



# Urban Freight Research (1972-2014)

A Systematic Review of the Field

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## ABSTRACT

The transportation sector is a major contributor to global greenhouse gas (GHG) emissions, and consequently, anthropogenic climate change. Transitioning to low-carbon policies, technologies and behaviours could provide opportunities for emissions reductions. Yet to date, there is little evidence of a meaningful and systemic low-carbon transport transition. Moreover, while there is some evidence of fossil fuel intensive private transport 'peaking', freight movements are growing. The urban freight industry in particular has undergone rapid transformation as social practices alter in the wake of information communication technologies and the Internet. Simultaneously, academic interest in urban freight delivery has grown. This paper represents the first attempt to take stock of this burgeoning literature, to sketch out the landscape, and to illuminate research gaps and priorities going forward. It presents the results of a quantitative systematic review of urban freight literature (n=265, 1972-2014), and a qualitative thematic review of a sub-sample of the literature (n=35) that were determined to have a sustainability focus. The paper reports on descriptive characteristics of the field, including the growth and direction of research, geographic focus and research themes. Findings are discussed in light of the need for radical GHG emissions reductions, and the contribution that urban freight research can make to this end.

**KEYWORDS:** Urban freight, courier, sustainability, systematic review, carbon intensity

## INTRODUCTION

It has been proposed that the earth has entered a new geological epoch (Crutzen & Steffen, 2003). This era, known as the Anthropocene, is distinguished from the previous epoch by the dominating influence of humans on biological, chemical and geological processes. The Anthropocene characterises the wide-ranging impacts that humans are having on the earth, including, but not limited to, climate change. Anthropogenic climate change is caused by the release of greenhouse gases (GHG) into the atmosphere, a large contribution of which relate to the current, high-carbon system of transportation. Transport is intricately connected to systems of production and consumption, and as such, is forced to adapt to evolving social and economic practices. The impacts of motorised transport modes on the local through to global environment are well-reported (Hickman & Banister, 2014). Local impacts include air pollution and road traffic accidents, and globally concerns relate to the release of carbon dioxide (CO<sub>2</sub>) into the atmosphere. Transport contributes 23% to energy-related CO<sub>2</sub> emissions (IEA, 2009), and *road transport* accounts for 72% of transport sector direct GHG emissions. Transport is also highly dependent on oil, exposing it to volatility in terms of price and supply. In 2010, 53% of global primary oil consumption was used to meet 94% of total transport energy demands (Sims et al., 2014). While there is evidence that, in some locations, household demand for car-based travel has 'peaked' (Goodwin & van Dender, 2013), new modes of consumption (e.g. online shopping) are changing demand for localised freight delivery systems.

Urban freight transport is defined as "*...being concerned with the movement of things (as distinct from people) to, from, within and, through urban areas*" (Ogden, 1992: p.14). The importance of urban freight movements relate not only to its role facilitating business activity, sustaining existing lifestyles, and driving economic growth (Anderson et al. 2005), but also as a distributor of consumer products including food (Aftabuzzaman & Mazloumi, 2011). Increasing demand for urban freight, and rising levels of urbanisation are driving academic interest in freight delivery, underscoring the importance of sustainability to this industry. At the same time, there is mounting pressure for a systemic, low-carbon

transport transition. Its dependence on oil, and the comparative difficulty in shifting from high-emitting heavy vehicle modes, makes urban freight a particularly interesting and important transport issue in the Anthropocene.

There has been a detectable shift in the urban freight industry over the past decade; a particularly relevant change is the transition from predominantly document delivery to the delivery of small parcels. In addition, the sites of delivery have changed as freight is increasingly delivered into residential spaces, the result of growing business to consumer interactions (e.g. online shopping). These changes have implications for material culture (e.g. the vans used), practices (e.g. delivery routes), and norms (e.g. delivery time expectations) (Stephenson et al., 2015; Stephenson et al., 2010). Thus it can be hypothesised that a wide variety of disciplines are interested in, and actively researching, the delivery of freight goods in urban spaces and that the growth in freight deliveries will result in increased academic attention over time. A second hypothesis relating to the environmental impact of freight is that the growth of freight delivery, coupled with increasing awareness of the need for CO<sub>2</sub> reductions (both in general and specifically related to transport), will draw attention to the environmental impacts of urban freight transport, evidenced by an increase in quantity and scope of publications.

To date, however, while there have been disciplinary or topical reviews of urban freight research (Arvidsson, Woxenius, & Lammgard, 2013; Wolpert & Reuter, 2012) there has been little by way of a comprehensive, systematic review of the wide-ranging urban freight literature. This paper addresses this gap by presenting the findings of a review of English language urban freight literature from academic journals and conference proceedings published between 1972 and 2014.

This paper is structured as follows; first, detailed methods are presented outlining the systematic approach adopted by the authors. Second, the quantitative measures are detailed, identifying key trends and gaps in the literature between 1972 and 2014. A subsample of the literature, n= 193 articles published between 2009 and 2014 is then used to examine more recent trends. Third, a qualitative thematic review of a sub-sample of the literature (n=35) focused on sustainability is presented, supported by quantitative trends. This is then followed by a discussion of the findings and the identification of research gaps and future research directions.

## **METHOD**

Research papers published in English language journals and conference proceedings on 'urban freight' were obtained by searching electronic databases of scientific journals. These two sources were selected due to their importance as outlets of academic research, use of a peer-review process, and disciplinary significance. The systematic literature review was conducted between February and July 2015, with documents exported on February 18th 2015. Two publications for 2015 were included in this sample, but excluded from analysis so not to misrepresent annual change trends.

Initially, four electronic databases were compared for the number of results and types of source materials obtained using the keywords "urban freight" (in quotation marks): Google Scholar, Web of Science, Academic OneFile, and Scopus. The search for "urban freight" yielded the following quantitative results for each database: Google Scholar (4700), Web of Science (239), Scopus (278), and Academic OneFile (6). Based on the number and accuracy of results, the "Scopus" and "Web of Science" databases were selected for us in this research. They offered a more focused and manageable number of results than Google Scholar. Furthermore, using both Scopus and Web of Science (WOS) overcame database

bias, since Scopus has “a noticeable European and Elsevier-publisher bias” whereas Web of Science has an American bias (HLWIKI, 2015). Additional key word search terms were considered including “metro freight”, “urban goods movement” and “urban logistics”, however these terms appeared to be discipline specific, the results replicated those from “urban freight”, or returned null results. It was therefore decided that just one term (“Urban Freight”) would be used in the literature search and retrieval. Limitations to this approach are acknowledged by the authors, with the sample potentially missing important urban freight literature that did not use the term “urban freight”.

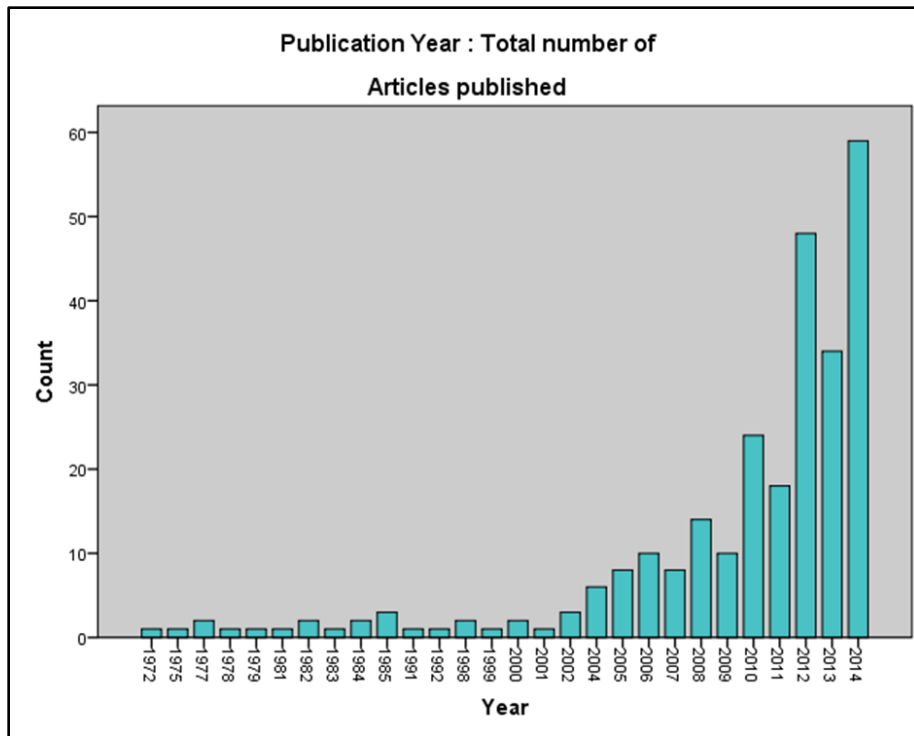
The review was conducted applying the systematic literature protocol described by Pickering and Byrne (2014). Search parameters included: Search article title, abstract, keywords (both), “urban freight” (both), date range: 1900 – present (WOS), date range: 1966 – present (Scopus), Document types – all (Scopus), Subject areas – all (Scopus). 504 articles were exported, excluding categories such as book chapter, review, conference review, book, editorial, report, undefined, editorial material, and meeting abstract. All references were imported into EndNote X7 reference software. Of the original 504 publications, ninety-four duplicates were excluded. All remaining references were screened for eligibility. For instance, 17 book chapters which had been incorrectly exported were excluded from the analysis. Full text copies were obtained for 289 articles, four articles could not be retrieved by the researchers, despite an intensive search and attempts via Interlibrary Loans. Twenty two articles were not reviewed due to incomplete information, and foreign language text. In total, 267 valid and complete articles for the period 1972 – 2015 were reviewed. This paper reports on 265 articles from 1972-2014, excluding 2 papers published in early 2015.

Categories for review were predetermined and iteratively reviewed by both researchers. All articles were reviewed and coded by one researcher. From each paper, the following information was recorded in an Excel database; Author(s), year, keywords, title, journal, journal discipline, conference proceeding (y/n), lead author’s institution, geographic scale of research, continent of area of study, country of area of study, cities used in research, research questions, type of study (conceptual/ empirical), methods used, quantitative vs. qualitative, variables measured, result highlights, gaps identified, sustainability discourse (y/n). The database was then uploaded to IBM SPSS, cleaned, and recoded where necessary (e.g. transformation of categorical variables to allow for analysis). Descriptive statistics were used to explore the dataset. This paper sketches the landscape of urban freight literature from 1972-2014, and presents the trends emerging from the published literature over this time using both quantitative and qualitative approaches.

## **RESULTS**

### ***Trends 1972-2014***

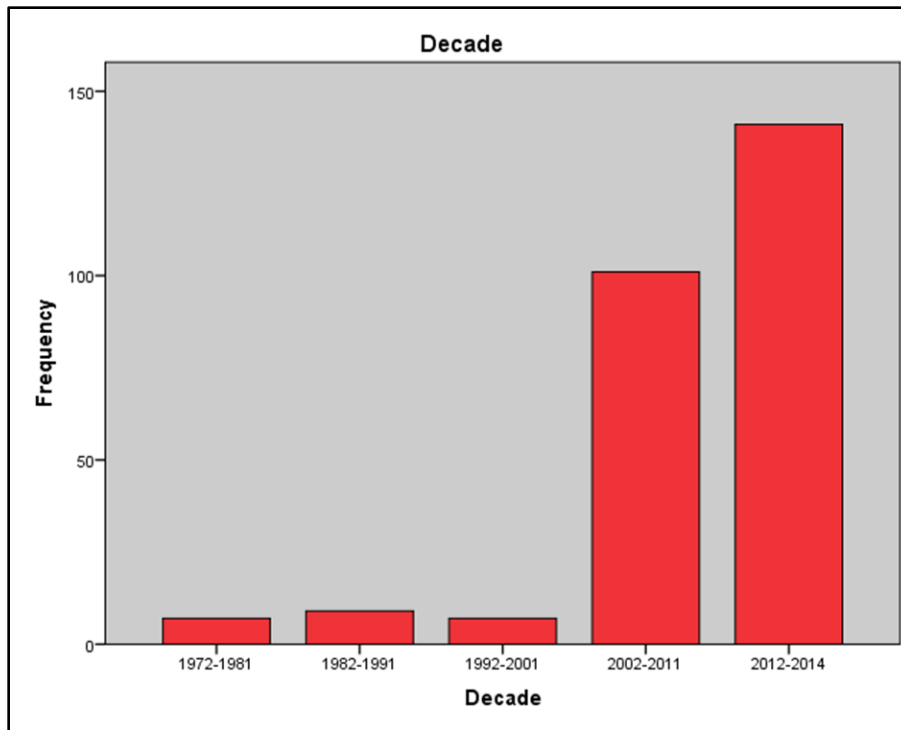
The research commenced with an examination of the trends in frequencies and places of publication. The acceleration of interest in urban freight movements in the last decade is presented in Figure 1. There is an increasing trend in the number of publications, with a more significant increase since the late 2000’s. Since 2004 there have been annual publications on urban freight issues, prior to this there was, on average, one publication each year, however there were several years without any publications included in the review. During the two years from 2012 to 2014, more publications on urban freight topics were produced than in any ten year period since 1972. Over 90% of urban freight articles have been published since 2002. By frequency, the number of publications in the 2002-2011 and 2012-2014 timeframes are substantially higher than the earlier 10 year periods (Figure 2).



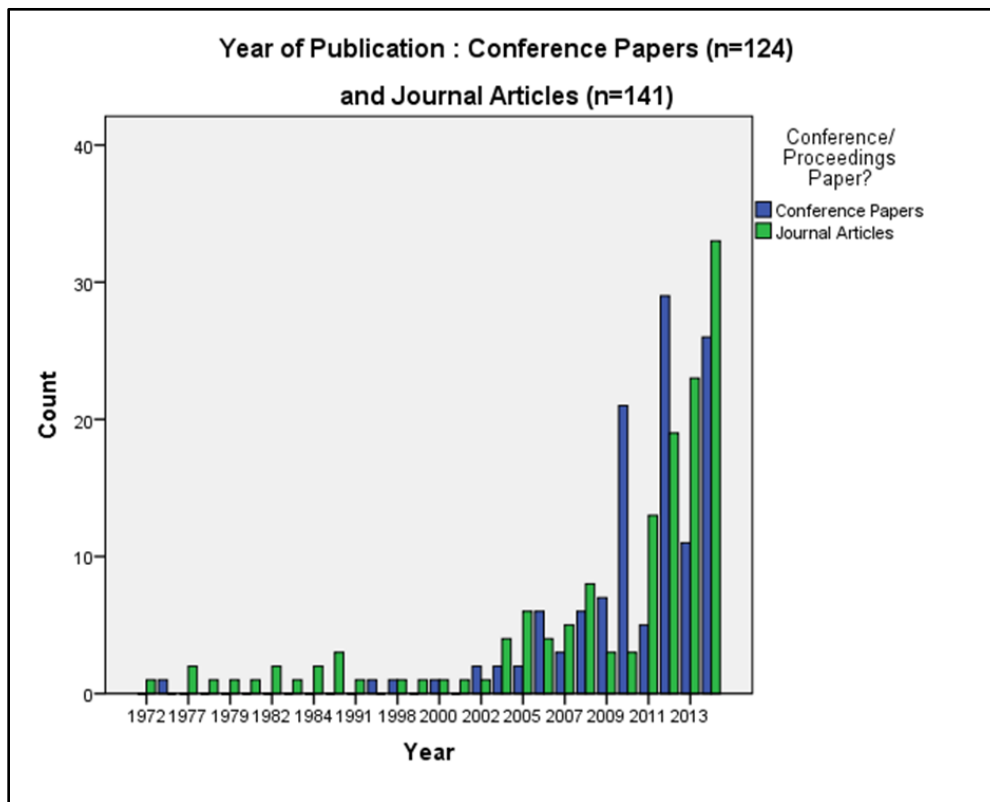
**FIGURE 1** A graph presenting the year of publication for reviewed articles and papers.

The systematic review found that of the 265 publications, 53% (n=141) were journals articles and 47% (n=124) were conference papers. Papers were published in a range of disciplinary and thematic journals and conference proceedings. Many of the conference papers were published through Elsevier’s *Procedia* open-access publication. The majority of the conferences were discipline-specific, particularly relating to engineering (e.g. *International Congress and Exposition on Noise Control Engineering*), or regional transport conferences (e.g. *Australasian Transport Research Forum*). There was also some evidence of thematic conferences such as the *International Conference on Urban Transport and the Environment*.

The analysis also showed consistency between types of academic outputs. When accounting for conference papers and journal articles separately, we found that both had seen increases in numbers of publications since the early 2000’s, with clear annual variability (Figure 3). Prior to 2000 there appears to have been little by way of conference papers on urban freight topics, and a marked increase from the turn of the millennium. This trend could be the result of the increasing number of transport and transport-related conferences worldwide, and propensity to require full conference paper submission. Peaks in conference papers may be associated with the occurrence of large, international conferences.

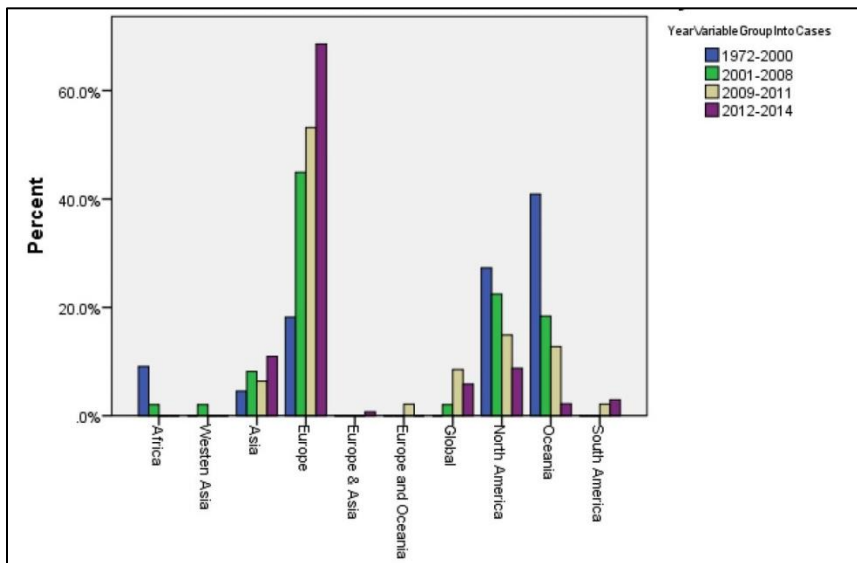


**FIGURE 2** A graph presenting the publication by decade in frequency.

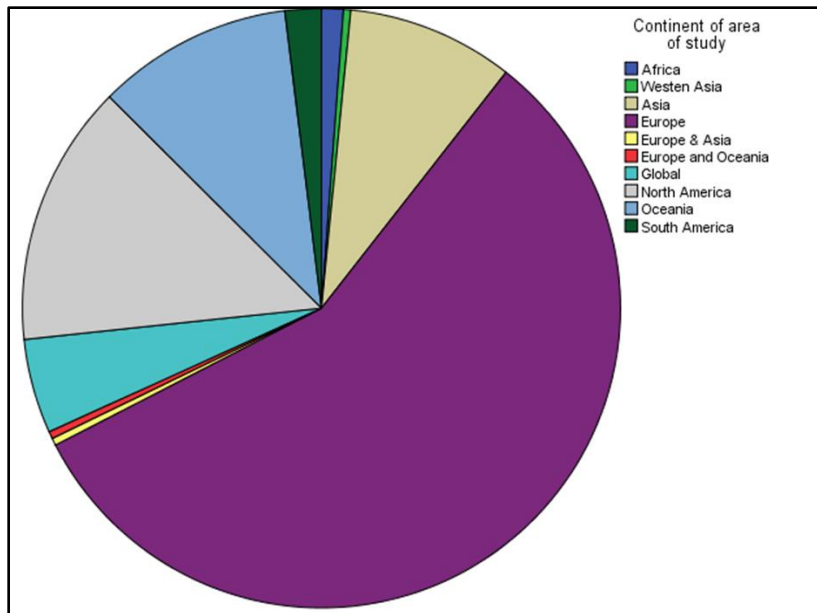


**FIGURE 3** A graph presenting the publications from 1972-2014 separated between conference paper publications and journal article publications.

This provides evidence of the growing interest in this research domain, but could also reflect the increase in academic publishing more broadly, particularly emerging from the Global South (King, 2004). In order to assess the geographic focus of urban freight research, we gathered data on the spatial scale and geographic areas of empirical research. Our analysis provided little evidence of research emerging from or focusing on the Global South. Within the sample, Europe and North America received the greatest attention. The research found that while Oceania and North America were popular areas of study in the period 1972-2000, this has shifted to a focus on European case studies since 2001 (Figure 4). Africa was also represented in the early papers (1972-2000) but only in one paper since that time. A small growth trend was identified for research focusing on urban freight in Asia. In terms of individual countries, Italy (n=36), Australia (n=27), the USA (n=25), and France (n=22), have received the greatest focus (Figure 5). This concurs with Rome (n=15) and Melbourne (n=6) as the most highly researched cities, respectively. The city-scale of analysis has proven to be the most popular for urban freight literature (n=141), followed by a greater, yet still sub-national scale approach (n=32, e.g. regional – prefecture, county or state), then multi-city (n=23), multi-national (n=23) and national (n=21).



**FIGURE 4** A graph presenting the continent of area of study across four time periods.



**FIGURE 5 A graph depicting the continent under examination in reviewed literature.**

The review found that a significant proportion of the published literature presents empirical research (n=178, 67%), 32% present conceptual findings and 1% use an alternative approach (e.g. historical analysis). Of the 178 articles presenting empirical research, 57% (n=101) employed a quantitative research approach, 32% (n=57) used mixed methods, and 11% (n=20) adopted a qualitative approach. The small number of qualitative papers is largely reflective of the transport field in general, which has historically had a quantitative-bias in terms of research approaches (Curl & Davison, 2014). There is, however, evidence of increasing application of a qualitative approach within our sample.

There were wide ranging methods adopted in this sample. These included; social research (e.g. surveys, interviews, focus groups, and workshops), internet/ desk based document analysis, modelling, and policy analysis. The methods used in the total reviewed articles (n=265) frequently incorporated multiple methods (n=111), or modelling (n=73), and these accounted for nearly 70% of all methods. Multi-method approaches included, for example: modelling, traffic counts and interviewing, or focus groups, surveys and stated choice experiments.

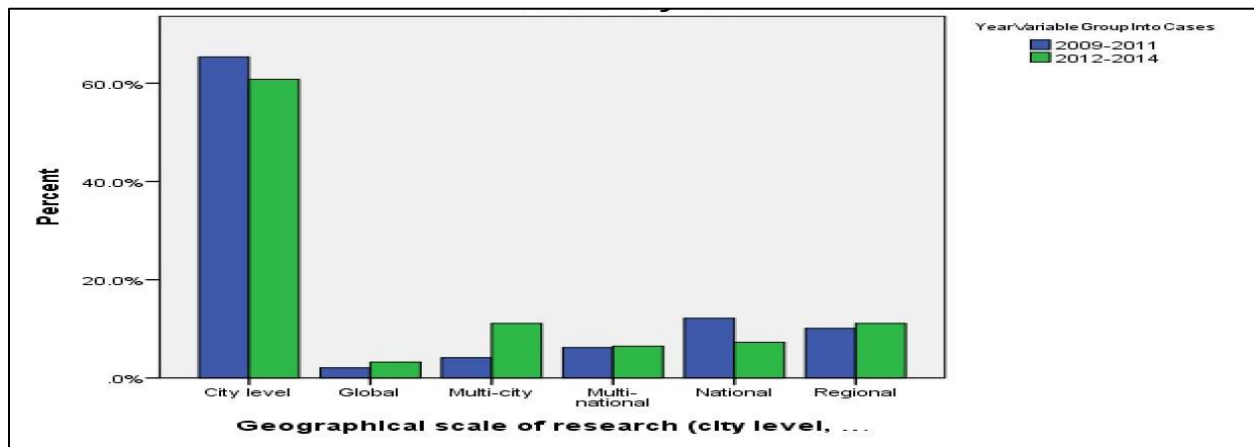
Keywords used in the publication provided an indication of the key themes as determined by the authors of the publications. Modelling of urban freight movements emerged as the central theme of the reviewed literature, followed by logistics and planning, policy measures and sustainability. The most commonly cited keywords or terms selected by the author(s) for their publications included; city logistics (76), urban freight transport (49), urban freight (46), freight transport (22), urban freight distribution (16), management (15), logistics (13), sustainability (13), simulation (11), urban transport (10). Our analyses found that 75 different journals were used to publish the urban freight articles, with no dominant outlet for this research which could reflect the diversity of disciplines and approaches contributing to this literature. The most frequently identified journal was the Transportation Research Record (n=16), followed by European Transport (n=12), Research in Transportation Business and Management (n=12), and the Journal of Transport Geography (n=8).

### **Trends 2009-2014**



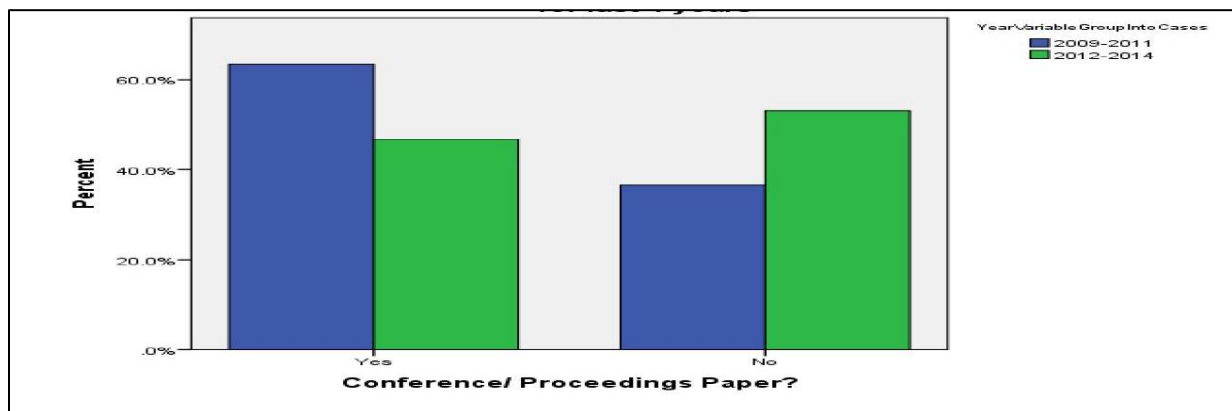
For the second stage of analysis, the data were divided into four time periods; 1972-2000, 2001-2008, 2009-2011, 2012-2014. These periods were selected to account for the rapid growth in urban freight literature from 2010 onwards, compared to the earlier period. After analysing the variables with the four groups, 2009-2011 and 2012-2014 were analysed separately as these two time periods account for 73% of the sample.

Across the time periods, we found a preference for single city-scale research, but a greater proportion of earlier papers (1972-2000 date range) also adopted national-scale and regional-scale research. Conversely, multi-city comparisons had greater application between 2001-2008 and 2012-2014. Figure 6, which presents findings from the 2009-2011 and 2012-2014 date ranges, suggests only minor variations in the geographic scale of the research published on urban freight across the two time periods. There is however, a slight increase in multi-city research in the 2012-2014 time period.



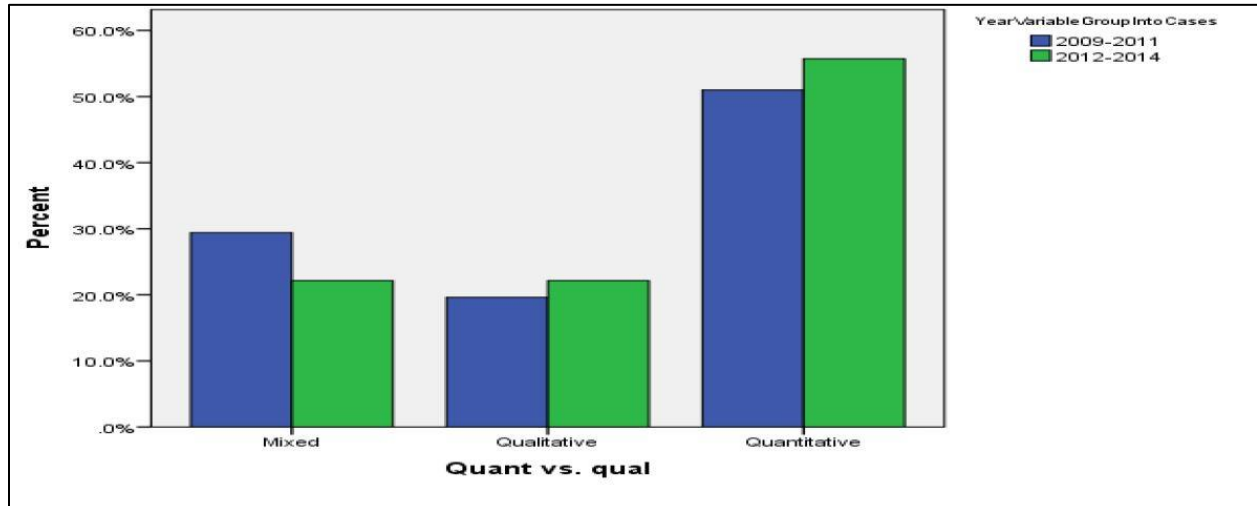
**FIGURE 6 A graph depicting the geographic scale of research for 2009-2011 and 2012-2014**

The trend in methodology across the four time periods indicated a stable preference for empirical studies (approximately 60%) over conceptual research (approximately 40%), with only small variations between the four time periods. There is some evidence of a growing preference for journal article publications over conference proceedings. This might be explained by the frequency of conferences and the subsequent development of journal articles from conference papers, or the research assessment exercise (e.g. REF in UK, PBRF in NZ) and their prioritisation of journal publications over conference papers.



**FIGURE 7 A graph presenting the findings of the question: Was the publication from a conference proceeding? For the 2009-2011 and 2012-2014 data.**

The review found an increase in both quantitative and qualitative research on urban freight in the 2012-2014 period when compared to the 2009-2011 period. This increase was offset by a decline in the percentage of mixed method papers in the 2012-2014 period.



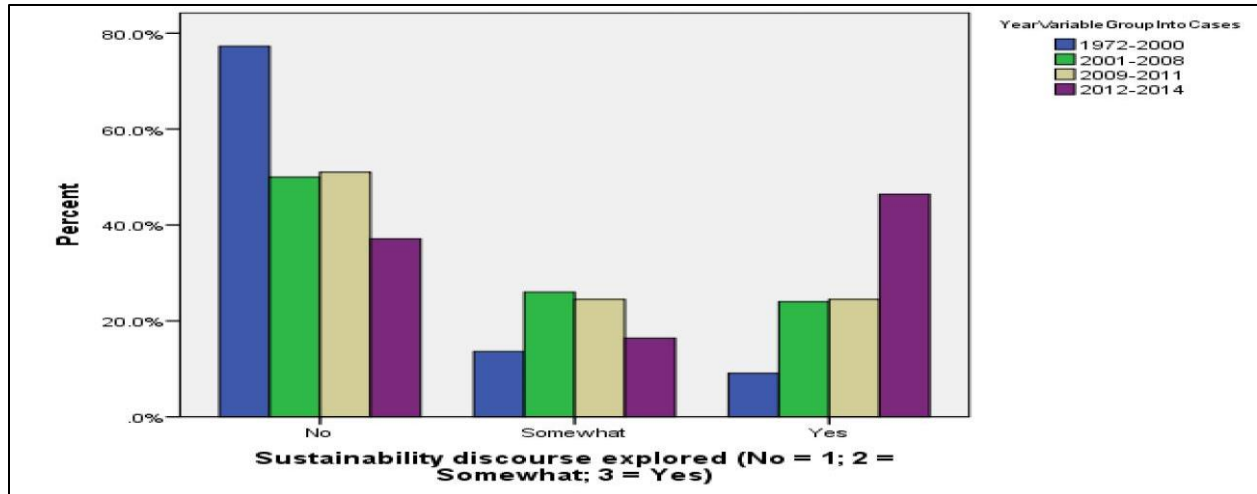
**FIGURE 8 A graph depicting the method used for the 2009-2011 and 2012-2014 data.**

### **Recent focus on sustainability**

Thirty five of the reviewed articles were specifically focused on environmental issues. These were identified through the inclusion of ‘sustainability’, ‘sustainable’, ‘low carbon’, ‘efficiency’, ‘energy’, ‘environment’, ‘carbon dioxide’ and/or ‘greenhouse gas’ in the title or keywords. The researchers assessed the context of these words where appropriate to ensure the application of the term was consistent with environmental sustainability goals. Sustainability research accounted for 13% of the total sample of reviewed articles.

The review provides evidence of growth in published research examining the environmental sustainability and environmental impacts of urban freight movements that is largely consistent with the trend of all urban freight publications. In the 1972-2000 time period, nearly 80% of urban freight publications had no relation to sustainability. The 2001-2008 and 2009-2011 present a similar trend with roughly 50% of publications having no sustainability focus, but the remaining 50% with ‘somewhat’ or a clear sustainability outcome to the research (Figure 7). The most recent time period, 2012-2014, presents a clear change trend, with over 40% of research focused on the sustainability aspects of urban freight, a significant increase from the earlier time periods.

The earliest urban freight publication specifically focused on the sustainability of the industry or related issues was published in 1991 (Ter Brugge, 1991). Published in *Studies in Environmental Science*, Ter Brugge stressed the importance of logistics, telematics and information technology, transport technologies and urban planning of the built environment in order to decrease energy consumption and environmental impacts of urban freight delivery; themes that are still evident in the more recent literature, and which emerged from the following thematic review.



**FIGURE 9** A graph depicting the literature in sample exploring sustainability discourse, across four time periods.

#### *Qualitative review of sustainability themes*

The sustainability-focused articles are being published through both conference papers (n=17) and journal articles (n=18). Twenty-one of the papers present empirical research, and of those, 10 used a mixed method approach, 8 quantitative and 3 qualitative methods. There is a European-bias within this sub-section of the reviewed literature, with 71% (n=25) of sustainability focused research examining European context and case studies. 49% of the articles are focused on a city scale. The overriding themes examined by the sustainability research included: transport policy, logistics and system management. In order to increase the sustainability of urban freight, it has been argued that logistical innovation, technological improvements and regulatory or policy measures are required (Pede et al., 2006; Quak, 2012). The following presentation and discussion will be structured around six broad themes emerging from the review: natural resources and environmental impacts, technological innovations, policy, behaviour, cooperation, collaboration and combined measures, and shared outcomes.

#### *Natural resources and environmental impacts*

The resource dependency and environmental impacts of the current system of urban freight delivery presents one theme emerging from the sustainability literature. For instance, Figliozzi (2011) highlighted that range of factors that contribute to emissions including levels of congestion, duration of congested conditions, and the variance between free-flow, optimal, and congested speeds (Figliozzi, 2011). However the negative environmental impacts from urban freight are not solely related to GHG emissions. They also include localised air pollution in urban centres, and the dependence of the freight industry on oil-based products. The oil dependence of the current transport system, and the peaking of world oil production, led Aftabuzzaman and Maloumi (2011) to argue that urban freight movements will be particularly disrupted by increasing fuel prices as oil becomes increasingly scarce. Since freight movements are uniquely dependent on heavy vehicles, they argue that *“it will fail to perform its principal objectives of facilitating access to essential life-saving products and supporting business activity and employment”* (p.700). Thus the literature around natural resources and environmental impacts encourage a breadth of thought beyond carbon emissions, and seeks to highlight the potential

implications of the current transport system. These literatures can help to contextualise the need for a low-carbon transition, and the role of the freight industry within it.

### *Technological innovations*

Technological innovations were highlighted throughout the reviewed literature as a mechanism for change not only relating to low-carbon technologies (e.g. electric vehicles) but also the use of Information Communication Technologies (ICTs) for efficiency gains. For instance, the use of ICT to increase route efficiency was highlighted by Arvidsson (2013) along with the value of efficiency gains along the supply chain. Similarly, the application of mobile devices (e.g. smartphones and tablets) to assist traffic control systems, and thereby reduce the negative impacts of the current transport system, was discussed by Iwan et al. (2014) who argued that the provision of real time information on traffic flows can aid decision-making, improve traffic flow and reduce congestion contributing to decreased fuel consumption and resultant emissions. Sustainable logistics systems may also provide opportunities to reduce costs, distances and emissions through the use of bicycle couriers and the bundling of consignments (Knaak, Kruse, & Page, 2006). Nevertheless, in terms of the value of telematics for efficiency and emission reduction, Walker and Manson (2014) provided evidence to suggest that telematics may not always result in increased efficiency of urban logistics. Indeed the topography of an urban environment may provide an important contingency factor in how and when to use telematics for this purpose.

Electric vehicles (EVs) have been proposed as a technological response to freight-transport emissions, yet operational range present challenges for their utility (“range anxiety”). With data from Amsterdam, van Duin et al.(2013) considered the opportunities and constraints for using EVs in the context of urban freight delivery. They find that electric trucks will become competitive at the point at which operational cost savings overcome the relatively higher initial purchase price of the vehicle. van Duin et al. (2013) concluded that, as a part of a broader urban consolidation concept, the current generation of EVs have the capacity to *“perform urban freight transport efficiently (19% reduction in vehicle kilometres) and meanwhile has the capability to improve air quality in the city centre due to the use of electric vehicles as well as reduce the CO<sub>2</sub> emissions for making the same deliveries and pick-ups in Amsterdam by 90%, and reduce noise nuisance in the inner cities of our (future) towns”* (p.16). Trams and Electric Distribution Vehicles (EDVs) have also been proposed as new modes for urban delivery, with the capacity to reduce road congestion, noise pollution and emissions (Arvidsson & Browne, 2013).

### *Policy*

General transport policy planning is highly applicable to the context of freight transport (Lindholm & Blinge, 2014).The capacity for policy measures to contribute to urban sustainability objectives was analysed by Anderson et al. (2005). Four measures; low emission zones, congestion charging, vehicle weight restrictions, and vehicle access time restrictions were found to impact upon freight companies in different. In other words, no one measure affected all freight delivery companies the same in terms of its cost to the company or on the environmental impact of delivery. Since there are highly specific geographic and built environment contexts that determine how freight operates in any particular location, policymakers need to be aware of and account for this variability in their transport planning (Anderson et al. 2005). The importance of including freight transport in broader transport policy making was highlighted by Lyons et al. (2012). Using the case of Mexico, Lyons et al. (2012) reported consequences of the non-inclusion of freight in planning as; trucks travelling on unsuitable roads or in

residential zones, longer routes (and thereby increased emissions), relocation of freight facilities, and increasing logistics costs and product prices. In sum, it appears from the literature that freight can be overlooked in transport policy, but with increasing demand for freight services, this could have dire consequences for sustainability and carbon emissions.

### *Behaviour*

In general, efficiency measures relating to urban freight focus on driver efficiency and vehicle efficiency (Arvidsson et al., 2013). The capacity of these efficiency gains to provide financial savings for freight drivers was argued to be particularly attractive. Nevertheless, there is little explicit engagement with either freight drivers (e.g. through social research methods), nor consumer behaviours (e.g. increasing demand for delivery) in the reviewed urban freight literature. While technologies are a central theme in the literature, the adoption of these technologies has not been examined to date. These present significant gaps in the current literature, and barriers to achieving environmentally sustainable urban freight delivery.

### *Cooperation, collaboration and combined measures*

The need for cooperation between freight operators was identified by Pede et al. (2006), who argued that the current model of individualised city logistics, contributes to inefficient systems of distribution. Nevertheless, best practice examples were presented by Quak (2012), and these include network collaboration, decoupling at the border of the city centre, along with technical approaches including engine solutions, reduced noise pollution, and Intelligent Transport Systems (ITS)/ ICT. Integration of land use and transport planning, and the uptake of alternative fuels and vehicles were identified by Aftabuzzman and Maloumi (2011) as opportunities for urban freight to address its carbon intensity and dependence. This was supported by Alessandrini et al. (2012) who provided evidence of rail used to transfer urban freight deliveries from consolidation areas on the periphery of the urban centre. This multi-modal distribution approach can reduce road-traffic congestion and associated CO<sub>2</sub> emissions. Moreover replacing current hub-oriented approaches to urban freight delivery with a “Fixed Exchange Point” system can better relates to urban courier’s actual work-sharing mechanisms, whilst also enabling greater ecological improvements (Knaak et al. 2006).

Measures including bundling of delivery goods (e.g. inner city logistics centre, permits and restrictions for delivery vehicles, contact between businesses to stimulate bundling), guiding routes for good delivery, and the use of clean vehicles were used in the CIVITAS initiative, across a series of European cities, with variable success (van Rooijen & Quak, 2014). In comparison to other types of mobility, the CIVITAS project found that urban freight mobility was relatively difficult to promote sustainable policies and practices. The competitiveness of the marketplace was identified as a reason for this, contributing to a lack of coordination across the industry. Yet successful implementation of the measures requires private business cooperation. Thus major changes are difficult to initiate without a history of cooperation and trust amongst industry players (van Rooijen & Quak, 2014). Moreover, an example of a relatively successful urban consolidation centre is provided by van Rooijen and Quak (2010). “Binnenstadservice.nl” in the Dutch city of Nijmegen has reduced the number of freight vehicles entering the city, and kilometres travelled. Yet the local impacts appear to be of greater success for safety than air pollution. Nevertheless, a reduction on kilometres travelled will result in reduced emissions with positive implications for climate change.

### *Shared outcomes*

The review provided evidence of an interest in interweaving environmental sustainability objectives with social sustainability (e.g. liveability) and customer satisfaction. For example, the ability to address both social and environmental sustainability is examined by Arvidsson (2013), and moves to make urban spaces safer and more liveable, might also contribute to negative environmental impacts. An example of this relates to load factors, which may increase due to access restrictions in some urban areas, and contribute to negative externalities. The ability to interweave sustainability objectives (e.g. emission reductions) with customer satisfaction is identified by Akyol and de Koster (2013), who argue that efficiency in terms of delivery times and reduced travel times can contribute to reduced emissions, decrease congestion and retailer satisfaction. Thus efficiency in terms of delivery times can have tangible environmental and business benefits. These findings identify opportunities to engage with the freight industry to promote low-carbon, environmentally sustainable options.

### **DISCUSSION & RESEARCH DIRECTIONS**

The first part of this paper presents a description of the structure of urban freight literature, based on a review of 265 journal articles and conference papers from 1972-2014. It provides evidence of the growing interest in the delivery of urban freight. Whether the rapid increase in published articles on urban freight and the sustainability of freight since 2012 is indicative of academic publishing trends more broadly is unclear. For instance, it has been reported that not only are journal publications increasing, but so too are the *range* of outputs including full conference papers (Larsen & von Ins, 2010). Nevertheless, there is evidence of increasing real-world trials dedicated to improving urban freight and city logistics (Browne, Allen, Nemoto, Patier, & Visser, 2012) and an increasing focus on the sustainability of urban freight.

In the introduction to this paper, we presented two general hypotheses, prior to a more general discussion and interpretation of the findings, we briefly return to these hypotheses:

**H<sup>1</sup>** = A wide variety of disciplines are interested in, and actively researching the delivery of freight goods in urban spaces and that the growth in freight deliveries will result in increased academic attention over time.

Our results suggest that a variety of disciplines are interested in the urban freight industry, and provide a wide range of empirical data to examine an array of phenomena. Despite little evidence of interdisciplinary approaches to examine urban freight, there is a clear growth trend in urban freight literature since the late 2000's, and there is no evidence of this trend slowing in the short to medium term.

**H<sup>2</sup>** = The growth of freight delivery coupled with increasing awareness of the need for CO<sub>2</sub> reductions (both in general and specifically related to transport) will stimulate attention to the environmental impacts of urban freight delivery, evidenced by an increase in quantity and scope of publications.

Our results find evidence of increasing interest in the sustainability of the urban freight industry, its impacts on global climate change, and the implications of dependence on finite resources (e.g. oil) for security in supply and price volatility. Nevertheless, this literature is still in its infancy, and needs more

focused attention, drawing from the established literatures on transport and the environment more generally.

Along with the quantitative review, this paper presented the findings of a qualitative review of 35 publications that were explicitly related to the environmental sustainability and carbon intensity of the urban freight industry. In presenting these findings, six overarching themes were identified. There appears to be an overrepresentation of technological and policy responses to the environmental impacts of urban freight. The clear necessity to lower the energy intensity of freight (MJ/tonne km), and fuels (CO<sub>2</sub>e/MJ) in order to address the carbon emissions from the freight industry can be achieved through enhanced vehicle performance, loading factors, the deployment of new vehicles, and the substitution of oil-based products with alternatives including biofuels and electricity (Sims et al., 2014). The review shows academic interests across logistics, policy, and technological advancements, particularly the use of ICT and ITS. Yet there was little by way of behavioural research into the adoption of technologies, demand-side expectations and aspirations for freight delivery, and engagement with urban freight actors.

From the literature included in this review, the use of 'smart technologies' appears to be limited to improving traffic flows and reducing congestion through 'mobility management', yet there are a range of applications for which smart technologies could provide clear sustainability benefits for the freight industry. These include new business models and approaches to freight delivery such as 'Deliveroo' in the UK. These businesses are returning to low-carbon modes (e.g. bicycle) to offer a fast alternative to traditional vehicle delivery systems, whilst also increasing the range of deliverable freight goods. The capacity of these niche operations to radically change the urban freight delivery system warrants further investigation.

This review provides evidence of a Global North bias to urban freight research to date. This is frequently the case with transport/ mobilities literature (Kwan & Schwanen, 2016), and wider academic publishing. Yet with intensifying patterns of consumption in many emerging economies and saturation of key transport infrastructure, it becomes increasingly important to examine urban freight delivery systems beyond the Global North. Moreover, the academic focus on a small number of urban centres (e.g. Rome, Melbourne), overlooks spatial differences in the provision of urban freight and the lived experiences of those involved in urban freight delivery.

There appears to be little coherence across the sustainability research, much of which is focused on highly disciplinary perspectives. In order to respond to the challenge of deep GHG emission reductions in the urban freight industry, a collective conversation across and beyond disciplines is required, incorporating both short and long term strategies (Sims et al., 2014). There is little evidence of engagement with wide ranging industry actors, and a relative dearth of research adopting qualitative research approaches compared to other approaches. Moreover, behavioural approaches including engagement with patterns of production and consumption, and uptake of new low-carbon technologies and/or practices are not evident from this review. This could point to a need for increased local-scale, in-depth research engaging with a range of actors. While there are lessons that can be learnt across spatial scales, the local scale complexities need to be incorporated into low-carbon responses.

## **CONCLUSIONS**

This review provides evidence of the growing attention paid to urban freight movements, across multiple disciplines, but with a Global North-bias. It also indicates a lack of attention to behavioural approaches to achieving more environmentally sustainable urban freight movements. The Anthropocene demands closer scrutiny into the impacts of human behaviours on the Earth. Transport-related GHG emissions are significant, and a low-carbon transition for the urban freight industry will require new ways of thinking about production, consumption and delivery of goods. The review presented in this paper highlights the need for greater diversity in terms of case study areas to include the Global South and emerging economies, particularly where saturated transport infrastructure and issues relating to air quality demand urgent attention. The evidence suggests that while there is a relatively coherent dialogue across the literature, disciplinary-siloes, and discipline specific conferences and journals may be limiting cross-fertilisation of ideas, concepts and strategies.

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## REFERENCES

- Aftabuzzaman, M., & Mazloumi, E. (2011). Achieving sustainable urban transport mobility in post peak oil era. *Transport Policy*, 18(5), p. 695-702
- Akyol, D. E., & De Koster, R. B. M. (2013). Non-dominated time-window policies in city distribution. *Production and Operations Management*, 22(3), p. 739-751
- Alessandrini, A., Site, P. D., Filippi, F., & Salucci, M. V. (2012). Using rail to make urban freight distribution more sustainable. *European Transport - Trasporti Europei* (50), p. 1-17
- Anderson, S., Allen, J., & Browne, M. (2005). Urban logistics - How can it meet policy makers' sustainability objectives? *Journal of Transport Geography*, 13, p. 71-81
- Arvidsson, N. (2013). The milk run revisited: A load factor paradox with economic and environmental implications for urban freight transport. *Transportation Research Part A: Policy and Practice*, 51, p. 56-62
- Arvidsson, N., & Browne, M. (2013). A review of the success and failure of tram systems to carry urban freight: the implications for a low emission intermodal solution using electric vehicles on trams. *European Transport - Trasporti Europei*, 54, p. 1825-3997
- Arvidsson, N., Woxenius, J., & Lammgard, C. (2013). Review of Road Hauliers' Measures for Increasing Transport Efficiency and Sustainability in Urban Freight Distribution. *Transport Reviews*, 33(1), p. 107-127
- Browne, M., Allen, J., Nemoto, T., Patier, D., & Visser, J. (2012). Reducing social and environmental impacts of urban freight transport: A review of some major cities. *Procedia - Social and Behavioral Sciences*, 39, p. 19-33
- Crutzen, P. J., & Steffen, W. (2003). How long have we been in the Anthropocene Era? *Climatic Change*, 61(3), p. 251-257



- Curl, A. & Davison, L. (2014). Transport geography: perspectives upon entering an accomplished research sub-discipline, *Journal of Transport Geography* 38, p. 100-105
- Figliozzi, M. A. (2011). The impacts of congestion on time-definitive urban freight distribution networks CO2 emission levels: Results from a case study in Portland, Oregon. *Transportation Research Part C: Emerging Technologies*, 19(5), p. 766-778
- Goodwin, P., & van Dender, K. (2013). 'Peak Car' - Themes and Issues. *Transport Reviews*, 33(3), p. 243-254
- Hickman, R. and Banister, D. (2014) *Transport, Climate Change and the City*, Abingdon, Routledge
- HLWIKI. (2015). Scopus vs. Web of Science. Retrieved 29 July 2015, from [http://hlwiki.slais.ubc.ca/index.php/Scopus vs. Web of Science](http://hlwiki.slais.ubc.ca/index.php/Scopus_vs._Web_of_Science)
- IEA. (2009). *Transport, Energy and CO<sub>2</sub>* (pp. 1-414)
- Iwan, S., Małeckki, K., & Stalmach, D. (2014) Utilization of mobile applications for the improvement of traffic management systems. *Vol. 471. 14th International Conference on Transport Systems Telematics, TST 2014* (pp. 48-58): Springer Verlag
- King, D.A. (2004). The scientific impact of nations, *Nature* 430, p. 311-316.
- Knaak, N., Kruse, S., & Page, B. (2006). *An agent-based simulation tool for modelling sustainable logistics systems*. Paper presented at the 3rd Biennial Meeting of the International Environmental Modelling and Software Society: Summit on Environmental Modelling and Software, iEMSs 2006, Burlington, VT.
- Kwan, M-P, & Schwanen, T. (2016). Geographies of mobility, *Annals of the American Association of Geographers*, 106:2, p.243-256.
- Lai, Y. C., Barkan, C. P. L., & Onal, H. (2008). Optimizing the aerodynamic efficiency of intermodal freight trains. *Transportation Research Part E-Logistics and Transportation Review*, 44(5), p. 820-834
- Larsen, P. O., & von Ins, M. (2010). The rate of growth in scientific publication and the decline in coverage provided by Science Citation Index. *Scientometrics*, 84, p. 575-603.
- Lindholm, M., & Behrends, S. (2012). Challenges in urban freight transport planning - a review in the Baltic Sea Region. *Journal of Transport Geography*, 22, p. 129-136
- Lindholm, M. E., & Blinge, M. (2014). Assessing knowledge and awareness of the sustainable urban freight transport among Swedish local authority policy planners. *Transport Policy*, 32, p. 124-131
- Lyons, L., Lozano, A., Granados, F., Guzman, A., & Antun, J. P. (2012). Impact of the recent environmental policies on the freight transportation in Mexico City. *Procedia - Social and Behavioral Sciences*, 39, p. 437-449
- Ogden, K. W. (1992). *Urban Goods Movement: A Guide to Policy and Planning*. USA: Ashgate Publishing.
- Ogunsanya, A. A. (1982). Spatial pattern of urban freight transport in Lagos metropolis. *Transportation Research Part A: Policy & Practice*, 16(4), p. 289-300

- Ogunsanya, A. A. (1984). Estimating intra-urban freight generation and attraction. *Transportation Research Part A: Policy & Practice*, 18(3), p. 181-189
- Pede, G., Alessandrini, A., Filippi, F., Ortenzi, F., Fonsati, C., & Villatico Campbell, F. (2006). *Which low environmental impact vehicles for freight distribution in big cities?* Paper presented at the 22nd International Battery, Hybrid and Fuel Cell Electric Vehicle Symposium and Exposition, EVS 2006, Yokohama.
- Pickering, C., & Byrne, J. (2014). The benefits of publishing systematic quantitative literature reviews for PhD candidates and other early-career researchers. *Higher Education Research & Development*, 33(3), p. 534-548.
- Quak, H. J. (2012). Improving urban freight transport sustainability by carriers - Best practices from The Netherlands and the EU project CityLog. *Procedia - Social and Behavioral Sciences*, 39, p. 158-171
- Sims, R., Schaeffer, R., Creutzig, F., Cruz-Núñez, X., D'Agosto, M., Dimitriu, D., . . . Tiwari, G. (2014). Transport. In O. Edenhofer, R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. v. S. Schlömer, C., T. Zwickel, & J. C. Minx (Eds.), *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.
- Stephenson, J., Barton, B., Carrington, G., Doering, A., Ford, R., Hopkins, D., . . . Wooliscroft, B. (2015). The energy cultures framework: Exploring the role of norms, practices and material culture in shaping energy behaviour in New Zealand. *Energy Research and Social Science*, 7, p. 117-123
- Stephenson, J., Barton, B., Carrington, G., Gnoth, D., Lawson, R., & Thorsnes, P. (2010). Energy cultures: A framework for understanding energy behaviours. *Energy Policy*, 38(10), p. 6120-6129
- Suksri, J., & Raicu, R. (2012). Developing a conceptual framework for the evaluation of urban freight distribution initiatives. *Procedia - Social and Behavioral Sciences*, 39, p. 321-332
- Ter Brugge, R. (1991). Logistical developments in urban distribution and their impact on energy use and the environment. *Studies in Environmental Science*, 45(C), p. 331-341
- Trentini, A., & Malhene, N. (2012). Flow management of passengers and goods coexisting in the urban environment: Conceptual and operational points of view. *Procedia - Social and Behavioral Sciences*, 39, p. 807-817
- van Duin, J. H. R., Tavasszy, L. A., & Quak, H. J. (2013). Towards E(lectric)-urban freight: First promising steps in the electric vehicle revolution. *European Transport - Trasporti Europei* (54), p. 1-19
- van Rooijen, T., & Quak, H. (2010). Local impacts of a new urban consolidation centre - the case of Binnenstadservice.nl. *Procedia Social and Behavioral Sciences*, 2(3), p. 5967-5979
- van Rooijen, T., & Quak, H. (2014). City Logistics in the European CIVITAS Initiative. *Eighth International Conference on City Logistics*, 125, p. 312-325
- Walker, G., & Manson, A. (2014). Telematics, urban freight logistics and low carbon road networks. *Journal of Transport Geography*, 37, p. 74-81

Wolpert, S., & Reuter, C. (2012). Status Quo of City Logistics in Scientific Literature Systematic Review. *Transportation Research Record* (2269), p.110-116