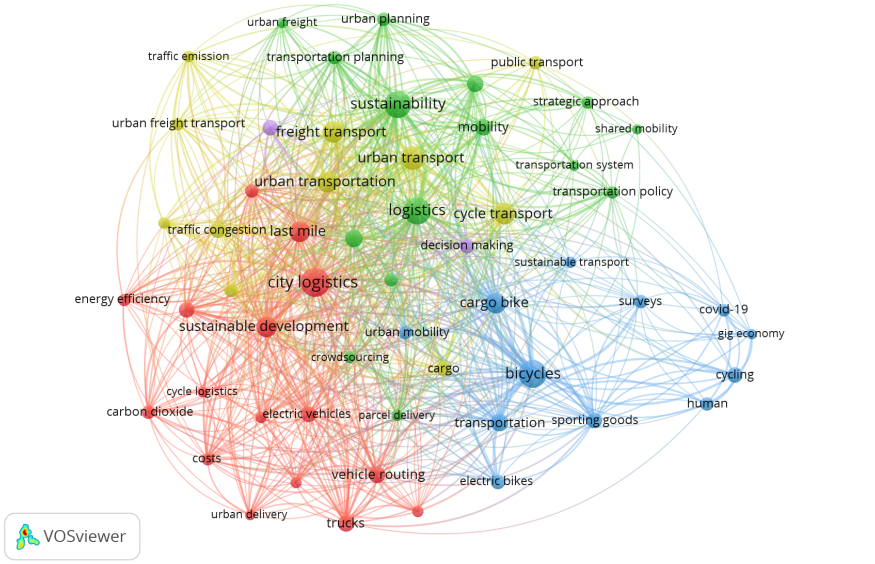

Figure 7: Co-occurrence of keywords per cluster

During the title and abstract screening stage, it became evident that the selected papers could be categorised into three distinct areas: transport planning, behaviour, and modelling. These categories represent different research focuses within the field of micro-freight. Additionally, the approved set of papers encompassed four main research methods: case studies, surveys, literature reviews, and mathematical modelling and/or optimization. As we proceed to the next stage of full-text review, we will gain a better understanding of the distribution of papers within each of these groups within the final set. This analysis will provide insights into the prevalence and significance of each area and method within the micro-freight literature.

The following subsection will present the qualitative analysis of the selected papers, offering an exploration of the main findings discovered thus far. This analysis will provide a comprehensive understanding of the contextual nuances, conceptual frameworks, and practical insights embedded within the literature on micro-freight.

3.1. Qualitative Analysis

In this subsection, we will explore the analysis of key literature reviews that have been approved following the title and abstract screening phase. These literature reviews provide a valuable foundation for addressing the research questions outlined in Section 2, namely the definitions, benefits, challenges, trends, and gaps associated with micro-freight.

Oliveira et al. (2017) highlight the emergence of new technologies and vehicles for last-mile deliveries, with a trend towards smaller and lighter options such as bicycles and tricycles, as well as the shift towards alternative energy sources like electricity. Bosona (2020) focuses on the challenges and opportunities in urban freight last-mile logistics (LML). The study identifies potential LML configurations, including light cargo vehicles and cargo bike-based delivery schemes, and discusses challenges related to technology, infrastructure, management, and logistic costs. It also highlights the opportunities for environmental, economic, and social sustainability in LML.

Narayanan & Antoniou (2022) focus on electric cargo cycles (E-cargo cycles) and present a comprehensive overview of their typology, factors influencing their penetration, and their impacts across various domains. The study also discusses policy requirements and decision-making considerations related to E-cargo cycles in both commercial and private transport settings. Golinska-Dawson & Sethanan (2023) examine innovations in sustainable urban freight (SUF) for energy-efficient smart cities. They classify these innovations as urban freight consolidation, the Consumer as a Service Provider (CaaSP) model, and transportation mode choices. The study emphasises the importance of energy-efficient practices and the use of smart technologies to reduce energy demand and enhance operational planning in SUF. The analysis of these relevant literature reviews sets the stage for starting to address the research questions.

Definitions: Micro-mobility is a term used to describe various modes of transportation, including cargo cycles and electrically-assisted tricycles. These modes of transport are often utilised for urban goods delivery and have gained increasing attention due to their potential to address sustainability and congestion challenges (Browne, Allen, & Leonardi, 2011). While the term "micro-freight" intuitively captures the concept of using micro-mobility for freight and delivery purposes, it is worth noting that it is not commonly used in academic literature. Nevertheless, the concept of applying micro-mobility to freight and delivery operations is well-recognized and studied in scholarly research.

City logistics is a broader term commonly used in the context of European Commission projects to encompass the sustainable management of urban freight and distribution (Schliwa et al., 2015). Within the realm of city logistics, the concept of cycle logistics emerges, encompassing various types of pedal cycles, both manual and electrically assisted, that are utilised for urban deliveries. This approach extends beyond the scope of individual cargo bikes and embraces a perspective on the entire urban freight movement. Sustainable city logistics address not only environmental considerations but also social and economic aspects, aiming to tackle issues such as congestion, quality of life, and carbon reduction (Schliwa et al., 2015).

Cargo bikes, particularly electrically-assisted variants, have emerged as the primary micro-mobility mode used for freight and urban goods delivery, and they have been extensively studied and reported in academic literature. These versatile vehicles offer a range of models, including post bikes, longtails, front-loaders, rear-loaders, and bike trailers, each with unique features and load capacities (Arnold et al., 2018; Perboli, Rosano, & Wei, 2019).

With load capacities ranging from 50 kg to 500 kg and battery ranges of up to 80 km, cargo bikes provide zero-emission alternatives for urban goods delivery (Naumov, 2021; Sheth et al., 2019). Their ability to navigate congested urban areas with ease, thanks to their manoeuvrability and speed, makes them particularly suitable for dense urban environments (Arnold et al., 2018; Perboli, Rosano, & Wei, 2019). By bridging the gap between conventional cargo cycles and cars, cargo bikes offer greater payload capacity and range while maintaining environmental benefits (Naumov, 2021; Sheth et al., 2019). Notably, electric assist (EA) cargo bikes have gained significant attention and adoption by major delivery companies like UPS, DHL, and FedEx (Sheth et al., 2019). These companies recognize that EA cargo bikes enable efficient and reliable urban deliveries while reducing circling and idling time, contributing to more sustainable and environmentally friendly transportation practices.

Benefits: Micro-freight solutions offer significant benefits in sustainable urban freight transport across environmental, social, and economic aspects. They have been recognized as powerful tools for reducing CO2 emissions in urban areas (Fontaine, 2022; Ramírez-Villamil et al., 2022). Cargo bikes

and e-cargo bikes, known for their energy efficiency, contribute to reduced emissions and fuel consumption by halting the engine when the cyclist stops. Besides, through the integration of micro-depots and optimised routing, they can avoid traffic-restricted zones in city centres, leading to further emission reductions (Navarro et al., 2016). Pilot projects in Barcelona and Valencia have demonstrated significant energy savings and the potential for substantial CO2 emission reductions with the full-scale implementation of micro-freight solutions (Navarro et al., 2016).

The utilisation of cargo bikes and tricycles as noiseless and non-polluting delivery options brings significant social benefits to urban communities, particularly in congested city centres and historical areas. These micro-freight options contribute to creating a sustainable and greener urban environment, enhancing their societal value (Fontaine, Minner, & Schiffer, 2022; Serrano-Hernandez, Ballano, & Faulin, 2021).

Micro-freight solutions, specifically cargo bikes and tricycles, offer notable economic benefits as efficient alternatives for small parcel delivery in urban areas. They have been found to be cost-effective and energy-efficient compared to traditional freight vehicles, with cargo bikes excelling in reducing fuel consumption and operating costs due to their energy-efficient design and routing optimization capabilities (Serrano-Hernandez et al., 2021). However, the economic aspect remains a focal point of concern, prompting further exploration of the long-term viability and scalability of micro-freight solutions.

The integration of micro-freight in urban areas aligns with the goals of smart city development, addressing trends such as urbanisation, e-commerce growth, and the need for on-demand deliveries. By reducing traffic congestion, air pollution, and greenhouse gas emissions, micro-freight contributes to the overall sustainability and post-pandemic recovery of cities (Hörcher, Ceder, 2021; Restrepo, 2021; Singh, & Graham, 2022).

Challenges: Micro-freight solutions, such as cargo bikes and tricycles, offer significant potential for sustainable urban freight transport. However, several challenges hinder their widespread adoption. One key challenge is the limited load capacity of micro-freight vehicles, resulting in increased distances travelled per parcel and potential inefficiencies in the delivery process (Browne, Allen, and Leonardi, 2011). Additionally, the reluctance of major courier companies to mix parcels from different providers in the same vehicle poses a barrier to the expansion of cycle logistics (Schliwa et al., 2015).

The economic viability of micro-freight solutions is a critical challenge due to the cost-driven nature of last-mile delivery business (Arnold et al., 2018). Achieving acceptable operating costs requires collaboration and resource sharing among logistics service providers (Golinska-Dawson & Sethanan, 2023). However, the lack of comprehensive data and accurate comparisons between micro-freight and traditional delivery solutions further complicates decision-making (Arnold et al., 2018).

Infrastructure and operational constraints also impede the adoption of micro-freight solutions. The need for dedicated cycling infrastructure, including wider cycle lanes and separated paths, is essential to ensure user safety and comfort (Narayanan & Antoniou, 2022). Factors such as steeper gradients, inadequate charging stations, and the lack of overnight storage facilities pose additional challenges for micro-freight operations (Narayanan & Antoniou, 2022). Furthermore, the organisational and managerial support necessary for introducing micro-freight solutions requires changes in delivery processes, schedules, and driver behaviour (Narayanan & Antoniou, 2022).

Perceptions and societal acceptance also present hurdles to the adoption of micro-freight solutions. Users' hesitancy to embrace E-cargo cycles and concerns related to weather conditions contribute to the slow uptake of these alternatives. Overcoming these challenges requires addressing user perceptions, highlighting the benefits of micro-freight solutions, and providing weather protection options (Narayanan & Antoniou, 2022).

Trends: Micro-freight adoption in urban areas is witnessing notable trends that are shaping the field. Energy-efficient modes of transportation for last-mile delivery, such as drones and mobile robots, are being explored through real-life case studies to validate their operational simplicity and robustness in various scenarios (Golinska-Dawson & Sethanan, 2023). Autonomous vehicles are also gaining attention, with further research needed to address challenges related to sensor technology, artificial intelligence, and blockchain for routing, tracking, and ensuring transportation sustainability and safety.

From a macroscopic perspective, innovative solutions for sustainable urban freight can be categorised into three main areas. Firstly, urban freight consolidation and trans-shipment optimise last-mile

delivery by consolidating goods at strategic hubs and utilising efficient transportation modes (Golinska-Dawson & Sethanan, 2023). Secondly, the choice of mode of transportation for last-mile delivery emphasises the use of electric vehicles, bicycles, electric scooters, and cargo bikes (Naumov & Pawluś, 2021; Narayanan & Antoniou, 2022). These sustainable alternatives enable flexible and eco-friendly delivery within urban areas. Lastly, involving consumers as service providers through crowd-shipping and peer-to-peer delivery models optimises resource utilisation, reduces the number of trips, and minimises energy demand in the last-mile delivery process (Perboli, Rosano, & Wei, 2022).

Gaps: The literature on micro-freight adoption reveals gaps in strategic and operational aspects (Perboli, Rosano, 2019). Existing models focus primarily on operational aspects, neglecting the business model and development of key players in parcel delivery systems. Integration of green transportation modes with traditional systems and consideration of cost structures, revenue, and policies are also lacking.

Research on electric cargo cycles highlights the need to explore their utilisation beyond delivery trips, including private transport and service trips (Narayanan & Antoniou, 2022). Country-specific restrictions and the lack of comprehensive evaluations are identified as gaps. The use of transport models and simulations can provide insights into a wider range of scenarios and policies.

Further research is needed in the critical area of urban transhipment point planning for regional e-bike delivery systems. Current approaches are often case-study-specific and fail to account for the stochastic nature of demand and detailed technological procedures. Simulation-based approaches offer a solution by considering demand uncertainty and resource constraints (Naumov, 2021).

4. Workshop

Australia has experienced a remarkable surge in micro-freight, particularly during and following the global COVID-19 pandemic. This growth has been driven by the rapid rise of e-commerce, e-food delivery, just-in-time distribution systems, and rapid response servicing. In 2022, online retail sales accounted for 15% of total retail sales in Australia, with a predicted doubling of this proportion by 2027 (Statista Research Department, 2023). Furthermore, online sales in the restaurant sector reached 30% in 2022, exhibiting an annual growth rate of around 20% since 2017. The availability of a wide range of products for online purchase, coupled with affordable or free delivery and flexible return policies, has been a significant factor contributing to the growth of e-commerce.

The exponential increase in demand for complex last-mile deliveries poses significant challenges for the logistics industry in Australia. The exponential increase in demand for complex last-mile deliveries poses significant challenges for the logistics industry in Australia. To fulfil this demand, a diverse range of logistics firms, as well as individual couriers, employ a variety of vehicles including trucks, cars, vans, mopeds, and an emerging fleet of micro-mobility modes. These micro-mobility modes encompass bicycles, e-bicycles, e-tricycles, e-cargo bicycles, e-scooters, and even skateboards. While these modes offer appealing advantages such as cost-effectiveness, environmental friendliness, and quicker delivery, they have entered Australian streets largely unregulated, often violating existing road rules. Consequently, safety concerns have been raised, and compatibility with existing transport options has become an issue.

To address these challenges, a workshop was conducted in Sydney in May 2023. The workshop brought together key stakeholders from academia, government, and industry. Its purpose was to identify and discuss the major issues surrounding micro-freight and explore potential strategies for planning, policy, regulation, and deployment. To contextualise some of the findings of the broader literature review, we consider the main themes arising from the workshop.

Benefits: Micro-mobility options, such as e-bicycles and e-scooters, offer multiple advantages for last-mile deliveries, particularly in densely populated urban areas. While sustainability considerations are evident, the growth of micro-mobility has primarily been driven by their potential to provide faster and more cost-effective delivery solutions. Additionally, these modes do not require operators to possess a licence, opening up employment opportunities for individuals without driving licences and reducing labour costs. The growth of the e-bicycle industry in Australia, with over 100,000 sales in 2022 (a doubling since before the pandemic) (Coulter, 2022), is a testament to this trend. Informal trials conducted in Sydney's CBD indicate that bicycle couriers can operate approximately twice as fast as van couriers and require less curbside parking space. This efficiency is due to bicycles' ability

to manoeuvre through congested traffic and park closer to the delivery destination, whereas van drivers often spend a significant portion of their time walking.

Challenges: The workshop primarily focused on the key challenges involved in facilitating the safe and effective deployment of micro-mobility modes for freight delivery:

- Micro-Hubs: Establishing micro-hubs, where goods can be consolidated for last-mile delivery, is crucial. However, finding suitable locations for these hubs in dense urban areas presents a challenge, as it requires repurposing land and identifying practical transfer points for efficient goods exchange between vans and micro-mobility vehicles.
- Vehicle Regulation: Australia's current vehicle classification framework and operational allowances for micro-mobility vehicles are relatively narrow compared to regulations in European countries. This restricts the potential of micro-mobility deliveries in the country. Safety concerns also arise from the use of illegal high-powered e-bicycles that exceed speed limits.
- Safety and Insurance: The use of illegal e-mobility devices, time-sensitive deliveries, and inadequate insurance coverage pose significant safety risks for riders and other road users. Moreover, temporary migrants face difficulties in obtaining appropriate insurance, and the high cost of insuring cargo bikes remains an ongoing concern (Australian Associated Press, 2022).
- Infrastructure: While micro-mobility modes hold promise for last-mile deliveries, Australia's current infrastructure is largely designed for cars and lacks proper accommodation for bicycles and micro-mobility vehicles. Improving infrastructure to support micro-mobility deliveries and create safer conditions for riders is essential.
- Evidence Base: There is a notable lack of empirical evidence regarding the benefits and costs of micro-mobility delivery solutions. Gathering comprehensive data on last-mile delivery modes is a complex task due to the involvement of multiple stakeholders.

Australia has significant potential for wider adoption of micro-mobility deliveries, considering the increasing congestion, parking challenges, cost reductions, and the growing inclination towards environmentally friendly practices (Transport for NSW, 2023; DCCEEW, 2023). However, the lack of supportive infrastructure, e-bike regulations, and pro-car policies hinder progress in this area. To fully realise the benefits of micro-freight, there is a need for political will and investment in appropriate infrastructure, incentives, and regulations. A comprehensive approach involving collaboration between academia, government, and industry is essential for promoting greener and more efficient last-mile deliveries in Australia.

The workshop in Sydney provided valuable insights into the challenges and opportunities of micro-freight in Australia, emphasising the need for collaborative efforts to address regulatory, safety, infrastructure, and research gaps. These discussions laid the foundation for sustainable and efficient last-mile deliveries, benefiting the logistics industry and society. Furthermore, upcoming workshops, such as the one that will take place in London, UK, in June, offer opportunities for comparative analysis and knowledge sharing, enabling valuable insights and best practices to be exchanged globally. Through international collaboration, we can strive for innovative and sustainable delivery systems, driving positive impacts for the logistics industry and society as a whole.

5. Discussion

The findings from the literature review and the workshop shed light on the challenges and opportunities of micro-freight in Australia. The literature review provided a comprehensive understanding of the broader trends and factors driving the growth of micro-freight, while the workshop included valuable insights from key stakeholders besides academia in government and industry.

One notable consistency between the literature review and the workshop is the significant growth of e-commerce and its impact on last-mile deliveries. Both sources highlighted the rapid rise of online retail sales and the increasing demand for efficient delivery solutions. This aligns with the workshop discussions, which emphasised the surge in micro-freight driven by the exponential growth of e-commerce, e-food delivery, and just-in-time distribution systems.

Another common finding between the literature review and the workshop is the emergence of micro-mobility modes as a promising solution for last-mile deliveries. The literature review highlighted the advantages of micro-mobility options, such as bicycles and e-scooters, in terms of cost-effectiveness and environmental friendliness. Similarly, the workshop discussions recognized the

potential of micro-mobility modes, including e-bicycles and e-scooters, in addressing the challenges of last-mile deliveries, particularly in densely populated urban areas.

However, both the literature review and the workshop identified several challenges associated with micro-freight. The literature review emphasised the need for appropriate infrastructure, supportive regulations, and incentives to fully realise the benefits of micro-mobility deliveries. Likewise, the workshop discussions highlighted challenges related to establishing micro-hubs, vehicle regulation, safety and insurance, infrastructure, and the lack of empirical evidence.

Importantly, the workshop provided a deeper understanding of these challenges by incorporating the perspectives of key stakeholders. It facilitated discussions on regulatory and policy gaps, safety concerns, and the need for collaboration between academia, government, and industry to address these issues. The workshop also served as a platform to exchange knowledge, experiences, and best practices among participants, enabling a more comprehensive and contextualised understanding of the challenges faced by the logistics industry in Australia.

6. Conclusion

This paper has presented a preliminary review of the challenges, opportunities, and future directions in the field of micro-freight. By synthesising the findings from the literature review and the insights gained from the workshop, this study has shed light on the various aspects of micro-freight, its benefits, challenges, and the need for collaborative efforts to address the gaps in this emerging field.

The literature review highlighted the exponential growth of micro-freight in response to the surge in e-commerce, e-food delivery, and just-in-time distribution systems. The adoption of micro-mobility modes, such as e-bicycles and e-scooters, has been driven by their cost-effectiveness, environmental friendliness, and faster delivery capabilities. However, challenges related to infrastructure, vehicle regulation, safety, and the lack of empirical evidence have been identified, necessitating strategic interventions and collaboration between academia, government, and industry.

The workshop provided a platform for key stakeholders to come together and discuss the major issues surrounding micro-freight, including the establishment of micro-hubs, regulatory frameworks, safety measures, insurance coverage, and infrastructure improvements. The discussions reinforced the importance of addressing these challenges to facilitate the safe and effective deployment of micro-mobility modes for last-mile deliveries in densely populated urban areas.

In conclusion, this preliminary version of the paper has provided valuable insights into the field of micro-freight. By considering the definitions, benefits, challenges, trends and gaps, this study contributes to the existing body of knowledge and highlights the need for further research, collaboration, and innovative solutions. As the full-text review is completed and the workshop in London approaches, this work sets the stage for a more comprehensive analysis and the exchange of knowledge on a global scale, aiming to advance the field of micro-freight and its implications for the logistics industry.

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