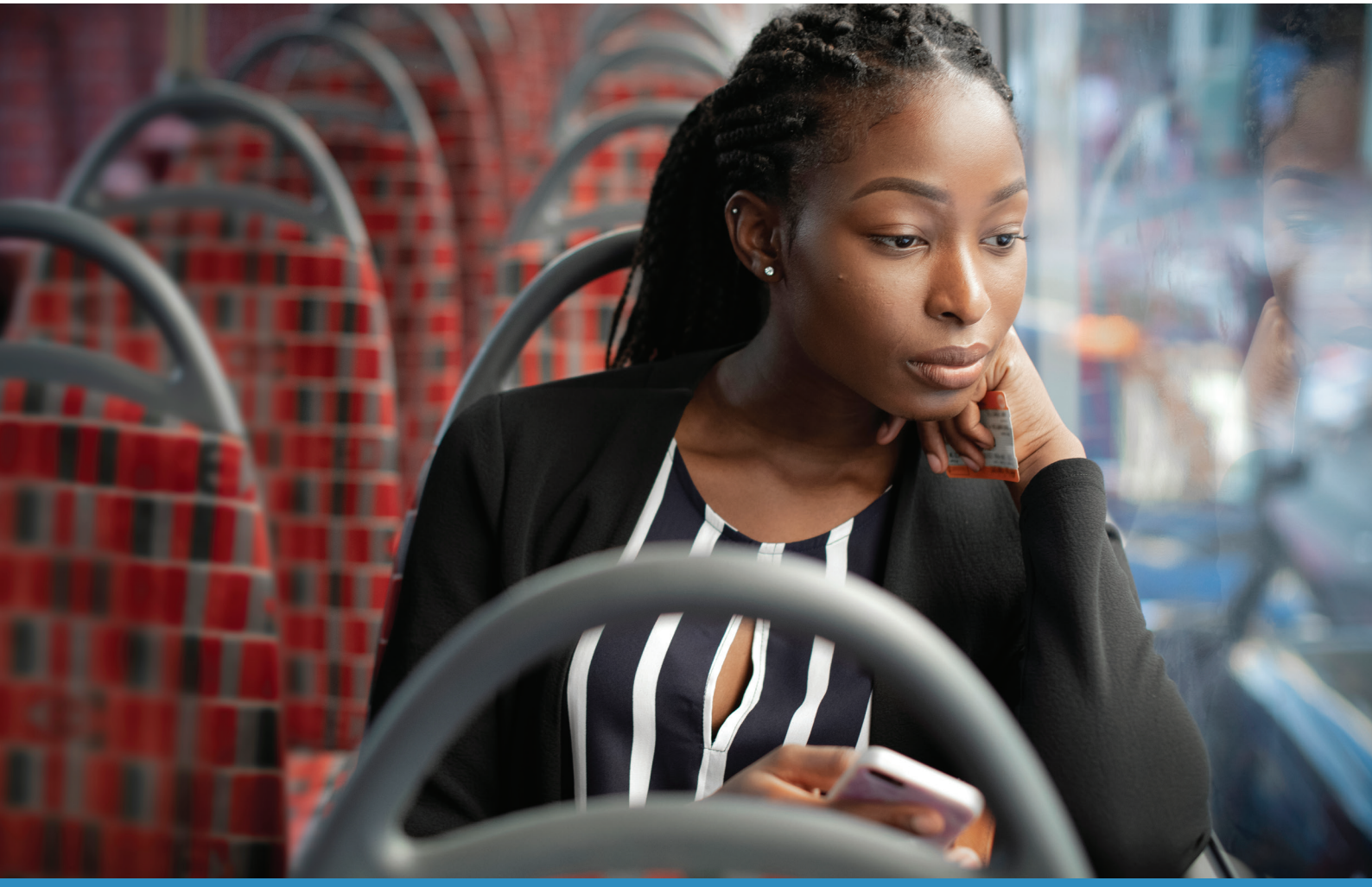
ROGER BEHRENS, ALEXANDRA NEWLANDS,
TAMZYN SULIAMAN, AWOT GEBREGZIABHER
AND DIANNE STEELE

PROJECT REPORT

INFORMAL AND SHARED MOBILITY:

A BIBLIOMETRIC ANALYSIS AND RESEARCHER NETWORK MAPPING



30 November 2021
A report commissioned by the Volvo Research and Educational Foundations

VREF
VOLVO RESEARCH & EDUCATIONAL FOUNDATIONS

CfTS
Centre for Transport Studies

UCT LIBRARIES

UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD
ENGINEERING & THE BUILT ENVIRONMENT

ABSTRACT

This study was commissioned by the Volvo Research and Educational Foundations to inform the content of the next phase of its *Future Urban Transport* programme. The aim of the study was to define the subject field (provisionally described by VREF as 'informal public transport' and 'shared mobility'), analyse its bibliometric attributes. The study method involved an analysis of the nomenclature and focus of seminal or consolidating in-field literature to delineate the scope of the study, a systematic search of multiple platforms for in-field English language publications between 2010 and the present, the creation and augmentation of a database for bibliometric analysis, and a survey of leading researchers across eight global regions.

The subject field was divided into four main categories of passenger services (flexible transport, informal transport, shared mobility and for-hire transport), which sit between purely private transport and scheduled mass public transport, and can be found in various guises across the Global North and Global South. The timeline of innovation in the field reveals complex and multi-directional global diffusion of service innovations, triggered by changed operating environments and technology disruption.

It was found that research in this field is growing fast (doubling every four years). The recent literature is dominated by authors affiliated to universities in Europe, Eastern Asia and Northern America at a regional scale, and to universities in China and the United States at a country scale. Shared mobility (and bike-sharing, car-sharing and ride hailing in particular) has received most attention (62%), followed by for-hire transport (17%), informal transport (11%), and flexible transport (10%). Most publications concerning shared mobility and for-hire transport were produced by lead authors in China (19,3% and 44,1%), followed by the United States (15,0% and 9,9%). Most publications concerning informal transport were produced in South Africa (18,2%) followed by India (9,8%), and concerning flexible transport were produced in the United States (13,1%) followed by Australia (9,6%). There has been extensive international research collaboration, with collaboration between research institutions in China and the United States found to be particularly strong, as was collaboration between China and other East Asian countries. Somewhat paradoxically, while the quantity of collaborations with universities in Africa, Latin America, and Western Asia was relatively small, authors from many countries within these regions are most likely to publish through international collaboration. Citation networks between institutions followed a similar pattern to collaboration networks.

Geographical gaps in the literature were found, with heatmaps revealing countries, particularly in Sub-Saharan Africa, that received no dedicated research attention. While difficult to quantify, there were also indications of thematic gaps in the literature, or at least disparity between the prevalence of a service type and the number of publications about it. Most notably, compared to their global prevalence, bike-sharing, car-sharing and carpooling were well researched, compared to informal for-hire transport and informal public transport, which received significantly less attention.

Given the multi-directional innovation diffusion in the subject field, and the disparity of research capacity and output across regions, it is a field of inquiry that presents rich possibilities for global research collaboration in the next phase of the FUT programme. The survey of leading researchers suggested that: integrating with mass public transport services; serving the needs of vulnerable passengers; regulating service providers; introducing electric vehicles into shared mobility and informal transport fleets; and digitalising aspects of informal transport operations; are priority future research needs.

CONTENTS

LIST OF FIGURES

1 INTRODUCTION

1.1 Background

Over the past two decades the Volvo Research and Educational Foundations' (VREF) has invested in research, education and communication through its *Future Urban Transport - How to deal with complexity* (FUT) programme. The objective of the FUT programme is to contribute new ideas and solutions for sustainable transportation systems in cities. Over the past decade, the FUT programme has supported research in the fields of urban freight, bus rapid transit, political leadership in the transformation of urban transport, and financing urban access. This phase of the FUT programme comes to an end in 2021, and VREF is currently developing the next phase. A first new initiative, *Mobility and Access in African Cities* (MAC), started in 2018/2019, and after a year of consultation and preparation, the Board of VREF approved a set of additional new themes to be added to the FUT programme, one of which is the provisionally titled *Informal Public Transport* (IPT) programme.[1]

The IPT programme is envisaged to span a diverse spectrum of passenger transport services that fall between scheduled mass transit services at one end, and private motor cars at the other. While the programme may subsequently narrow its focus, at the outset it's focus was deliberately inclusive. It has explicit interests in 'informal public transport' and 'shared mobility modes', but also in other forms of flexible and for-hire service not generally included in these terms, but conceptually similar. The nature of the service provided to passengers by a regulated taxicab in Beijing and by an unregulated motorcycle *okada* in Lagos, for instance, is similar, and it would be difficult to justify excluding the former from consideration while including the latter. This diverse and inclusive focus will enable the programme to support research on shared mobility services prevalent in the Global North, as well as informal transport services prevalent in the Global South. To inform the design and content of the IPT programme in greater detail, VREF commissioned a bibliometric investigation of, and researcher network mapping within, these fields.

The terms of reference of the bibliometric study specified three outputs:
- "a bibliometric study;
- an informed discussion of possible subject definition, scope and delineation; and
- a university/research team/researcher mapping."

An earlier interim project report addressed the second on the above outputs. This project report, which incorporates sections from the earlier interim report, addresses the remaining two outputs of the study.

1.2 Aim of the study

In order to satisfy its terms of reference, the study pursued the following three aims:
- to clarify and delineate the scope of the bibliometric investigation;
- to analyse the bibliometric attributes of English language scholarly publications within the defined scope, published between 2010 and the present; and
- to identify leading researchers and research institutions in the field, across global regions.

[1] Other themes include: *Walking as a mode of transport*; *Politics, leadership and power in the transformation of urban mobility*; and a follow up of the thematic programme on *Urban freight*.

1.3 Outline of sections

The project report is divided into seven chapters. The following chapter describes the method employed in defining the scope of the study, in analysing the bibliometric attributes of the field, and in identifying and profiling leading researchers and research institutions. Chapter 3 describes the field of study and its origins, and defines the scope of the bibliometric investigation. Chapter 4 presents the findings of the bibliometric investigation, in terms of trends, thematic foci, geographical distribution of authors and research contexts, as well collaboration between authors and research institutions. Chapter 5 identifies gaps in the literature and discusses future research priorities. Chapter 6 revisits the aims of the study and draws conclusions.

2 METHOD

This chapter describes the methods used in the study. It starts by describing how the scope of the study was delineated (Section 2.1). It then explains the processes followed in searching for publications (Section 2.2), screening the publications found (Section 2.3), augmenting the bibliometric database with additional data fields (Section 2.4), and analysing the data (Section 2.5). It goes on to describe the method employed in surveying leading researchers identified in bibliometric analysis (Section 2.6). It ends by noting the methodological limitations encountered in the study (Section 2.7).

2.1 Subject definition and scope delineation

To define the subject field, and to delineate the scope of the study, a preliminary (non-exhaustive) literature search was conducted. The literature search focussed on finding seminal or consolidating publications in the field. It was not limited to a particular time period. The findings of the preliminary literature review served to supplement and update the authors' prior knowledge of the field.

Figure 1 *Service taxonomy matrix*

Service characteristics		Vehicles: scooter	rickshaw	bi(tri)cycle	motorised 2-wheeler	motorised 3-wheeler	sedan / light vehicle	minibus	midibus	bus	driverless (mini)bus	trolleybus	light rail train	surface train	underground train
infrastructure	ROW A full separation														
	ROW B partial separation														
	ROW C no separation														
	on-route stop/station facilities														
	terminal facilities														
service type	urban passenger services														
	urban freight services														
frequency and span	scheduled														
	unscheduled														
routing	fixed route service														
	area/radial service														
passenger autonomy	private transport														
	for hire transport														
	demand-responsive transit														
	public transport														
passenger interface	electronic hailing														
	on-demand boarding-alighting														
	on-demand route deviation														
business formality	formal compliant business														
	semi-formal business														
	informal non-compliant business														
competition regulation	fully regulated														
	partly regulated														
	unregulated														

The preliminary literature review led to an identification of terminology used to describe the array of informal transport and shared mobility service types, and to the identification of seminal or consolidating publications in these fields. Because it became apparent that different terms can be used in different parts of the world to describe essentially the same service types, and because the same term in different parts of the world can be used to describe different service types, a 'service taxonomy matrix' was developed to analyse similarities and differences in the scope and definitions of terminology in common usage (see Figure 1). The service taxonomy matrix was applied to the terminology found in the literature, and to seminal or consolidating publications.

The columns of the matrix are vehicle types used in passenger transportation.[2] The list comprises common vehicles, and is non-exhaustive (e.g., it omits uncommon passenger vehicles like animal-drawn carts, cable cars, automated guideway transit, and monorail). The rows of the matrix are selected service characteristics relevant to how the scope of informal public transport and shared mobility concepts and terms have been defined in the literature. These service characteristics therefore include operating, business, and regulatory features, as the definitions of service types often hinge upon the degree to which they are prioritised, scheduled, fixed to routes, formalised (i.e., tax compliant), and regulated.

2.2 Publication search

The search for relevant publications – referred to as a 'scoping review' in the bibliometrics field – was restricted to scholarly English language publications, published between 2010 and 2021. Eligible publications were defined as: journal articles; conference papers; early access articles; preprints; books; book chapters; and monographs. Trade journals, magazines, standards, courses, meeting abstracts, review articles and book reviews were therefore excluded. The scoping review process followed the established good-practice Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) scoping review guidelines (PRISMA 2019). Thus, the search strategy was comprehensive, transparent, and replicable.

Table 1 *Search terms*

("paratransit" OR "informal transport" OR "intermediate transport" OR "informal for-hire transport" OR "informal public transport" OR "informal transit" OR "intermediate public transport" OR "share taxi" OR "shared taxis" OR "sharing systems" OR "sharing system" OR "carsharing" OR "car-sharing" OR "free floating" OR "bike-sharing" OR "bike pooling" OR "bikepooling" OR "dockless bikes" OR "scooter-sharing" OR "ridesharing" OR "ride sharing" OR "carpooling" OR "car pooling" OR "vanpooling" OR "van pooling" OR "slugging" OR "lift-sharing" OR "liftsharing" OR "ridesourcing" OR "ride sourcing" OR "electronic hailing" OR "e-hailing" OR "transport network companies" OR "ride hailing" OR "ridehailing" OR "courier network services" OR "ridesplitting" OR "ride splitting" OR "shared taxi" OR "shared taxis" OR "flexible transport" OR "demand-responsive transport" OR "demand responsive transit" OR "flexible transport services" OR "microtransit" OR "for-hire transport" OR "metered taxis" OR "metered taxi" OR "taxis" OR "taxi" OR "cabs" OR "taxicabs")	AND "transport"

The scope of the study, delineated through the application of the service taxonomy matrix, informed the identification of terms for use in the search for publications. Test searches were conducted on a preliminary list of individual terms that included 34 generic terms (e.g., paratransit, informal transport, microtransit, bike-sharing and ride haling), as well as 38 common service brand and colloquial names (e.g. *jeepney*, *bajaji*, *Bridj*. *Mobike*, *Bolt*, and *Uber*), across various databases, to determine the

[2] Note that for the purposes of this matrix a 'travel mode' is defined as a particular combination of vehicles and (shared and/or separated) rights-of-way. Thus the 'vehicles' identified in the matrix are not synonymous with 'modes' (e.g., buses could form part of the bus rapid transit mode in Guangzhou, the conventional bus mode in London, or the informal bus mode in Nairobi).

viability of each` term for inclusion in the search strategy. Following this test, brand and colloquial names were removed from the list of search terms, as they did not yield greater publications than the generic terms on their own. Table *1* presents the final list of 53 search terms in the scoping review.

Two academic citation databases (Scopus and Web of Science) were initially identified as search platforms. However, upon further investigation, a decision was made to include the Dimensions artificial intelligence platform, as it offered access to preprints, so that more recent publications could be included in the study. Three other, subject specific, databases were also included.

The final list of six databases used in the scoping review included:

- Dimensions;
- Engineering Village;
- Institute of Electrical and Electronics Engineers (IEEE);
- ProQuest: Technology Collection;
- Scopus; and
- Web of Science.

Using the search terms listed in Table *1*, keyword searches were conducted in each database. The individual search terms where then combined using Boolean operators. Results were exported to EndNote software (a bibliographic management tool).

2.3 Publication screening

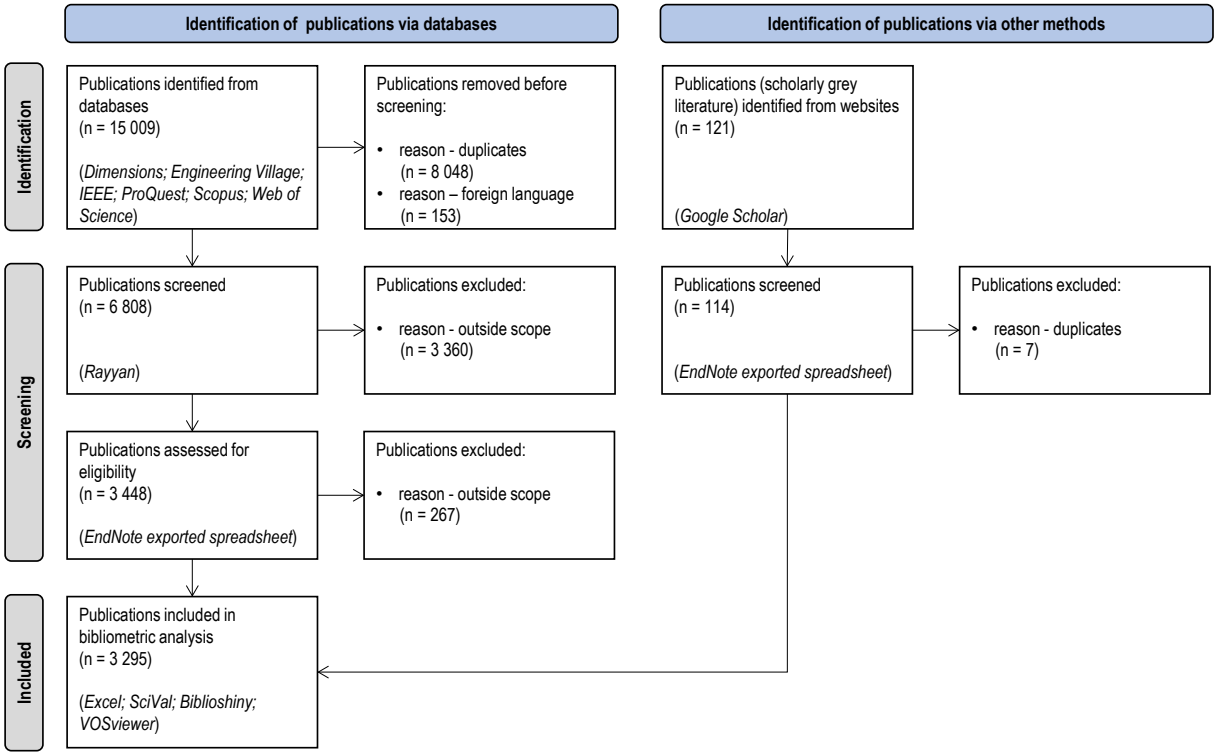
The exported EndNote library comprised 15 009 results harvested from the six databases. The process followed in screening publications is presented in Figure *2*. First, the EndNote library was deduplicated, which left 7 971 results. These 7 971 results were then exported into Rayyan software, a screening tool, and a further 1 010 publications were removed through deduplication. An additional 153 foreign language publications were removed.

The titles and abstracts of the remaining 6 808 publications were then screened for relevance. In this process a further 3 360 publications were excluded on the grounds that they did not meet the inclusion criteria of the study. Inclusion criteria included: whether the publication fell within the defined scope of the study (explained later in Section 3.3); and whether the publication dealt with the use of applications in service provision. So, for instance, publications found in the IEEE database concerning the electronic engineering behind the development of a vehicle dispatching application were excluded, whereas publications concerning the use of this application in service operations were included. The screened dataset of 3 448 publications was then extracted as a flat file database in Microsoft Excel software.

A supplementary literature search of scholarly grey literature was then conducted. This search involved the use of 12 search terms which reflected the scope of the study. The search was conducted using the Google Scholar search engine. For each search term, the first 10 pages of Google Scholar results were scanned to find scholarly reports not found in the earlier scoping review. This supplementary search yielded 121 publications. After deduplication, this resulted in a further 114 publications added to the study database.

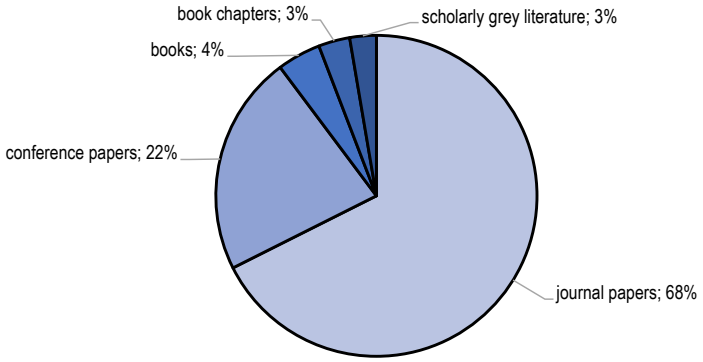
In the process of database augmentation (described in Section 2.4), a further 267 publications were removed because they did not meet inclusion criteria. The final study database therefore comprised 3 295 publications (97% from the scoping review, and 3% from the scholarly grey literature search). Figure *3* illustrates the publication types within the study database. Most publications were journal papers (68%), followed by conference papers (22%).

Figure 2 *PRISMA flow diagram*



Note:
1. PRISMA = Preferred Reporting Items for Systematic Reviews and Meta-Analyses

Figure 3 *Publications, by type (N=3 295, 2010-2021)*



2.4 Bibliometric data augmentation

Following the export of the bibliometric data from EndNote into a Microsoft Excel database, additional data fields were added. The purpose of the data augmentation was to enable analysis of: the relative attention given to different research fields; the geographical distribution of research contexts; the geographical distribution of authors; and the weighted ranking of author output.

(continent, bespoke global region, United Nations' sub-region, and country). The global regions assembled from the United Nations Statistics Division's 22 sub-regions, for subsequent data analysis, are illustrated in Figure 3.

Figure 4 *Map of global regions*

The single data field of combined co-authors exported from EndNote was separated into 27 data fields for each co-author (derived from the publication with the most co-authors). Two sets of co-author data fields were created: one with just one initial to resolve undercounting errors (e.g., Scopus data misrepresents Susan Shaheen's bibliometrics as it has data for 'S. Shaheen' and 'S. A. Shaheen'); and another set with all initials to assist in resolving misattributed authorship (e.g., there are seven authors from seven universities with the name 'Y. Wang'). A data field indicating the total number of authors for each publication was also added. A relational database of authors was created in which both lead and secondary co-authorship could be counted and weighted.

In total, 130 new data fields were added, resulting in a final database of 151 fields and 3 295 records. The relational author database consisted of 30 fields and 6 565 records (7 110 records when multiple initials were applied).

2.5 Bibliometric data analysis

The available bibliometric analysis tools are unable to process combined datasets drawn from multiple sources. This is because the source databases each comprise unique metadata, which are inconsistent and vary in quality. This required that when analysing the final database of this study with these software tools, the source databases (principally Dimensions, Scopus and Web of Science) had to be analysed separately. For this reason, and because the final, cleaned and augmented, database was captured in Microsoft Excel software, Microsoft Excel was used as the default in data analysis. Other software packages were used only when the analysis could not be performed in Microsoft Excel. So, Microsoft Excel was used to analyse: temporal trends; the relative attention given to different research themes; geographical distributions of research activity; and the identification of leading researchers and research institutions.

The bibliometric data were also analysed using the following three other software packages:

- VOSviewer, analysing data from the Scopus and Web of Science datasets, was used to enhance understanding of the attention given to different research themes, through the generation of keyword co-occurrence networks. VOSviewer was also used to explore collaboration and citation networks between authors, research institutions and countries.

- Biblioshiny (Bibliometrix R-package) was used to enhance understanding of country collaboration networks, and the geographical distribution of research activities, though the generation of Sankey plots and networks maps.
- SciVal, analysing data from Scopus, was used to extract citation data, and to provide input into the indices developed to identify leading researchers and research institutions. Two SciVal generated reports are appended as Appendices A and B.

2.6 Researcher survey

To explore future research intentions and priorities in the subject field, a survey was administered amongst 40 leading researchers. Research ethics approval was requested and obtained from the Ethics in Research Committee of the University of Cape Town's Faculty of Engineering and the Built Environment.

The survey questionnaire included two open-ended questions. The first asked the respondents to identify any research projects in the fields of informal public transport and/or smart mobility they are involved in, that have yet to produce publications in peer-reviewed journals (and therefore would not have been identified in our search of the major databases), and what plans they have, if any, to undertake research in these fields in the next five years. The second question asked the respondents what they regard to be the top three priority in-field research gaps in their global region.

The questionnaire, together with an information sheet explaining the scope of the study and providing preliminary findings, regarding research field categories and the geographical distribution of research activity, was distributed via a personalised email. A reminder email was circulated at the time of the requested reply date (16 August 2021).

A response rate of 58% (23 out of 40) was achieved. Responses were captured and analysed in a Microsoft Excel database. Word clouds were generated using Jason Davies software.

2.7 Limitations

The following limitations in the research method applied, should be noted:

- While the bibliometric search covered the established academic journals included in the major databases (Scopus, Web of Science, Dimensions, IEEE, and Engineering Village), it would have missed less established journals and smaller regional conference proceedings that are not included in these platforms. The extent of such less established journals and smaller regional conference proceedings is unknown. The supplementary search for scholarly grey literature in Google Scholar targeted influential project reports from non-academic institutions like the World Bank and the World Resources Institute, and is unlikely to have found uncited papers from less established journals and smaller regional conference proceedings. Hence the study database may have skews if the publications not found have different bibliometric attributes.
- When undertaking specialised bibliometric co-occurrence, collaboration and citation network analysis, dependent on SciVal, VOSviewer or Biblioshiny software, the source data (Scopus, Web of Science or Dimensions) was determined by the software, and did not match the study database 100% as some publications in the study database were derived from other searches. Hence the co-occurrence, collaboration and citation networks may have skews if the publications not included have different bibliometric attributes.

3 SUBJECT DEFINITION

This chapter defines the subject field. It starts by highlighting, in chronological sequence, the key themes covered in the 'informal public transport' and 'shared mobility' literatures, and discussing innovation and diffusion in these sectors of the passenger transport market (Section 3.1). It then identifies common terms used in these literatures, and applies the service taxonomy matrix to clarify their scope (Section 3.2). It ends by delineating the scope of, and selecting the terms to be used in, the subsequent bibliometric investigation (Section 3.3).

3.1 Overview of the literature

A preliminary, non-exhaustive literature review identified the following seminal publications and key themes covered in the 'informal public transport' and 'shared mobility' literatures.[3] These are grouped by decade in the following two sub-sections. Thereafter, patterns of innovation and diffusion in these sectors of the passenger transport market, apparent from the preliminary literature review, are discussed.

3.1.1 *Informal public transport*

1970s

- The term 'paratransit' is first used in the United States to refer to unscheduled services that complement mass public transport systems. In early definitions, paratransit refers to all passenger travel modes falling between autonomous private transport and scheduled fixed-route public transport.
- Authors argued that the eradication of 'jitneys' had robbed American cities of an important complementary public transport service, and that a variety of unscheduled, demand-responsive shared services should be allowed to re-establish (e.g., Saltzman 1973; Kirby *et al.* 1974; Orski 1975).
- The main arguments advanced in this literature with respect to paratransit regulation and integration were essentially that existing regulations presented a major obstacle to the emergence of innovative paratransit services, and that allowing freer market entry and fare deregulation would enable a rich mix of new services to emerge as well as fare structures that better reflected the actual operating costs of services.
- Reducing the barriers to market entry was argued to increase the supply of, and competition between, services, and thereby reduce fares, incentivize service quality improvement, and eliminate illegal operations.

1980s

- Literature on paratransit or 'informal public transport' services in Global South cities emerge, with South-east Asian cities receiving the greatest initial attention (e.g., Rimmer 1984, Roth 1987).
- The main arguments advanced in the literature from this period were essentially that these services perform an important role in passenger transport systems, often providing niche services under conditions in which conventional scheduled services cannot be sustained.
- Some authors from this period argued that the Global South offered commercially successful models of demand-responsive service provision that, with modification, could be transferred to the Global North (e.g., Silcock 1981, Roth and Shephard 1984, Cervero 1985, Chujoh 1989).

[3] Consolidating publications that assisted in unpacking the chronology included: Behrens *et al.* (2021); Canales *et al.* (2107); Cassius et al. (2021); Cervero (2020); Mulley (2009); Schalekmap and Saddier (2020); Shaheen *et al.* (2015); Soares Machado *et al.* (2018); Tirachini (2019); and Tun *et al.* (2020).

1990s

- The literature from this period focussed attention onto informal public transport service recognition and quality improvement.
- Cervero (1992), for instance, studying eight case cities in Indonesia, Malaysia, the Philippines, and Thailand, cautioned that any attempt at retrenching informal public transport's role should be governed by market conditions rather than by government decree.

2000s

- In a comprehensive global study of 'informal transport', Cervero (2000) presented potential strategy options for rationalising and improving services, ranging from operator organisation, to regulation, financial support, infrastructure improvement, traffic management and operator training. From a spectrum of policy responses ranging from 'acceptance', to 'recognition', 'regulation' and 'prohibition', Cervero (2000) argued that 'recognition' policies (unrestricted market entry, but regulating areas of operation, and service, vehicle and employment standards) and 'regulation' policies (regulating both market entry, and areas of operation and operating standards) are most commonly appropriate.
- Other literature, however, raised concerns around the potential dangers of unbridled 'in the market' competition (e.g., Sohail *et al.* 2006, Cervero and Golub 2007, Golub *et al.* 2009). The paratransit industry was not advanced by authors like Golub *et al.* (2009) as an alternative to mass public transport system improvement, but as an important auxiliary upon which many poor households will continue to depend.
- Gwilliam (2008) argued that policy options are less choices, than phases of a 'regulatory cycle', involving: (1) political pressure to keep public transport fares uneconomically low, and a lack of competition, lead to inefficiencies and decline in monopolistic or oligarchical public transport undertakings; (2) multiple smaller self-regulated informal transport operators emerge to fill the service gaps that result from declining formal public transport services; (3) the weak regulatory regimes associated with informal transport, and aggressive in-the-market competition, lead to poor quality of service; and (4) public authorities seek to reduce the number of operators and reintroduce large formal public transport businesses in an attempt to improve service quality levels. The cycle is repeated once the efficiencies of larger formal public transport undertakings begin to decline due either to a lack of competition or a failure in regulatory enforcement.
- Sohail *et al.* (2006) noted the importance of the capacity of the industry to self-regulate in conditions of weak government regulation and enforcement capacity, and argued for regulatory frameworks that strike a balance between avoiding the negative externalities of informal transport, while avoiding overly detailed or 'heavy' regulations that increase the potential for non-compliance and corruption.
- Research attention was given to the merits and transferability of 'bus rapid transit' (BRT) successes in Latin American cities as a means of replacing and assimilating informal public transport operators (e.g., Wright 2001; Hensher and Golub 2008; Gauthier and Weinstock 2010, Hidalgo and Carrigan 2010).
- Research attention was also given to technology-supported 'demand-responsive transport' or 'flexible transport services' in Global North contexts, as cities sought alternatives to private car dependency in lower density environments in which conventional public transport systems are not viable, and sought to cope with mandates to provide services for the disabled (e.g., Mageean and Nelson, 2003, Palmer *et al.*, 2004, Brake and Nelson, 2007). Echoing earlier authors from the 1980s, Finn (2012) suggested that paratransit operations in the Global South may hold lessons on how some of the barriers to implementation (see Mulley *et al.* 2012) might be overcome.

2010s

- The most recent decade has seen studies exploring the nature and extent of informal public transport business in the Global South in greater detail, and studies exploring public policy measures that might be taken to improve quality of service.
- Tun *et al.* 2020 provide a comprehensive review of informal and semiformal transport services in Latin America, arguing that in many cities, these services will continue to coexist with formal

services and will play an important role, especially for the transport-disadvantaged. Therefore, improving access for all will mean investing in such services.

- Informal public transport research in Sub-Saharan Africa has focussed on analysing and mapping route networks (Klopp and Cavoli 2019, Saddier *et al.* 2016, Coetzee *et al.* 2018, Du Preez *et al.* 2019), understanding business models (Schalekamp and Saddier 2020), and improving and integrating informal services into 'hybrid' public transport networks comprised of informal (unscheduled) and formal (scheduled) operators (Behrens et al. 2016, 2017a, 2017b, Plano *et al.* 2020).
- An emerging trend in the informal public transport literature relates to potentially disruptive technologies, most commonly in the form of electronic hailing applications (Boutueil and Quellerier 2020, Flores Dewey, 2019). Behrens *et al.* (2021) argue that these digital platforms may have a significant impact on operating practices, but few cities in the Global South have regulatory frameworks in anticipation of this change.

3.1.2 *Shared mobility*

1970s

- During this decade, literature on ridesharing and its variants emerged. Hartgen (1977) reviews studies on ridesharing behaviour and discusses how ridesharing might be encouraged further. Interestingly, the author found that the incidence of ridesharing in the United States (10% of work trips at the time of writing) had not increased significantly during the oil crisis of 1973.
- The main incentives for carpooling to work, the most common form of ridesharing, were identified as limited parking space, reduced fuel consumption and traffic congestion, and savings in the cost of car operation and ownership. Policies used in promoting carpooling include fuel price increases, and preferential traffic control and parking measures (Ben-Akiva and Atherton 1977).
- Another form of ridesharing, vanpooling, which started in 1973, was found to be used by employers to increase parking space availability and reduce their parking space provision costs, as well as to provide their employees with a 'tax-free' fringe benefit. Other benefits of vanpooling were argued to include reductions of pollution and traffic congestion, and fuel conservation (Maxwell and McIntyre 1979).

1980s

- Further research into vanpooling was undertaken by Wartick (1980). The author argued that employer-organised vanpooling was the best commuter solution of this decade, in the United States, as inflation, fuel shortages, traffic congestion, and pollution were making single-occupant vehicles costly and unsustainable. He argued that employers who did not consider the transportation of their employees could be faced with an unhappy workforce and a limited labour pool from which to draw.

1990s

- Literature from this period further discussed carpooling and its history (Ferguson 1997). Carpooling in the United States was traced back to World War II when, due to oil and rubber shortages, there was a need to use cars and fuel sparingly. The incidence of carpooling then dropped, and only increased again in the 1970s due to the oil crises. In the mid-1980s, oil prices started to drop, which caused another decrease in carpooling which has since levelled out.
- The concept of car-sharing, an early innovation in passenger transport sharing, originated in Switzerland in 1948 as a car-sharing cooperative known as 'Sefage', which operated until 1998 (Harms and Truffer, 1998). Car-sharing developed significantly in other parts of Europe in the 1980s and in North America and Asia in the 1990s. Car-sharing emerged as a 'organised short-term car rental' and allowed individuals to gain the benefits of private cars without the associated costs and responsibilities of car ownership. Literature from this period (e.g., Shahen *et al.*, 1998) argued that large social, environmental, and economic benefits are associated with car-sharing,

and that governments and organisations should therefore enable and support these transport services.

2000s

- During the 2000s, more literature on transport sharing systems emerged, specifically relating to car-sharing and a growth in bike-sharing services. Shaheen and Cohen (2007) found that, globally, car-sharing occurred in approximately 600 cities and 18 countries. The authors forecast continued growth in this mode of transport, especially in new and emerging markets.
- Bike-sharing, a concept that had emerged in the 1960s, had grown slowly since then. 'First-generation' bike-sharing emerged in Amsterdam in 1965, in the form of a system of unlocked, free-to-use bicycles placed around the city. This early scheme proved difficult to sustain due to damage and theft (Shaheen *et al.,* 2010). 'Second-generation' bike-sharing emerged in Copenhagen in 1995, utilising a 'coin deposit system' in which a refundable deposit was needed to unlock the bicycle. It also experienced theft problems, however, due to there being no way to track users (DeMaio, 2009; Ma *et al.,* 2019). It was in 2005, in Lyon (France), that the first large-scale bike-sharing programme was launched, with over 15 000 members. By the end of this decade, there were 120 bike-sharing programmes globally, showing a growth trend in bike-sharing systems as the price of fuel rose and traffic congestion worsened (DeMaio 2009).
- Literature from this period also focused on slugging, also known as casual or impromptu carpooling (Burris and Winn 2006). Slugging emerged in American cities with high occupancy vehicle lanes, as drivers and passengers connected via 'slug lines' to gain access to use of these facilities. Personal security risk was, however, identified as a problem with this way of travelling, due to an inability to screen passengers and drivers (Kelley 2007).

2010s

- The rapid advancement of technology during this decade, particularly in smartphone applications, led to the emergence of ubiquitous electronic ride hailing services. Instead of hailing taxicabs on the kerbside, passengers were now able to hail taxis from anywhere (He and Shen 2015).
- Smartphone technology also led to the subsequent development of 'ridesplitting', which is a form of on-demand ridesourcing in which passengers split a ride and fare (e.g., UberPOOL) (Chen *et al.* 2017). Ridesplitting services had similarities to earlier 'shared taxis' in the Global South, which also reduce the fare for passengers and reduce the cost for the taxi operator (Hosni *et al.* 2014).
- During the 2010s a large body of literature on 'shared mobility' emerged, and continues to emerge, reflecting the broader shifts towards 'shared economies' occurring at this time. A consolidating publication in this field by perhaps the most prominent author, Susan Shaheen, defined shared mobility as a 'strategy that enables users to gain short-term access to transportation modes on an 'as-needed' basis' (Shaheen *et al.* 2015). This definition of shared mobility included car-, bike-, and scooter-sharing, the earlier forms of ridesharing (i.e., car- and vanpooling), as well as the emergent ridesourcing services such as electronic ride hailing and the more recent ridesplitting. Electronic hailing technology has also been used to provide services such as food and package delivery (e.g., Uber Eats), which have become known as 'courier network services'.
- Literature on vehicle electrification in shared mobility services developed towards the end of this decade, with authors such as Shaheen (2018) and Taiebat and Xu (2019) noting that the use of shared electric vehicles could significantly reduce per-kilometre greenhouse gas emissions. Pavelenko *et al.* (2019) observed that the electrification of shared mobility vehicles could also lead to an acceleration of fuel saving and operating cost benefits.
- A significant amount of literature in this period originated from authors in Asia, who are at the forefront of technological advances in the shared mobility field. For example, bike-sharing grew most rapidly in Asia during this decade and continues to do so today, leading to a considerable amount of literature written on the topic (e.g., Guo *et al.* 2017, Zhang and Mi 2018). Ridesourcing services such as Didi and Ola Cabs were established in 2012 in China (Zhu *et al.,* 2017) and in 2010 in India (Panigrahi *et al.,* 2018) respectively.
- Shared mobility, specifically ridesourcing, spread to the African continent during the 2010s. Uber arrived on the continent in 2013 and has since expanded to operations in 15 African cities, with

over 1 million users in Sub-Saharan Africa (Park *et al.* 2021). Locally developed platforms, like SafeBoda in Kampala (Muni *et al.* 2020), SWVL in Cairo (Hamdy *et al.* 2021) and Twende in Dar es Salaam (Divall *et al.* 2021), followed soon after.

- Evaluations of the shared mobility phenomenon (e.g. by Murphy and Feigon 2016), argued that shared mobility services enhance urban access, can complement public transport services, and are associated with reduced household expenditure on transportation and lower car ownership.
- Literature on American 'microtransit' services, identified as an additional form of shared mobility (similar in nature to the 'demand-responsive transport' services that had emerged in Europe), also emerged in the 2010s. 'Microtransit' was defined by the United States Department of Transportation as 'a privately owned and operated shared transportation system that can offer fixed routes and schedules, as well as flexible routes and on-demand scheduling'. Microtransit aims to supplement conventional public transport services and is largely enabled by smartphone technology (Westervelt *et al.* 2018).

3.1.3 *Patterns of innovation and diffusion*

Figure 5 *Transport service innovations in the Global North and Global South (1860-2020)*

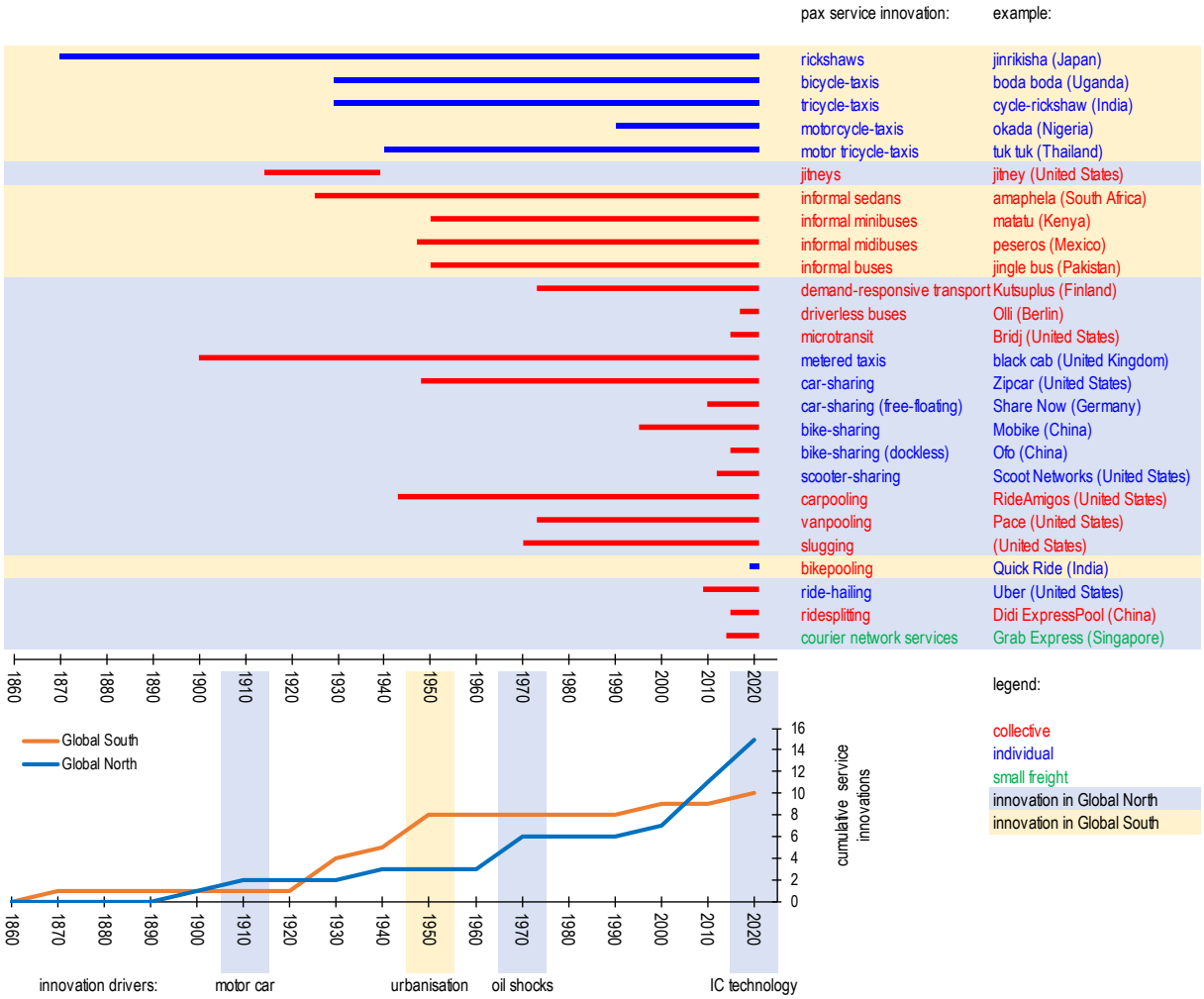
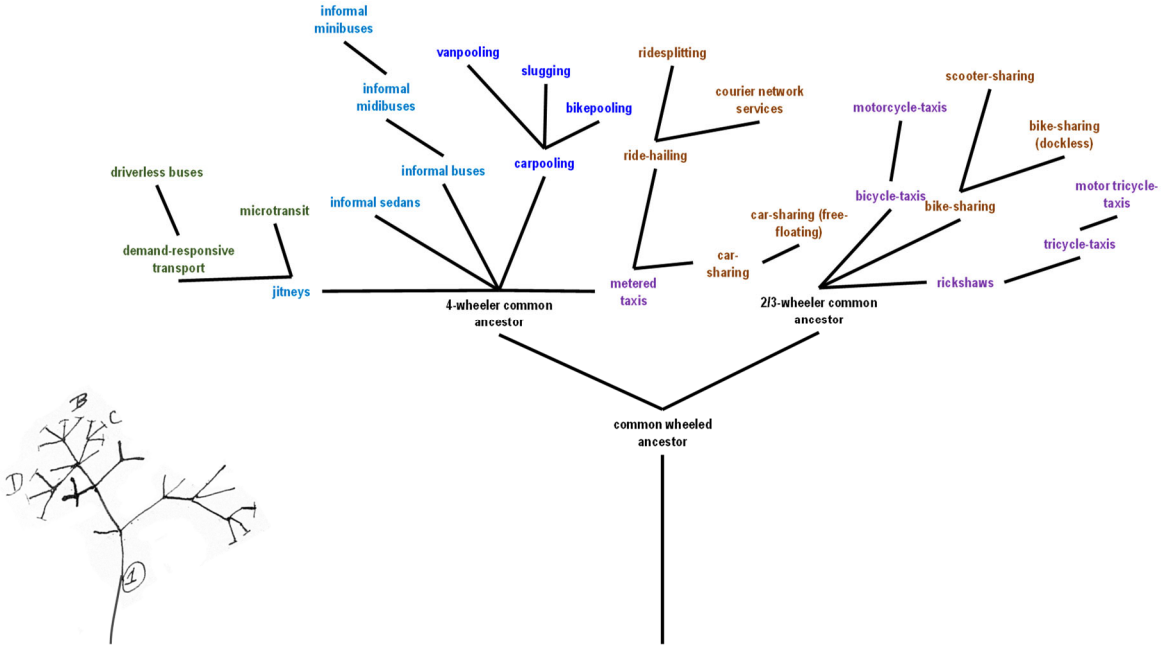


Figure 5 illustrates the chronological emergence of transport services. The chart in the lower half of the figure illustrates cumulative growth in innovations, demonstrating how, in the latter half of the previous century, innovation was concentrated in the Global South as city transport systems came under increased pressure from accelerating urbanisation and small-scale entrepreneurs responded to

unserved passenger markets. In the current century, however, technology disruptions in information and communication systems have shifted the concentration of service innovation to the Global North. This growth of passenger transport service innovation resembles Darwinian evolution amongst biological species (see Figure 6), with the driver of change being changes in environment and technological disruption in the former, as opposed to changes in environment and beneficial mutation in the latter.

Figure 6 *Evolution metaphor in transport service innovation*



While it is difficult to track exactly how and where some service innovations emerge, and what their antecedents were, it is nevertheless clear that they diffuse from in one region to another. An important feature of these innovation diffusions is that they have occurred bi-directionally between the Global North and the Global South. Services like cycle rickshaws in Dhaka, informal minibus services (*robots*) in Kingston and shared taxis (*amaphela*) in Cape Town, are reflected in the emergence of *velotaxis* in Berlin, dollar vans in New York and ridesplitting (*uberPOOL*) in San Francisco. In the opposite direction, carpooling in Washington, ride hailing in San Francisco, bikesharing (*Bycykler København*) in Copenhagen and demand-responsive transport (*Kutsuplus*) in Helsinki, are reflected in bike pooling (*Quick Ride*) in Pune, motorcycle-taxi hailing (*SafeBoda*) in Kampala, dockless electric-bikesharing (*Mobike*) in Shanghai and ride-sourced jitneys (*Jetty*) in Mexico City.

3.2 Common terminology and scope

As indicated earlier, a feature of the literature on informal public transport and smart mobility is the use of duplicative or inconsistent terminology. Different terms have been used in different parts of the world to describe essentially the same service type (e.g., 'demand-responsive transport' in Europe and 'flexible transport services' in Australia). The same terms in different parts of the world have been used to describe different service types (e.g., 'carsharing' in the United Kingdom and the United States). This duplication and ambiguity of terminology has fuelled authors to adopt even more terms to describe their particular field of interest. Some authors have even used different terms to describe the same transport services in different publications. So, this sub-section serves to clarify the meaning and scope of the terms found in the preliminary literature review, using the service taxonomy matrix

created for this purpose (see Figure 1). The terms analysed are ordered according to the broadness of their scope (from broadest to narrowest).

Paratransit

Defining features:

- unscheduled service frequencies and spans (running parallel to mass transit services, hence 'para-transit')
- operator decides destination and time of service
- demand responsive boarding and alighting
- a wide range of vehicle types, including taxicabs and motorcycle-taxis, but most common is minibus

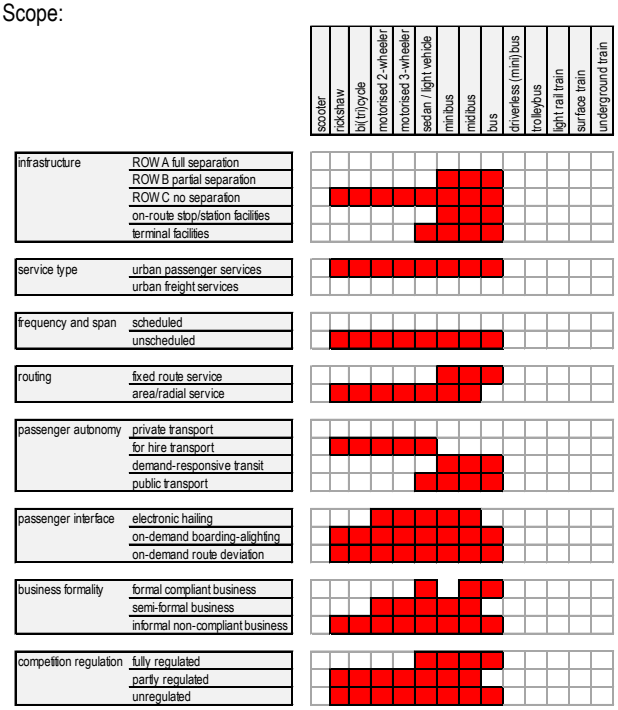
Example services:

- matatus (Kenya)
- dollar vans (United States)
- tap taps (Haiti)
- jeepneys (Philippines)

Example authors:

- Cervero 1992, 1997
- Kirby *et al.* 1974
- Rimmer 1984
- Saltzman 1973
- Silcock 1981

Scope:



Informal transport (variants: informal transportation; informal transit; shared transport; share taxi)

Defining features:

- services provided by numerous informal or semi-formal businesses
- services range from for-hire to public transport
- a wide range of vehicle types, most common is minibus

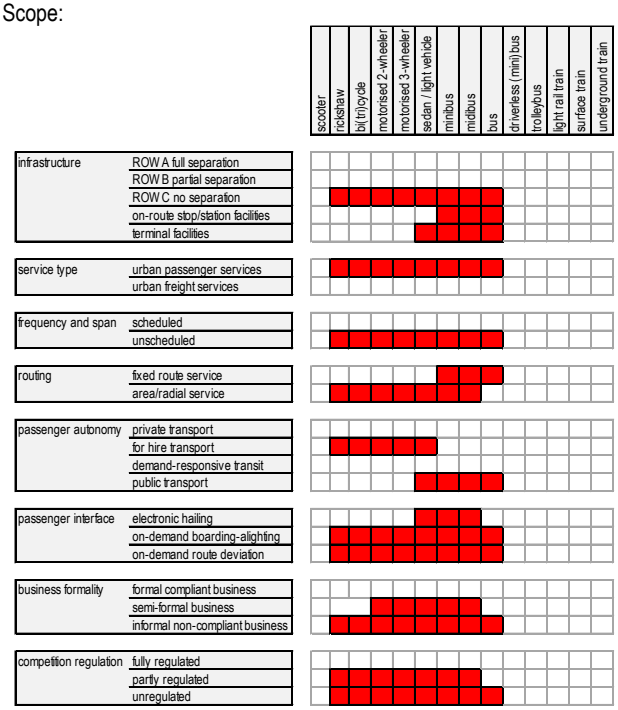
Example services:

- becaks (Indonesia)
- tuk tuks (Thailand)
- robots (Jamaica)
- marshrutka (Kazakhstan)
- peseros (Mexico)
- buseta (Colombia)

Example authors:

- Cervero 2000
- Cervero and Golub 2007
- Schalekamp and Saddier 2020
- Tun *et al.* 2020

Scope:



Intermediate transport (variant: intermediate public transport)

Defining features:

- services that fall between private cars and conventional public transport modes (hence 'intermediate')
- a wide range of vehicle types, most common is motorised 3-wheelers
- a term prevalent in Asia (particularly India), broadly equivalent to 'paratransit'

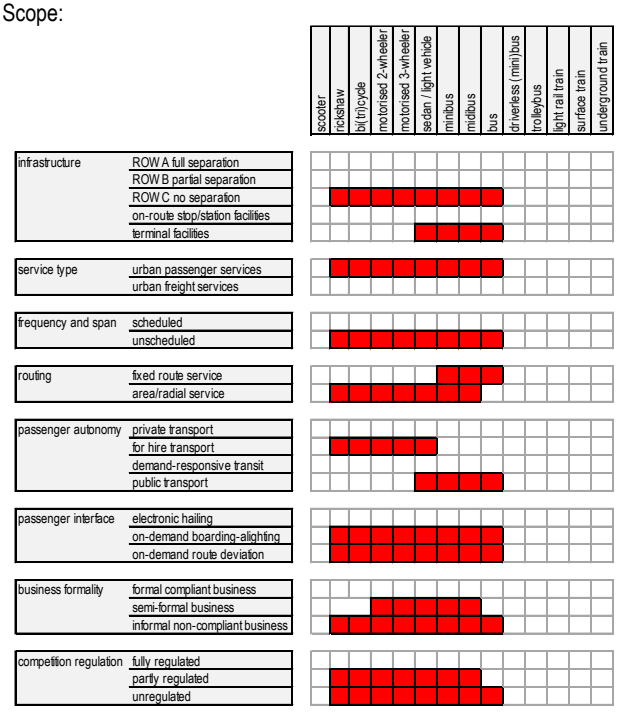
Example services:

- cycle rickshaws (India)
- autorickshaws (India)

Example authors:

- Gadepalli 2016
- Kunhikrishnan and Srinivasan 2018

Scope:



Demand responsive transport (variants: demand responsive transit; flexible transport services)

Defining features:

- telematics-based services designed for suburban environments within which mass transit services struggle for viability
- pre-booked, or real-time route flexibility, to match passenger requests
- most common vehicle is a midibus

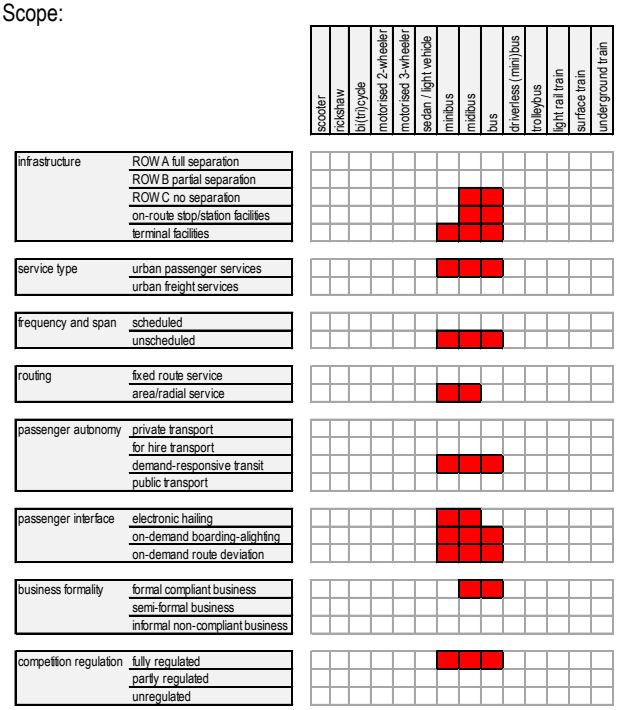
Example services:

- ArrivaClick (United Kingdom)
- Dial-A-Ride (United States)
- Kutsuplus (Finland)
- SAMPLUS (Belgium)
- flx (South Africa)

Example authors:

- Mageean, and Nelson 2003
- Mulley and Nelson 2009
- Mulley *et al.* 2012
- Finn 2012

Scope:



Microtransit

Defining features:

- smartphone application-enabled services
- fixed routes, or real-time route flexibility, to match passenger pick-up and drop-off requests
- most common vehicles are minibuses and midibuses

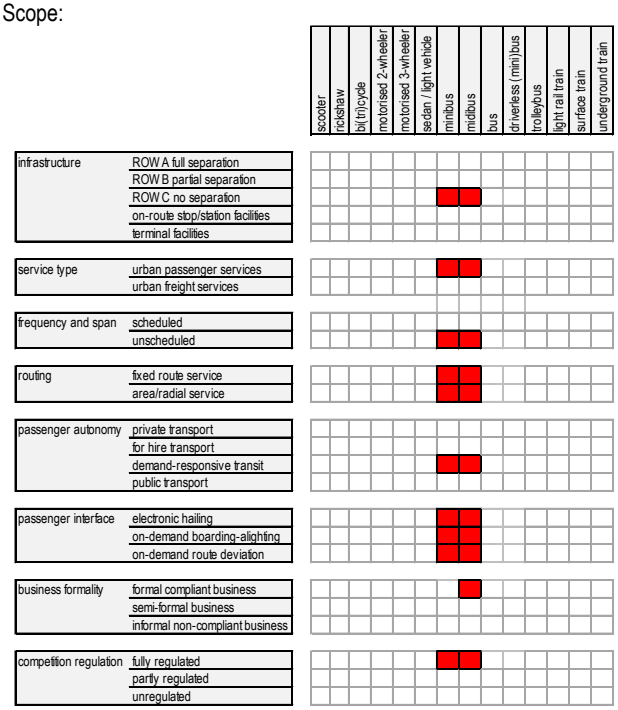
Example services:

- Chariot (United States)
- Bridj (United States)
- Via (United States)

Example authors:

- Shaheen *et al.* 2015
- Shaheen *et al.* 2020
- Westervelt *et al.* 2018

Scope:



Sharing systems (variants: car-sharing; bike-sharing; scooter-sharing)

Defining features:

- registered car-sharing scheme members rent vehicles, at lower costs than conventional car rental
- most common vehicle is a sedan
- use variations include: 'roundtrip'; 'free-floating'; 'peer-to-peer'; and 'fractional ownership'
- bike-share and scooter-share schemes operate on a similar basis, often supported by smartphone apps

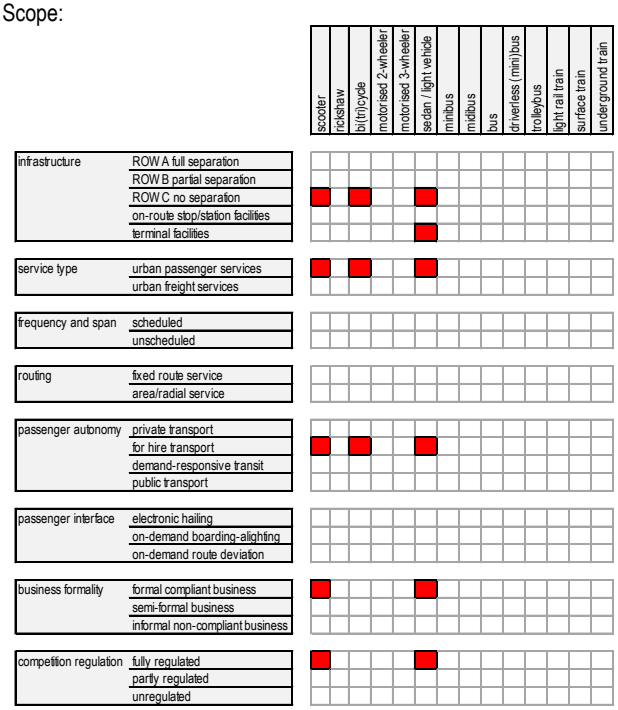
Example services:

- Zipcar (United States)
- City CarShare (United States)
- ByCylken (Denmark)
- Mobike (China)
- Scoot Networks (United States)

Example authors:

- Shaheen *et al.* 1998
- Shaheen and Cohen 2007

Scope:



Ridesharing (variants: carpooling; slugging; vanpooling)

Defining features:

- private cars are shared by multiple passengers to reduce VKT (through fuel cost contributions or rotating vehicle use)
- most common vehicle is a sedan
- carpooling is pre-arranged sharing through (internet or smartphone application) ride-matching services
- slugging is casual real-time carpooling
- vanpooling is pre-arranged sharing on a company owned minibus, without a professional driver

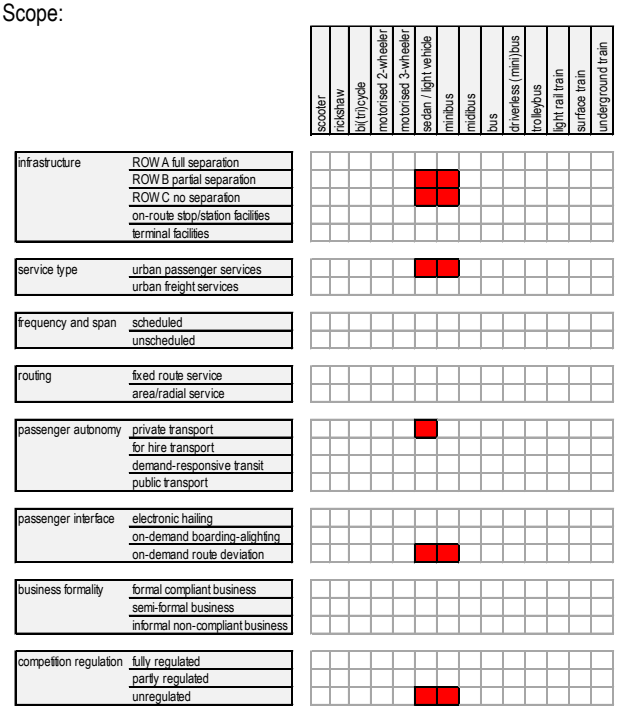
Example services:

- uGoMyWay (South Africa)
- King County Metro Vanpool Program (United States)

Example authors:

- Kelley 2007
- Ma and Wolfson 2013
- Shaheen *et al.* 2015
- Teal 1987

Scope:



Ridesourcing (variants: ride hailing, electronic hailing; courier network services)

Defining features:

- smartphone applications are used to hail roaming vehicles affiliated to Transport Network Companies (TNCs)
- app features can include driver and passenger rating
- most common vehicle is a sedan
- some TNCs (e.g., Uber Eats, Grab) offer supplementary package and food delivery services in tandem with passenger services (termed 'courier network services')

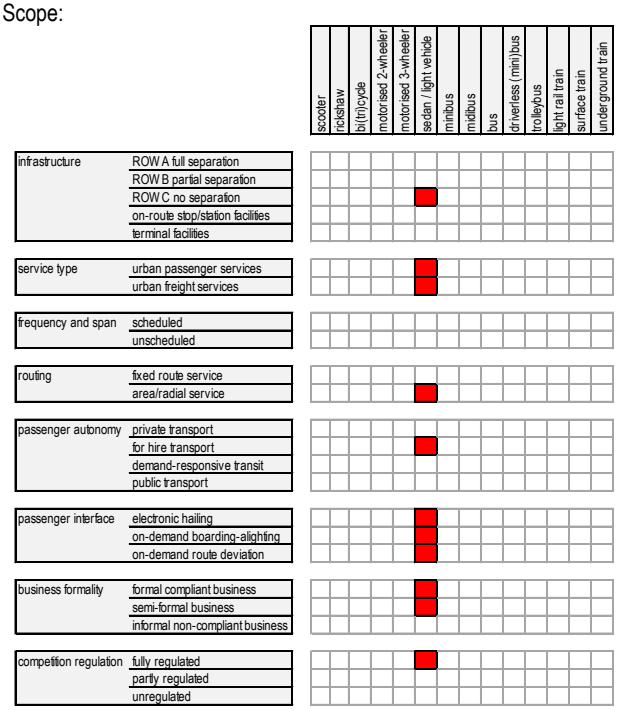
Example services:

- Uber (United States)
- Lyft (United States)
- Bolt (Estonia)
- Didi (China)
- Grab (Singapore)
- Ola (India)

Example authors:

- Shaheen *et al.* 2015
- Wang and Yang 2019

Scope:



Ridesplitting (variant: shared taxi)

Defining features:

- a form of smartphone application-based ridesourcing in which unique passengers, with aligned trip origins and destinations, are matched to the same TNC driver in real time
- fares are split among users
- most common vehicle is a sedan

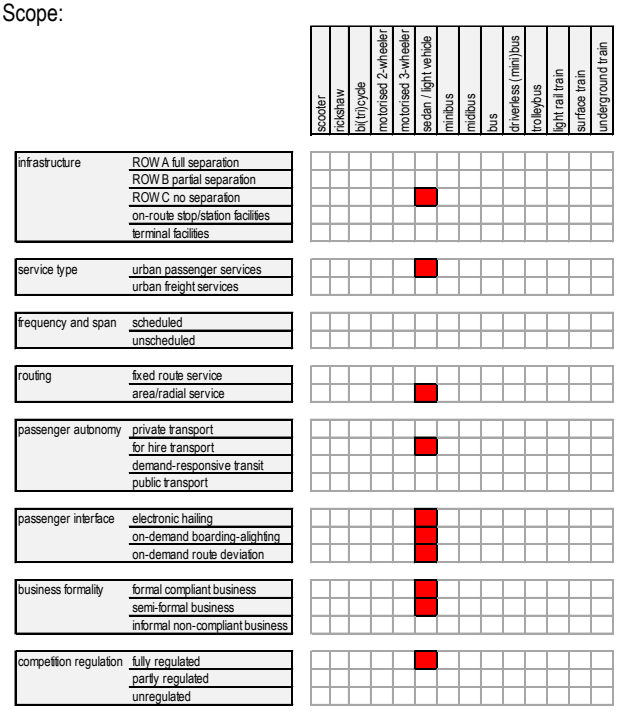
Example services:

- UberPOOL (United States)
- Lyft Line (United States)

Example authors:

- Hosni *et al.* 2014
- Schwieterman and Smith 2018
- Shaheen *et al.* 2015
- Wang and Yang 2019

Scope:



3.3 Definition of scope and chosen terminology

Based on the study's terms of reference, and the earlier analysis of scope in the preliminary literature review, Figure 7 presents the delineated scope chosen for the bibliometric study. An array of possible vehicle types is included, from scooters to driverless minibuses. Services with full right-of-way separation, and fixed schedule and service span operating obligations, are excluded, as are purely private transport modes.

This scope delineation has the following notable features:

- the research field covers formal and regulated, and informal and unregulated, unscheduled or flexible services (with 'informal' and 'unregulated' meaning small private businesses operating without tax compliance and without legal permission from a regulatory authority);
- the research field covers both for-hire and public transport type unscheduled or flexible services (with 'for-hire' meaning services in which the passenger, or group of passengers, have exclusive temporary use of the vehicle, as well as autonomy over the destination and time of service, and 'public transport' meaning services which are shared by multiple passengers and therefore individual passengers do not have autonomy over the route and time of service);
- the research field spans services operating in both the Global South and the Global North; and
- the research field includes emerging innovations in digital platforms, automation, fuel technologies, and the expansion of for-hire passenger service offerings into urban freight delivery.[4]

[4] Courier, parcel and food delivery services, without a complementary passenger service, fall outside the scope of the study.

Figure 7 *Scope delineation*

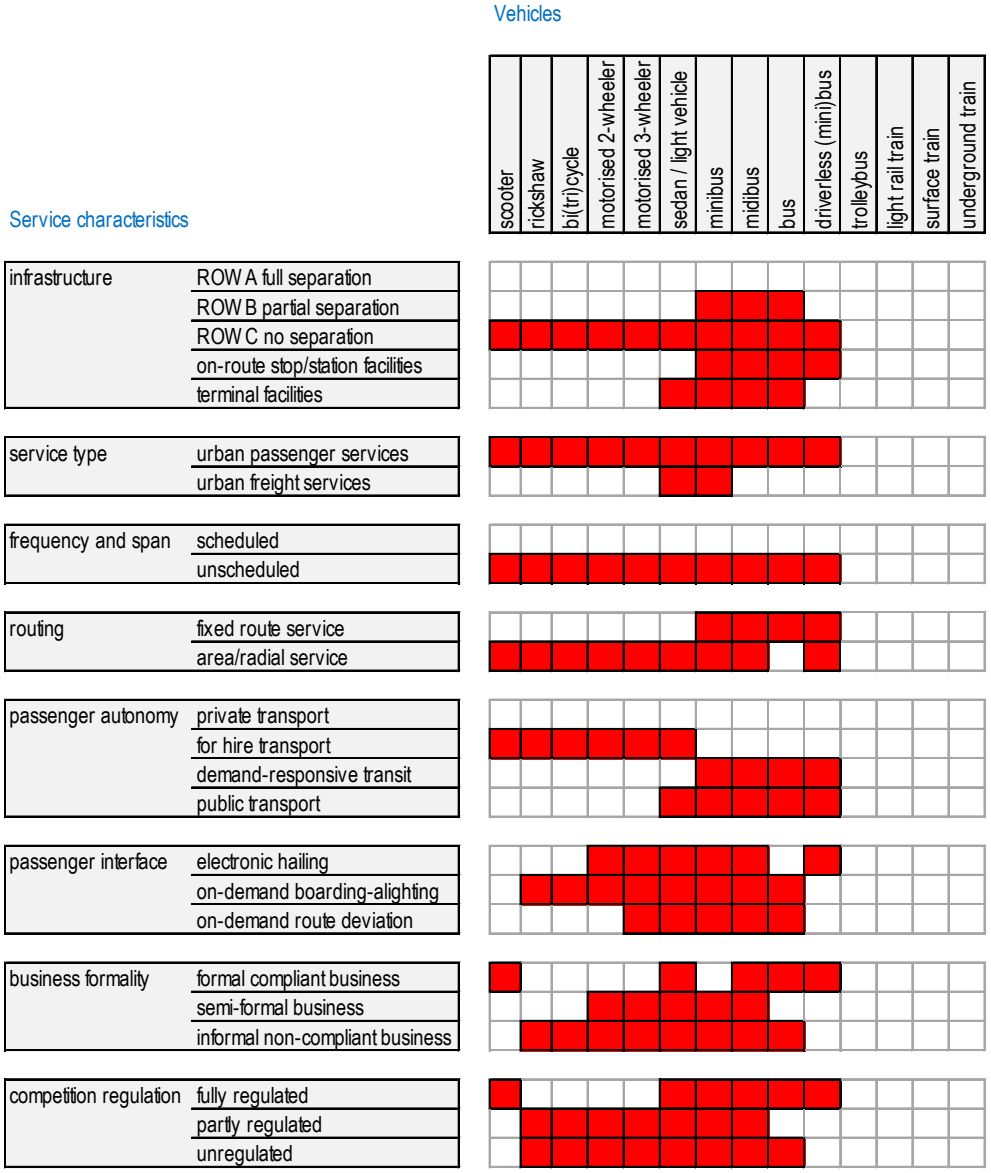
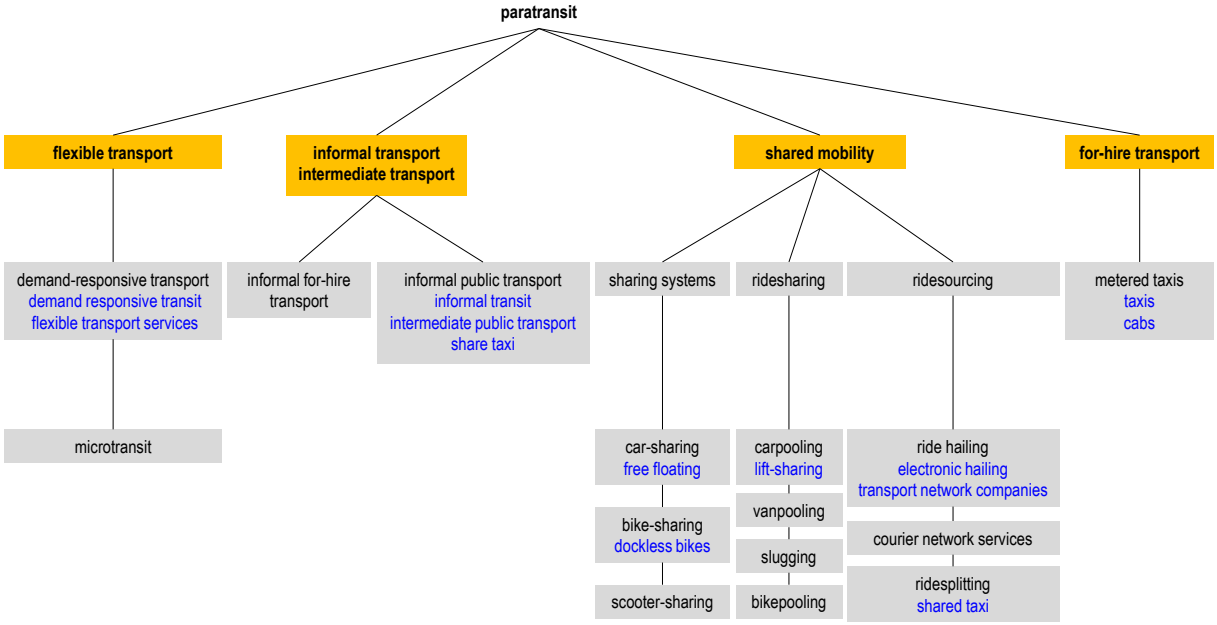


Figure 8 presents the terms selected for use in reporting the results of the bibliometric investigation. In the following chapters, the results will be reported under four main categories of 'paratransit':

- 'flexible transport' (including 'demand-response transport' and 'microtransit');
- 'informal transport' (including 'informal for-hire transport' and 'informal public transport')
- 'shared mobility' (including 'sharing systems', 'ridesharing' and 'ridesourcing')
- 'for-hire transport' (including 'metered taxis')

Figure 8 *Nested research fields*



Note:

1. Terms in black indicate terms selected for use in the reporting of bibliometric findings. Terms in blue indicate synonyms or variants not used in reporting. All terms were, however, included in the search for publications (see Table 1).

4 BIBLIOMETRIC FINDINGS

This chapter presents the findings of the bibliometric investigation. It starts by analysing temporal trends in publication over the review period (Section 4.1). It then analyses the relative attention given to different research fields, and how this has shifted over time (Section 4.2). It goes on to analyse the geographical distribution of lead author affiliations and research contexts (Section 4.3). It ends by analysing patterns of collaboration, and citation, between authors, research institutions and countries (Section 4.4).

4.1 Publication trends

Figure 9 presents growth in publications by lead authors affiliated to research institutions located in the Global North and Global South, illustrating a broadly similar growth trend in both regions, but higher output in the Global North (2 080 vs 1 215 publications in total). Figure 10 drills down into the eight global regions identified for this study, illustrating a relatively stronger growth trend in Europe, Eastern Asia and Northern America. Figure 11 drills down further into the top 20 countries, illustrating a dramatic increase in publication output from research institutions in China, and to a lesser extent in the United States, relative to the rest. So, the near parity of growth trends in the Global North and Global South observed in Figure 9 is due largely to China's contribution (accounting for 55% of all publication in the Global South).

Figure 9 *Annual publication trends in the Global North and Global South (N=2 961, 2010-2020)*

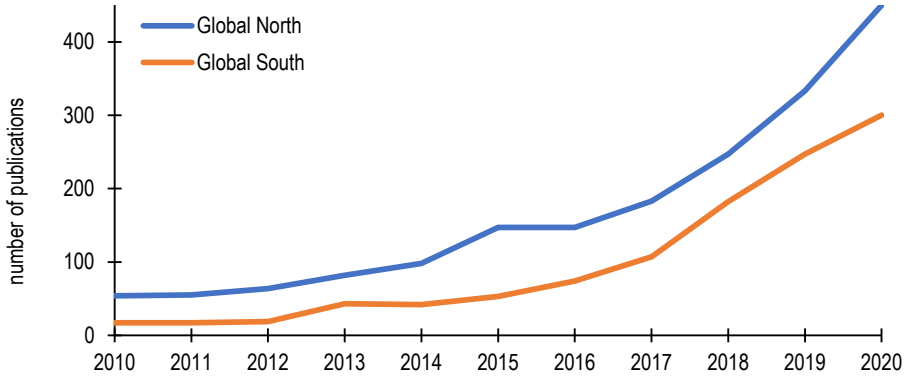


Figure 10 *Annual publications, by global region (N=2 961, 2010-2020)*

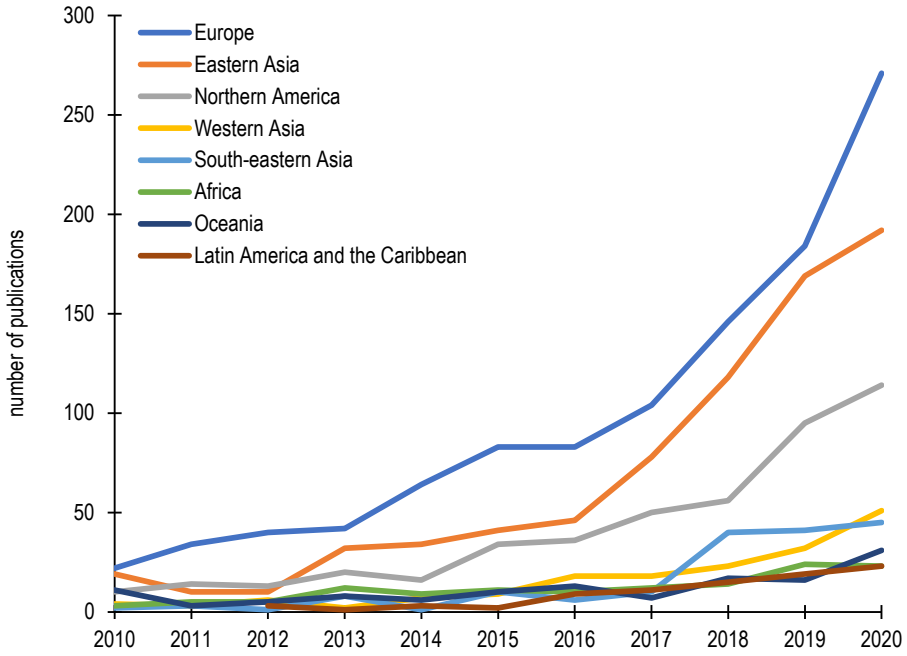
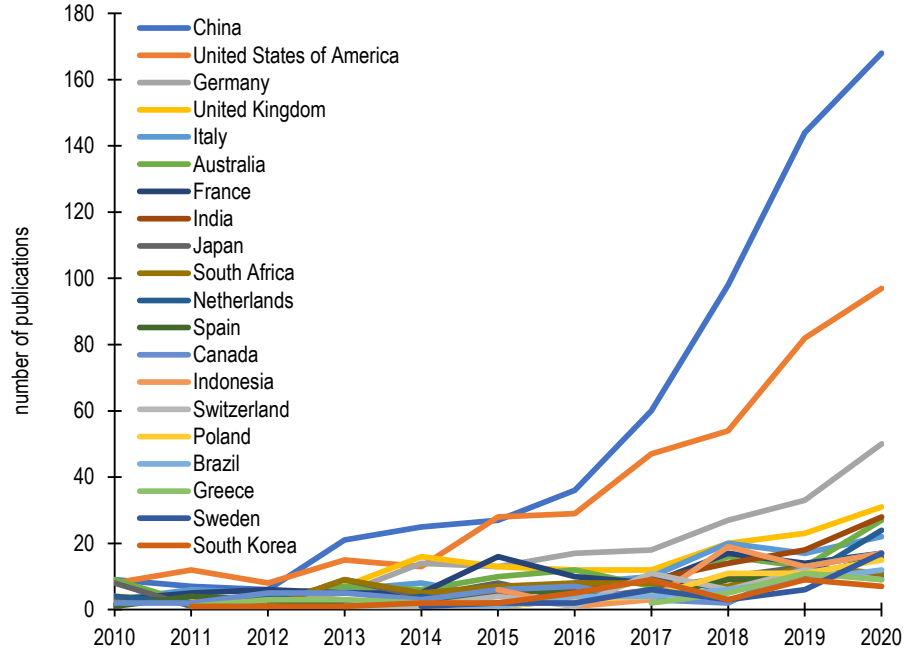


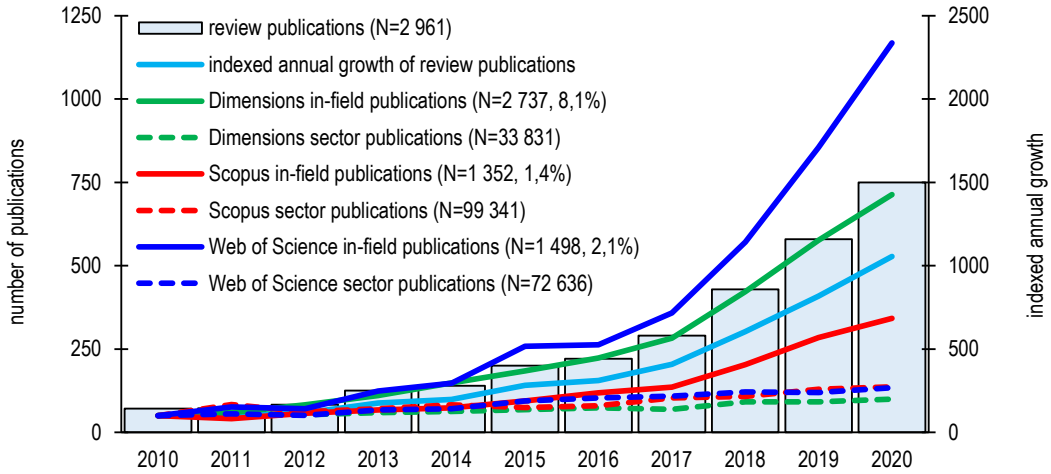
Figure 11 *Annual publications, by top 20 countries (N=2 961, 2010-2020)*



Absolute growth in publications is, however, not necessarily an indication that the field of study is attracting greater attention, as the introduction of new journals (as online formats have reduced the cost of publishing) and growing pressure on academics to 'publish or perish' over the past decade has likely increased the overall quantity of academic output. To control for this, Figure 12 compares an indexed growth of in-field publications, with that of all publications within the transportation sector. This analysis shows that the growth of transport sector publications in the three main databases (Dimensions, Scopus and Web of Science), with annual growth rates ranging between 7,2% and

10,6%, is significantly lower than the annual growth rates of the in-field publications found within these databases. The annual growth rate of in-field publications derived from the Dimensions database was 30,5%, 21,2% for in-field publications from the Scopus database, and 37,0% for in-field publications from the Web of Science database. The field of study has, therefore, clearly grown rapidly.

Figure 12 *Indexed annual growth of publication, by database (2010-2020)*



Notes:
1. Dimensions sector publications = 'Transportation and Freight Services' category
2. Scopus sector publications = 'Transportation' All Science Journal Classification (ASJC) field name
3. Web of Science sector publications = 'Transportation' and 'Transportation Science and Technology' categories
4. The databases are analysed independently, as there is some duplication of publications across them.
5. The term 'in-field' refers to publications found in the respective databases that fall within the defined scope of the study.

4.2 Research fields

Having explored where growth in publications has occurred, the following four figures shift attention to the fields of research. Figure *13* illustrates that bike-sharing, ride hailing, metered taxis and car sharing have received greater attention than other fields in recent years. Considering the four main research field categories in this study, the annual growth rate of shared mobility publications was highest (38,6%), followed by informal transport (21,5%), for-hire transport (16,4%), and flexible transport (11,2%). Figure 14 presents indexed annual growth rates for disaggregated research fields, and for crude benchmarking purposes, compares these to a weighted mean growth rate of transportation sector publications in the three main databases. This figure indicates that the fastest growth in publications has been experienced in bike-sharing, ride hailing and scooter-sharing (albeit from a low base).

Figure 13 *Annual publications, by research field (N=2 961, 2010-2020)*

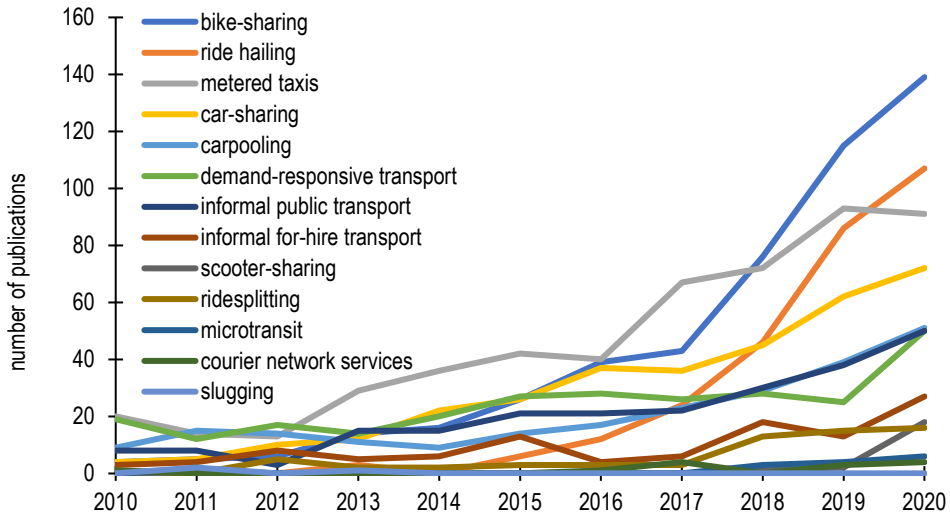


Figure 14 *Indexed growth of annual publications, by research field (N=2 961, 2010-2020)*

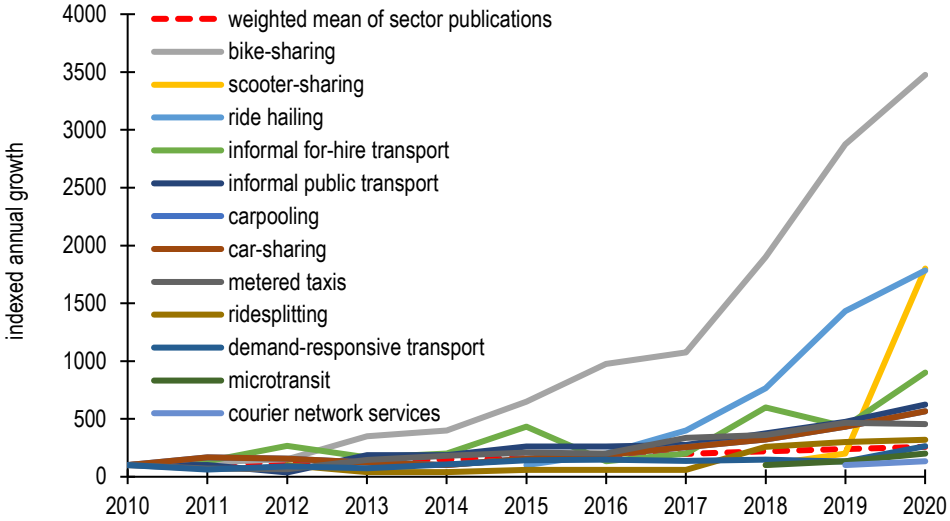
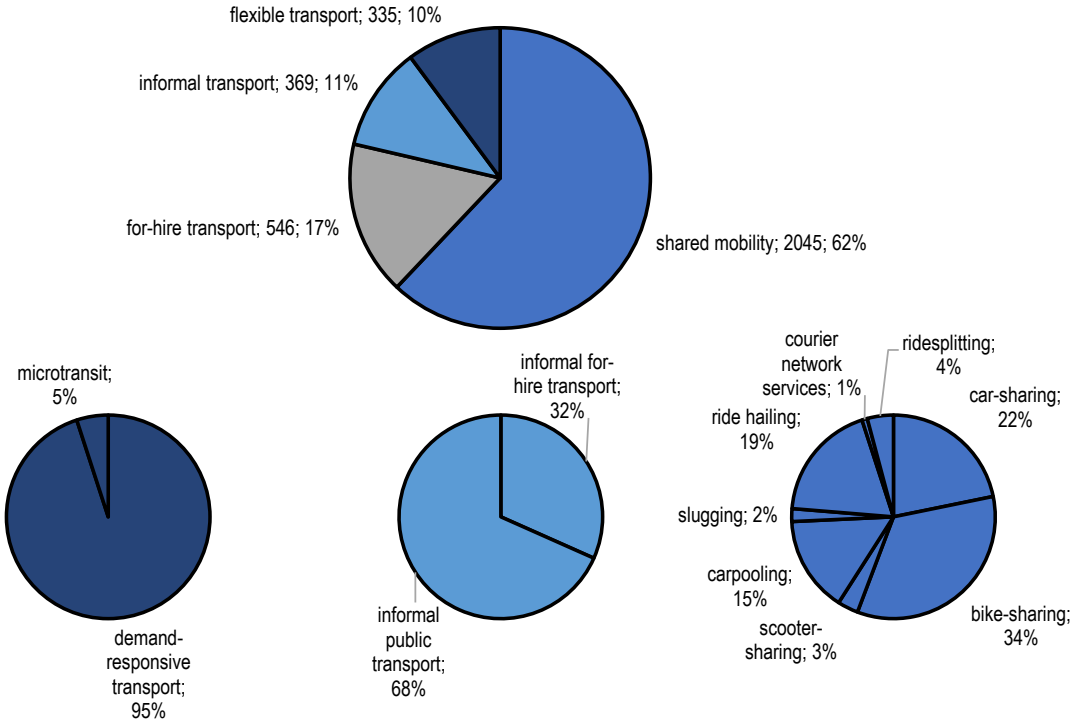


Figure 15 illustrates the proportion of publications in the different research fields, across the entire study period. Unsurprisingly, given the growth observed earlier in bike-sharing, ride hailing and car-sharing, 62% of publications fall into the shared mobility research field category, followed by for-hire transport (17%), informal transport (11%) and flexible transport (10%). The lower half of the figure presents a disaggregation of these fields.

Figure 15 *Research fields (N=3 295, 2010-2021)*



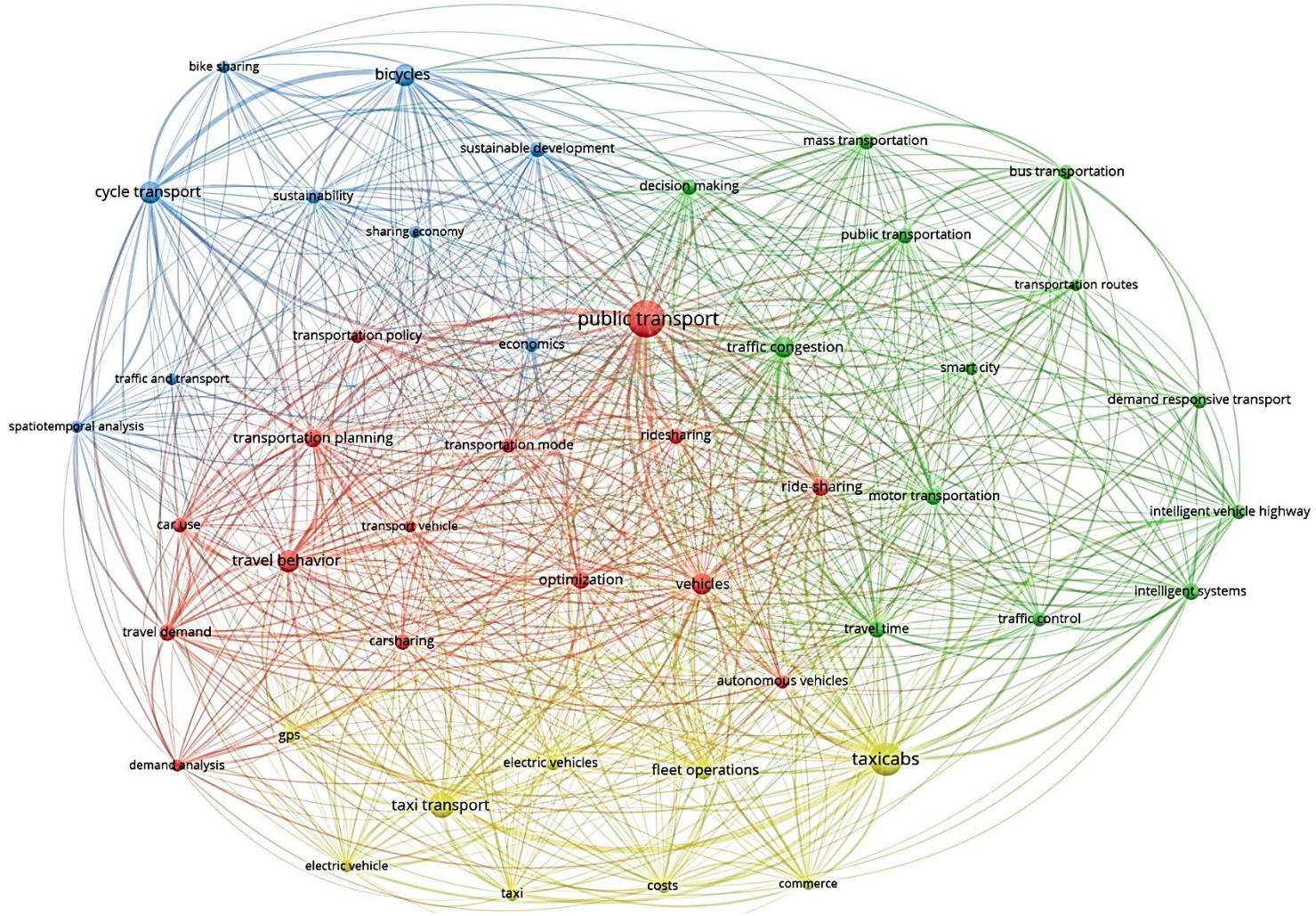
Notes:
1. There is no further breakdown of 'for-hire transport' as there were no sub-categories introduced in research field coding.

An alternative, weakly triangulating, perspective on attention to research fields can be derived from abstract keyword co-occurrence analysis (see Figure 16). This analysis reveals four main thematic clusters: a (blue) cluster around bicycle and bike-sharing; a (yellow) cluster around metered taxis; a (red) cluster around travel behaviour and sharing systems and ridesharing; and a (green) cluster around technology and public transport. Regulation and formality do not emerge from this co-occurrence networking, suggesting these themes have received less attention.

4.3 Research activity distributions

The following two figures explore where publications have been produced, and the contexts they have studied. Figure 17(a) maps the distribution of lead author affiliations across countries, with the resulting heatmapping reflecting the dominance of China and the United States found in earlier top 20 country analysis (see Figure 11). Figure 17(b) maps those publications in which a single country research context could be identified. Of the 1 309 (39,7%) publications excluded from this map, 175 (5,3%) were multi-country research contexts, and 1 134 (34,4%) where purely theoretical or technical in nature, and therefore coded as acontextual. The heatmapping reveals, unsurprisingly, that China and the United States have received greatest research attention, but also that there are countries, particularly in Sub-Saharan Africa, that received no dedicated attention in the publications found (but some may of course have formed a part of multi-country studies). The global distribution of research activity in the subject field, and the country contexts that have been studied, is therefore uneven.

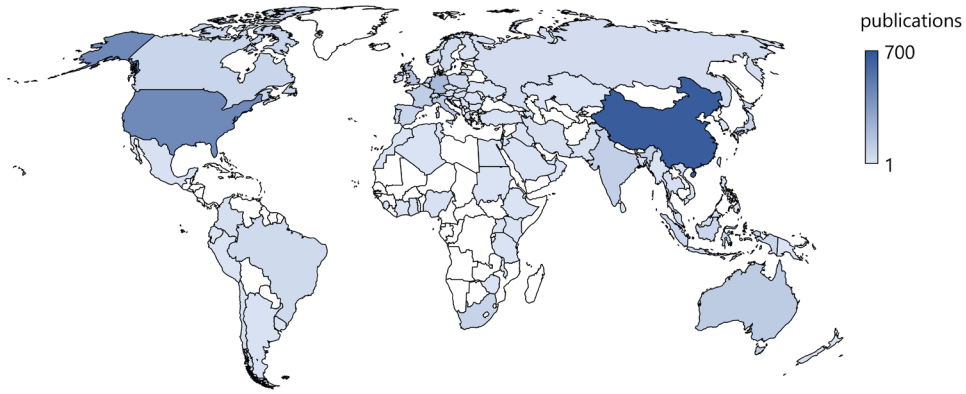
Figure 16 *Research field co-occurrence network, from keywords in publication abstracts (2010-2021)*



Notes:
1. Plot data includes only keywords mentioned at least 35 times in in-field publication abstracts, and is derived from Scopus (N=1 518) data.
2. The network is generated by the software VOSviewer. The size of plot circles indicates how often a keyword is mentioned. Circle colours indicate a clustering of similar research themes.

Figure 17 *Global distribution of research activity (2010-2020)*

(a) lead author affiliation country (N=3 295)



(b) research context country (N=1 986)

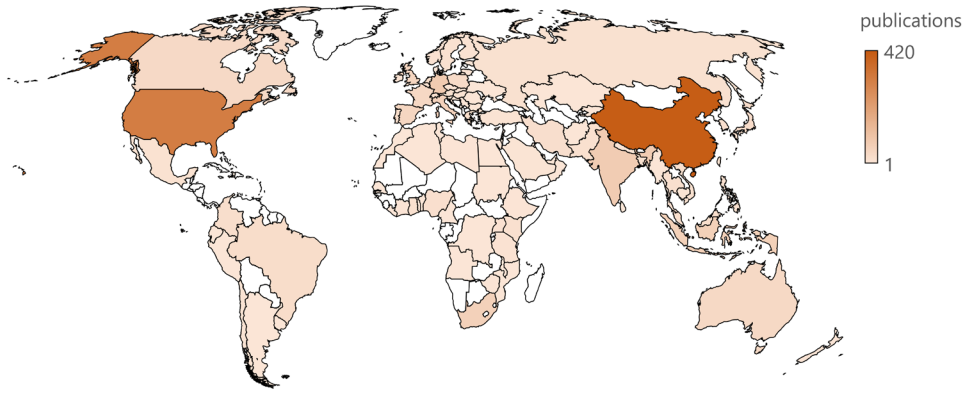
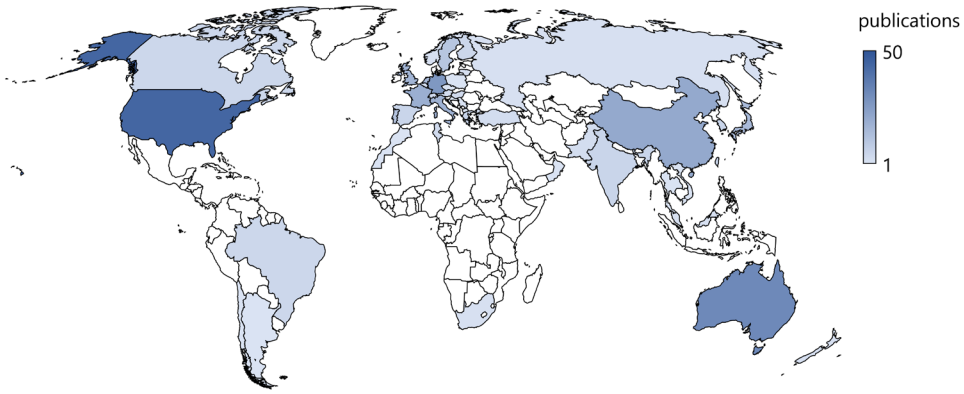


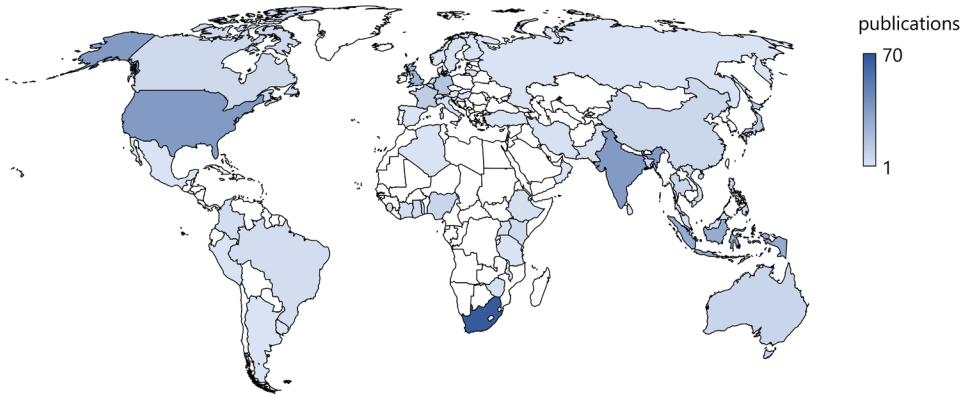
Figure 18 (a-d) disaggregates the distribution of lead author affiliations into the four main research field categories. The heatmapping reveals that most publications concerning flexible transport were produced by lead authors at research institutions in the United States (13,1%), followed by Australia (9,6%) and Germany (8,1%). Most publications concerning informal transport were produced by institutions in South Africa (18,2%%), followed by India (9,8%) and the United States (9,8%). Most publications concerning shared mobility were produced by institutions in China (19,3%), followed by the United States (15,0%) and Germany (6,9%). Most publications concerning for-hire transport were produced by institutions in China (44,1%), followed by the United States (9,9%) and the United Kingdom (2,7%). The unevenness of global research activity distribution is therefore even more pronounced when the subject field is disaggregated.

Figure 18 *Distribution of lead author affiliation country, by research field*

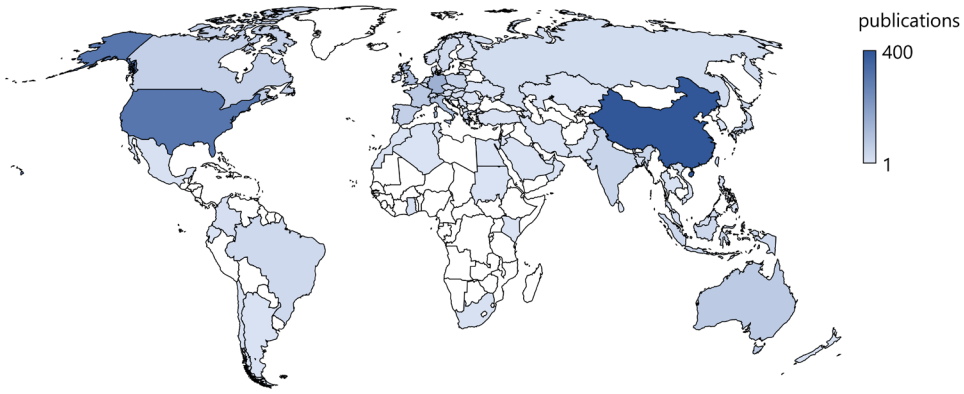
(a) flexible transport publications (N=335, 2010-2021)



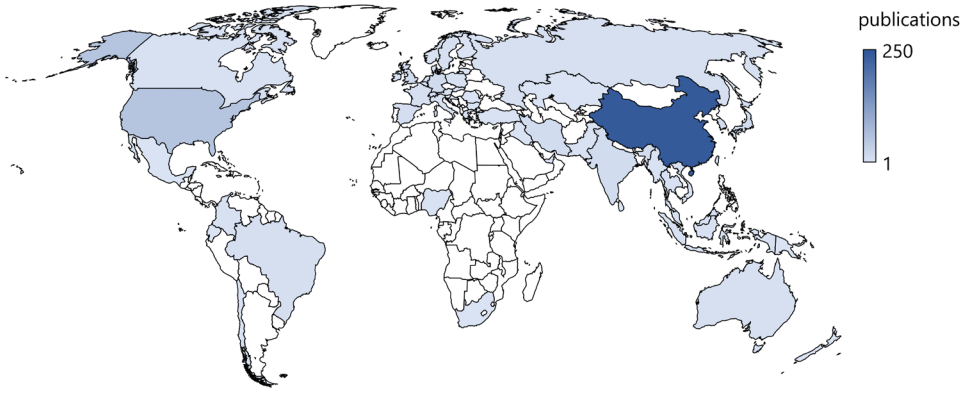
(b) informal transport publications (N=369, 2010-2021)



(c) shared mobility publications (N=2 045, 2010-2021)



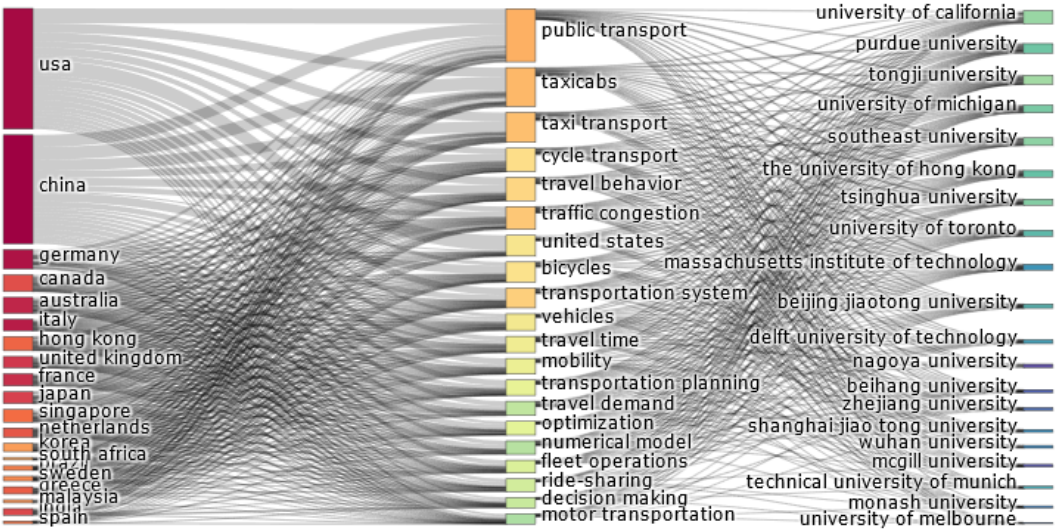
(d) for-hire transport publications (N=546, 2010-2021)



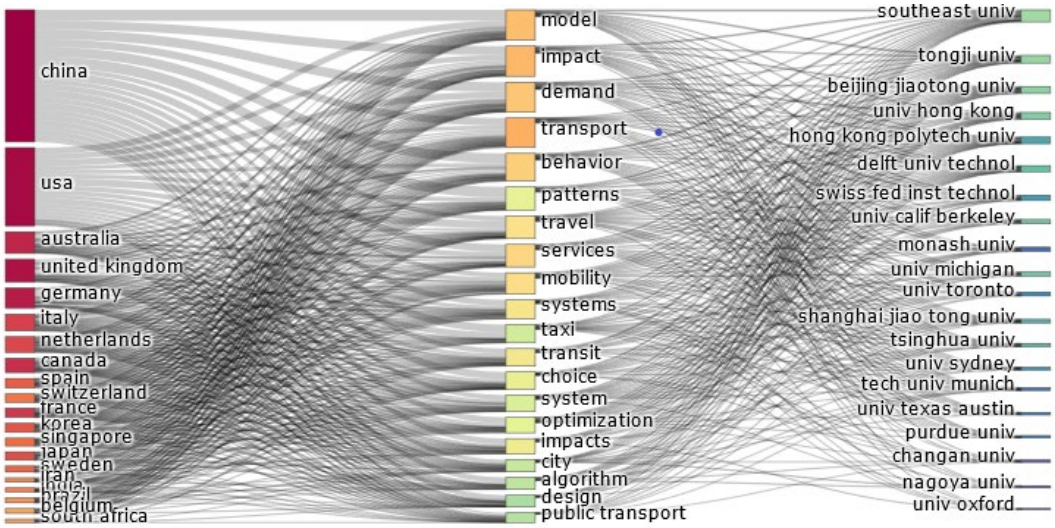
An alternative perspective on the geographical distribution of research activity can be derived from Sankey plotting. Figure 19(a-b) presents three-field plots of the top 20 most productive countries, the top 20 occurring keywords in abstracts, and the top 20 most productive research institutions, for the Scopus and Web of Science databases respectively. The plots corroborate the dominance of China and the United States in publication output found in earlier analysis, and illustrate, somewhat obscurely, the diversity of research fields authors in these countries engage in. A hallmark of the large body of research undertaken in China is the application of mathematical modelling methods in the optimisation of for-hire and shared mobility services.

Figure 19 *Three-field plot: top 20 countries; keywords; and lead author affiliations (2010-2021)*

(a) in-field Scopus data (N=1 518)



(b) in-field Web of Science data (N=1 705)



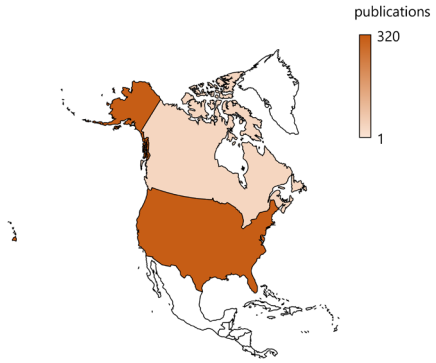
Notes:
1. The plot is generated by the software Biblioshiny.
2. The databases are analysed independently, as there is some duplication of publications across them.

The following eight figures explore the geographical distribution of research activities within, and about, each of the eight global regions. Part (a) of each figure maps the amount of research attention different countries in the region received. Part (b) maps where the lead authors, who have undertaken research focussed on countries within the region, are located. The supplementary text provides insight into the degree to which in-region research has been conducted by in-region authors, as well as insight into the attention given to different research fields.

In some cases, the large majority of publications are written in-region. Most notably, 93% of publications about Oceania were written by lead authors at Oceanic research institutions, and 93% of publications about Europe were written by lead authors at European research institutions. In other regions, a larger proportion of publications are written outside the region. Most notably, 36% of publications about Africa were written by lead authors at research institutions outside Africa, and, somewhat surprisingly, 30% of publications about Northern America were written by lead authors affiliated to research institutions outside the region. The former is perhaps explained by lower research capacity and funding (e.g., the mean number of SciVal authors at the top five African research institutions was 5,4, compared to 43,8 in Eastern Asia), whereas the latter is perhaps explained by a higher level of international co-authorship (sufficiently detailed data on secondary co-authorship affiliation to test this is however not available).

Figure 20 *Distribution of publications focussed on Northern America (N=351, 2010-2021)*

(a) research context of publications



number of publications:	351
number of authors:	1 049
lead authors inside region (%):	70
lead authors outside region (%):	30
flexible transport publications (%):	8
informal transport publications (%):	1
shared mobility publications (%):	75
for-hire transport publications (%):	15

(b) lead author affiliations

Figure 21 *Distribution of publications focussed on Latin America and the Caribbean (N=75, 2010-2021)*

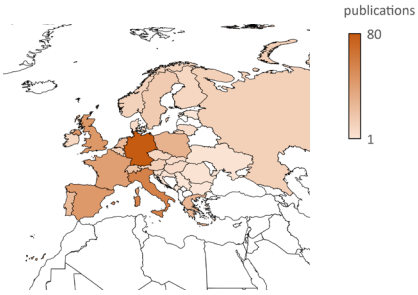
(a) research context of publications

number of publications:	75
number of authors:	239
lead authors inside region (%):	84
lead authors outside region (%):	16
flexible transport publications (%):	1
informal transport publications (%):	20
shared mobility publications (%):	60
for-hire transport publications (%):	19

(b) lead author affiliations

Figure 22 *Distribution of publications focussed on Europe (N=534, 2010-2021)*

(a) research context of publications



number of publications:	534
number of authors:	1 660
lead authors inside region (%):	93
lead authors outside region (%):	7
flexible transport publications (%):	12
informal transport publications (%):	1
shared mobility publications (%):	76
for-hire transport publications (%):	11

(b) lead author affiliations

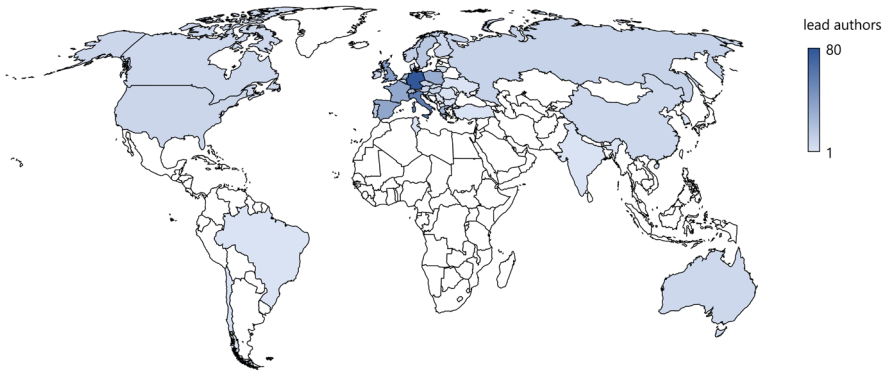
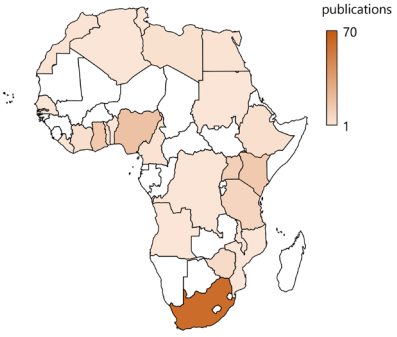


Figure 23 *Distribution of publications focussed on Africa (N=169, 2010-2021)*

(a) research context of publications



number of publications:	169
number of authors:	435
lead authors inside region (%):	64
lead authors outside region (%):	36
flexible transport publications (%):	4
informal transport publications (%):	81
shared mobility publications (%):	12
for-hire transport publications (%):	4

(b) lead author affiliations

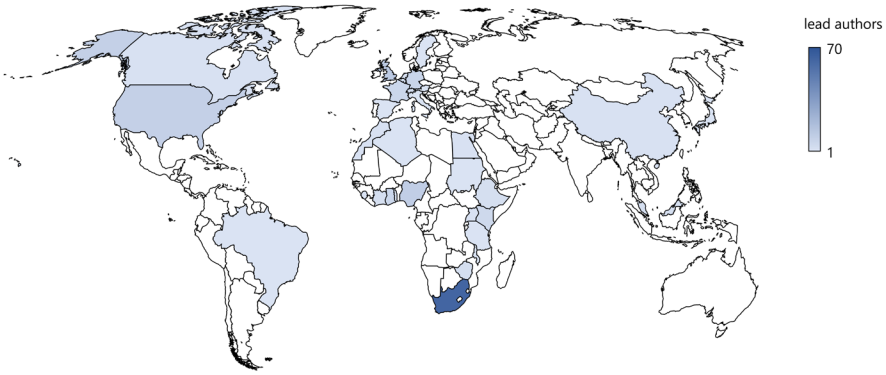
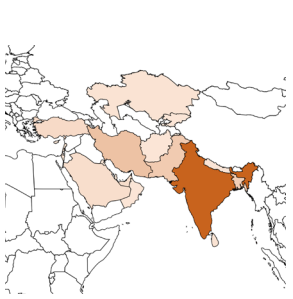


Figure 24 *Distribution of publications focussed on Western Asia (N=163, 2010-2021)*

(a) research context of publications



number of publications:	163
number of authors:	500
lead authors inside region (%):	74
lead authors outside region (%):	26
flexible transport publications (%):	6
informal transport publications (%):	39
shared mobility publications (%):	37
for-hire transport publications (%):	17

(b) lead author affiliations

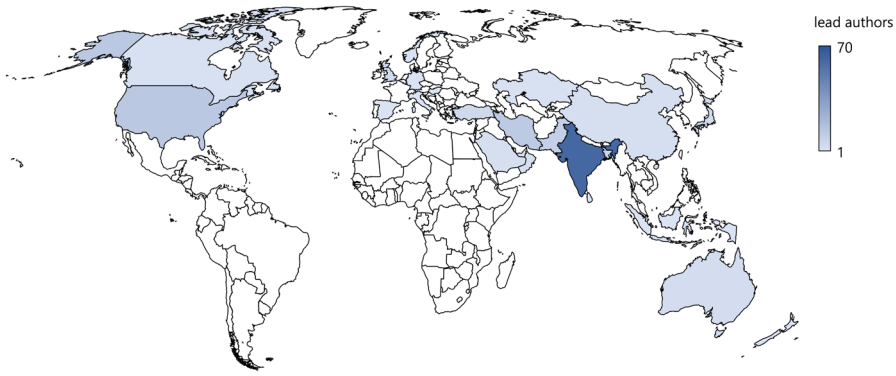
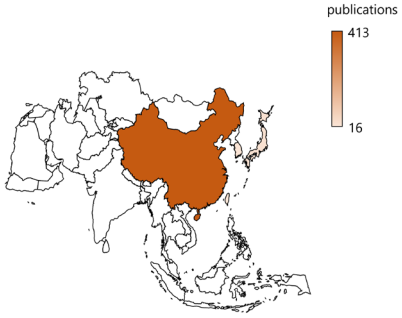


Figure 25 *Distribution of publications focussed on Eastern Asia (N=476, 2010-2021)*

(a) research context of publications



number of publications:	476
number of authors:	1 858
lead authors inside region (%):	86
lead authors outside region (%):	14
flexible transport publications (%):	4
informal transport publications (%):	1
shared mobility publications (%):	59
for-hire transport publications (%):	36

(b) lead author affiliations

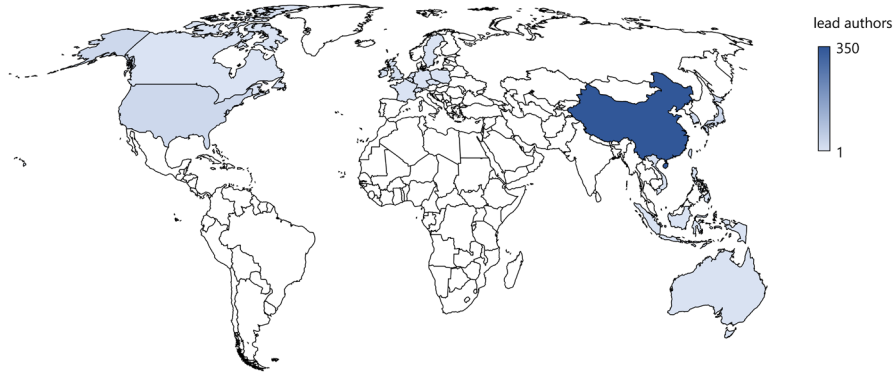
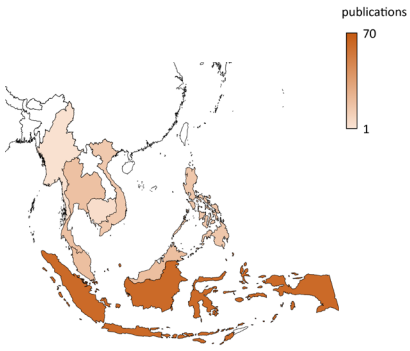


Figure 26 *Distribution of publications focussed on South-eastern Asia (N=174, 2010-2021)*

(a) research context of publications

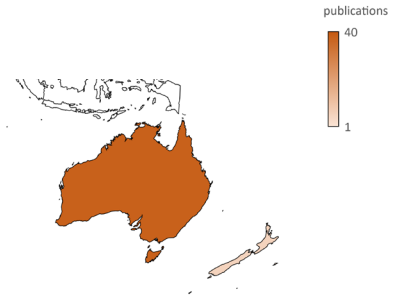


number of publications:	174
number of authors:	569
lead authors inside region (%):	74
lead authors outside region (%):	26
flexible transport publications (%):	4
informal transport publications (%):	38
shared mobility publications (%):	43
for-hire transport publications (%):	15

(b) lead author affiliations

Figure 27 *Distribution of publications focussed on Oceania (N=45, 2010-2021)*

(a) research context of publications



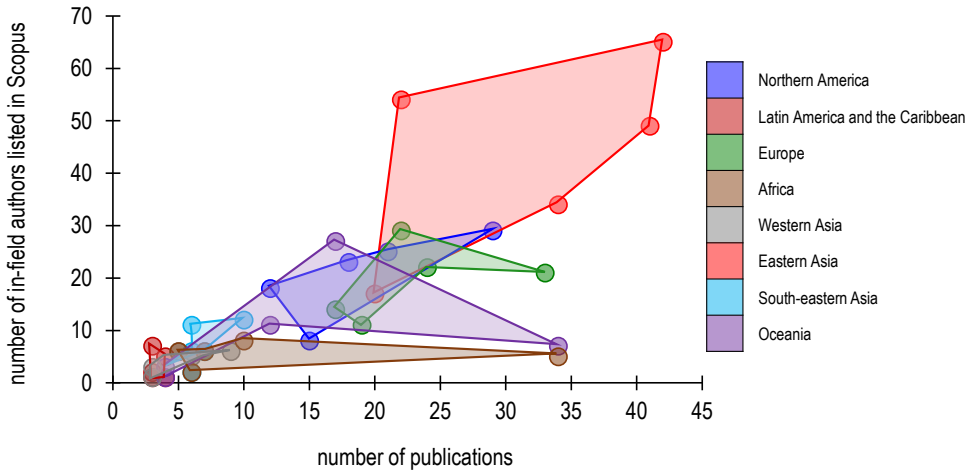
number of publications:	45
number of authors:	130
lead authors inside region (%):	93
lead authors outside region (%):	7
flexible transport publications (%):	27
informal transport publications (%):	0
shared mobility publications (%):	64
for-hire transport publications (%):	9

(b) lead author affiliations

4.4 Authorship and collaborations

The purpose of this section is to explore patterns of collaboration and citation, at an author, research institution and country level. Figure 29 plots the number of authors and publications of the top five research institutions in each of the eight global regions. The figure illustrates the research capacity strength, and associated publication output, of the Eastern Asia institutions relative to the other regions.

Figure 28 *Top 5 research institutions' publications and authors, by global region (N=3 295, 2010-2020)*



Notes:
1. Leading research institutions were identified by an institution ranking index, comprised of a weighted: publication output score (50%; mean author productivity score (25%); a mean author impact score (based on in-field Scopus citation data) (20%); and a research capacity score (based on the number of Scopus authors) (5%).

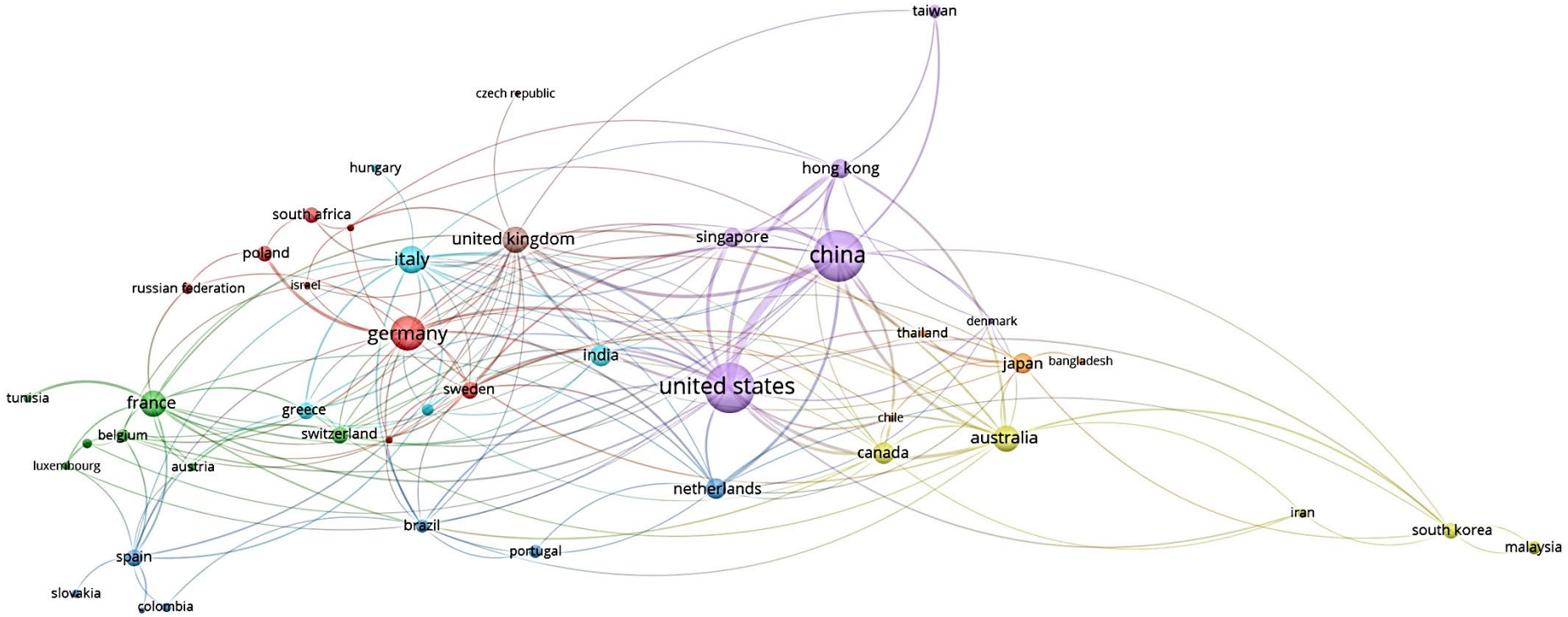
Figure 29 presents a global collaboration network analysis of multi-country co-authored, in-field publications. This analysis shows that, by a considerable margin, Chinese and American authors produced most multi-country co-authored publications, followed by Germany, Italy and the United Kingdom. The width of network linkages, together with cluster colours, suggest particularly strong collaboration between China and the United States, and between China and other East Asian countries. The pattern of network linkages also demonstrates that the European countries (particularly France, Germany, Italy, The Netherlands, Spain, and the United Kingdom) have strong cultures of international collaboration, presumably in part due to the requirements of European research funding frameworks.

As a counterpart of collaboration, Figure 30 presents a global network analysis of in-field citations. The pattern that emerges is similar to that of multi-country collaboration, in so far as the United States and China produce the greatest number of citations, followed by Germany. The width of network links suggests particularly strong citation linkages between the United States and China, Canada, Germany, and Italy.

The following eight figures (Figure 31 to Figure 38) unpack country collaboration networks by global region. The networks for Northern America and Europe reveal strong interregional collaborations, largely contained within the Global North. The networks for Latin America and Western Asia reveal less extensive interregional collaborations, but extended across the Global South and the Global North. The strongest South-North collaborations can be observed in the networks for Eastern Asia, followed by Oceania and South-eastern Asia. Eastern and South-eastern Asia also reveal South-South collaborations, and Oceania North-North collaboration. In contrast to the other global regions, the network for Africa reveals largely in-region collaboration.

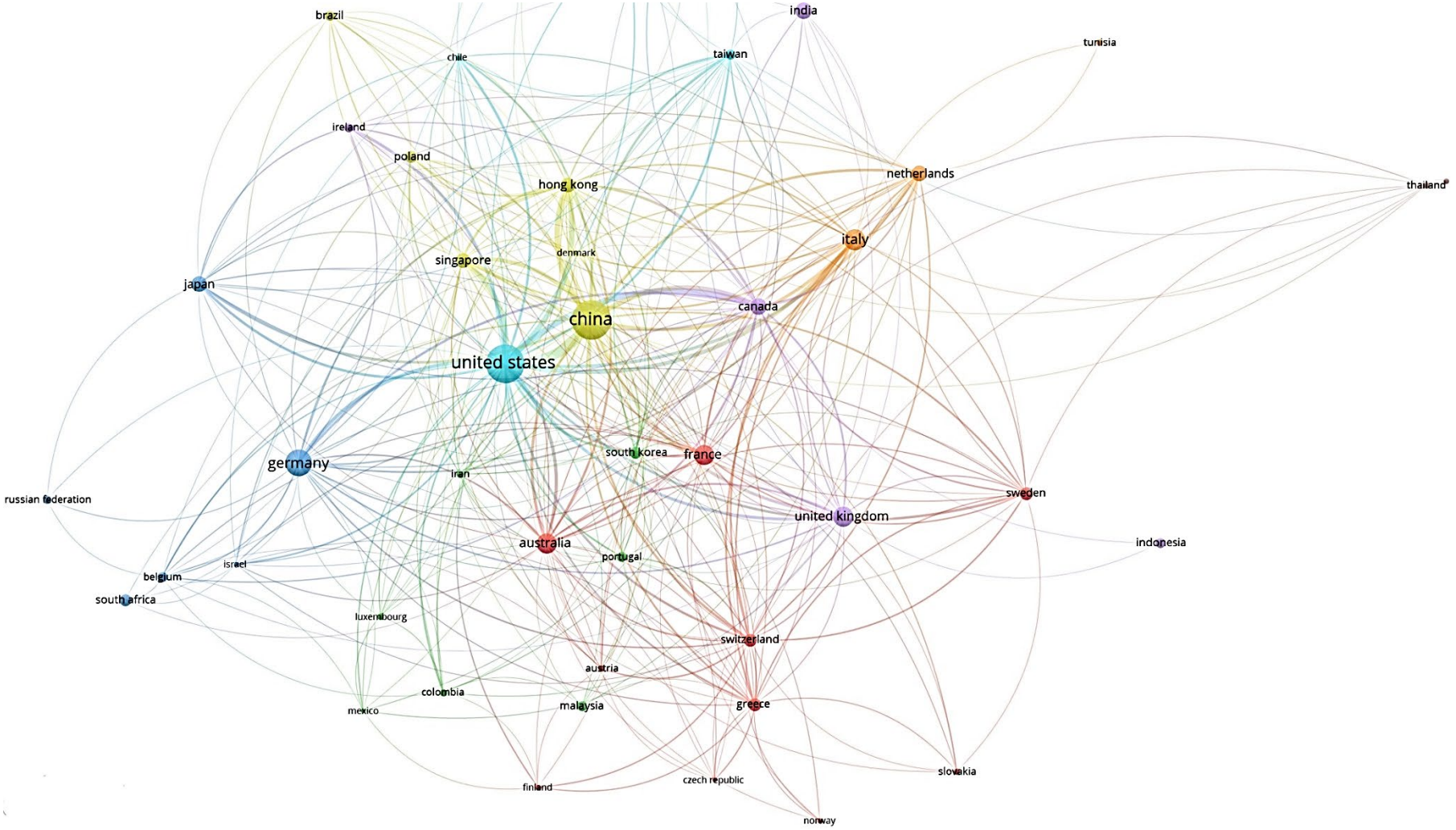
The following four maps (Figure 39 to Figure 41) explore collaboration through geographical mapping. Figure 39(a-b) maps multi-country co-authorship linkages between countries, using in-field Scopus and Web of Science data. Read together, the heatmapping and link widths confirm the dominance of the United States and China in collaboration observed in earlier analysis, and, perhaps more usefully, highlight which countries do not collaborate with others in the study field (with the obvious gaps in Africa, Latin America, and Western Asia). Figure 40 provides an, unfortunately heavily obscured, complement to Figure 39(a), indicating what percentage of a country's publications are written with authors from another country. The pattern revealed suggests that larger, more productive countries have a smaller proportion of publications with multi-country co-authorship, even if they produce the greatest amount of international collaboration (e.g. the United States at 46%), whereas publications from countries with relatively small outputs are more likely to be international collaborations (e.g., New Zealand at 100%, and a group of unidentifiable African and South-eastern Asian countries). Figure 43 maps those publications in the study database that were coded as having multi-country research contexts. The heatmapping suggests that the United Kingdom and United States were the countries most likely to produce publications focussed on multi-country contexts.

Figure 29 *Country collaboration networks (2010-2021)*



Notes:
1. In-field co-authorship data are extracted from the (N=1 518) Scopus data.
2. The network is generated by the software VOSviewer. The size of plot circles indicates the number of multi-country co-authored publications produced by that country. Plot circle colours indicate a clustering of similar research themes.

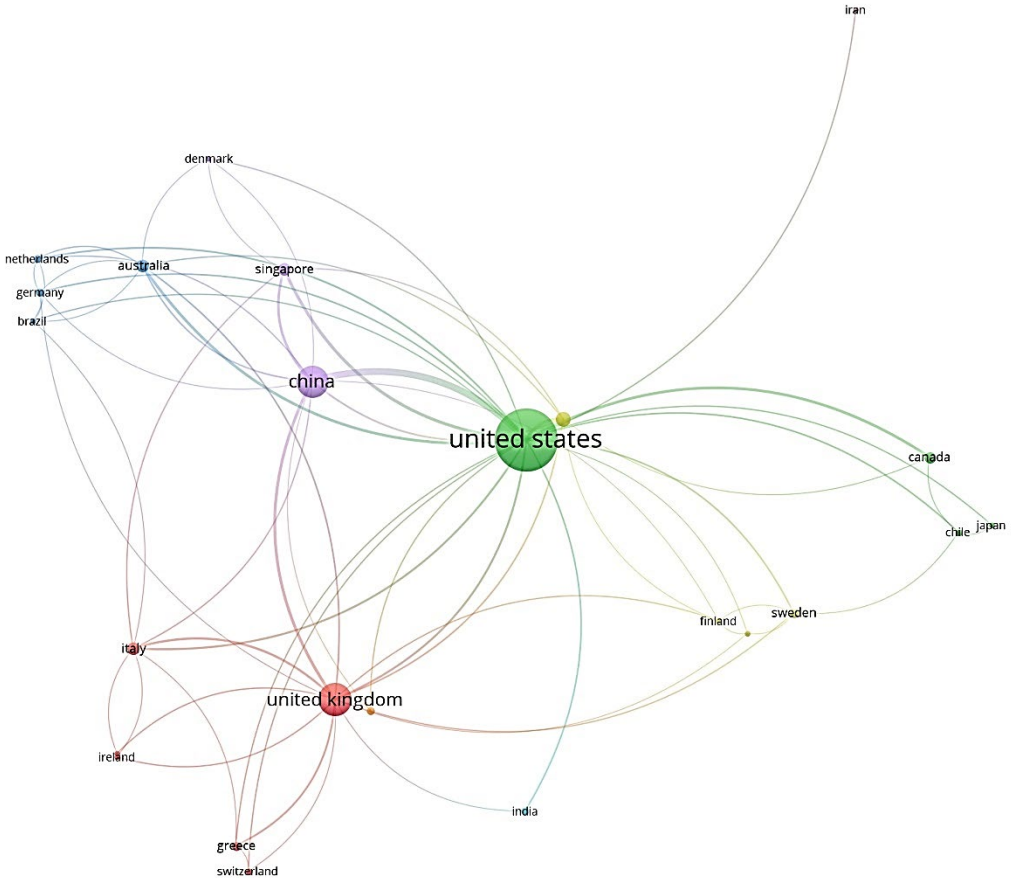
Figure 30 *Country citation networks (2010-2021)*



Notes:

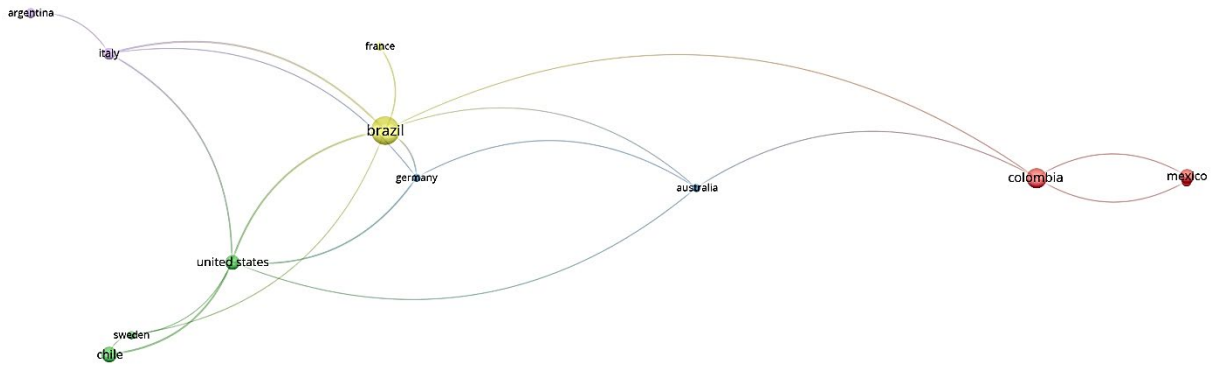
1. Plot data includes only authors with at least five in-field citations, and is derived from (N=1 518) Scopus data.
2. The network is generated by the software VOSviewer. The size of plot circles indicates how often authors affiliated to research institutions in that country have been cited by authors from other countries, and the width of lines between countries indicates the amount of citations between authors in the two countries. Plot circle colours indicate a clustering of similar research themes.

Figure 31 *Northern America country collaboration network (2010-2021)*



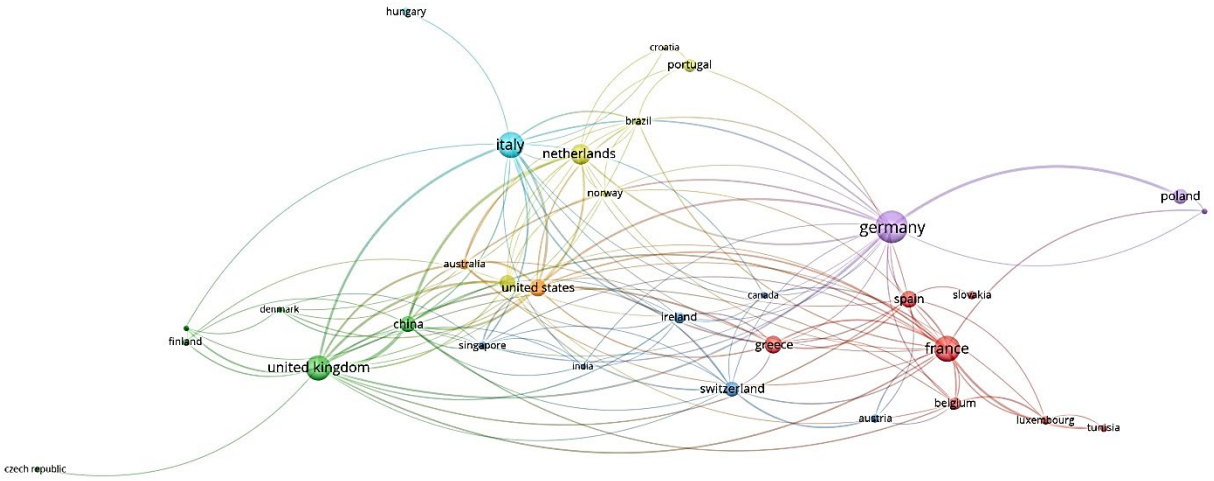
Notes:
1. The network is generated by the software VOSviewer, with Scopus data. The size of plot circles indicates the number of multi-country co-authored publications produced by that country. Plot circle colours indicate a clustering of similar research themes.

Figure 32 *Latin American and the Caribbean country collaboration network (2010-2021)*



Notes:
1. The network is generated by the software VOSviewer, with Scopus data. The size of plot circles indicates the number of multi-country co-authored publications produced by that country. Plot circle colours indicate a clustering of similar research themes.

Figure 33 *Europe country collaboration network (2010-2021)*

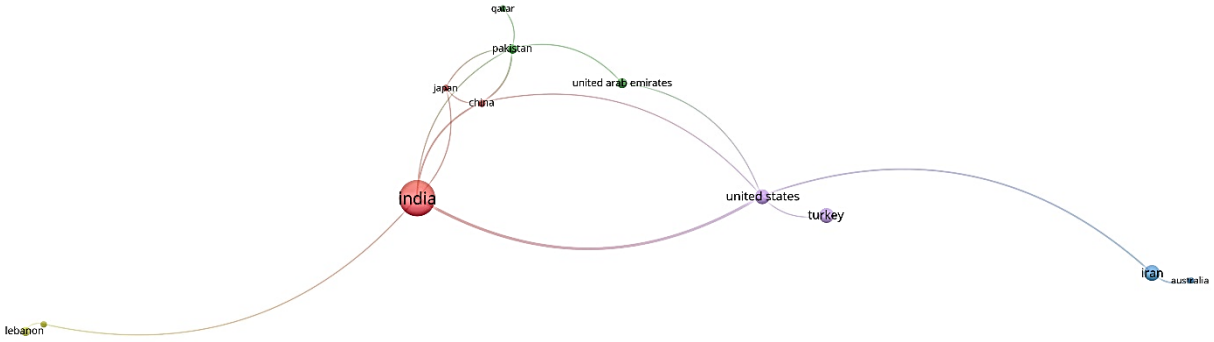


Notes:
1. The network is generated by the software VOSviewer, with Scopus data. The size of plot circles indicates the number of multi-country co-authored publications produced by that country. Plot circle colours indicate a clustering of similar research themes.

Figure 34 *Africa country collaboration network (2010-2021)*

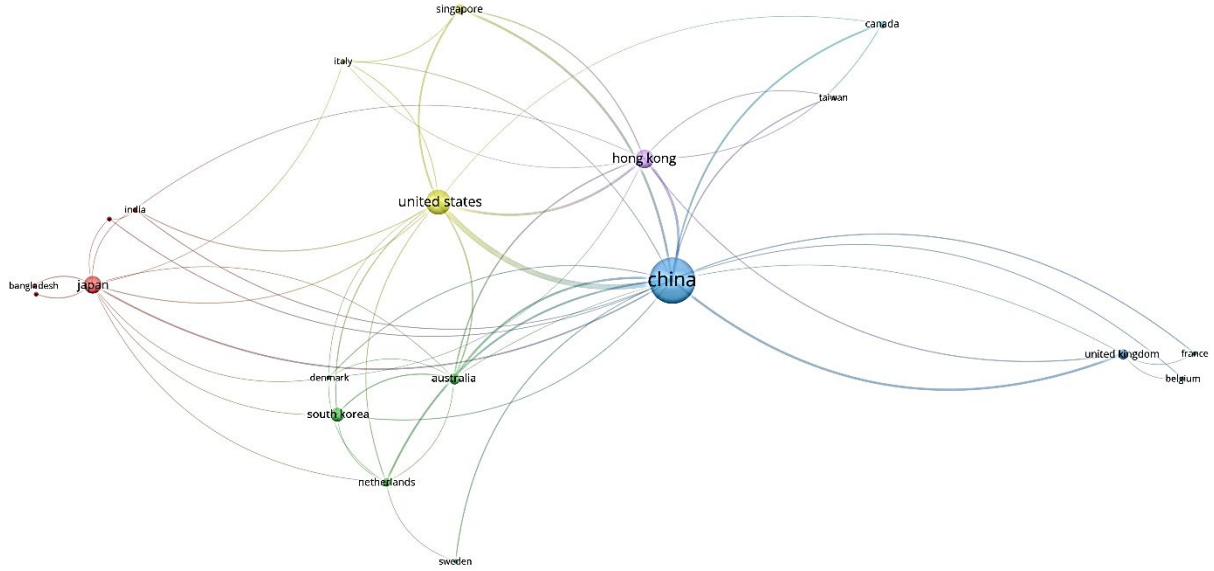
Notes:
1. The network is generated by the software VOSviewer, with Scopus data. The size of plot circles indicates the number of multi-country co-authored publications produced by that country. Plot circle colours indicate a clustering of similar research themes.

Figure 35 *Western Asia country collaboration network (2010-2021)*



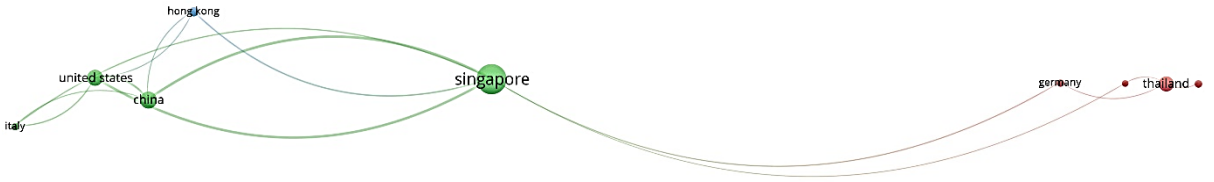
Notes:
1. The network is generated by the software VOSviewer, with Scopus data. The size of plot circles indicates the number of multi-country co-authored publications produced by that country. Plot circle colours indicate a clustering of similar research themes.

Figure 36 *Eastern Asia country collaboration network (2010-2021)*



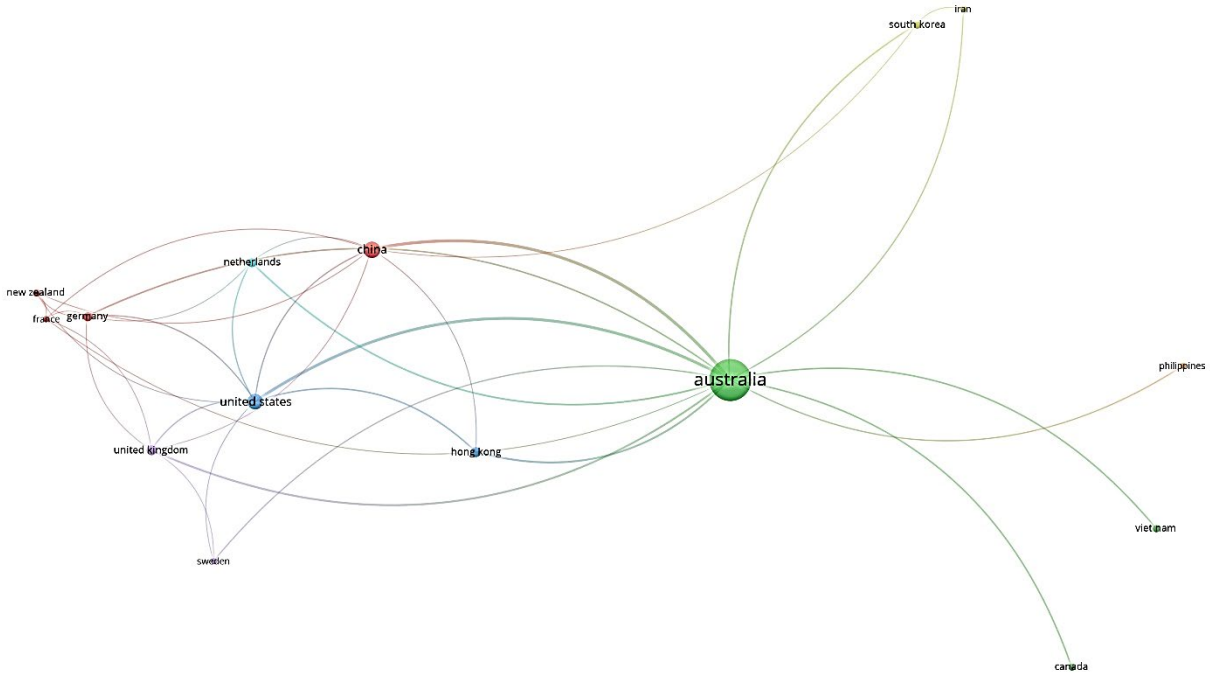
Notes:
1. The network is generated by the software VOSviewer, with Scopus data. The size of plot circles indicates the number of multi-country co-authored publications produced by that country. Plot circle colours indicate a clustering of similar research themes.

Figure 37 *South-eastern Asia country collaboration network (2010-2021)*



Notes:
1. The network is generated by the software VOSviewer, with Scopus data. The size of plot circles indicates the number of multi-country co-authored publications produced by that country. Plot circle colours indicate a clustering of similar research themes.

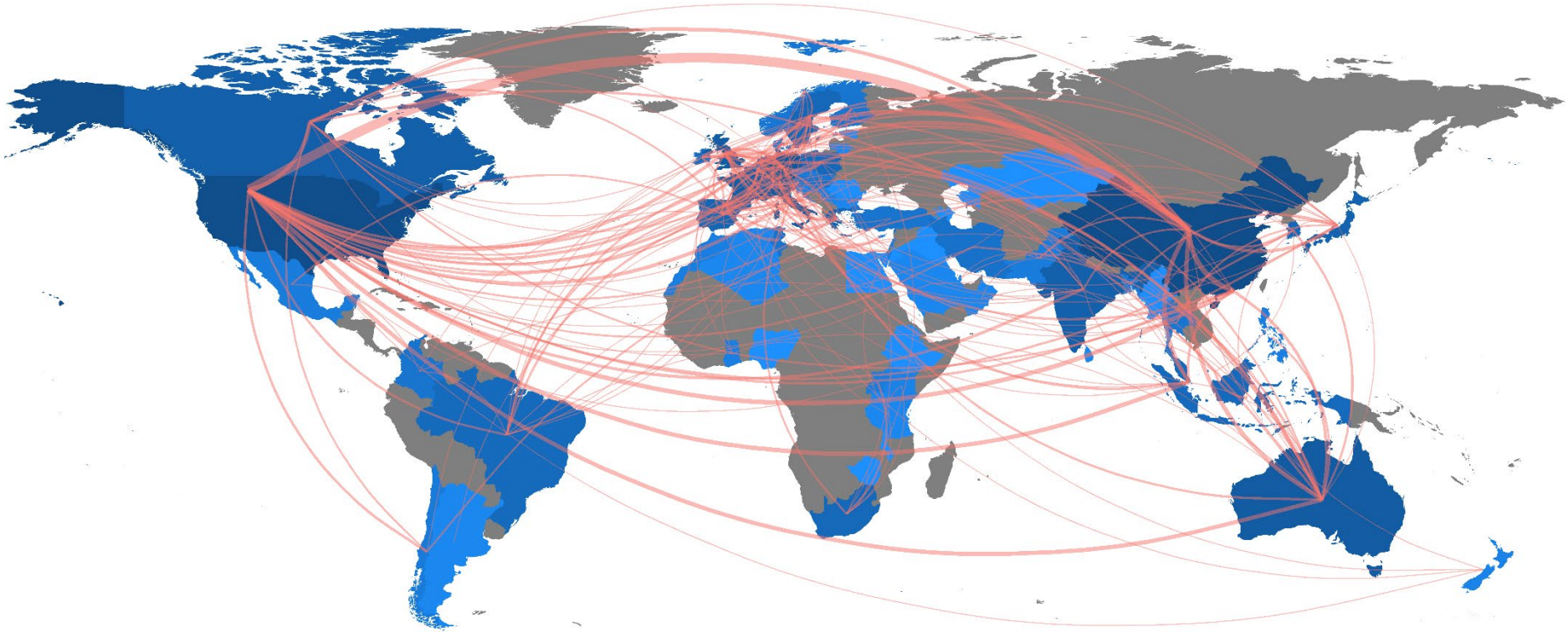
Figure 38 *Oceania country collaboration network (2010-2021)*



Notes:
1. The network is generated by the software VOSviewer, with Scopus data. The size of plot circles indicates the number of multi-country co-authored publications produced by that country. Plot circle colours indicate a clustering of similar research themes.

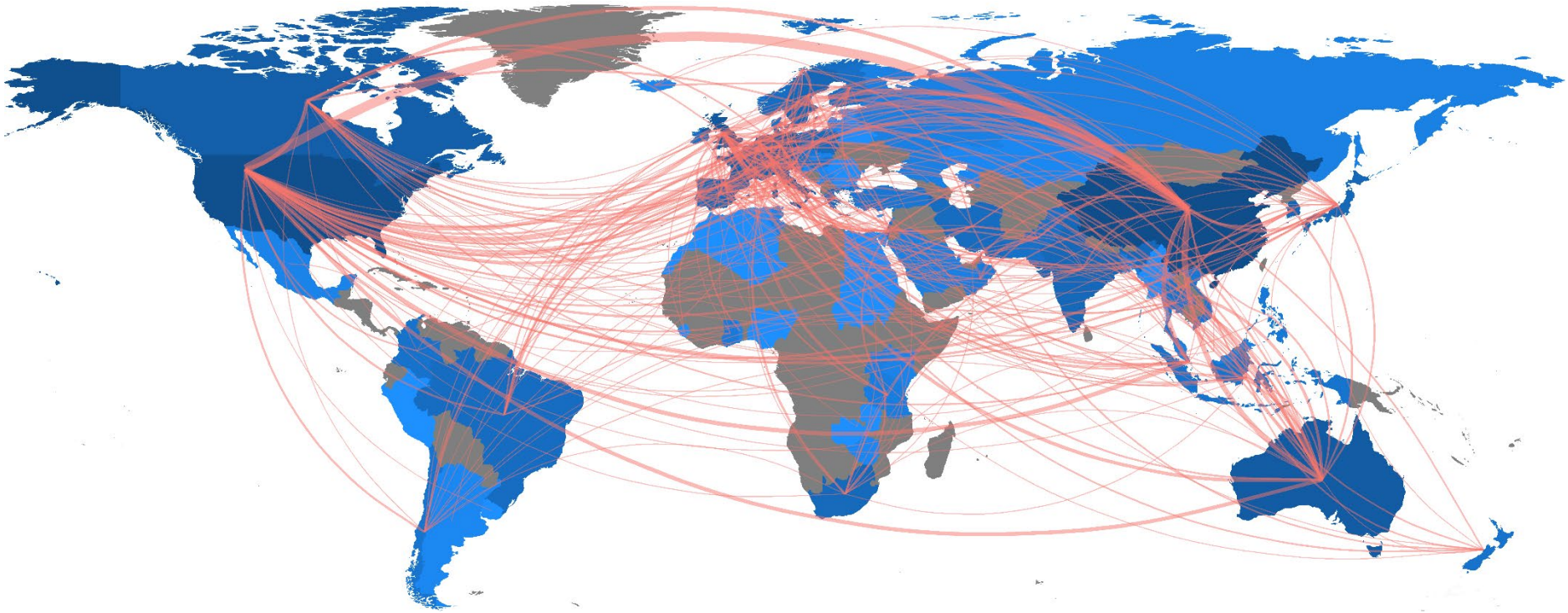
Figure 39 *Map of country collaboration linkages (2010-2021)*

(a) in-field Scopus data (N=1 518)



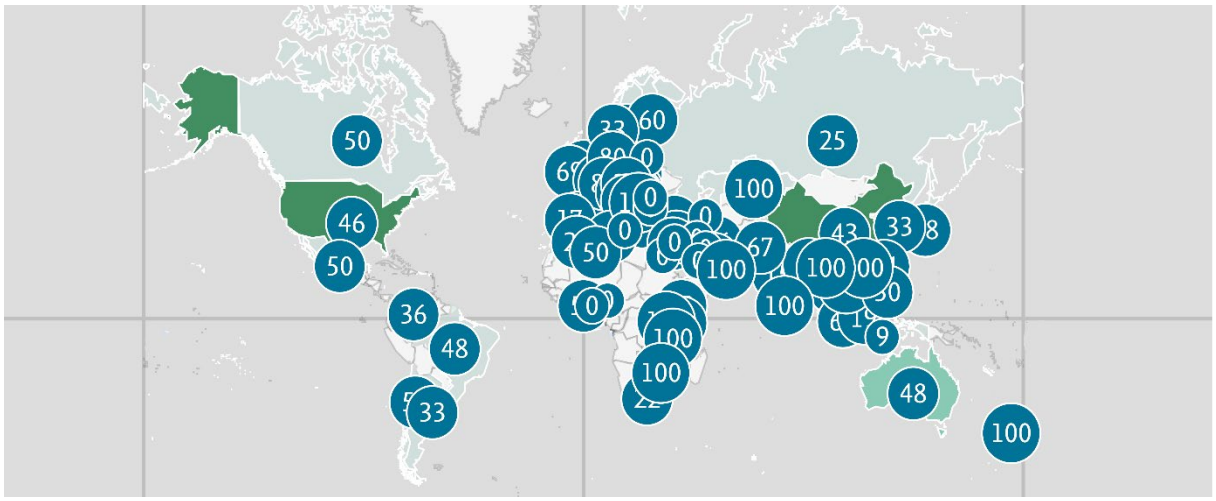
Notes:
1. Blue heatmapping indicates the number of multi-country co-authored publications for countries with at least one co-authored in-field publication.
2. The width of lines between countries indicates the number of publications with co-authors from the two countries.
3. The map is generated by the software Biblioshiny.

(b) in-field Web of Science data (N=1 705)



Notes:
1. Blue heatmapping indicates the number of multi-country co-authored publications for countries with at least one co-authored in-field publication.
2. The width of lines between countries indicates the number of publications with co-authors from the two countries.
3. The map is generated by the software Biblioshiny.

Figure 40 *Map of top 100 country collaboration (percentage, 2011-2020)*



Notes:
1. Values indicate the percentage of publications co-authored with one or more authors affiliated to a research institution in another country.
2. Green heatmapping indicates publication output
3. Data source: SciVal (N=1 518 Scopus data)

Figure 41 *Distribution of lead authors of multi-country research publications (N=175, 2010-2021)*

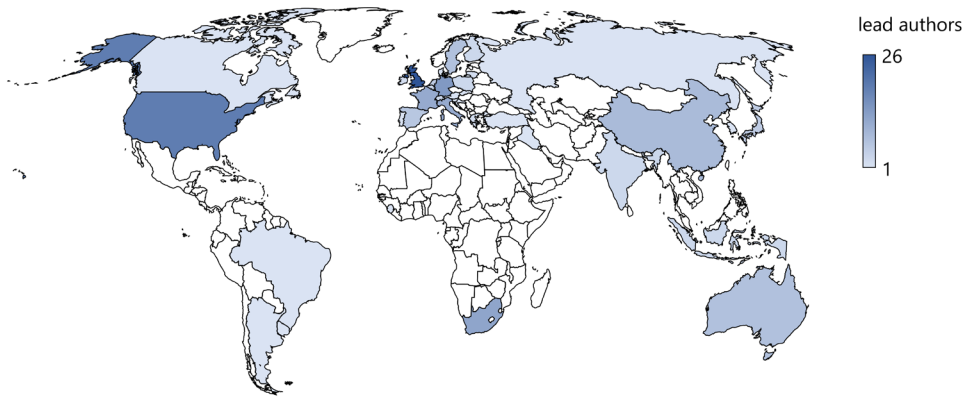
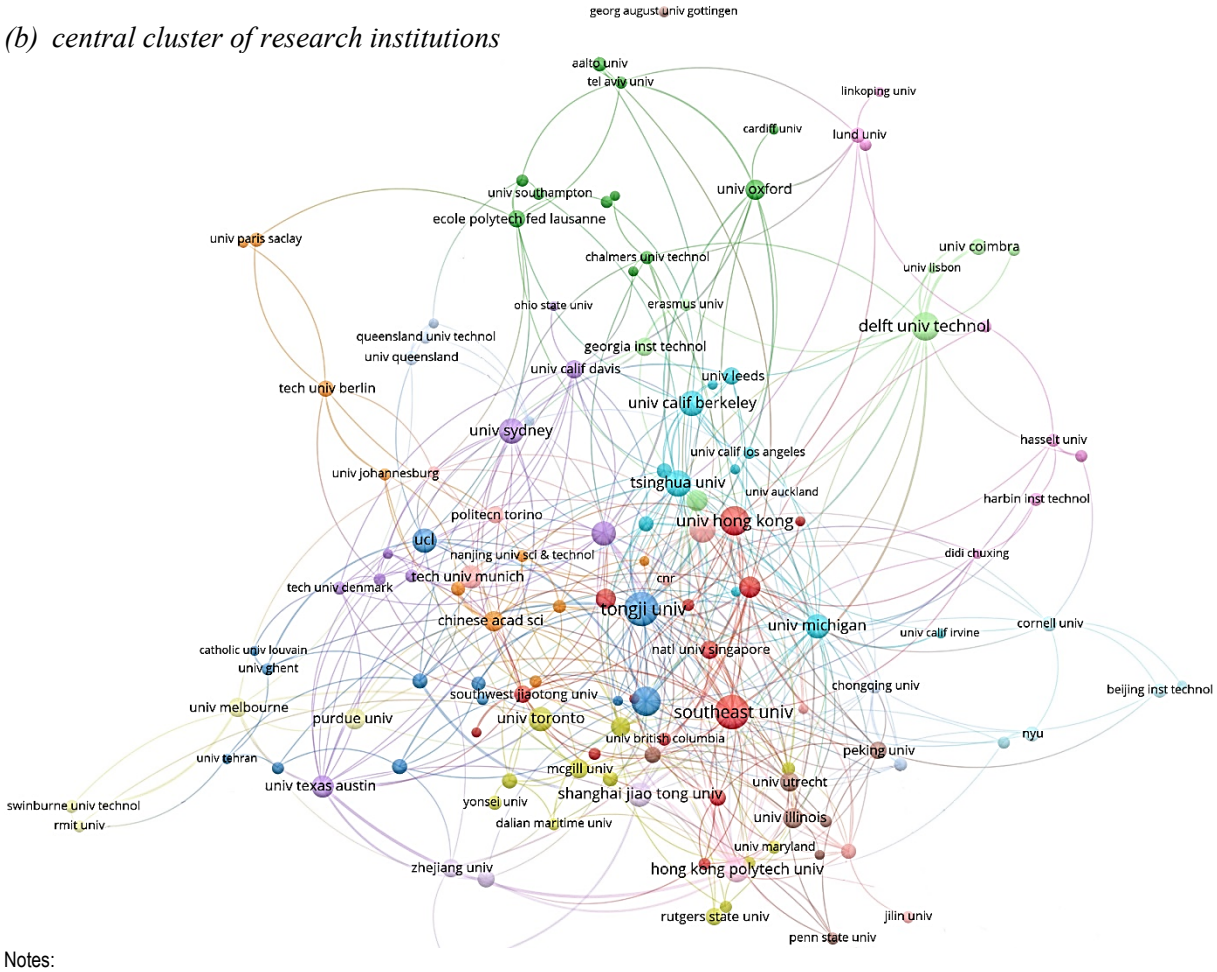


Figure 42(a-b) shifts attention from collaboration between countries, to collaboration between research institutions. Part (a) of the figure maps all institutions, revealing a central cluster of collaborating institutions, and set of 10 significantly smaller satellite clusters. (Note that the collaborations in these smaller satellite clusters would only become visible if the minimum number of publications for affiliated authors was dropped from seven to a lower number.) Part (b) of the figure enlarges the central cluster. It reveals a complex pattern in which the Eastern Asian universities emerge with the greatest collaboration (Southeast University, Tongji University, and the University of Hong Kong). Outside Eastern Asia, the University of Sydney, the University of California, Berkeley, the University of Michigan, and Delft University of Technology emerge as most frequent collaborators.

Figure 42 *Research institution collaboration networks (2010-2021)*

(a) all research institutions

(b) central cluster of research institutions



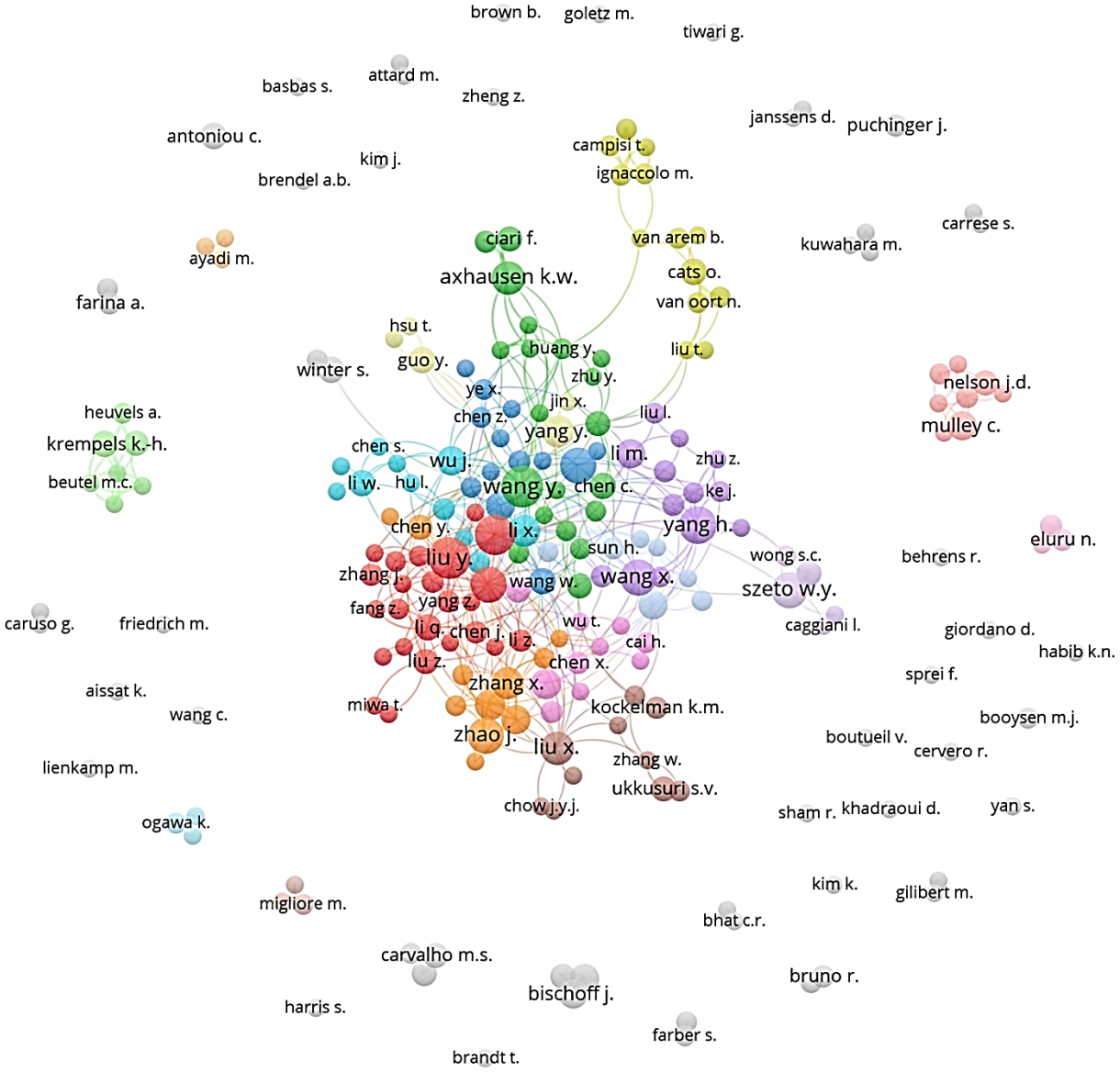
Notes:

1. Plot data includes only institutions with an affiliated author(s) with seven or more in-field publications in the (N=1 518) Scopus data.
2. The network is generated by the software VOSviewer. The size of plot circles indicates the relative number of (multi-institution) co-authored publications produced by that research institution. Plot circle colours indicate a clustering of similar research themes.

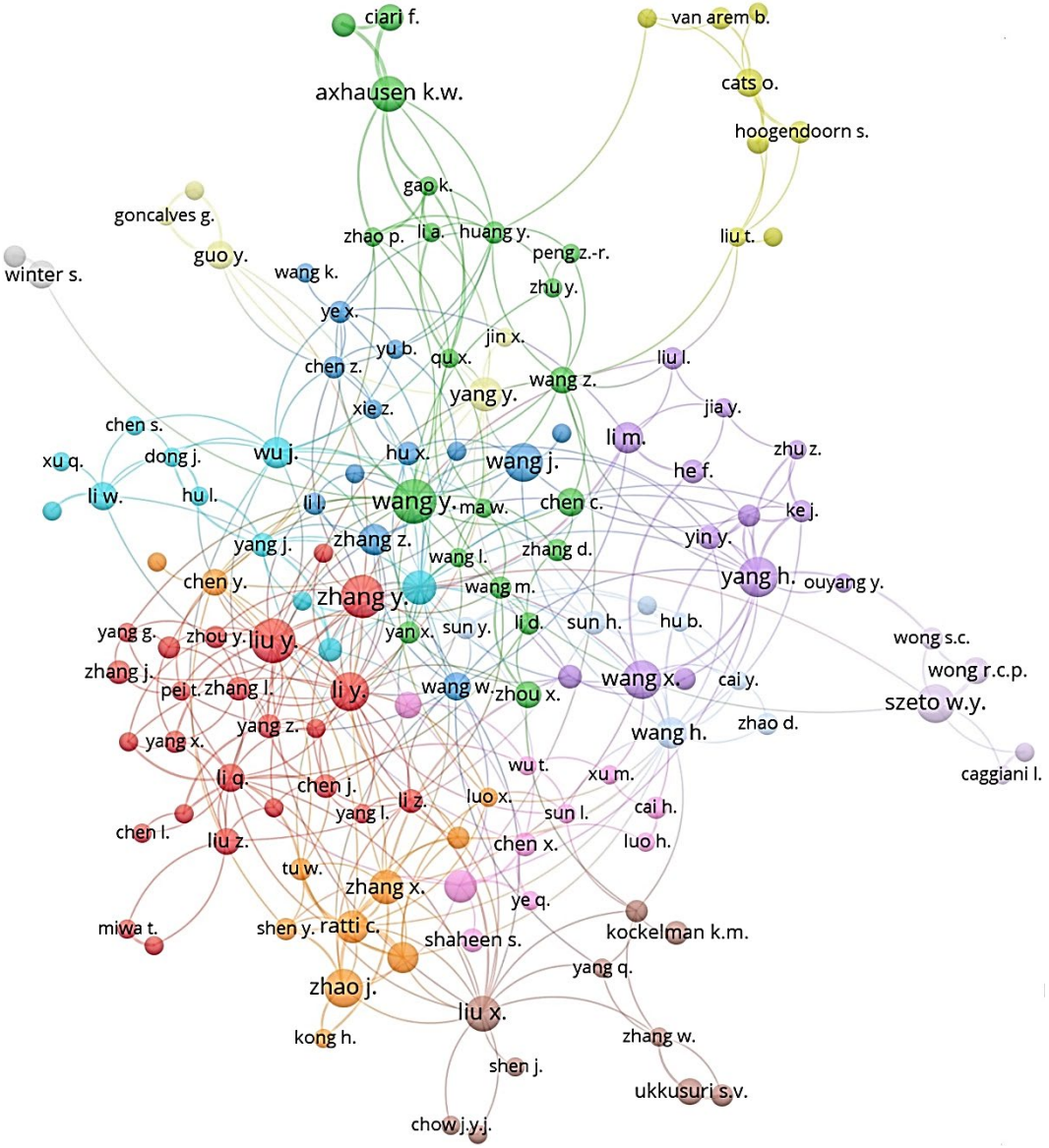
Figure 43(a-b) explores collaboration between individuals (with at least three co-authored in-field publications). Like the research institution network, a large central cluster of collaborating authors emerges, surrounded by numerous smaller satellite clusters. The central cluster is dominated by Eastern Asian authors, with European and Northern American authors joined at the periphery of the cluster. At least 15 of the top 30 authors identified appear in the central cluster (note that the software does not label all plots so there may be more). This evidence suggests fairly extensive collaboration across the leading author group. But some of the leading authors collaborate in smaller satellite clusters. At least seven of the top 30 authors appear in four satellite clusters.

Figure 43 *Author collaboration networks (2010-2021)*

(a) all authors



(b) central cluster of authors



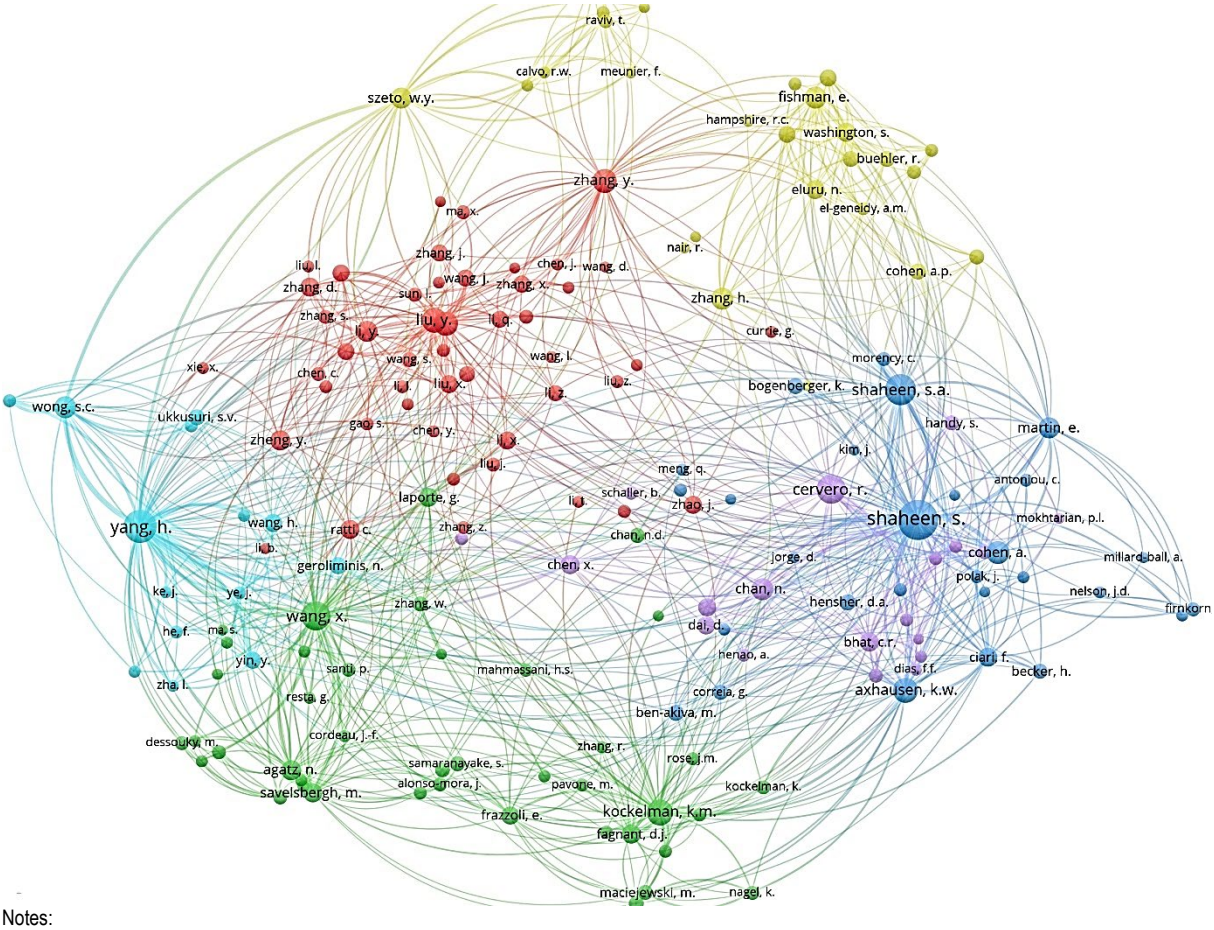
Notes:
1. Plot data includes only authors with three or more in-field co-authored publications in the (N=1 518) Scopus data.
2. The network is generated by the software VOSviewer. The size of plot circles indicates the relative number of co-authored publications by that author. Plot circle colours indicate a clustering of similar research themes.

Figure 44 extends the analysis of authors, providing insight into publication impact and cognateness, by plotting a co-citation network. In this instance, plotting authors with at least 30 in-field citations. The size of plot circles indicates how often an author has been cited by other authors, and the width of lines between authors indicates how often this pair of authors has been cited in the same reference list by a third party. From the plot circle colours, five main thematic clusters emerge, each dominated by one or two authors.

The research fields in which these dominant authors have been most active, is likely to provide an indication of the clustered theme. For instance, in the top yellow cluster the dominant authors are Wai Yuen Szeto (affiliated to the University of Hong Kong) whose in-field research has focussed on modelling bike-sharing systems and metered taxi markets, and Elliot Fishman (affiliated to the Institute for Sensible Transport) who has undertaken extensive reviews of bike-sharing systems. So, the yellow thematic cluster is likely to revolve around bike-sharing. In the case of the left turquoise cluster, the most heavily co-cited author is Hai Yang (affiliated to Hong Kong University of Science

and Technology) whose in-field research has focussed, *inter alia*, on modelling ridesourcing demand. In the case of the centre red cluster, the dominant author is Yu Liu (affiliated to Peking University) whose research has focussed on analysing travel behaviour using metered taxi trip data. In the case of the bottom green cluster, the dominant authors are Kara Kockelman (affiliated to the University of Texas at Austin) whose in-field research has focussed on shared autonomous vehicles, and Xiaolei Wang (affiliated to Tongji University) whose research has focussed on ridesourcing pricing strategies. In the case of the right blue cluster, the dominant author is Susan Shaheen (affiliated to the University of California, Berkeley) whose research has focussed on multiple forms of shared mobility. Note that because of inconsistent initialling, the software plots Susan Shaheen twice (as 'shaheen, s. a.' and 'shaheen, s.'). If these plots are considered in combination, she emerges as the most co-cited author in the study field.

Figure 44 *Author co-citation networks (2010-2021)*



Notes:

1. Plot data includes only authors with at least 30 in-field citations, and is derived from the (N=1 518) Scopus data.
2. The network is generated by the software VOSviewer. The size of plot circles indicates how often an author has been cited by other authors, and the width of lines between authors indicates the amount of times these two authors have been cited in the same reference list by a third party. Plot circle colours indicate a clustering of similar research themes.

5 RESEARCH GAPS AND PRIORITIES

This chapter discusses what is missing from, and what is needed to supplement, the existing body of literature in the subject field. It starts by discussing geographical and thematic gaps in the literature (Section 5.1). Drawing from the survey of the leading researchers identified in Chapter 5, it then goes on to discuss priority future research needs (Section 5.2).

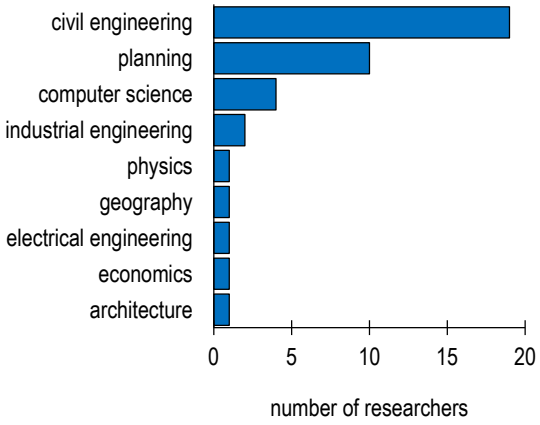
5.1 Gaps

From a geographical perspective, the bibliometric analysis of research activity distribution reported in Section 4.3 highlighted some clear geographical gaps in the literature. Heatmapping analysis revealed that there are countries, particularly in Sub-Saharan Africa, that received no dedicated research attention in any of the research field categories. So, there are parts of the world about which there is little available academic literature. Although it should be acknowledged there are of course other sources of knowledge embedded in the reports of governments, consultancies and funding agencies operating in these regions, that are less easily accessed. The number of publications about a country, and the number of publications produced by research institutions within that country, were found to be strongly correlated (ρ=0,987). So, it is unsurprising that most of the countries about which there were no dedicated publications, were also countries from which no publications were found.

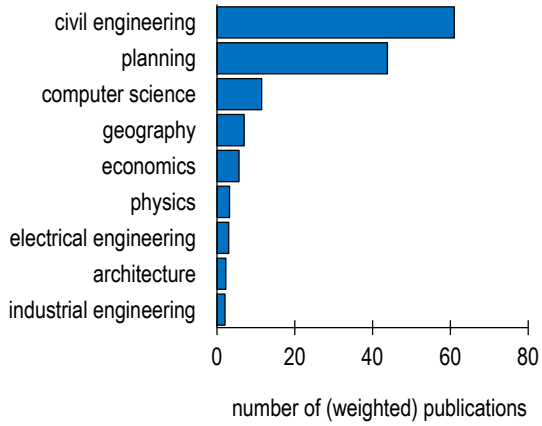
From a thematic perspective, the bibliometric analysis of research fields reported in Section 4.2 revealed gaps, or at least disproportionality, in the literature with respect to service types. While difficult to quantify, as demonstrated by Fountas *et al.* (2020), this analysis suggests a disparity between the prevalence of a service type and the number of publications about it. Most notably, compared to their global prevalence, bike-sharing, car-sharing and carpooling are well researched, compared to informal for-hire transport and informal public transport, which have received significantly less attention. Bike-sharing, car-sharing and carpooling seldom register more than a few percentage points in modal splits (Shi *et al*. 2021, Ma *et al.* 2020). Informal transport services on the other hand hold large shares of modal splits in regions with predominantly captive passenger populations and no formal public transport service offerings (Behrens *et al*. 2021, Tun *et al*. 2020).

Figure 45 *Disciplinary backgrounds, by leading researcher and weighted publications*

(a) leading researchers (N=40)



(b) combined leading researcher weighted publications (N=139)

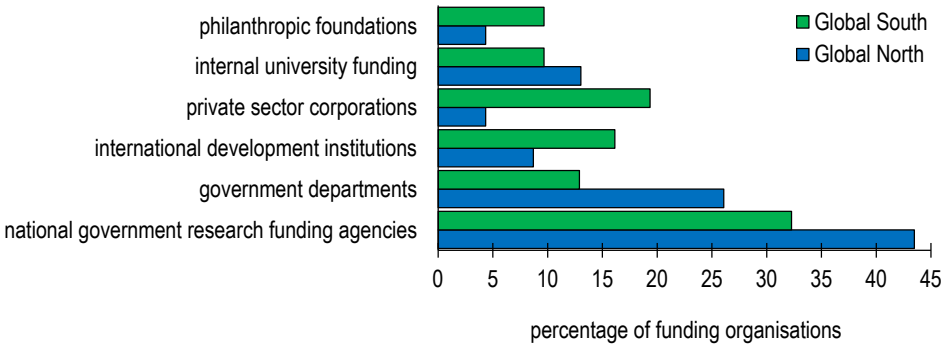


Note:
1. The disciplinary backgrounds of leading researchers were compiled from undergraduate and postgraduate degrees listed in online curricula vitae, and in a minority of instances where an online curriculum vitae was not available, imputed from the researcher's home university department.
2. Leading reserachers were identified by an author ranking index, comprised of a weighted publication output score, and a (combined Scopus and Web of Science) citation score.

A further dimension to the thematic gaps in the literature relates to the disciplines that have conducted the research, and their associated theoretical perspectives and methodological approaches. Using the top five ranked leading researchers in each global region as a crude indicative sample of the several thousand authors and co-authors found in the bibliometric search, Figure 45(a-b) presents disciplinary backgrounds by number of researchers and publications (weighted by the number of co-authors). This analysis suggests that the leading researcher group is dominated by the civil engineering discipline (48% of researchers and 44% of publications), followed by city planning (25% of researchers and 31% of publications). Relatively few of the researchers have backgrounds in the economic and social sciences, suggesting that new insights might be possible in the subject field – on social, political, institutional, economic, historical and cultural variables – if more research publications are attracted from these fields.

Further data on sources of research funding were scraped from leading researcher web profiles. In the case of the leading researchers located in Global North universities, all online acknowledgements were for research funding organisations located (or at least head-quartered) in the Global North. In the case of the leading researchers located in Global South universities, 62% of acknowledged research funders were located in the Global South, and 38% were in the Global South. Figure 46 presents the available information on the types of research funding organisations which support these leading researchers. While no data are available on the quantum of funding distributed, this analysis suggests a greater dependence on funding from national research funding agencies and government departments amongst Global North researchers (70% vs. 45% in the Global South), and greater dependence on private sector corporations and philanthropic foundations amongst Global South researchers (38% vs. 9% in the Global North). Hence these data suggest that research agendas in the Global South are more influenced from out-of-region funders than is the case in the Global North.

Figure 46 *Leading researcher funders (N=54)*



Note:
1. Research funding organisations were compiled from acknowledgements in online researcher profiles. Fourteen of the 40 researchers did not have web profiles with research funding acknowledgements.
2. Leading researchers were identified by an author ranking index, comprised of a weighted publication output score, and a (combined Scopus and Web of Science) citation score.

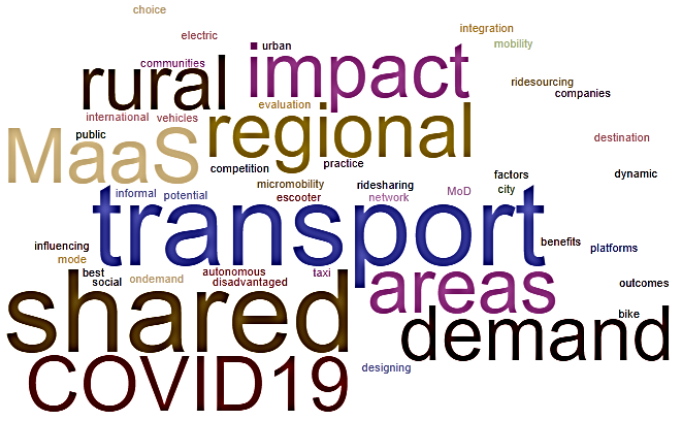
5.2 Priorities

The top five ranked leading researchers in each global region were surveyed to solicit information on their current and planned research activities (that would not have been reflected in the literature search because publications are either in preparation or planned), and to explore their views on priority research needs. A lower than hoped for survey response rate (58%) precluded the insertion of detailed information on current and planned research activities into the earlier leading researcher profiles. Findings in this regard are therefore generalised observations.

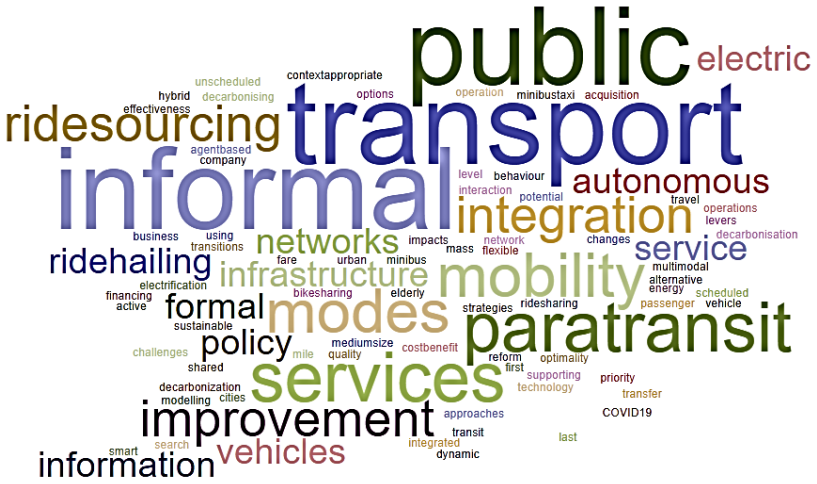
Most researchers indicated that their earlier work in the subject field is ongoing. Only three of the respondents indicated that they were not currently engaged in research in the field. Figure 47(a-b) presents world clouds of responses to the question on current and planned research, divided into respondents affiliated to countries with and without extensive informal transport. Dominant research fields amongst respondents affiliated to countries without extensive informal transport (in Eastern Asia, Europe, Northern America, and Oceania) included: shared mobility operations; Mobility as a Service (MaaS); and the impacts of COVID-19 of shared mobility services. Dominant research fields amongst respondents affiliated to countries with extensive informal transport (in Africa, Latin America and the Caribbean, South-eastern Asia, Western Asia) included: informal public transport operations; ridesourcing; quality of service improvement; and informal-formal service integration.

Figure 47 *Leading researcher current and planned research fields*

(a) researchers from regions without extensive informal transport (n=10)



(b) researchers from regions with extensive informal transport (n=13)



Notes:
1. The word clouds, generated with Jason Davies software, plot the top 250 words, using a logarithmic scale.
2. Leading researchers were identified by an author ranking index, comprised of a weighted publication output score, and a (combined Scopus and Web of Science) citation score.

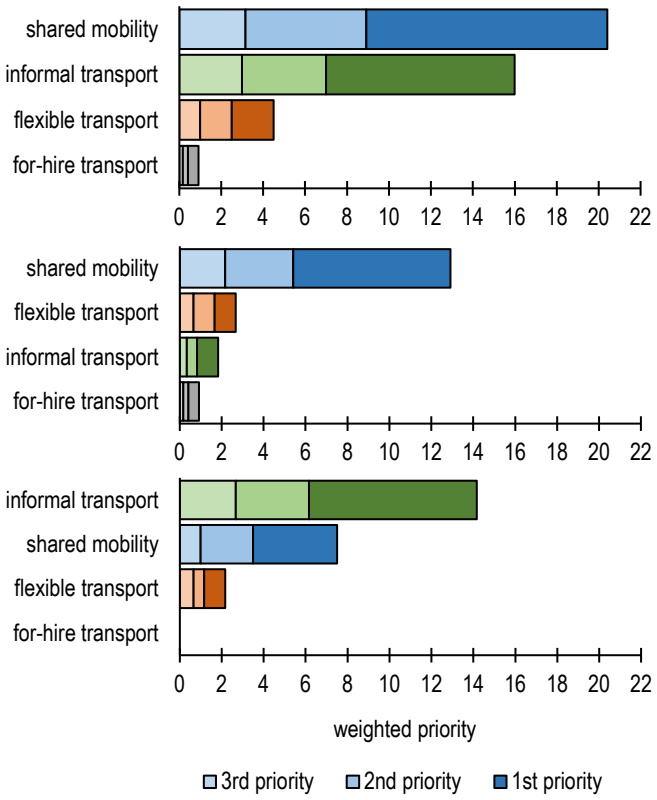
Figure 48 presents the prioritised research field categories of all respondents combined, as well as by the prevalence of informal transport. Overall, shared mobility was prioritised the most, especially by researchers affiliated to research institutions in countries without extensive informal transport. However, in countries with extensive informal transport, unsurprisingly, informal transport services received greater priority. Interestingly, for-hire transport received relatively little priority.

Figure 48 *Leading researcher priorities, by research field*

(a) all researchers (n=23)

(b) *researchers from regions without extensive informal transport (n=10)*

(c) *researchers from regions with extensive informal transport (n=13)*



Notes:
1. Weighted priorities were calculated by assigning a value of 1,0 to first ranked priorities, 0,5 to second ranked priorities, and 0,3 to third ranked priorities.
2. For the purposes of this analysis, regions without extensive informal transport included Eastern Asia, Europe, Northern America, and Oceania, while regions with extensive informal transport included Africa, Latin America and the Caribbean, South-eastern Asia, Western Asia.
3. Leading researchers were identified by an author ranking index, comprised of a weighted publication output score, and a (combined Scopus and Web of Science) citation score.

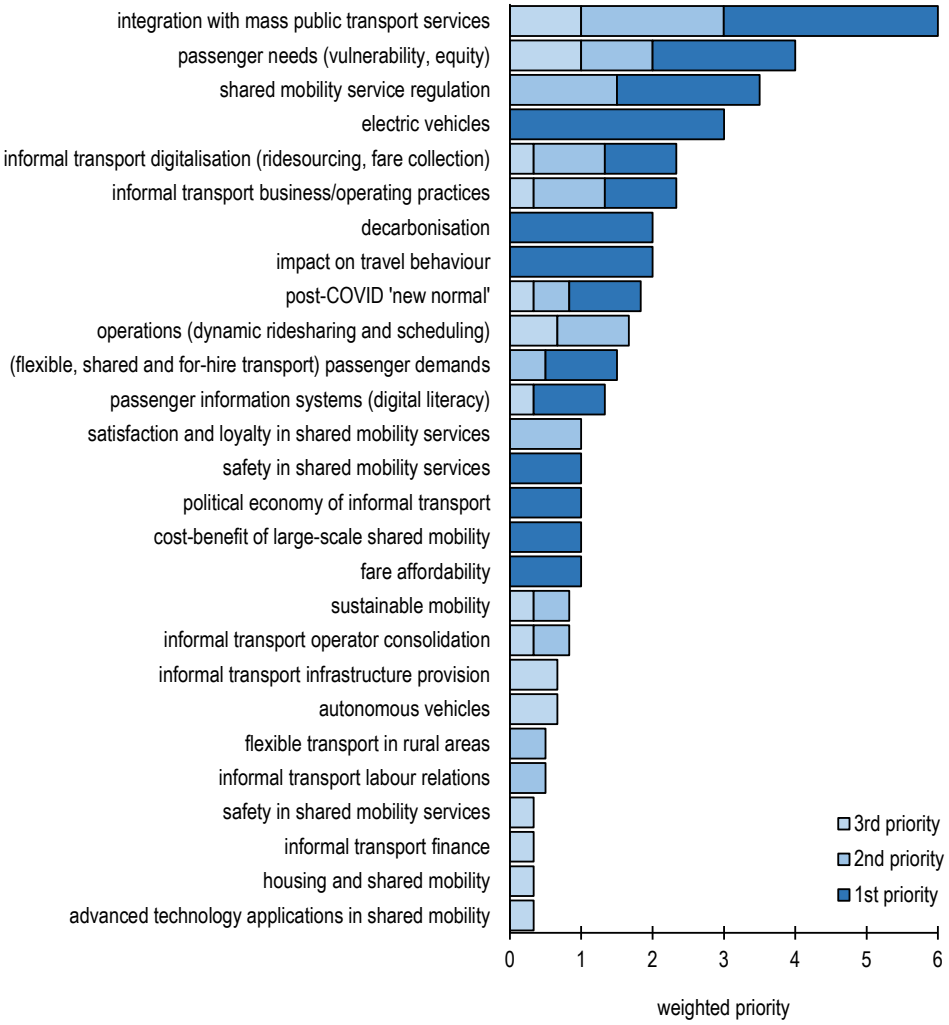
Figure 49(a-c) presents a more detailed disaggregation of prioritised research needs. For all respondents combined, the top five prioritised research needs included investigating:

- the integration of (shared mobility, flexible transport, and informal transport) services with mass public transport services;
- the needs of vulnerable passengers, and equity, in service provision;
- the regulation of shared mobility services;
- the introduction of electric (shared mobility and informal transport) vehicles; and
- the digitalisation (particularly ridesourcing and fare collection) of informal transport services.

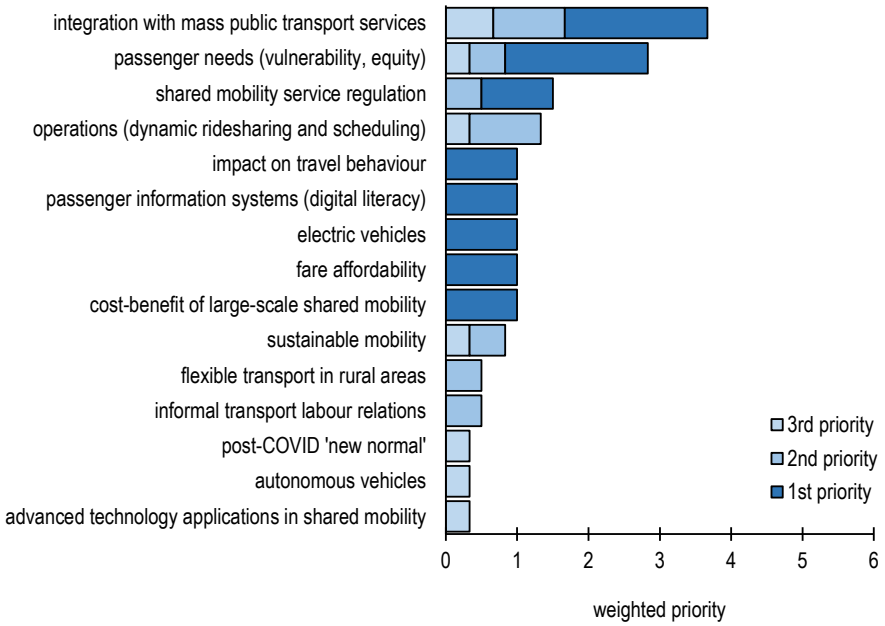
Separation of leading researchers into those affiliated to research institutions in countries with and without extensive informal transport, however, revealed some differences in priority. While integrating (shared mobility, flexible transport, and informal transport) services with mass public transport services was a pervasive priority, in countries without extensive informal transport, exploring the ability of (shared mobility and flexible transport) services to serve all passenger market segments equitably, and improving shared mobility operations (particularly dynamic ridesharing), assumed greater importance. In countries with extensive informal transport, digitalisation of informal transport service operations, and understanding the business and operating practices of informal transport, assumed greater importance.

Figure 49 *Leading researcher priorities, by keyword*

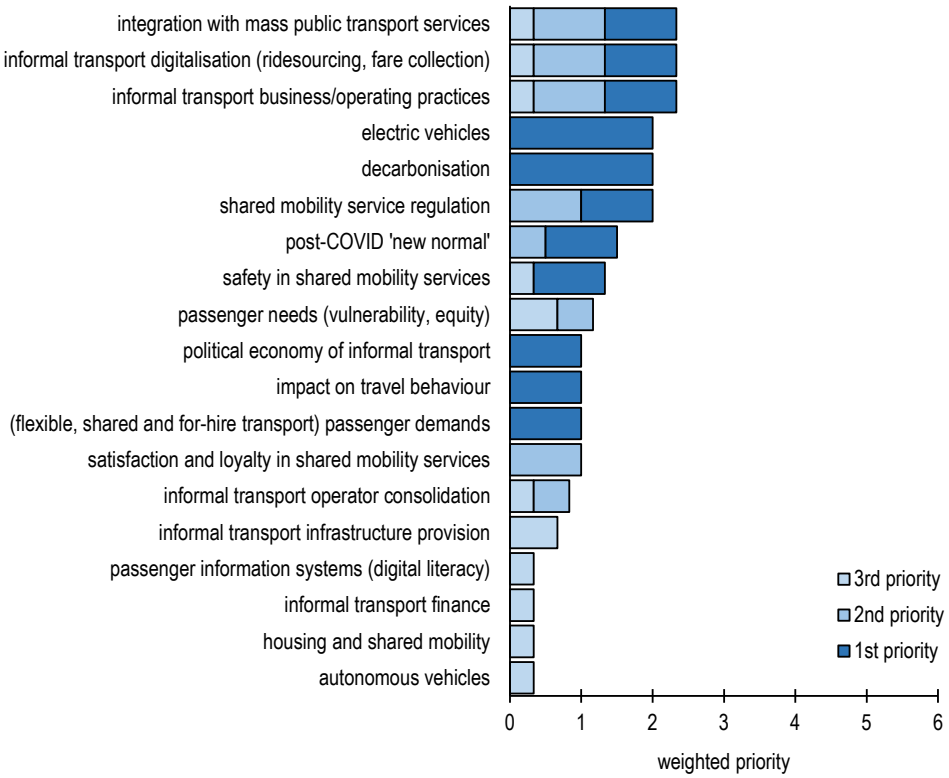
(a) all researchers (n=23)



(b) researchers from regions without extensive informal transport (n=10)



(c) researchers from regions with extensive informal transport (n=13)



Notes:
1. Weighted priorities were calculated by assigning a value of 1,0 to first priorities, 0,5 to second priorities, and 0,3 to third priorities.
2. For the purposes of this analysis, regions without extensive informal transport included Eastern Asia, Europe, Northern America, and Oceania, while regions with extensive informal transport included Africa, Latin America and the Caribbean, South-eastern Asia, Western Asia.
3. Leading researchers were identified by an author ranking index, comprised of a weighted publication output score, and a (combined Scopus and Web of Science) citation score.

Reflecting upon the research priorities identified by the group of leading researchers, and the range of disciplines engaged in the subject field discussed in Section 5.1, a further set of cross-cutting research priorities are commented on below:

Political economies
The political economies within which informal transport and shared mobility services operate, and the systems of formal and informal governance that impact upon them, need to be better understood. The private entrepreneurial, and often atomised, nature of informal transport and shared mobility service providers creates a complex multi-stakeholder environment. There are sometimes elements of regulatory capture in this environment. Without an understanding of the array of stakeholders, and surrounding political economic contexts, it will be difficult to identify appropriate supportive policies and regulatory frameworks, and to evaluate the feasibility of interventions. Such research will require inputs from economists, sociologists, criminologists, and political scientists, among others.

Businesses and operations
The scale and nature of businesses and operations, that are the intended subjects of reform policies, need to be better understood. Greater insight is needed into labour relations and how businesses are managed. Little is known in many cities about the range of route and service types provided, how they interact with each other and with other travel modes, boarding and alighting locations, goods carrying practices, how passengers transfer between services, and the degree of route complementarity or duplication in city-wide public transport networks. Little quantitative and comparable data are available on operating inefficiencies and service inequities. Greater understanding is required of potential route optimisation, mode integration, and service coverage, and the implications this would have for regulatory regimes, business viability, and employment levels. Such research will require inputs from business scientists, transit economists, sociologists, systems engineers, and data scientists, among others.

Stakeholder willingness
Linked to the first bullet above, the willingness of stakeholders to accept policy and regulatory change needs to be better understood. Knowledge of the attitudes towards potential policy interventions of the full array of stakeholders involved in the provision and utilisation of informal transport and shared mobility services is incomplete. Consideration of appropriate policy actions will require insight into what vested interests exist, how powerful are they, and the degree to which they present path dependencies. Little is also known of how best to engage multiple stakeholders in a meaningful way, that enables effective collaboration in policy formulation, and leads to a greater willingness to accept policy interventions. Such research will require inputs from behavioural economists, social psychologists, and sociologists, among others.

Vehicle acquisition
In the case of informal transport in particular, vehicle acquisition practices and finance arrangements, and their implications for rates of fleet renewal and vehicle roadworthiness, need to be better understood. Greater quantitative information is needed on the potential emission reduction benefits of adopting lower emission vehicles or alternative fuels at scale. Little is known of good practices regarding vehicle deprivation costing and preparation for fleet renewal vehicle acquisition. Insight is needed into the real lending risk to financial institutions, and what vehicle finance terms are reasonable and fair. Little research has been undertaken into the range of potential reforms (e.g., business management, third party insurance, depreciation costing, driver behaviour, vehicle maintenance, emissions reduction, etc.) that might accompany public sector assistance in vehicle finance. Such research will require inputs from financial economists, business scientists, and environmental scientists, among others.

Technology diffusion
What drives the diffusion of technologies, and why some service providers adopt technologies while others do not, needs to be better understood. Greater insight is needed into the impacts of technology adoption (e.g., ride hailing, vehicle tracking, speed governors, cashless fare collection) on more

equitable service coverage, passenger quality of service, and operating efficiencies and revenues. With respect to the adoption of ridesourcing technologies in informal transport in particular, research is needed to assess potential vehicle productivity impacts and regulatory implications (i.e., when operating licenses are route-based). Such research will require inputs from information and technology scientists, and science and technology studies, among others.

6 CONCLUSION

This study set out to define the subject field, analyse its bibliometric attributes, and profile leading researchers and institutions.

Regarding the subject field, it is argued that it is comprised of four main categories of passenger transport services – flexible transport, informal transport, shared mobility and for-hire transport – which can be disaggregated further into 15 distinct sub-categories. This array of service types sits between purely private transport on one side, and scheduled mass public transport services on the other. Different forms of these so-called 'paratransit' services can be found across the Global North and Global South. The timeline of innovation in the subject field points to complex and multi-directional global diffusion of service innovations, triggered by changed operating environments and technology disruptions.

Regarding bibliometric attributes, it was found that the research field is growing fast, with publications increasing at an average rate of 26,6% per annum over the past decade. The existing body of literature, as represented by a study database of 3 295 publications, is dominated by authors affiliated to universities in Europe, Eastern Asia and Northern America at the scale of global regions, and to universities in China and the United States at a country scale. In this literature, most attention (62%) has been given to shared mobility (and to bike-sharing, car-sharing and ride hailing in particular), followed by for-hire transport (17%), informal transport (particularly informal public transport) (11%), and flexible transport (10%).

Over the past decade, most publications concerning shared mobility were found to be produced by lead authors affiliated to research institutions in China (19,3%) followed by the United States (15,0%). Similarly, most publications concerning for-hire transport were produced in China (44,1%) and the United States (9,9%). Most publications concerning informal transport were produced in South Africa (18,2%) followed by India (9,8%), and most publications concerning flexible transport were produced in the United States (13,1%) followed by Australia (9,6%).

Analysis of co-authorship revealed extensive global research collaborations in the subject field, particularly amongst Eastern Asian universities and authors. Collaboration between research institutions in China and the United States was found to be particularly strong, as was collaboration between China and other East Asian countries. Southeast University, Tongji University, and the University of Hong Kong emerged as the Eastern Asian universities with the most extensive collaboration networks. Outside Eastern Asia, the University of Sydney, the University of California, Berkeley, the University of Michigan, and Delft University of Technology emerged as most frequent collaborators. Somewhat paradoxically, the collaboration network analysis suggested that, while the quantity of co-authorship collaborations with universities in Africa, Latin America, and Western Asia was small relative to other global regions, authors from many of the countries within these regions are most likely to publish through multi-country research collaboration.

Analysis of citation networks were found to follow a similar pattern to collaboration networks at the scale of research institutions. However, co-citation network analysis at the author scale provided additional insight, particularly into the most influential authors in the subject field. Most notably, these included: Susan Shaheen (affiliated to the University of California, Berkeley) whose research has focussed on multiple forms of shared mobility; and Hai Yang (affiliated to Hong Kong University of Science and Technology) whose in-field research has focussed, amongst other things, on the modelling of ridesourcing demand.

Regarding leading researchers and institutions, the top five authors and institutions (which in all but one case were found to be universities) were identified in each of the eight global regions. These authors and institutions revealed large disparities in publication and citation across regions, particularly between Eastern Asia, Europe and Northern America on one hand, and Africa, Latin

America and the Caribbean, South-eastern Asia and Western Asia on the other. In the case of publications, in Europe for instance, the mean number of lead author publications of the top five institutions was 23,0, compared to 3,2 in Latin America and the Caribbean (4,6 vs. 1,5 for authors). In the case of citations, in Northern America for instance, the mean in-field (Scopus) citations of the top five institutions were 480, compared to 40 in South-eastern Asia (493 vs. 12 for authors). These disparities were correlated to disparities in the number of active authors (as a proxy for research capacity), strongly in the case of publication (ρ=0,947) and moderately in the case of citation (ρ=0,761). In Eastern Asia for instance, the mean number of (SciVal) authors in the top five institutions was found to be 43,8, compared to 5,4 in Africa.

The bibliometric analysis also pointed to some clear geographical gaps in the literature. Heatmapping analysis revealed that there are countries, particularly in Sub-Saharan Africa, that received no dedicated research attention in any of the research field categories. So, there are parts of the world about which there is little available academic literature. Although it should be acknowledged that are of course other sources of knowledge embedded in the reports of governments, consultancies and funding agencies operating in these regions, that are less easily accessed. The number of publications about a country, and the number of publications produced by research institutions within that country, were found to be strongly correlated (ρ=0,987). So, it is unsurprising that most of the countries about which there were no dedicated publications, were also countries from which no publications were found. While difficult to quantify, there are also indications of thematic gaps in the literature, or at least disparity between the prevalence of a service type and the number of publications about it. Most notably, compared to their global prevalence, bike-sharing, car-sharing and carpooling are well researched, compared to informal for-hire transport and informal public transport, which have received significantly less attention.

Given the multi-directional innovation diffusion in the subject field, and the disparity of research capacity and output across global regions, it is a field of inquiry that presents rich possibilities for global research collaboration in the next phase of the FUT programme. The survey of the leading researcher group suggested that: integrating with mass public transport services; serving the needs of vulnerable passengers; regulating service providers; introducing electric vehicles into shared mobility and informal transport fleets; and digitalising aspects of informal transport operations; are priority future research needs.

REFERENCES

Behrens, R, McCormick, D & Mfinanga, D. (2016) *Paratransit in African cities: Operations, regulation and reform*. Routledge, New York.

Behrens, R, Chalermpong, S & Oviedo, D. (2021) Informal paratransit in the Global South, in Mulley C, Nelson J & Ison S (eds). *The Routledge handbook of public transport.* Routledge, New York.

Behrens, R, Hawver, H, Birungi, C & Zuidgeest, M. (2017a) Case study investigation of unscheduled feeder and scheduled trunk service relationships in Cape Town. 36th Southern African Transport Conference, Pretoria.

Behrens, R, McCormick, D, Orero, R & Ommeh, M. (2017b) Improving paratransit service: Lessons from inter-city matatu cooperatives in Kenya. *Transport Policy 53*, pp. 79-88.

Ben-Akiva, M & Atherton, T. (1977) Methodology for short-range travel demand predictions: Analysis of carpooling incentives. *Journal of Transport Economics and Policy*, Vol. 11, No. 3, pp. 224-261.

Boutueil, V & Quillerier, T. (2020) The rise of paratransit digital platforms in large African metropolises: Competitive strategies between international and local platforms. Transportation Research Board Annual Meeting, Washington.

Brake, J and Nelson, J. (2007) A case study of flexible solutions to transport demand in a deregulated environment. *Journal of Transport Geography*, Vol. 15, No. 4, pp. 262-273.

Burris, M and Winn, J. (2006). Slugging in Houston – Casual carpool passenger characteristics. *Journal of Public Transportation*, Vol. 9, No. 5, pp. 23-40.

Canales, D, Bouton, S, Trimble, E, Thayne, J, Da Silva, L, Shastry, S, Knupfer, S & Powell, M. (2017) Connected urban growth: Public-private collaborations for transforming urban mobility. Coalition for Urban Transitions, World Resources Institute.

Cassius, S, El Deeb, N, Sorour, M, Turner, S, Dalkman, H, Gauthier, A, Kost, C & Mason, J. (2021) The future of paratransit and shared mobility: Mapping report. Institute for Transportation and Development Policy, Volvo Research and Educational Foundations.

Cervero, R. (1985) Deregulating urban transportation. *Cato Journal*, Vol. 5, No. 1, pp. 219-238.

Cervero, R. (1992) Paratransit in Southeast Asia: A market response to poor roads. Reprint No. 90. *Review of Urban and Regional Development Studies*, Vol. 3, pp. 3-27.

Cervero, R. (1997) *Paratransit in America: Redefining mass transportation*. Praeger, Westport.

Cervero, R. (2000) *Informal transport in the developing world*. United Nations Commission on Human Settlements, Nairobi.

Cervero, R & Golub, A. (2007) Informal transport: A global perspective. *Transport Policy*, Vol. 14, No. 6, pp. 445-457.

Chen, X, Zahiri, M, & Zhang, S. (2017) Understanding ridesplitting behavior of on-demand ride services: An ensemble learning approach. *Transportation Research Part C: Emerging Technologies*, Vol. 76, pp. 51-70.

Chujoh, U. (1989) Learning from medium- and small-sized bus services in developing countries: Is regulation necessary? *Transportation Research Part A*, Vol. 23, No. 1, pp. 19-28.

Coetzee, J, Krogscheepers, C & Spotten, J. (2018) Mapping minibus-taxi operations at a metropolitan scale – methodologies for unprecedented data collection using a smartphone application and data management techniques. 37th Southern African Transport Conference, Pretoria.

DeMaio, P. (2009) Bike-sharing: History, impacts, models of provision, and future. *Journal of Public Transportation*, Vol. 12, No. 4, pp. 41-56.

Divall, D, Kureya, T, Bishop, T, Barber, C, Green, C & Clark, S. (2021) The potential role of mobile phone technology in rural motorcycle and three-wheeler taxi services in Africa, *Transportation Planning and Technology*, Vol. 44, No. 1, pp. 30-44.

Du Preez, D, Zuidgeest, M & Behrens, R. (2019) A quantitative clustering analysis of paratransit route typology and operating attributes in Cape Town. *Journal of Transport Geography*, Vol. 80, 102493.

Ferguson, E. (1997) The rise and fall of the American carpool: 1970-1990. *Transportation*, Vol. 24, No. 4, pp. 349-376.

Finn, B. (2012) Towards large-scale flexible transport services: A practical perspective from the domain of paratransit. *Research in Transportation Business and Management*, Vol. 3, pp. 39-49.
Flores Dewey, O. (2019) App-based collective transport service in Mexico City: A start-up case study. International Transport Forum Discussion Papers (No. 2019/01). OECD Publishing.
Fountas, G, Sun, Y, Akizu-Gardoki, O & Pomponi, F. (2020) How do people move around? National data on transport modal shares for 131 countries, *World*, Vol. 1, pp. 34-43.
Gadepalli, R. (2016) Role of intermediate public transport in Indian cities. *Economic and Political Weekly*, Vol. 11, No. 9, pp. 46-49.
Gauthier, A & Weinstock, A. (2010) Africa: Transforming paratransit into BRT. *Built Environment*, Vol. 36, No. 3, pp. 317-327.
Golub, A, Balassiano, R, Araújo, A & Ferreira, E. (2009) Regulation of the informal transport sector in Rio de Janeiro, Brazil: welfare impacts and policy analysis. *Transportation*, Vol. 36, pp. 601-616.
Guo, Y, Zhou, J, Wu, Y & Li, Z. (2017) Identifying the factors affecting bike-sharing usage and degree of satisfaction in Ningbo, China. *PLoS ONE*, Vol. 12, No. 9. DOI: 10.1371/journal.pone.0185100.
Gwilliam, K. (2008) Bus transport: Is there a regulatory cycle? *Transportation Research Part A: Policy and Practice*, Vol. 42, pp. 1183-1194.
Hamdy, H, El Deen, B, El-Toukhy, I, Elsagheer, A & Mohamed, A, (2021) Online bus services: A view of Swvl Company. In *Handbook of research on decision sciences and applications in the transportation sector*, IGI Global, Hershey.
Harms, S & B. Truffer. The Emergence of a Nationwide Carsharing Co-operative in Switzerland. Prepared for EAWAG—Eidg. Anstalt fur Wasserversorgung und Gewasserschutz, Switzerland, March 1998.
Hartgen, D. (1977) Ridesharing behavior: A review of recent findings. Research Report 130, New York State Department of Transportation.
He, F & Shen, Z. (2015) Modeling taxi services with smartphone-based e-hailing applications. *Transportation Research Part C: Emerging Technologies,* Vol. 58, pp. 93-106.
Hensher, D & Golob, T. (2008) Bus rapid transit systems: a comparative assessment. *Transportation*, Vol. 35, pp. 501-518.
Hidalgo, D & Carrigan, A. (2010) BRT in Latin America: High capacity and performance, rapid implementation and low cost. *Built Environment*, Vol. 36, No. 3, pp. 317-327.
Hosni, H, Naoum-Sawaya, J & Artail, H. (2014) The shared-taxi problem: Formulation and solution methods. *Transportation Research Part B: Methodological*, Vol. 70, pp. 303-318.
Kelley, K. (2007) Casual carpooling-enhanced. *Journal of Public Transportation*, Vol. 10, No. 4, pp. 119-130.
Kirby, R, Bhatt, K, Kemp, M, McGillivray, R & Wohl, M. (1974) *Para-transit: Neglected options for urban mobility*. The Urban Institute, Washington DC.
Klopp, JM & Cavoli, C. (2019) Mapping minibuses in Maputo and Nairobi: Engaging paratransit in transportation planning in African cities. *Transport Reviews,* Vol. 39, pp. 657-676.
Kunhikrishnan, P & Srinivasan, K. (2018) Investigating behavioral differences in the choice of distinct intermediate public transport (IPT) modes for work trips in Chennai city. *Transport Policy* Vol. 61, pp. 111-122.
Ma, S & Wolfson, O. (2013) Analysis and evaluation of the slugging form of ridesharing. SIGSPATIAL'13, Orlando.
Ma, X, Yuan, Y, Van Oort & N, Hoogendoorn, S. (2019) Bike-sharing systems' impact on modal shift: A case study in Delft, the Netherlands. *Journal of Cleaner Production,* Vol. 259.
Mageean, J & Nelson, J. (2003) The evaluation of demand responsive transport services in Europe. *Journal of Transport Geography*, Vol. 11, No. 4, pp. 255-270.
Maxwell, D & McIntyre, J. (1979) Economics of vanpooling. *Transportation Research Record*, Vol. 724, pp. 52-57.
Mulley, C & Nelson, J. (2009) Flexible transport services: A new market opportunity for public transport. *Research in Transportation Economics*, Vol. 25, No. 1, pp. 39-45.

Mulley, C, Nelson, J, Teal, R, Wright, S & Daniels, R. (2012) Barriers to implementing flexible transport services: An international comparison of the experiences in Australia, Europe and USA. *Research in Transportation Business and Management*, Vol. 3, pp. 3-11.
Murphy, C & Feigon, S. (2016) Shared mobility and the transformation of public transit. Transportation Research Board.
Muni, K, Kobusingye, O, Mock, C, Hughes, J, Hurvitz, P & Guthrie, B. (2020) Motorcycle taxi programme increases safe riding behaviours among its drivers in Kampala, Uganda, *Injury Prevention*, Vol. 25, pp. 5-10.
Orski, C. (1975) Paratransit: The coming of age of a transportation concept. *Transportation*, Vol. 4, No. 4, pp. 329-334.
Palmer, K, Dessouky, M & Abdelmaguid, M. (2004) Impacts of management practices and advanced technologies on demand responsive transit systems. *Transportation Research Part A*, Vol. 38, No. 7, pp. 495-509.
Panigrahi, A, Shahi, S & Amarsingh, R. (2018) Success story of a start-up – a case study of Ola Cabs. *Journal of Business and Management,* Vol. 20, pp. 30-37.
Park, Y, Kim, JY & Pan, B. (2021) The influence of Uber on the tourism industry in sub-Saharan Africa. *Journal of Travel Research,* Vol. 60, No. 7, pp. 1598-1611.
Pavlenko, N, Slowik, P & Lutsey, N. (2019) When does electrifying shared mobility make economic sense? The International Council of Clean Transportation.
Plano, C, Behrens, R & Zuidgeest, M. (2020) Towards evening paratransit services to complement scheduled public transport in Cape Town: Driver attitudinal survey of alternative policy interventions. *Transportation Research Part A: Policy and Practice*, Vol. 132, pp. 273-289.
PRISMA. (2019) PRISMA for scoping reviews. http://www.prisma statement.org/Extensions/ScopingReviews
Rimmer, P. (1984) The role of paratransit in Southeast Asian cities. *Singapore Journal of Tropical Geography*, Vol. 5, No. 1, pp. 45-62.
Roth, G. (1987) *The private provision of public services in developing countries*. EDI Series in Economic Development, Oxford University Press, New York.
Roth, G & Shephard, A. (1984) *Wheels within cities: New alternatives for passenger transport*. Adam Smith Institute, London.
Saddier, S, Patterson, Z, Johnson, A & Chan, M. (2016) Mapping the jitney network with smartphones in Accra, Ghana: The AccraMobile experiment. *Transportation Research Record,* Vol. 2581, pp. 113-122.
Saltzman, A. (1973) Para-transit: Taking the mass out of mass transit. *Technology Review*, Vol. 75, No. 8, pp. 46-53.
Schalekamp, H & Saddier, S. (2020) Emerging business models and service options in the shared transport sector in African cities. VREF for the Mobility and Access in African Cities (MAC) initiative, The state of knowledge and research, Gothenburg.
Schwieterman, J & Smith, C. (2018) Sharing the ride: A paired-trip analysis of UberPool and Chicago Transit Authority services in Chicago, Illinois. *Research in Transportation Economics*, Vol. 71, pp. 9-16.
Shaheen, S & Cohen, A. (2007) Growth in worldwide carsharing an international comparison. *Transportation Research Record*, Vol. 1992, pp. 81-89.
Shaheen, S, Zhang, H, Elliot, M & Guzman, S. (2010) China's Hangzhou public bicycle. *Journal of the Transportation Research Board,* Vol. 2247, pp. 33-41.
Shaheen, S, Chan, N, Bansal, A & Cohen, A. (2015) Shared mobility: Definitions, industry developments, and early understanding. Available: https://escholarship.org/uc/item/2f61q30s [2021, May 11].
Shaheen, S. (2018) Shared mobility: the potential of ridehailing and pooling. In Sperling D (ed). *Three revolutions: Steering automated, shared, and electric vehicles to a better future.* Island Press, Washington DC.
Shaheen, S, Cohen, A, Chan, N & Bansal, A. (2020) Sharing strategies: Carsharing, shared micromobility (bikesharing and scooter sharing), transport network companies, microtransit,

and other innovative mobility modes, in Deakin E (ed). *Transportation, land use, and environmental planning*. Elsevier, Amsterdam.
Shaheen, S, Sperling, D & Wagner, C. (1998) Carsharing in Europe and North America: Past, present, and future. *Transportation Quarterly*, Vol. 52, No. 3, pp. 35-52.
Shi, K, Shao, R, De Vos, J, Cheng, L & Witlox, F (2021) The influence of ride-hailing on travel frequency and mode choice. *Transportation Research Part D*, Vol. 101, 103125.
Silcock, S. (1981) Urban paratransit in the developing world: Foreign summaries. *Transport Reviews*, Vol. 1, No. 2, pp. 151-168.
Soares Machado, C, de Salle Hue, N, Berssaneti, F & Quintanilha, J. (2018) An overview of shared mobility. *Sustainability*, Vol. 10, 4342.
Sohail, M, Maunder, D & Cavill S. (2006) Effective regulation for sustainable public transport in developing countries. *Transport Policy*, Vol. 13, No. 3, pp. 177-190.
Taiebat, M & Ming, X. (2019) Synergies of four emerging technologies for accelerated adoption of electric vehicles: Shared mobility, wireless charging, vehicle-to-grid, and vehicle automation. *Journal of Cleaner Production,* Vol. 230, pp. 794-797.
Teal, R. (1987) Carpooling: Who, how and why. *Transportation Research Part A: General*, Vol. 21, No. 3, pp. 203-214.
Tirachini, A. (2020) Ride-hailing, travel behaviour and sustainable mobility: An international review. *Transportation*, Vol. 47, pp. 2011-2047.
Tun, T, Welle, B, Hidalgo, D, Albuquerque, C, Castellanos, S, Sclar, R & Escalante, D. (2020) *Informal and semiformal services in Latin America: An overview of public transportation reforms*. World Resources Institute, Washington.
Wang, H & Yang, H. (2019) Ridesourcing systems: A framework and review. *Transportation Research Part B,* Vol. 129, pp. 122–155.
Wartick, S. (1980) Employer-organized vanpooling: A program for the 1980s. *Business Horizons*, Vol. 23, No. 6, pp. 48-56.
Westervelt, M, Huang, E, Schank, J, Borgman, N, Fuhrer, T, Peppard, C & Narula-Woods, R. (2018) UpRouted: Exploring Microtransit in the United States. (January):1–27. Available: www.enotrans.org [2021, May 12].
Wright, L. (2001) Latin American busways: Moving people rather than cars. *Natural Resources Forum*, Vol. 25, pp. 121-134.
Zhang, Y & Mi, Z. (2018) Environmental benefits of bike sharing: A big data-based analysis. *Applied Energy*, Vol. 220, pp. 296–301. DOI: 10.1016/j.apenergy.2018.03.101.
Zhu, G, Li, H & Zhou, L. (2017) Enhancing the development of sharing economy to mitigate the carbon emission: A case study of online ride-hailing development in China. *Natural Hazards,* Vol. 91, pp. 611-633.