A Scientometric Analysis of Public Transport Research

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Abstract

Public transport research involves a lot of disciplinary and interdisciplinary research applying methods, techniques, and technologies to investigate, regulate, and advance public transport. The importance of research in this area has led to a huge amount of publications in recent years. In this study, we conducted a comprehensive scientometric analysis of related literature published in 2009–2013 to empirically explore the consistence, focus areas, and key contributors of public transport research from a meta-perspective, providing novel insights into publication patterns, major topics, research impact, and productivity by focusing on short-term developments. As such, the results of this study provide a novel perspective on public transport research and may help achieving an overview on important characteristics.

Keywords: Public transport, public transport research, scientometric analysis, scientometrics, keyword cluster analysis.

Introduction

Public transport, as a mode of transportation moving people from one place to another by publicly-used forms of conveyance (Levinson et al. 2015), plays an essential role not only for providing sustainable transport forms (Krygsman et al. 2004) and serving the urban and inter-urban travel needs of those who are dependent on efficient transport means, but also for supporting social equity principles (Webster and Bly 1982). The performance of local public transport in terms of accessibility, safety, and efficiency not only affects inhabitants day by day, but also influences the destination satisfaction of visitors such as business travelers and tourists (Thompson and Schofield 2007). Further, the quality of public transport as well as the interplay between different inter-urban and urban transportation systems, including car and bike sharing systems, become increasingly important not only in our modern society, but also in developing countries (Sohail et al. 2006). Public transport demand is stimulated by social and economic conditions (e.g., city population, income, car ownership, land use) as well as by direct demand factors such as fares and service quality (Webster and Bly 1982). Against this backdrop, public transport research consists of a range of research activities to understand, regulate, and advance public transport from several perspectives and under certain circumstances. Consequently, the field involves not only disciplinary research, but also requires interdisciplinary and even transdisciplinary research to tackle current and future challenges, meaning that scholars from different subjects and practitioners share their experiences and perspectives in collaborative works to study the subject in its wider context, such as the interplay with technical, economic, social, and information technology-related aspects. Challenges include those related to planning and operations, information management, regulations, traffic congestion, safety and security, energy consumption, and health issues in urban environments.

Given the considerable number of research contributions in recent years, reflecting the international scope of transport research and the growing number of people researching in transport (Banister 2014), it is essential to investigate the current state of public transport. The huge growth in publications require an overseeable entry point on a meta level to better explore specific aspects in greater depth in a next step, which is especially important for new researchers aiming to become experts in the field (Banister 2014). This entry point can be provided by a scientometric analysis of public transport research, which extends, on a higher level, common public transport-related reviews on specific topics.

Scientometrics refers to quantitative studies and methods to measure and analyze science from a meta-perspective (Van Raan 1996; Schwarze et al. 2012). Scientometric studies can support the development and improvement of an academic discipline (Lewis et al. 2007; Straub 2006) by serving as a vital basis for defining and debating future research agendas (Serenko and Bontis 2004). Assuming that scientific activities are reflected through scientific publications, scientometric studies apply empirical measures to analyze scientific output of a specific field. A scientometric analysis can give some indication of research activities in general, such as with respect to research outlets, research impact, co-citations, influential countries/affiliations/authors, and development of key topics. For further reading, see, e.g., Hood and Wilson (2001), Leydesdorff (2002), Leydesdorff and Schank (2008), Van Raan (1996), Straub (2006), and Voß and Zhao (2005). Going further, scientometrics, as an evaluation tool of science, increasingly impacts the resource distribution of research institutions (Voß and Zhao 2005) and can be used to analyze how research is funded. While evaluating science has a long tradition in many fields, we identified an absence of scientometric studies in the area of public transport research.

In this paper, we present a comprehensive scientometric analysis that empirically explores publications related to public transport covered by Elsevier's Scopus database from 2009 to 2013. Although it might be interesting to extend the timeframe, we intended to focus on the past five years to better reflect recent developments rather than biasing implications with long-term developments. The latter may be considered in future research. For the analysis of short-term developments, we aimed to comprehensively cover publications that are available in Scopus for that timeframe to provide empirical insights on public transport research in general. In total, we investigated 7,868 publications. With our study, we aimed to explore general patterns on how research is conducted and conveyed within the community as well as what key contributing and influencing forces are serving the current and future development of public transport research. Our scientometric analysis was structured according to these research questions. By applying scientometric means to the body of publications, we provided extensive insights into publishing patterns (e.g., academic disciplines, contributing countries, number of authors, and distribution of outlets) and analyzed frequent keywords as well as keyword co-occurrences to identify widely-discussed topics and current trends. Finally, we explored the application of Lotka's law, which describes a frequency distribution of scientific productivity widely applied in scientometric studies.

Generally, this paper presents novel insights from a meta-perspective. Due to limitations of space, this study does not intend to give an overview of public transport in general (for further reading, the reader is referred to, e.g., Larson and Odoni 1981; Ceder 2007; White 2008; Levinson et al. 2015, together with some of those contributions to the field exemplified in the appendix that follows). To the best of our knowledge, this is the first scientometric analysis in the field of public transport research.

The remainder of this paper is organized as follows. The next section briefly describes the methodology and methods being applied. Then, publishing patterns are investigated and further analyzed to understand the consistence of the research area. Key topics as well as dependencies between topics of public transport research are observed by analyzing top keywords and keyword clusters, and the impact and productivity of public transport research is examined. The results from applying Lotka's law to our observations are also presented, and, finally, a conclusion and ideas for further research are given.

Research Methodology

Several steps were necessary to retrieve scientometric findings from a selection of publications. This scientometric analysis intended to explore a large number of peer-reviewed publications published in the years 2009–2013 in, or at least strongly related to, the field of public transport research. We chose a period of five years to focus primarily on recent publications. A comprehensive and accurate collection of corresponding publications builds a foundation to gain empirical evidence for supporting the meta-scientific findings. The methodology basically encompassed the phases of data collection, data cleansing, data processing, and proofreading, further explained in the following.

Data Collection and Cleansing

For the collection of bibliographic data, we used Elsevier's Scopus, which provides advanced functionality to export structured data, including citations and bibliographic data as well as abstracts, keywords, and references based on a search query. A comprehensive collection of structured data on publications builds the basis for semi-automatic data processing activities and minimizes extremely cost- and labor-intensive manual processing (Heilig and Voß 2014; Serenko and Bontis 2004). The reason for choosing Scopus is that it provides decisive advantages over other bibliographic databases such as Thomas Reuter's Web of Science (WoS). In addition to advanced export functionality and more frequent updates, Scopus covers more than twice as many publications from the area of public transport research (see Table 1). In comparison, WoS covers only 53% of the transport-related journals that are indexed by Scopus and does not provide any additional journals that are not already covered by Scopus (see Appendix A). The numbers also indicate a constant increase of publications, which was recently discussed in Banister (2014). Although Google Scholar stands out in its coverage of citation counts, it does not provide means to export structured bibliographic data. Nevertheless, we manually incorporated citation counts from Google Scholar to provide a more accurate picture on top publication citation patterns (see Appendix B). A limitation of using bibliography databases is, however, that it can take a while until new publications are indexed.

TABLE 1. Number of Publications per Year

Database	2009	2010	2011	2012	2013	Overall
Scopus	1,269	1,318	1,618	1,745	1,918	7,868
ISI WoS	654	646	673	764	801	3,538

To retrieve a comprehensive amount of publications, a generic search query is used based on empirical observations during our study. We used the terms **public transport*, *public transit*, *mass transit*, and *urban transport** in the fields Title, Abstract, Keywords, and Source Title (title of the publication outlet). The asterisk represents a wildcard character so that other terms such as *urban transportation* also are considered. As we also obtained some non-related publications from fields such as biochemistry and medicine (mainly due to the term *mass transit*), we further refined the search query by specifying superior research disciplines, including engineering, geography and environmental science, material science, energy, decision sciences, mathematics, computer science, business and economics, and social sciences. The search query found 8,087 data records in the period from 2009 to 2013 (as of May 19, 2014). Then, a cleansing method detected and removed inaccurate data records (e.g., unspecified authors/title, double entries, etc.). The final selection of data records represents a selection of 7,868 publications containing 160,132 references and 22,247 unique keywords. Note that one keyword refers to a complete entry in the keywords list such as that *public transport*, for example, is considered as one keyword, which also applies for acronyms. Only 91.85% of those publications had a non-empty bibliography, resulting in an average of 22.16 references per article (median value of 16 references). Most publications, at an average 92.18%, are written in English. A small percentage, 4.68%, are published in Chinese (i.e., Mandarin) where the metadata can be processed in English.

Data Processing

Besides rather general classification and aggregation methods, we applied scientometric methods from the literature to measure research productivity and impact. Further, we implemented methods to analyze keywords and keyword clusters.

Research Productivity

Research productivity is measured predominantly by the aggregated number of publications of an individual author, a specific affiliation, and/or of a certain publication outlet. Different approaches are used in the literature to measure research productivity: straight count, author position, and equal credit (Holsapple et al. 1994; Serenko and Bontis 2004). The straight count method assigns a score of 1 to each of the co-authors of a publication and, thus, does not discriminate among authors. Although this might be reasonable for alphabetically-ordered author lists, the method undervalues the productivity of single-author papers and favors individual co-authors of multi-author papers in which the main contributor is the first author. In contrast, the author position method assigns higher scores to anterior authors (Howard et al. 1987). The consideration of the author's position, however, might lead to erroneous results when author lists are ordered alphabetically. The equal credit method compensates those errors by scoring individual authors based on the reciprocal of the number of authors. Consequently, the productivity of individual authors decreases by each additional author. In this study, we focused on the equal credit method, as it involves the least tradeoff and error-proneness.

Research Impact

The research impact was measured based on the citations of publications. We calculated the individual citations of journals, conferences, affiliations, and authors as well as the Normalized Citation Impact Index (NCII), which takes into account the longevity of publications (Serenko and Bontis 2004). Note that we considered all citations for measuring impact, not only those retrieved from publications within our selection.

Keyword and Keyword Cluster Analysis

To analyze current focus areas, trends and the interrelation of certain keywords in the field of public transport, we implemented a method for counting all occurrences and co-occurrences of keywords. While the latter involves a huge amount of comparative operations to identify and count common combinations of keywords, a simple count method as used to retrieve top keywords.

Proofreading

To ensure the correctness of the scientometric findings, semi-automatic reviews were conducted to find and correct inconsistencies. These inconsistencies might result from a non-standard specification of certain metadata or missing identification numbers. For instance, the author's affiliation description might occur in different forms and may require careful checking to determine if identical authors are merged correctly; otherwise, related data must be merged manually.

Analysis of Publishing Patterns

To begin, we analyzed the overall consistence of public transport research in terms of publishing patterns. First, we identified major scientific disciplines mainly responsible for the progress in this area of research. Then, we identified contributing countries and investigated publishing patterns on the document level. This involved an analysis of the co-authorship distribution, distribution of document types, referencing patterns, and the number of publications per publication outlet to partially understand how research is produced and conveyed within the community.

Academic Disciplines

To better understand the consistence of public transport research, it is essential to analyze the distribution of main contributing academic disciplines. Thereby, some implications on dominant disciplines can be derived in general. Note that Scopus assigns each publication to at least one academic discipline, i.e., subject area (Scopus 2012). The range of subject areas is limited and not specifically related to the area of public transport. Due to these limitations, we extend the analysis of subject areas by specifically analyzing keywords presented in a later section.

The results in Table 2 reveal some interesting patterns. While it is not surprising that most of the research activities stem from social sciences and engineering, the high percentage of computer science-related research demonstrates the importance of information and communication technology (ICT) and information systems in public transport nowadays. Further, the environmental impact of public transport systems increasingly is being investigated, leading to research on eco-friendly fuel and vehicle alternatives, traffic control, and other measures for reducing harmful air pollution. This requires more research on the interface between public transport and other disciplines such as computer science and environmental science.

TABLE 2.
Academic Disciplines Related to Public Transport

Academic Discipline	Avg. (%)
Social Sciences	32.86
Engineering	28.46
Computer Science	13.35
Environmental Science	8.07
Decision Sciences	4.94
Mathematics	3.53
Business, Management, and Accounting	3.17
Economics, Econometrics, and Finance	2.77
Energy	2.25
Materials Science	0.60

The small percentage of research from mathematics and decision sciences, which plays an essential role in the planning and operation of public transport systems and related structures (such as for route design, timetable development, and crew scheduling; see e.g., Ceder 2007; Kroon et al. 2009; Levinson et al. 2015), can be explained by the fact that more than one academic discipline can be assigned to one publication. Further note that the small share of economics-related research does not mean that research is not based on economics, but that related publications often are not, or not only, labeled as pure economics research papers. As the field involves a lot of interdisciplinary research, theories and methods from the field of mathematics and decision sciences often are combined with engineering and computer science research activities. The same applies for studies focusing on public transport aspects from a business and economics perspective—for instance, in the context of infrastructure investments, which is also related to engineering research (e.g., civil engineering). The concentration of research activities of the various academic disciplines also is reflected in the results of the keyword and keyword cluster analysis described later, in which important topics and interrelations between topics are explored.

Contributing Countries

Next, we analyzed the distribution of contributing countries. To consider the impact of contributions, we separately investigated the main contributing countries of publications that are cited at least 10 times by other publications. Table 3 lists the top contributing countries of both selections with a contribution frequency *f* of at least 1.00%. The numbers indicate that most of the publications are published by scholars from China (18.82%), followed by a large portion of publications from the United States and the United Kingdom. Note that we do not distinguish whether an author is a native or, for instance, a visiting scholar publishing with an affiliation in the respective country. The numbers demonstrate that most research contributions are from countries with a relatively large share of public transport. Some of them are facing serious transport problems, such as those related to traffic congestion (see, e.g., Vickerman 2000). Nevertheless, we must consider that some countries, such as the United States, United Kingdom, Germany, and China, are generally top research contributors in rather fundamental topics important for their development due to their leading role in the global economy and technological progress, as also demonstrated in other scientometric studies (see e.g., Heilig and Voß 2014). Taking into account the number of citations, we observe that authors from the United States (21.84%) have published most of widely-recognized publications.

TABLE 3.
Contributing Countries

Rank	Country	*f* (%)*	Rank	Country	*f* (%)**
1	China	18.82	1	United States	21.84
2	United States	14.85	2	United Kingdom	28.35
3	United Kingdom	5.66	3	China	7.07
4	Australia	4.60	4	Italy	6.42
5	Germany	3.99	5	Australia	6.00
6	Canada	3.67	6	Canada	4.93
7	Italy	3.58	6	Germany	4.93
8	Spain	3.50	8	Spain	4.50
9	France	3.43	9	Netherlands	3.64
10	Japan	2.52	10	France	3.21
11	Netherlands	2.03	10	Sweden	3.21
12	India	1.91	12	Belgium	2.36
13	Sweden	1.69	13	Greece	1.71
14	Belgium	1.67	13	Switzerland	1.71
15	Taiwan	1.40	13	Japan	1.71
16	South Korea	1.32	16	Chile	1.50
17	Portugal	1.26	17	Taiwan	1.28
18	Switzerland	1.24	17	Hong Kong	1.28
19	Austria	1.20	17	Brazil	1.28
20	Brazil	1.10	20	Portugal	1.07
Total		79.45	Total		88.01

**All publications*
***Publication citations ≥ 10*

Co-Authorship Distribution

By analyzing the co-authorship distribution, we observed that the number of co-authors per publication (*f*) lies between 1 and 3 for almost three-quarters of all publications *n*, as shown in the last column of Table 4. A relatively high percentage, at an average 22.06% of publications, is published by a single author. Although a high number of authors might indicate that collaboration may have some advantages over research by individual researchers, for instance, due to the high degree of interdisciplinarity in the field, the numbers demonstrate that public transport research often is very specialized and concerns individual issues, for instance, based on certain conditions in an area of interest. The high percentage of single-authored works underlines these findings. By analyzing co-authorship distribution for multiple time-periods, however, we identified a decline of single-authored publications and a general increase of publications that are published by more than three authors. One of the main reasons is the growing demand for integrative approaches to further advance public transport, requiring interdisciplinary and transdisciplinary research collaborations.

TABLE 4.
Co-Authorship Distribution

# of Authors	2009 (%)	2010 (%)	2011 (%)	2012 (%)	2013 (%)	Overall (%)
1	26.48	24.45	23.99	18.31	17.08	22.06
2	27.11	30.13	27.98	27.32	27.41	27.99
3	23.72	22.94	25.46	26.87	25.70	24.94
4	13.87	13.55	13.65	16.09	16.41	14.71
5	5.28	4.39	5.29	6.39	7.68	5.81
6	1.81	2.50	2.09	2.51	3.06	2.39
7	0.95	1.21	0.80	1.37	1.40	1.15
> 7	0.79	0.83	0.74	1.14	1.25	0.95
n	1,269	1,318	1,618	1,745	1,918	7,868

Publication Outlet

The conscious selection of an appropriate publication outlet often impacts the visibility and citations of publications. Therefore, we explored the distribution of publication outlets to identify the preferences of the community in terms of sharing and conveying knowledge. In Table 5, the numbers show that most of the publications, average 54.39%, are published as a journal paper. An increasing pressure to publish and the growing competition among journals and conferences further contribute to a growing number of publications per year (Banister 2014), leading to a discussion on different publishing strategies of authors and editors as well as on the quality impact (see, e.g., Faria and Goel 2010).

TABLE 5.
Number of Publications by Document Type

Outlet	2009 (%)	2010 (%)	2011 (%)	2012 (%)	2013 (%)	Overall (%)
Article	51.22	55.39	51.55	56.68	57.14	54.39
Conference paper	42.63	38.85	40.17	38.28	36.97	39.38
Review	1.73	1.06	2.16	2.35	1.88	1.84
Short survey	2.52	1.59	1.11	0.74	0.16	1.23
Article in press	-	0.08	0.06	0.46	2.50	0.62
Other	1.89	3.03	4.94	1.49	1.36	2.54
n	1,269	1,318	1,618	1,745	1,918	7,868

The numbers of journal and conference papers lie close together, and the distribution seems to be stable for the period 2009–2013. Although in some fields conference publications are preferred, such as in computer science (Vardi 2009), the main reason for scholars to choose a journal is that their work naturally gains superior consideration, in particular if the journal has a high impact factor or a good reputation (Banister 2014). Apart from that, some scholars may prefer to get quick feedback and to present and discuss current progress to an (international) audience of researchers in the same field for which a dedicated conference would be a better choice. In the field of public transport, we see that both alternatives are frequently used to convey knowledge and insights of research activities.

Referencing Patterns

Next, we analyzed reference patterns of journal and conference papers having a non-empty bibliography. From a scientometric perspective, referencing patterns are essential to understand to what extent existing works build the basis for research progress. In this context, "efficient" means that a publication has a high impact and, thus, largely contributes to the existing knowledge basis. For this purpose, we compared the median (MED) of references per publication with the number of citations. We chose the median as it represents a robust statistic. Generally, we distinguished between journal and conference papers, as depicted in Table 6. A table row describes the median number of references MED depending on the minimum number of citations that a group of publications *n* receives. For example, the median number of references of a journal paper that is cited by 25–49 other publications is 36; the median of a journal that is cited by 1–4 other publications is 27.

TABLE 6.
Referencing Patterns

Min. Citations	n (Conference)	MED	n (Journal)	MED
0	2959	9	4019	24
1	489	12	2329	27
5	75	19	798	29
10	23	26	325	33
25	1	28	61	36
50			9	40
100			1	148

The numbers show a general pattern: a publication retrieves more citations the more publications it cites. Indeed, the coverage of important works is generally recognized as a significant indicator for the impact of publications (Straub 2006). By comparing journal and conference referencing patterns, we observed that journal papers contain more references in general, mainly for the simple reason that the page limits for conference papers often are more restrictive forcing scholars to cut some references.

Keyword and Keyword Cluster Analysis

After analyzing some general publishing patterns, a keyword analysis was conducted to gain deeper insights into important topics, current trends, and relationships between topics reflected by keyword clusters. This supports a better understanding of focus research activities. Generally, keywords are used to abstractly summarize and classify the content of a scientific publication. By aggregating the occurrence of keywords in consecutive time periods, it is possible to identify research trends. Implicit relationships between topics can be identified by analyzing co-occurrences of keywords. For gaining these insights, we implemented methods to aggregate unique keyword occurrences and occurrences of keyword clusters with different lengths. Based on the large bibliographic data basis, we extracted 22,247 unique keywords and analyzed top keywords in the area of public transport. A ranking of keywords with a high frequency (f greater than or equal to 50) is shown in Table 7, indicating the importance of certain topics, challenges, methodologies, and technologies frequently discussed in the last five years. At a glance, important topics can be identified, such as reflected by the keywords *accessibility*, *traffic congestion*, *bus rapid transit*, *sustainable transport*, and *mobility*. Plenty of research activities aim to find sustainable solutions for related challenges currently faced in particular by urban/metropolitan areas.

TABLE 7.
Top Keywords ($f \geq 50$)

Rank	Keyword	f	Rank	Keyword	f
1	transportation	336	30	climate change	66
2	accessibility	158	30	vehicles	66
3	traffic congestion	156	33	urban development	64
4	optimization	145	33	mode choice	64
5	urban planning	141	35	transportation policy	63
6	transportation planning	135	36	bus	61
7	sustainable development	132	37	decision making	60
8	transportation system	127	37	genetic algorithm	60
9	mobility	116	37	united kingdom	60
10	traffic management	110	40	economics	59
11	sustainability	105	40	travel behavior	59
11	urban traffic	105	40	bus rapid transit	59
13	buses	103	43	commuting	58
14	urban areas	102	43	intelligent transportation systems	58
15	land use	99	45	intelligent systems	56
15	light rail transit	99	46	GPS	55
17	China	98	46	public transportation systems	55
18	travel time	97	46	evaluation	55
19	GIS	88	46	transport policy	55
19	planning	88	50	traffic engineering	54
21	transport	87	50	transportation development	54
22	United States	86	52	public transport systems	53
23	research	79	52	computer simulation	53
24	bus transportation	78	54	people movers	52
25	simulation	76	55	sustainable transport	51
26	traffic control	74	55	bus transport	51
27	motor transportation	69	57	walking	50
28	metropolitan area	67	57	surveys	50
28	transport planning	67	57	urban area	50
30	design	66			

This includes activities in designing *transport policies* and involves *urban and transport planning* as well as *urban development* based on *surveys*, *optimization*, and *simulation* studies with regards to transport *economics*, efficiency, and environmental impacts. Moreover, the keyword ranking demonstrates a focus of research on certain transport modalities such as *buses* and *light rail* vehicles. We further see that the top three contributing countries appear in the ranking of top keywords. This confirms that research on public transport often is related to certain countries with a relatively large share of public transport often facing severe challenges of implementing and advancing their public transport systems, as demonstrated by the ranking of top contributing countries. We also can see the strong influence of transportation research in general due to its implication on public transport (e.g., regarding infrastructure and safety aspects) as well as due to the impact of public transport on transportation in general (e.g., regarding sustainable transportation planning and development). Moreover, the importance of innovative technologies and information systems is confirmed, reflected by the keywords *GIS* (geographic information system), *traffic control*, and *intelligent transportation systems* (ITS). This further explains the essential role of computer science-related research, or, in general terms, the importance of interdisciplinary research in the field of public transport. By analyzing the occurrence of some particular keywords per year, it is possible to identify some current trends, for example, related to the focus on sustainability and transport vehicle technologies, expressed by the keywords *sustainability*, *bus rapid transit*, and *electric vehicles*. These exemplary research trends are depicted in Table 8.

TABLE 8.
Keyword Trends

Keyword	2009	2010	2011	2012	2013
sustainability	7	11	23	21	36
bus rapid transit	6	10	10	11	18
electric vehicles	5	6	2	12	16

Topic coherence can be observed by analyzing keyword co-occurrences. We used the term *keyword cluster* to describe a group of a certain number of keywords that co-occur frequently. As mentioned previously, a method was implemented to investigate the occurrence of all possible keyword combinations of different length by a pairwise comparison of respective keyword clusters. As some keywords refer to the superordinate area (e.g., *transportation*, *public transportation*, *mass transit*, *urban transport*, etc.), we excluded these keywords for the keyword cluster analysis to gain meaningful results. In the following, we present the results of the keyword cluster analysis for keyword cluster with two elements (Table 9) and three elements (Table 10).

TABLE 9.
Top Keyword Cluster of Length 2 ($f \geq 15$)

Rank	Keyword Cluster		*f*
1	buses	bus transportation	27
2	cost effectiveness	multimodal transportation	21
2	Europe	Eurasia	21
4	transportation system	transportation planning	20
4	urban planning	United States	20
6	traffic management	traffic congestion	19
6	mass transit systems	light rail transit	19
8	intelligent systems	intelligent transportation systems	18
8	roads and streets	motor transportation	18
8	transportation system	traffic congestion	18
11	gas emissions	greenhouse gases	17
11	transportation planning	united states	17
11	urban planning	sustainable development	17
11	automation	people movers	17
11	transportation development	transportation system	17
16	mobility	accessibility	15
16	railroad transportation	railroads	15
16	rapid transit	light rail transit	15
16	transportation system	transportation	15
16	urban transportation systems	transportation	15
16	urban planning	urban development	15

While some keyword clusters only contain word synonyms (e.g., *gas emissions* and *greenhouse gases*), some keyword clusters expose multiple interesting interrelations, such as between *multimodal transportation* and *cost effectiveness*, which reflects the impact of public transport as a part of transportation in general. Some keyword clusters further reveal the coherence between fundamental topics, such as that *transportation planning* is related to *transportation infrastructure* and *transportation development* as well as to *transportation safety* and *road transport*. Consequently, the keyword cluster analysis provides the data for creating a topic network, which consists of nodes (representing topics) and edges (representing the relationship between topics). An extension of the keyword analysis would be the application of text mining methods based on the content of the publication (e.g., a simple word count). As computational time exponentially grows by increasing the number of publications to be analyzed, it would be beneficial to implement the method as a MapReduce algorithm to count words in publications in a parallel fashion to measure their importance (see, e.g., Akritidis and Bozanis 2012; Agrawal et al. 2011; Dean and Ghemawat 2008).

TABLE 10. Top Keyword Cluster of Length 3 ($f \geq 5$)

Rank	Keyword Cluster			*f*
1	buses	bus transportation	bus stop	10
2	bus transport	transportation system	railway transport	9
3	people movers	light rail transit	automation	8
3	gas emissions	greenhouse gases	global warming	8
3	bus services	bus transportation	buses	8
3	carbon dioxide emissions	carbon dioxide	global warming	8
3	people movers	airports	international airport	8
3	bus terminals	bus stop	bus transportation	8
9	traffic congestion	motor transportation	roads and streets	7
9	automotive engineering	commercial vehicles	automobiles	7
9	road network	motor transportation	roads and streets	7
12	traffic control	motor transportation	road network	6
12	highway administration	motor transportation	roads and streets	6
12	bus transport	transportation system	transportation development	6
12	emission control	gas emissions	greenhouse gases	6
12	buses	bus transportation	travel time	6
12	buses	bus terminals	bus stop	6
18	urban development	metropolitan area	urban planning	5
18	public transportation networks	transportation routes	algorithms	5
18	traffic management	transportation system	traffic congestion	5
18	highway traffic control	intelligent transportation systems	intelligent systems	5
18	buses	bus transportation	traffic congestion	5
18	bus rapid transit	light rail transit	rapid transit	5
18	population densities	population statistics	economics	5
18	railway transport	transportation system	transportation development	5
18	traffic management	roads and streets	motor transportation	5
18	transportation planning	transportation infrastructure	transportation development	5
18	bus stop	arrival time	bus transportation	5
18	road transport	traffic congestion	traffic management	5
18	buses	bus transportation	bus route	5
18	transportation safety	transportation planning	road transport	5
18	bus transport	railway transport	transportation development	5

Citation Patterns

After providing some insights into publishing patterns, current topics, and related trends, we evaluated the impact of contributions by applying scientometric means. A widely-accepted indicator for measuring the impact in a field of research is the number of citations a contribution receives. As the time a publication is available has a significant influence on its citations, we used both aggregated citations and NCII. The NCII makes citations of publications comparable by taking into account the longevity of each publication, which refers to the number of years the publication has been in print (Heilig and Voß 2014; Serenko and Bontis 2004), as shown in equation (1). A paper published in 2009, for instance, has a publication longevity of five years. Citations of the first year fully count for the calculation.

$$NCII = \frac{number\ of\ citations\ per\ publication}{publication\ longevity\ (in\ years)} \tag{1}$$

Overall Citation Patterns

First, we analyzed the distribution and impact of publications in general. The numbers in Table 11 reveal some important patterns. The time significance is reflected by the contrary trend of citations concerning the number of publications. Generally, an increase of the average NCII per publication can be observed for the first two years. In contrast, the results show a declining trend of the average NCII per publication between 2011 and 2013 and a strong decrease in 2013. One of the main reasons for a lower average NCII in 2012 and 2013 is that a lot of works citing those publications still are not covered in Scopus. Nevertheless, we observed that the standard deviation of the numbers from the average NCII per publication over time between 2009 and 2012, which is 0.06 from a mean of 0.67, is not significant. Consequently, we observed that the distribution of citations is evenly distributed.

TABLE 11.
Overall Citation Pattern

Year	2009	2010	2011	2012	2013
Number of publications	1,269	1,318	1,618	1,745	1,918
Number of citations	4,066	3,860	3,370	2,118	756
Longevity (in years)	5	4	3	2	1
Overall NCII	813.20	965.00	1,123.33	1,059.00	756.00
Avg. NCII/publication	0.64	0.73	0.69	0.61	0.39

Outlet Citation Patterns

As shown previously, the large number of journal papers suggests that the scientific community in the field of public transport publishes mostly in journals. By analyzing the distribution of citations with regard to different publication outlets, the reason for the superior role of journal papers becomes obvious. Although conference papers account for only 8.52% of the overall citations on average, journal papers have a huge scientific impact, accounting for 86.99% of the overall citations.

TABLE 12.
Outlet Citation Patterns

Outlet	2009 (%)	2010 (%)	2011 (%)	2012 (%)	2013 (%)	Overall (%)
Journal paper	85.19	87.44	84.54	87.58	90.21	86.99
Conference paper	9.99	9.79	9.26	8.55	5.03	8.52
Review	4.01	1.66	5.58	3.45	4.76	3.89
Other	0.81	1.11	0.62	0.42	-	0.59
Number of citations	**4,066**	**3,860**	**3,370**	**2,118**	**756**	**14,170**

Journal Citations

Due to the superior role of journal papers and their scientific impact, a ranking of top-cited journals (see Table 13) has been generated to reflect the impact of specific journals. While n is the number of publications related to public transport, n_{all} reflects the number of all articles published by the respective journal within the defined time period to demonstrate the concentration of public transport research in those journals. Furthermore, we attached a column with the Impact Factor (IF) and 5-year IF from the 2013 *Journal Citation Reports* (JCR). The IF and 5-year IF calculate the average number of citations per publication based on the preceding two and five years, respectively. However, some of the top cited journals are not covered by the JCR, such as *Public Transport* and *Research in Transportation Economics*.

Publication Citation Patterns

As a further step, we measured the impact of individual publications and generated a ranking of top publications in the area of public transport research (see Appendix B; note that not all articles in the ranking are referenced in the bibliography). For this purpose, the NCII and the total count of citations f for each publication is calculated. An additional column, R_f, includes the ranking by the total count of citations. Publications with a high citation number and a relatively low NCII are attached in the end of the ranking, ordered by f. Moreover, we added citation information of Google Scholar f^G (as of August 26, 2014) and a respective ranking R_{fG}. We observe that important topics, identified with the keyword analysis, are represented in the titles of top publications. The ranking further provides an overview on important literature in the area of public transport.

TABLE 13. Top Cited Journals ($f \geq 75$)

Rank	ISSN	Journal	Publisher	*f*	n	n_{all}	IF (2 y)	IF (5 y)
1	0965-8564	Transportation Research Part A: Policy and Practice	Elsevier	978	137	522	2.525	2.855
2	0967-070X	Transport Policy	Elsevier	813	175	473	1.718	2.084
3	0966-6923	Journal of Transport Geography	Elsevier	747	146	758	2.214	2.768
4	0968-090X	Transportation Research Part C: Emerging Technologies	Elsevier	530	86	591	2.006	2.433
5	0191-2615	Transportation Research Part B: Methodological	Elsevier	402	67	547	3.894	4.439
6	0361-1981	Transportation Research Record	TRB	380	225	4608	0.442	0.636
7	0049-4488	Transportation	Springer	280	81	280	1.617	2.061
8	1361-9209	Transportation Research Part D: Transport and Environment	Elsevier	265	53	469	1.626	1.626
9	1866-749X	Public Transport	Springer	210	65	73	-	-
10	0733-9488	Journal of Urban Planning and Development	ASCE	204	56	196	0.931	0.900
11	0301-4215	Energy Policy	Elsevier	176	31	4257	2.696	3.402
12	1366-5545	Transportation Research Part E: Logistics and Transportation Review	Elsevier	169	21	484	2.193	2.943
13	0308-518X	Environment and Planning A	Pion Ltd.	158	23	996	1.694	2.485
14	0733-947X	Journal of Transportation Engineering	ASCE	150	68	668	0.877	1.073
15	1556-8318	International Journal of Sustainable Transportation	T&F	149	31	120	1.447	1.505
16	0013-936X	Environmental Science & Technology	ACS	133	8	-	5.481	6.277
17	0264-2751	Cities	Elsevier	132	32	455	1.836	2.055
18	0739-8859	Research in Transportation Economics	Elsevier	114	73	262	-	-
19	0144-1647	Transport Reviews	T&F	100	25	225	1.551	2.310
20	0042-0980	Urban Studies	SAGE	98	20	1172	1.330	1.961
21	0360-5442	Energy	Elsevier	96	8	3343	4.159	4.465
22	0048-9697	Science of the Total Environment	Elsevier	94	17	5169	3.163	3.906
23	0094-1190	Journal of Urban Economics	Elsevier	91	8	262	1.888	3.277
24	1570-6672	Journal of Transportation Systems Engineering and Information Technology	Elsevier	84	105	274	-	-
25	1567-7141	European Journal of Transport and Infrastructure Research	TU Delft	77	14	118	1.023	1.132
26	0304-3894	Journal of Hazardous Materials	Elsevier	75	5	7514	4.331	5.123
26	1524-9050	IEEE Transactions on Intelligent Transportation Systems	IEEE	75	18	755	2.472	2.935

n = number of publications
n_{all} = number of all articles published by the respective journal within the defined time period
IF = Impact Factor
TRB = Transportation Research Board
ASCE = American Society of Civil Engineers
ACS = American Chemical Society
T&F = Taylor & Francis

Author Citation Patterns

The impact of individual authors can be derived from the number of citations of co-authored publications. In Table 14, a ranking of top authors based on their individual citations is provided. The top three cited authors are Robert Cervero (University of California, Berkeley), Fred Mannering (Purdue University), and Dominique Lord (Texas A&M University). We further observed that most of the top researchers are from the United States. Note that name changes (e.g., after marriage) are not considered and may have implications for the ranking.

TABLE 14. Top Cited Authors ($f \geq 70$)

Rank	Name	Affiliation	Country	n	NCII	*f*
1	Cervero, Robert	University of California, Berkeley	United States	15	41.433	175
2	Mannering, Fred	Purdue University	United States	3	40.167	158
3	Lord, Dominique	Texas A&M University	United States	2	38.500	154
4	Kennedy, Chris	University of Toronto	United States	8	33.083	142
5	Currie, Graham	Monash University	Australia	30	36.367	132
6	Pucher, John	Rutgers University	United States	7	45.000	127
7	Phdungsilp, Aumnad	Dhurakij Pundit University	Thailand	2	24.250	114
8	Dell'Olio, Luigi	University of Cantabria	Spain	12	33.167	104
9	Ibeas, Angel	University of Cantabria	Spain	10	28.767	100
10	Steinberger, Julia	University of Klagenfurt	Austria	1	17.000	85
10	Pataki, Diane	University of California, Irvine	United States	1	17.000	85
10	Méndez, Gara Villalba	Autonomous University of Barcelona	Spain	1	17.000	85
10	Gasson, Barrie	University of Cape Town	South Africa	1	17.000	85
10	Hansen, Yvonne	University of Cape Town	South Africa	1	17.000	85
10	Ramaswami, Anu	University of Colorado Denver	United States	1	17.000	85
10	Hillman, Tim	University of Colorado Denver	United States	1	17.000	85
17	Burinskiene, Marija	Vilnius Gediminas Technical University	Lithuania	5	16.867	83
18	Hensher, David	University of Sydney	Australia	23	28.333	80
19	Karlaftis, Matthew	National Technical University of Athens	Greece	11	20.233	76
20	Gomez, Luis Fernando	Foundacion FES Social	Colombia	1	15.000	75
20	Jacoby, Enrique	Pan-American Health Organization	United States	1	15.000	75
20	Sarmiento, Olga L.	University of Los Andes	Colombia	1	15.000	75
20	Neiman, Andrea	University of Illinois, Chicago	United States	1	15.000	75
20	Daganzo, Carlo F.	University of California, Berkeley	United States	6	26,333	75
25	Li, Jianqiu	Tsinghua University	China	6	21.483	70

n = number of publications

Affiliation Citation Patterns

Finally, the performance of research institutions in terms of citations was evaluated. The NCII is calculated based on the citations of authors belonging to the affiliation at the time of publication. In the ranking of the top 30 affiliations in Table 15, we see that the University of Toronto, the University of California, Berkeley, and Monash University are the leading research institutions in the field of public transport. Most of the influential affiliations are from the United States confirming the results given in an earlier section.

TABLE 15.
Top Research Institutions (NCII ≥ 40.00)

Rank	Affiliation	Country	NCII
1	University of Toronto	Canada	92.45
2	University of California, Berkeley	United States	87.70
3	Monash University	Australia	76.23
4	University of Sydney	Australia	71.18
5	Tsinghua University	China	65.43
6	Rutgers University	United States	56.73
7	Karlstad University	Sweden	53.37
8	University of Melbourne	Australia	52.83
9	University of Hong Kong	China	50.85
10	Beijing Jiaotong University	China	49.80
11	Texas A&M University	United States	49.03
12	University of Minnesota	United States	48.63
13	Delft University of Technology	Netherlands	46.02
14	Purdue University	United States	44.17
15	Queensland University of Technology	Australia	44.00
16	University of Leeds	United Kingdom	41.62

Research Productivity

The scientometric measurement of research productivity is just as important as analyzing citation patterns for the evaluation of science from a meta-perspective. The overall research productivity is an important indicator for the development of a field of research. It reflects the number of publications individuals contribute to the overall knowledge base within a specific time frame.

Individual Research Productivity

First, we focused on the individual productivity of scholars by using the equal credit method, as discussed earlier. Table 16 provides a ranking of the top 20 scholars in terms of research productivity based on the overall number of co-authored publications, n. The top three scholars are Corrine Mulley (University of Sydney), Graham Currie (Monash University), and Avishai Ceder (University of Auckland). Graham Currie is also one of the most cited authors (Rank = 5, see Table 14). Most of the top contributors are from institutions located in China, which confirms the results of the contributing countries analysis given in an earlier section. As an extension of that section, we see that mostly the high productivity of a handful of scholars located in Australia contribute to the overall productivity. Moreover, we see that only one scholar from the United Kingdom, John Nelson

(University of Aberdeen), is in the top 20 of highly-productive scholars. Consequently, the high overall productivity of institutions located in the United Kingdom (see Table 3) must be generated by a large number of scholars carrying out research in the field.

TABLE 16. Top Individual Productivity (Equal Credit Method)

Rank	Author	Affiliation	Country	n	Score
1	Mulley, Corinne	University of Sydney	Australia	34	15.23
2	Currie, Graham	Monash University	Australia	30	12.43
3	Ceder, Avishai	University of Auckland	New Zealand	24	11.83
4	Cervero, Robert	University of California, Berkeley	United States	15	8.87
5	Hensher, David	University of Sydney	Australia	23	8.82
6	Chen, Yanyan	Beijing Jiaotong University	China	23	8.20
7	Zhang, Guo-wu	Beijing Jiaotong University	China	9	8.20
8	Kumar, Ashok	University of Toledo	United States	17	7.75
9	El-Geneidy, Ahmed	McGill University	Canada	18	7.07
10	Nelson, John	University of Aberdeen	United Kingdom	17	6.27
11	Delbosc, Alexa	Monash University	Australia	14	6.08
12	Wang, Wei	Southeast University	China	21	5.75
13	Kadiyala, Akhil	University of Toledo	United States	12	5.25
14	Yang, Xiaoguang	Tongji University	China	18	5.15
15	Karlaftis, Matthew G.	National Technical University of Athens	Greece	11	5.08
16	Chen, Xuewu	Southeast University	China	14	4.90
17	Gordon, Cameron	University of Canberra	Australia	7	4.75
18	Tirachini, Alejandro	University of Sydney	Australia	13	4.70
19	Chen, Yu-yi	Beijing University of Technology	China	12	4.37
20	Jin, Wen-zhou	South China University of Technology	China	11	4.25

Lotka's Law

We extended the analysis on research productivity by exploring the overall productivity distribution patterns of all authors being active in the field of public transport. This helps not only to understand the structure of this field, but also enables a comparison with other fields and an estimation of future research productivity. For this, prior scientometric studies tested the application of Lotka's law (Serenko and Bontis 2004), which describes a frequency distribution of scientific productivity in a certain field of research. According to Alfred J. Lotka, the proportional relationship between the number of scholars accounting for p publications is about $1/p^{\alpha}$, where $\alpha = 2$ (Coile 1977). On basis of these observations, the theoretical relationship between the number of publications p and the proportional number of all authors making p contributions $f(p)$ is expressed by equation (2):

$$f(p) = {}^{C}/_{p^{\alpha}} \quad (2)$$

where α and C are non-negative constants to be determined from the observations and p = 1, 2, 3, 4, etc. The constant C corresponds to the number of authors who have contributed to the field only once, as in Serenko and Bontis (2004). The start and end point of the time period of investigation are arbitrary as a matter of principle (Wagner-Döbler and Berg 1995).

According to Pao (1986), the Lotka distribution is independent on the period of time investigated. To test the application of Lotka's law, an optimal value of α must be found that fits the distribution of observations. This value can be used to verify Lotka's law and to predict an approximate number of authors contributing a certain frequency of publications (Kretschmer and Rousseau 2001; Serenko and Bontis 2004). Therefore, we calculated the optimal value for α minimizing the sum of absolute errors. By this, we found an α value of 2.62, which is considerably higher than the theoretical α proposed by Lotka (α = 2), but not exceptional regarding other scientometric studies. As discussed in Serenko and Bontis (2004), prior scientometric studies in other fields obtained different values for α within the ranges of 1.5 to 3 (Bonnevie 2003), 1.95 to 3.26 (Chung and Cox 1990), and 2.21 to 2.46 (Cocosila et al. 2011).

The reason for the higher value of α in the area of public transport is that approximately 78.98% of contributors have published only one publication, whereas Lotka assumed that approximately 60% of contributors have a single publication (Coile 1977). This phenomenon can be explained by the fact that scholars often collaborate with practitioners whose primary concern is to explain and solve specific problems rather than producing extensive research on a variety of problems. Thus, those non-academics tend to publish less frequently than academics. Further, note that selecting a certain time period in the development of a scientific area has effects on the frequency distribution, as it generally depends on the individual behavior of authors and on the inflow of new authors (Wagner-Döbler and Berg 1995).

Furthermore, the inequality of the frequency with which scholars are able to contribute has roots in the Matthew Effect (Wagner-Döbler and Berg 1995) and the related theory of cumulative advantage proposed by Price (1976). That is, more eminent scholars are given more credit and are repeatedly rewarded by other scientists. A good reputation promotes the collection of research funds and cultivates co-authored publications with other scholars aiming to collaborate. In Appendix C, we compared the domain-specific optimal value α as well as the aggregated error with the theoretical α proposed by Lotka (α = 2). By analyzing the coefficient of determination (R2), we observe that both the predictions for α = 2 and α = 2.62 fit well to the observed number of authors ($R^2\alpha{=}2, {}_{\alpha=2.62} \geq 0.99$). Of course, R^2 is improved by finding the optimal value for α as the aggregated error decreases. Consequently, we demonstrated that Lotka's law can be used to predict the number of authors that contribute p = 1, 2, 3, 4, etc. publications.

Conclusion

In this study, we conducted a scientometric analysis of public transport research based on a large bibliographic data basis of respective contributions, published in the period from 2009 to 2013. With the empirical findings of this scientometric analysis, we provide novel insights into a range of publishing patterns. The results indicate that most contributions are produced in the United States, China, and the United Kingdom and that mostly social science, engineering, and computer science disciplines are involved. Regarding co-authorship, we see a trend towards multi-authorship contributions to better address interdisciplinary research challenges. Knowledge is conveyed primarily through journal papers, which gain superior consideration in comparison with conference papers. Further, we observe current research topics and trends as well as relationships between topics by analyzing keywords and keyword clusters.

The results demonstrate the role of research in designing public transport policies and planning based on surveys, optimization, and simulation studies that consider economic, efficiency, and environmental factors. In addition, the importance of innovative ICT solutions and information systems for public transport is reflected. The concentration of topics and trends can be compared with current and future challenges for elucidating research gaps. In general, we see a trend and major research efforts to better integrate different problems and research disciplines in the area of public transport, allowing for system-wide improvement and innovations based on interdisciplinary and even transdisciplinary research activities.

By applying scientometric methods, we further present valuable rankings on current driving forces in terms of research productivity and impact, respectively, as well as on research outlets and topics. The intention of this study was to provide a novel meta-perspective on public transport research that extend common review papers and further helps scholars and practitioners to get a quick overview on important aspects. Consequently, our results may help steer individual projects, extend research collaborations, and select a proper publication outlet, to name a few benefits.

Finally, we conducted an experiment to verify the satisfaction of Lotka's law, showing that the distribution of productivity can be compared to several other research areas as our results show that the theoretical distribution fits to the observed data. Methodologically, the empirical findings demonstrate the strength of a scientometric analysis to extensively investigate a field of interest. As demonstrated, the results of the scientometric analysis are not only valuable for discussing and defining future research agendas in the area of public transport. Technically, the semi-automated process of assessing a large amount of publications makes it possible to easily obtain a comprehensive overview of a particular research area. This, in contrast, cannot be achieved by a structured literature review to that degree. Therefore, the study represents a good starting point for academics and practitioners to identify the sources and concentration of the existing knowledge base.

For further research, the temporal scope of our scientometric analysis could be expanded to explore long-term developments in the area of public transport. In methodological terms, we intend to investigate network structures among authors as well as the relationship between topics and authors. A respective visual representation would help to see at a glance pivotal elements and their connections to each other. By exploring those connections, we aim to measure and explain their potential impact on the structure and development of public transport research from different perspectives, for instance, by exploring the effect of maintaining a high level of collaboration or networking in scientific circles on research productivity and citations of individual authors.

Another interesting aspect for further research is the analysis of collaboration structures between academics and professionals to explore how public transport research is influenced by practice. More importantly, the analysis of network structures may help to observe the lack of research or collaboration such as by identifying missing connections (e.g., between topics), as shown in Schwarze et al. (2012). Technically, we intend to further improve the applied data processing methods to further reduce manual proofreading activities by means of data mining techniques and accuracy metrics. In this regard, we aim to apply MapReduce algorithms to parallelize computations to reduce computation time.

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Appendix A

TABLE 17.
Comparison of Journal Coverage of Scopus (2015) and WoS (2015)

ISSN	Journal Title	WoS
18245463	Advances in Transportation Studies	-
08669546	Archives of Transport (active until 2012)	-
2213624X	Case Studies on Transport Policy	-
22120122	Economics of Transportation	-
15677141	European Journal of Transport and Infrastructure Research	X
18253997	European Transport - Trasporti Europei	-
18670717	European Transport Research Review	-
19391390	IEEE Intelligent Transportation Systems Magazine	X
15249050	IEEE Transactions on Intelligent Transportation Systems	X
20429738	IET Electrical Systems in Transportation	-
1751956X	IET Intelligent Transport Systems	X
18688659	International Journal of Intelligent Transportation Systems Research	-
17566517	International Journal of Shipping and Transport Logistics	X
15568318	International Journal of Sustainable Transportation	X
03918440	International Journal of Transport Economics	-
10096744	Journal of Transportation Systems Engineering and Information Technology	-
01976729	Journal of Advanced Transportation	X
15472450	Journal of Intelligent Transportation Systems	X
2095087X	Journal of Modern Transportation	-
1077291X	Journal of Public Transportation	X
22109706	Journal of Rail Transport Planning and Management	-
09696997	Journal of Air Transport Management	X
16711637	Journal of Traffic and Transportation Engineering	-
22141405	Journal of Transport and Health	X
19387849	Journal of Transport and Land Use	-
00225258	Journal of Transport Economics and Policy	X
09666923	Journal of Transport Geography	X
00225266	Journal of Transport History	-
0733947X	Journal of Transportation Engineering	X
19439962	Journal of Transportation Safety and Security	-
19387741	Journal of Transportation Security	-
15706672	Journal of Transportation Systems Engineering and Information Technology	-
18744478	Open Transportation Journal	-
03037800	Periodica Polytechnica Transportation Engineering	-
16137159	Public Transport	-
1016796X	Public Transport International (active until 2012)	-
22105395	Research in Transportation Business and Management	-
07398859	Research in Transportation Economics	X
10375783	Road and Transport Research	X

ISSN	Journal Title	WoS
23275626	SAE International Journal of Transportation Safety	-
0360859X	Special Report - National Research Council, Transportation Research Board	-
00404748	Texas Transportation Researcher	-
16484142	Transport	X
14076160	Transport and Telecommunication	-
0967070X	Transport Policy	X
18960596	Transport Problems	-
01441647	Transport Reviews	X
00494488	Transportation	X
22143912	Transportation Geotechnics	-
00411612	Transportation Journal	X
19427867	Transportation Letters	X
03081060	Transportation Planning and Technology	X
09658564	Transportation Research Part A: Policy and Practice	X
01912615	Transportation Research Part B: Methodological	X
13619209	Transportation Research Part D: Transport and Environment	X
13665545	Transportation Research Part E: Logistics and Transportation Review	X
13698478	Transportation Research Part F: Traffic Psychology and Behaviour	X
03611981	Transportation Research Record	X
00411655	Transportation Science	X
18128602	Transportmetrica (active until 2012)	X
23249935	Transportmetrica A: Transport Science	X
21680566	Transportmetrica B	X
17494729	World Review of Intermodal Transportation Research	-
10062823	Journal of Wuhan University of Technology (Transportation Science and Engineering)	-

Appendix B

TABLE 18.
Top Publications (by NCII)

Rank	R_f	R_{fG}	Publication	NCII	f	f^G
1	1	1	Lord D., Mannering F. (2010) The statistical analysis of crash- frequency data: A review and assessment of methodological alternatives. Transportation Research Part A: Policy and Practice, 44(5): 291-305.	38.50	154	294
2	2	3	Kennedy C., Steinberger J., Gasson B., Hansen Y., Hillman T., Havranek M., Pataki D., Phdungsilp A., Ramaswami A., Mendez G.V. (2009) Greenhouse gas emissions from global cities. Environmental Science and Technology, 43(19): 7297-7302.	17.00	85	178
2	4	2	Glaeser E.L., Kahn M.E. (2010) The greenness of cities: Carbon dioxide emissions and urban development. Journal of Urban Economics, 67(3): 404-418.	17.00	68	286

Rank	R_f	R_{fG}	Publication	NCII	f	f^G
4	9	26	Wang W., Zhang W., Guo H., Bubb H., Ikeuchi K. (2011) A safety-based approaching behavioral model with various driving characteristics. Transportation Research Part C: Emerging Technologies, 19(6): 1202-1214.	16.67	50	72
5	154	60	Giles-Corti B., Bull F., Knuiman M., McCormack G., Van Niel K., Timperio A., Christian H., Foster S., Divitini M., Middleton N., Boru B. (2013) The influence of urban design on neighborhood walking following residential relocation: Longitudinal results from the RESIDE study. Social Science and Medicine, 77(1): 20-30.	16.00	16	36
6	5	16	Rakopoulos D.C., Rakopoulos C.D., Hountalas D.T., Kakaras E.C., Giakoumis E.G., Papagiannakis R.G. (2010) Investigation of the performance and emissions of bus engine operating on butanol/diesel fuel blends. Fuel, 89(10): 2781-2790.	15.75	63	90
7	12	6	Pucher J., Buehler R., Seinen M. (2011) Bicycling renaissance in North America? An update and re-appraisal of cycling trends and policies. Transportation Research Part A: Policy and Practice, 45(6): 451-475.	15.33	51	97
8	3	4	Cervero R., Sarmiento O.L., Jacoby E., Gomez L.F., Neiman A. (2009) Influences of built environments on walking and cycling: Lessons from Bogotá. International Journal of Sustainable Transportation, 3(4): 203-226.	15.00	38	57
9	6	24	Chen X., Xia X., Zhao Y., Zhang P. (2010) Heavy metal concentrations in roadside soils and correlation with urban traffic in Beijing, China. Journal of Hazardous Materials, 181(1-3): 640-646.	14.50	34	141
9	54	29	Blocken B., Janssen W.D., van Hoo T. (2012) CFD simulation for pedestrian wind comfort and wind safety in urban areas: General decision framework and case study for the Eindhoven University campus. Environmental Modelling and Software, 30: 15-34.	14.50	29	61
11	14	20	Daganzo C.F., Gayah V.V., Gonzales E.J. (2011) Macroscopic relations of urban traffic variables: Bifurcations, multivaluedness and instability. Transportation Research Part B: Methodological, 45(1): 278-288.	13.67	16	86
11	14	19	Geroliminis N., Sun J. (2011) Properties of a well-defined macro- scopic fundamental diagram for urban traffic. Transportation Research Part B: Methodological, 45 (3): 605-617.	13.67	41	87
13	8	15	Bissell D. (2010) Passenger mobilities: Affective atmospheres and the sociality of public transport. Environment and Planning D: Society and Space, 28(2): 270-289.	12.75	51	97
14	21	30	Wu Y., Wang R., Zhou Y., Lin B., Fu L., He K., Hao J. (2011) On-road vehicle emission control in Beijing: Past, present, and future. Environmental Science and Technology, 45(1): 147-153.	12.67	38	57
15	30	8	Duranton G., Turner M.A. (2011) The fundamental law of road congestion: Evidence from US cities. American Economic Review, 101(6): 2616-2652.	11.33	34	141

Rank	R_f	R_{fG}	Publication	NCII	f	f^G
16	32	56	Dell'Olio L., Ibeas A., Cecin P. (2011) The quality of service desired by public transport users. Transport Policy, 18(1): 217-227.	11.00	33	53
16	32	56	Li Z., Chen C., Wang K. (2011) Cloud computing for agent-based urban transportation systems. IEEE Intelligent Systems, 26(1): 73-79.	11.00	33	53
16	305	62	Redman L., Friman M., Garling T., Hartig T. (2013) Quality attributes of public transport that attract car users: A research review. Transport Policy, 25: 119-127.	11.00	11	23
19	7	9	Eliasson J., Hultkrantz L., Nerhagen L., Rosqvist L.S. (2009) The Stockholm congestion - charging trial 2006: Overview of effects. Transportation Research Part A: Policy and Practice, 43(3): 240-250.	10.80	54	125
20	99	61	Abou-Zeid M., Witter R., Bierlaire M., Kaufmann V., Ben-Akiva M. (2012) Happiness and travel mode switching: Findings from a Swiss public transportation experiment. Transport Policy, 19(1): 93-104.	10.00	20	28
20	344	64	Camacho T.D., Foth M., Rakotonirainy A. (2013) Pervasive technology and public transport: Opportunities beyond telematics. IEEE Pervasive Computing, 12(1): 18-25.	10.00	10	12
22	10	30	Jakimavicius M., Burinskiene M. (2009) A GIS and multi-criteria- based analysis and ranking of transportation zones of Vilnius city. Technological and Economic Development of Economy, 15(1): 39- 48.	9.80	49	57
22	10	13	Crainic T.G., Gendreau M., Potvin J.-Y. (2009) Intelligent freight-transportation systems: Assessment and the contribution of operations research. Transportation Research Part C: Emerging Technologies, 17(6): 541-557.	9.80	49	109
24	18	10	Santos G., Behrendt H., Teytelboym A. (2010) Part II: Policy instruments for sustainable road transport. Research in Transportation Economics, 28(1): 46-91.	9.75	39	116
25	50	28	Angel S., Parent J., Civco D.L., Blei A., Potere D. (2011) The dimensions of global urban expansion: Estimates and projections for all countries, 2000-2050. Progress in Planning, 75(2): 53-107.	9.67	29	70
26	57	58	Eboli L., Mazzulla G. (2011) A methodology for evaluating transit service quality based on subjective and objective measures from the passenger's point of view. Transport Policy, 18(1): 172-181.	9.33	28	51
27	23	6	Shaheen S., Guzman S., Zhang H. (2010) Bikesharing in Europe, the Americas, and Asia. Transportation Research Record, 2143: 159-167.	9.25	37	152
27	23	12	Thiagarajan A., Biagioni J., Gerlich T., Eriksson J. (2010) Cooperative transit tracking using smart-phones. In: Proceedings of the 8th ACM Conference on Embedded Networked Sensor Systems (SenSys 2010), 85-98, ACM.	9.25	37	110
29	114	63	Yu B., Yang Z.-Z., Jin P.-H., Wu S.-H., Yao B.-Z. (2012) Transit route network design-maximizing direct and transfer demand density. Transportation Research Part C: Emerging Technologies, 22: 58-75.	9.00	18	22

Rank	R_f	R_{fG}	Publication	NCII	f	f^G
29	59	59	Awasthi A., Chauhan S.S. (2011) Using AHP and Dempster-Shafer theory for evaluating sustainable transport solutions. Environmental Modelling and Software, 26(6): 787-796.	9.00	27	45
29	61	16	Lin J.-R., Yang Ta-Hui T.-H. (2011) Strategic design of public bicycle sharing systems with service level constraints. Transportation Research Part E: Logistics and Transportation Review, 47(2): 284-294.	9.00	27	90
(36)	13	7	Crainic T.G., Ricciardi N., Storchi G. (2009) Models for evaluating and planning city logistics systems. Transportation Science, 43(4): 432-454.	8.60	43	144
(41)	14	22	Feng K., Hubacek K., Guan D. (2009) Lifestyles, technology and CO2 emissions in China: A regional comparative analysis. Ecological Economics, 69(1): 145-154.	8.20	41	78
(48)	17	30	Middleton J. (2009) "Stepping in time": Walking, time, and space in the city. Environment and Planning A, 41(8): 1943-1961.	8.00	40	57
(49)	18	23	Vandenbulcke G., Steenberghen T., Thomas I. (2009) Mapping accessibility in Belgium: a tool for land-use and transport planning? Journal of Transport Geography, 17(1): 39-53.	7.80	39	77
(49)	18	21	Coveney J., O'Dwyer L.A. (2009) Effects of mobility and location on food access. Health and Place, 15(1): 45-55.	7.80	39	85
(55)	21	14	Cao X.J., Mokhtarian P.L., Handy S.L. (2009) The relationship between the built environment and non-work travel: A case study of Northern California. Transportation Research Part A: Policy and Practice, 43(5): 548-559.	7.60	38	108
(57)	23	11	Ewing R., Dumbaugh E. (2009) The built environment and traffic safety: A review of empirical evidence. Journal of Planning Literature, 23(4): 347-367.	7.40	37	112
(57)	23	18	Wang D., Chai Y. (2009) The jobs-housing relationship and commuting in Beijing, China: the legacy of Danwei. Journal of Transport Geography, 17(1): 30-38.	7.40	37	88
(23)	27	27	Currie G. (2010) Quantifying spatial gaps in public transport supply based on social needs. Journal of Transport Geography, 18(1): 31-41.	8.75	35	71
(67)	28	25	Von Ferber C., Holovatch T., Holovatch Y., Palchykov V. (2009) Public transport networks: Empirical analysis and modeling. European Physical Journal B, 68(2): 261-275.	7.00	35	73
(23)	28	32	Hu X., Chang S., Li J., Qin Y. (2010) Energy for sustainable road transportation in China: Challenges, initiatives and policy implications. Energy, 35(11): 4289-4301.	8.75	35	54

Appendix C

TABLE 19.
Lotka's Law – Frequency Distribution of Contributions by Author

No. of Publications	No. of Authors	Predicted Number of Authors (α = 2)	Difference Observed - Predicted (α = 2)	Predicted Number of Authors (α = 2.62)	Difference Observed - Predicted (α = 2.62)
1	7,653	7,653.00	0.00	7,653.00	0.00
2	1,282	1,913.25	631.25	1,244.90	37.10
3	366	850.33	484.33	430.30	64.30
4	162	478.31	316.31	202.50	40.50
5	90	306.12	216.12	112.86	22.86
6	46	212.58	166.58	70.00	24.00
7	26	156.18	130.18	46.74	20.74
8	18	119.58	101.58	32.94	14.94
9	11	94.48	83.48	24.19	13.19
10	7	76.53	69.53	18.36	11.36
11	9	63.25	54.25	14.30	5.30
12	2	53.15	51.15	11.39	9.39
13	2	45.28	43.28	9.23	7.23
14	2	39.05	37.05	7.60	5.60
15	3	34.01	31.01	6.35	3.35
16	3	29.89	26.89	5.36	2.36
17	1	26.48	25.48	4.57	3.57
18	1	23.62	22.62	3.94	2.94
19	1	21.20	20.20	3.42	2.42
21	3	17.35	14.35	2.63	0.37
28	1	9.76	8.76	1.24	0.24
31	1	7.96	6.96	0.95	0.05
Total	9,690	12,231.38	2,541.38	9,906.75	291.81
				R^2 (α = 2.00)	0.99001
				R^2 (α = 2.62)	0.99987

About the Authors

Leonard Heilig (*leonard.heilig@uni-hamburg.de*) holds a B.Sc. from the University of Münster (Germany) and an M.Sc. from the University of Hamburg (Germany) in Information Systems. Currently, he holds a position at the Institute of Information Systems at the University of Hamburg. He spent some time at the University of St Andrews (Scotland, UK) focusing on security management, web technologies, and software engineering. Practical experiences include work at companies such as Adobe, Airbus Group Innovations, and Beiersdorf Shared Services. His current interest focuses on business-oriented cloud computing.

Prof. Dr. Stefan Voß (*stefan.voss@uni-hamburg.de*) is director of the Institute of Information Systems at the University of Hamburg. In addition to being professor in Hamburg, he holds a visiting position at the PUCV in Valparaiso, Chile. Previous positions include full professor and head of the department of Business Administration, Information Systems and Information Management at the University of Technology Braunschweig (Germany) from 1995 to 2002. He holds degrees in Mathematics (diploma) and Economics from the University of Hamburg and a Ph.D. and the habilitation from the University of Technology Darmstadt. His current research interests are in quantitative/information systems approaches to supply chain management and logistics, including applications in maritime shipping, public mass transit, and telecommunications. He is author and co-author of several books and numerous papers in various journals and serves as editor of *Netnomics* and *Public Transport*.