https://dx.doi.org/10.1016/j.trb.2020.05.016

A bibliometric overview of *Transportation Research Part B: Methodological* in the past forty years (1979–2019)

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Abstract: In 1979, *Transportation Research Part B: Methodological* (*TR-Part B*) split from its mother journal *Transportation Research*, which was founded by Dr. Frank A. Haight in 1967, to set off on a journey as an independent journal with a theme on methodological development of transportation science. Since then, *TR-Part B* has been a leading international journal in the field of transportation research. Motivated by the 40th anniversary of *TR-Part B* (1979–2019), this paper utilized a bibliometric analysis technique to present a lifetime overview of the development characteristics and contribution details of *TR-Part B* in the past 40 years. The data used in this analysis were derived from the *Core Collection Database* of *Web of Science*, producing a total of 2,697 papers that were regular articles and reviews published in *TR-Part B* during the study period from 1979 to 2019. A systematic bibliometric analysis was conducted using *VOSviewer* software around two main aspects. First, analysis was conducted on publication and citation structures, the leading authors, organizations, and regions/countries with the most number of academic publications in *TR-Part B*, as well as those individuals and sources citing *TR-Part B* the most. Second, a visualization of the bibliometric characteristics of *TR-Part B* was presented in a knowledge mapping network analysis of co-authorship and bibliographic coupling. This paper reviews the contributions made to the lifetime development of *TR-Part B* during the past four decades and reveals insightful bibliometric findings.

Keywords: *Transportation Research Part B: Methodological***,** Bibliometrics, Development review, Web of Science, *VOSviewer*

1 Introduction

In 1967, Dr. Frank A. Haight (1919–2006), one of the founding fathers of modern transportation research, founded the journal *Transportation Research* (*TR*) with the aim to improve international communication of transportation research. To accommodate different facets and nature of various research outcomes, *Transportation Research* later split into two parts in 1979: *Part A: Policy and Practice (TR-Part A)*, and *Part B: Methodological (TR-Part B)*; there then followed forty glorious years of *TR-Part B* (ISSN: 0191-2615), which advanced the methodological development of transportation science globally.

In 2018, a new member–*Transportation Research Interdisciplinary Perspectives* (*TRIP*)– joined the *TR* series, resulting in a more complete coverage of the social science aspects of transportation. Among the six journals (i.e., *Parts A* to *F*) in the *TR* series, *TR-Part B* has long been the top ranking journal with the highest impact factor(IF),[1] due to its strict requirements for expertise on and analysis of the methodological basis of transportation studies, including operational research theories and statistical, econometric, and mathematical models.

According to the journal homepage,[2] *TR-Part B* publishes papers on all methodological aspects of the subject of transportation, and particularly those that require mathematical proof and analysis. The general theme of the journal is to develop solutions to problems affecting important aspects of the design and/or analysis of transportation systems. Research areas covered by *TR-Part B* include traffic flow, design and analysis of transportation networks, control and scheduling, optimization, queuing theory, logistics, supply chains, and the development and application of statistical, econometric, and mathematical models to address transportation problems. *TR-Part B*'s aims and scope are complementary to *TR-Part A*, *Part C: Emerging Technologies* (*TR-Part C*), and *Part D: Transport and Environment*. The complete set of *TR* journals forms the most cohesive and comprehensive reference for current research in transportation science. For a brief review of the progress of *TR-Part B* in the past decades, together with the visions and intended actions that the Editor-in-Chief of this journal would implement in the next few years, one can refer to Bhat (2019).

As the Scientometrics rapidly develops over recent years, it is common to investigate the development history of a specific subject/topic or an international journal by conducting a bibliometric overview. For example, some existing bibliometric studies on a specific subject or topic have analyzed co-authorship networks (Sun and Rahwan, 2017), themes and trends (Sun and Yin, 2017) in transportation research, road safety studies (Zou et al., 2018; Hagenzieker et al., 2014), safety culture research (van Nunen et al., 2018), operations research and management science (Merigó and Yang, 2017), and innovation (Merigó et al., 2016).

Meanwhile, international journals have celebrated their respective anniversaries and analyzed their past academic performance by publishing bibliometric-based overviews. Recently, to celebrate the 150th anniversary, the journal *Nature* (since November 1869) launched a special issue on November 6, 2019, to explore the past, present and future of *Nature* and of science, in which a bibliometric technique is largely used (Monastersky and Van Noorden, 2019). A similar bibliometric technique has been used to provide an overview of performance and trends by many other journals, including the *European Journal of Operational Research* (1977–2016) (Laengle et al., 2017), *Information Sciences* (1968–2016) (Merigó et al., 2018; Yu et al., 2017), *Journal of Business Research* (1973–2014) (Merigó et al., 2015), *Knowledge-Based Systems* (1991–2014) (Cobo et al., 2015), *International Journal of Intelligent Systems* (1986–2015) (Merigó et al., 2017), and the *Journal of Business & Industrial Marketing* (1986–2015) (Valenzuela et al., 2017). In the specific field of transportation research, to celebrate the first fifty years of the *Transportation Research* journals (1967–2017), a bibliometric overview of the half-century developmental journey of the seven parts of the *TR* journals (i.e., the initial *Transportation Research* (1967–1978) and *TR-Part A* to *TR-Part F*) was conducted by Modak et al. (2019).

In this paper, the focus is on a specialized bibliometric overview of the development of *TR-Part B*, which has been the top journal in the *TR* series. Motivated by the 40th anniversary of *TR-Part B* (1979–2019), the objective of this paper is to provide an informative, bibliographic overview of *TR-Part B* over its lifetime. To achieve this goal, a wide range of bibliometric indicators are used,

[1] As a newly launched journal, *TRIP* does not yet have impact factor data. According to the 2018 Journal Citation Report by Clarivate Analytics (2019), the latest IF of *TR-Part B* is 4.574, which is just smaller than that of *TR-Part C* (5.775) in the *TR* series.

[2] https://www.journals.elsevier.com/transportation-research-part-b-methodological/.

including the number of publications, citations, citations per paper, and *h*-index (Alonso et al., 2009; Franceschini and Maisano, 2010). The VOSviewer software (van Eck and Waltman, 2010) is employed to compute and visualize the bibliometric networks.

The remainder of the paper is structured as follows. Section 2 introduces data sources, data cleaning methods, the bibliometric methodology and analytical tool that to be used throughout the paper. Section 3 analyzes a wide range of bibliometric issues, including the publication and citation structures, the prolific units with most publications in *TR-Part B*, and those citing *TR-Part B* the most. Section 4 presents a visualization analysis of *TR-Part B* using VOSviewer software on co-authorship and bibliometric coupling. Finally, Section 5 summarizes the key findings of this analysis together with recommendations for further study.

2 Methodology

As an important tool for document analysis, bibliometrics is the branch of library and information science that involves quantitative research of bibliographic material (Broadus, 1987; Pritchard, 1969) and has been widely used to provide general overviews of a set of literature documents. This section introduces the data sources, the data cleaning methods, and the analytical VOSviewer software tool used in this paper.

2.1 Data sources and data cleaning

2.1.1 Data description

The data used in this study were derived from the *Core Collection Database* of *Web of Science* (WoS) (http://www.webofknowledge.com/). To review the entire lifetime of *TR-Part B*, the dataset, which consisted of a total of 2,743 documents, covered all official publications in *TR-Part B* right from the first issue in 1979 up to the final issue of 2019.

These 2,743 documents belong to five manuscript types, i.e., *Article*, *Review*, *Editorial material*, *Correction*, and *Biographical item*. Table 1 gives their counts and corresponding percentages. Given that the latter three manuscript types (i.e., *Editorial material*, *Correction*, and *Biographical item*) contribute differently in the academic domain, the manuscript types in this study were exclusively limited to regular *Articles* (A) and *Reviews* (R). In the rest of this paper, the label "manuscript" should be interpreted narrowly as being either an *Article* or a *Review*. We will also use the label "papers" to refer to these manuscripts.

Table 1. Manuscript types and the number of manuscripts published in *TR-Part B* (1979–2019).

Manuscript types	Counts	Percentage
Article (A)	**2,680**	**97.70%**
Review (R)	**17**	**0.62%**
Editorial material	27	0.98%
Correction	18	0.66%
Biographical item	1	0.04%
Total (1979–2019)	**2,743**	**100%**

The *Full Record and Cited References* of a total of 2,697 articles and review manuscripts

(2,680 articles and 17 reviews) published in *TR-Part B* from 1979 to 2019 were downloaded from WoS to conduct the analysis throughout the paper. Note that WoS restricts the citing publications to those papers indexed by *Citation Indexes* and *Chemical Indexes*.[3]

2.1.2 Corrections of author names and other units

Several important issues had to be resolved with the raw publication data from WoS before conducting further analysis. Of these, the ambiguity of author names was the most challenging problem, as author names were often recorded in different formats in WoS. Sun and Rahwan (2017) encountered the same problem in their study on co-authorship network in transportation research. Two particular challenges with regard to author name ambiguities are discussed below.

The first challenge with names was that a specific author may have more than one variant. Usually, the family name of an author was listed accurately, but the listing/initials of the first and middle names were not always consistent. For example, it was found in the data set that the name of the scholar "Train, Kenneth E." had four variants: (1) Train, K, (2) Train, K.E., (3) Train, Kenneth, and (4) Train, Kenneth E. These variants of the same author needed to be identified and merged into a single name format. The second challenge was the difficulty in distinguishing different authors who had the same family name and the same initial for their first name. This was more common among the community of Asian scholars with the same family names. For instance, when the authorship of the 80 papers resulting from a search of "Yang, H" was thoroughly investigated, six were verified not to be the scholar Hai Yang affiliated with The Hong Kong University of Science and Technology (HKUST) and had to be eliminated, so that the number reduced to 74.

To address the two challenges discussed above, Sun and Rahwan (2017) designed an author name correction algorithm with which to refine the data. However, when a more in-depth investigation of the data was carried out, it was found that the situation encountered was a little more complicated than addressing just the two issues mentioned above.

- *Typographical errors*. Typographical errors occasionally occurred in the raw data set. For example, one of the current 74 papers most likely to be authored by Hai Yang was recorded as "Yang, Hal", which was eventually confirmed to be "Yang, Hai" through official email verification. As a result, it was finally verified that the number of academic papers authored by Hai Yang (HKUST) in the dataset was 74. Another instance of this was that the surname of "Holguin-veras, Jose", which was mistakenly recorded as "Hoiguin-veras".
- *Different full spelling of given names*. In general, two names with the same surname and different full spelling of given names should be considered as two individual authors. However, an exception exists when an author chooses to use different given names in different papers. For example, the names "Recker, Will W." and "Recker, Wilfred W." in the dataset were verified to be that of the same scholar affiliated with the University of California, Irvine, as the listings shared the same email "wwrecker@uci.edu" ; similarly, several papers by "Smith, Mike" in the data set were later verified to be by "Smith, Michael J." (University of York, England) by the fact that these papers were included in the "publication list" of the official homepage of "Mike Smith."

The issues mentioned above could not be easily resolved by a programing algorithm alone. Instead, a process of manual confirmation was required in many instances. In addition to author

[3] *Citation Indexes* of WoS Core Collection include SCI-E, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI; While *Chemical Indexes* include CCR-E (Current Chemical Reactions-Expanded) and IC (Index Chemicus).

name correction, other organization- or region-related adjustments of the raw dataset were also implemented. For example, given that HEC Montreal and Polytechnique Montreal are officially affiliated to the University of Montreal, the contributions of these two institutes (though have also made important contributions to *TR-Part B*, separately) were identified and emerged into those of the University of Montreal to make the dataset in WoS consistent for analysis through the study period 1979–2019. What's more, given the academic influence of scholars and organizations in Hong Kong, China on *TR-Part B*, "Hong Kong, P R China" was specifically identified so as to be independently analyzed as a *region,* rather than merged into "China."

2.2 Analytical tool and bibliometric methods

2.2.1 Bibliometric methods

For ease in analysis construction and result interpretation, two major bibliometric methods (co-authorship and bibliographic coupling) available in the VOSviewer software were used in this paper. These are summarized below.

Co-authorship, which was first mentioned by Beaver and Rosen (1978, 1979a, 1979b), is mainly used to analyze the co-signatures of authors in published papers. The logic of co-authorship is straightforward in that if two authors co-author a published paper, they are considered to have a mutually cooperative relationship, which is expressed as a link connecting the two authors in a co-authorship network. In the current paper, co-authorship is not only analyzed among different authors, but also among different universities.

Bibliographic coupling of documents, the idea of which originated with Kessler (1963), is used to measure the similarity of two different manuscripts by computing the number of identical references cited in them. In general, the number of citation couplings can be used to quantitatively measure the degree of static connection between the two manuscripts (note that the results of bibliographic coupling of two manuscripts are fixed and invariant, because once a manuscript is published, the list of references will not be changed). The more the number of common citations, the stronger is the coupling between the two manuscripts. In the current paper, the theory of bibliographic coupling analysis is extended to coupling across all the manuscripts at the levels of authors and organizations.

2.2.2 VOSviewer and its basic methods

This study was conducted using the bibliometric analysis software VOSviewer (v.1.6.14), which is widely recognized as a strong analytic package in the field of bibliometrics. VOSviewer stands for Visualization of Similarity Viewer, and was originally developed by Dr. N. J van Eck and Dr. L. Waltman (van Eck and Waltman, 2010) from Leiden University. A number of advanced features, including *co-authorship*, *co-occurrence*, *bibliographic coupling*, and *co-citation* networks, are available in VOSviewer to present bibliometric relationships among authors, terms, documents, and cited references.

The core algorithms embedded in VOSviewer include the construction of similarity matrices (Waltman et al., 2010), the unified approach of VOS mapping and clustering of bibliometric networks (Waltman et al., 2010; van Eck and Waltman, 2010; van Eck and Waltman, 2009), and the principle of density graphing (van Eck and Waltman, 2010). In the interests of brevity and focus, the methodological details of these algorithms are not discussed here, but interested readers can refer to the papers listed above.

3 Statistical results

This section presents the statistical analysis of publication- and citation-related structures of *TR-Part B* in the past forty years. In this section, every author, paper, organization or country is treated and analyzed as an independent unit without interactions. Interactions between these units are investigated later in Section 4.

3.1 Publication and citation structures

3.1.1 Analysis of annual publications

The number of manuscripts published each year in a journal can be considered as an indicator of that journal's academic impact. The annual quantity of publications in *TR-Part B* from 1979 to 2019 is depicted in Figure 1, which clearly shows the temporal evolution of the scale of publication. Clearly, there has been an increasing trend over time in the number of articles published in *TR-Part B*, commensurate with the increasing intensity of research and activity in the transportation field over time.

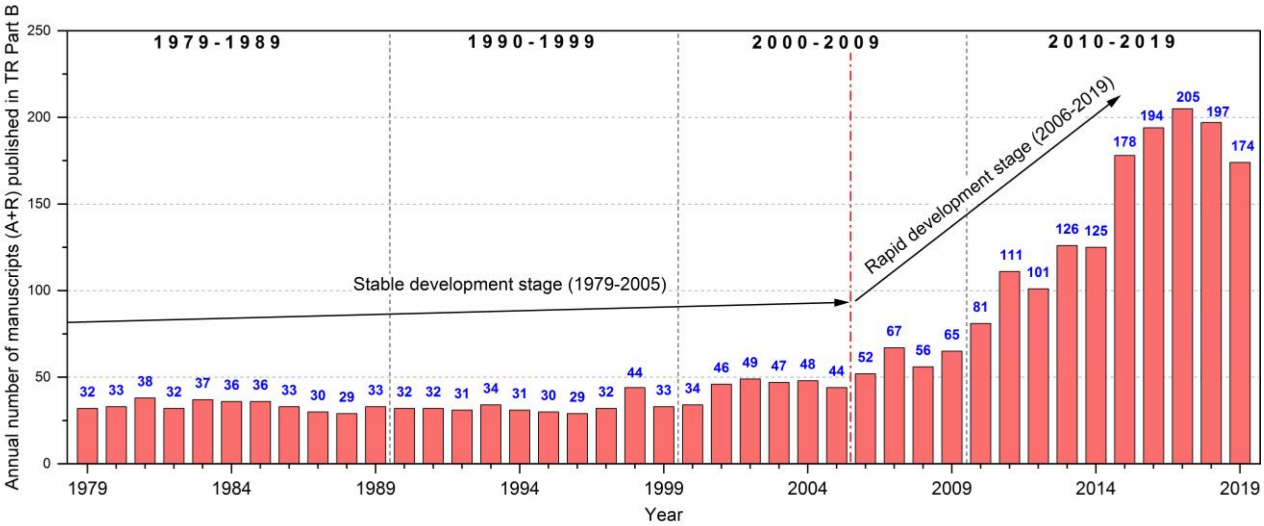

Figure 1. Annual number of manuscripts (A+R) published in *TR-Part B* (1979–2019).

As shown in Figure 1, the forty-year lifetime of *TR-Part B* may be categorized into two development stages: a stable development stage (1979–2005) and a rapid development stage (2006–2019). During the stable development stage, the journal published an average of about 40 papers each year. After stepping into the rapid development stage, the number of annual publications first exceeded 100 in 2011 (i.e., 111 academic papers), and it only took another six years (to 2017) to exceed 200 (i.e., 205 academic papers). By decade, the number of papers published in *TR-Part B* is: 369 (1979–1989), 328 (1990–1999), 508 (2000–2009), and 1,492 (2010–2019).

3.1.2 Citation structures of TR-Part B

TR-Part B has published many articles that have been highly cited by global scholars and have had a profound influence on the development of transportation research. Table 2 shows the 50 most frequently cited academic papers (top 1.85%) of the 2,697 ones published in *TR-Part B* from 1979 to 2019. In the case of two papers with the same number of citations, the more recently published paper is listed first.

The top two papers in this list are studies by Daganzo (1994) and Daganzo (1995) with a total of 1,342 and 982 citations at the time of writing of this paper, respectively. Both the papers are two of the most important studies on the cell transmission model, the first paper involving the representation of traffic on a highway, and the second paper focusing on dynamic prediction of the evolution of multi-commodity traffic flows over complex networks. In addition, there are some other noteworthy and interesting findings from Table 2. First, in relation to the individually influential contributions of 39 first authors to the 50 most frequently cited papers, Carlos F. Daganzo ("Daganzo, CF" in Table 2) contributed the most papers with a total of six, followed by Chandra R. Bhat ("Bhat CR") with three, and P. G. Gipps ("Gipps, PG"), Nikolas Geroliminis ("Geroliminis, N"), Gordon F. Newell ("Newell, GF"), and Hong Kam Lo ("Lo, HK"), each with two. All other first authors contributed one paper to the list.

It is interesting to note that all but four papers in Table 2 were published before 2010 (that is, in the year 2009 or prior to that). This suggests that citations in transportation research take time to accumulate, rather than a paper accumulating a large number of citations immediately upon publication, as is not uncommon in some other disciplines such as the medical sciences or the life sciences. The only four papers that appear in Table 2 that were published in 2010 or after are Furuhat et al. (2013) on ridesharing, Bektas and Laporte (2011) on the pollution-routing problem, Geroliminis and Sun (2011) on macroscopic fundamental diagram for urban traffic, and Rawls and Turnquist (2010) on pre-positioning of emergency supplies. To further normalize the number of citations of a paper by the number of years since publication, the last column of Table 2 identifies the average number of annual citations of each paper (TC/TS where TC=total citations; TS=time span since publication). The cell transmission model by Daganzo (1994) published in 1994 has the highest TC/TS value of 53.68 (1,342 citations over 25 years), followed by the study of Bektas and Laporte (2011) on the pollution-routing problem with a TC/TS of 49.38 (395 citation in 8 years), the paper by Geroliminis and Daganzo (2008) on the macroscopic fundamental diagram with a TC/TS of 45.73 (503 citations over 11 years), and the paper by Daganzo (1995) again on the cell transmission model with a TC/TS of 40.92 (982 citations over 24 years).

Table 2. The 50 most frequently cited academic papers published in *TR-Part B* (1979–2019).

R	TC	Title	Author(s)	Year	TS	TC/TS
1	1342	The cell transmission model: A dynamic representation of highway traffic consistent with the hydrodynamic theory	Daganzo, CF	1994	25	**53.68**
2	982	The cell transmission model, part II: Network traffic	Daganzo, CF	1995	24	**40.92**
3	802	A behavioral car-following model for computer-simulation	Gipps, PG	1981	38	21.11
4	599	A latent class model for discrete choice analysis: Contrasts with mixed logit	Greene, WH; Hensher, DA	2003	16	37.44
5	513	A continuum theory for the flow of pedestrians	Hughes, RL	2002	17	30.18
6	503	Existence of urban-scale macroscopic fundamental diagrams: Some experimental findings	Geroliminis, N; Daganzo, CF	2008	11	**45.73**
7	469	A simplified theory of kinematic waves in highway traffic, part I: General theory	Newell, GF	1993	26	18.04
8	464	Requiem for second-order fluid approximations of traffic flow	Daganzo, CF	1995	24	19.33
9	434	Existence, uniqueness and stability of traffic equilibria	Smith, MJ	1979	40	10.85
10	402	Quasi-random maximum simulated likelihood estimation of the mixed multinomial logit model	Bhat, CR	2001	18	22.33
11	395	The pollution-routing Problem	Bektas, T; Laporte, G	2011	8	**49.38**
12	390	Dynamic prediction of traffic volume through kalman filtering theory	Okutani, I; Stephanedes, YJ	1984	35	11.14
13	382	Structural equation modeling for travel behavior research	Golob, TF	2003	16	23.88
14	382	Optimal strategies: A new assignment model for transit networks	Spiess, H; Florian, M	1989	30	12.73
15	381	Urban gridlock: Macroscopic modeling and mitigation approaches	Daganzo, CF	2007	12	31.75
16	367	Simulation estimation of mixed discrete choice models using randomized and scrambled Halton sequences	Bhat, CR	2003	16	22.94
17	362	Examining the impacts of residential self-selection on travel behavior: A focus on methodologies	Mokhtarian, PL; Cao, Xinyu	2008	11	32.91
18	357	Real-time freeway traffic state estimation based on extended Kalman filter: A general approach	Wang, YB; Papageorgiou, M	2005	14	25.50
19	350	Pedestrian route-choice and activity scheduling theory and models	Hoogendoorn, SP; Bovy, PHL	2004	15	23.33
20	341	Cellular automata microsimulation for modeling bi-directional pedestrian walkways	Blue, VJ; Adler, JL	2001	18	18.94
21	339	Joint mixed logit models of stated and revealed preferences for alternative-fuel vehicles	Brownstone, D; Bunch, DS;	2000	19	17.84

			Train, K			
22	330	A model for the structure of lane-changing decisions	Gipps, PG	1986	33	10.00
23	324	A simplified car-following theory: A lower order model	Newell, GF	2002	17	19.06
24	318	A new continuum model for traffic flow and numerical tests	Jiang, R; Wu, QS; Zhu, ZJ	2002	17	18.71
25	306	A comprehensive analysis of built environment characteristics on household residential choice and auto ownership levels	Bhat, CR; Guo, Jessica Y	2007	12	25.50
26	302	Some traffic features at freeway bottlenecks	Cassidy, MJ; Bertini, RL	1999	20	15.10
27	292	Pre-positioning of emergency supplies for disaster response	Rawls, CG; Turnquist, MA	2010	9	32.44
28	288	A non-equilibrium traffic model devoid of gas-like behavior	Zhang, HM	2002	17	16.94
29	285	Lane-changing in traffic streams	Laval, JA; Daganzo, CF	2006	13	21.92
30	283	Capacity reliability of a road network: An assessment methodology and numerical results	Chen, A; Yang, H; Lo, HK; Tang, WH	2002	17	16.65
31	279	A tabu search heuristic for the static multi-vehicle dial-a-ride problem	Cordeau, JF; Laporte, G	2003	16	17.44
32	279	The dynamic berth allocation problem for a container port	Imai, A; Nishimura, E; Papadimitriou, S	2001	18	15.50
33	277	Bus network design	Ceder, A; Wilson, NHM	1986	33	8.39
34	263	An analytical approximation for the macroscopic fundamental diagram of urban traffic	Daganzo, CF; Geroliminis, N	2008	11	23.91
35	254	Assessing the influence of design dimensions on stated choice experiment estimates	Caussade, S; Ortuzar, JD; Rizzi, LI; Hensher, DA	2005	14	18.14
36	249	Some developments in equilibrium traffic assignment	Fisk, C	1980	39	6.38
37	237	Estimation of trip matrices from traffic counts and survey data: A generalized least-squares estimator	Cascetta, E	1984	35	6.77
38	237	The most likely trip matrix estimated from traffic counts	Vanzuylen, HJ; Willumsen, LG	1980	39	6.08
39	234	Discrete choice models of pedestrian walking behavior	Antonini, G; Bierlaire, M; Weber, M	2006	13	18.00

40	234	A heuristic algorithm for the multivehicle advance request dial-a-ride problem with time windows	Jaw, JJ; Odoni, AR; Psaraftis, HN; Wilson, NHM	1986	33	7.09
41	232	Ridesharing: The state-of-the-art and future directions	Furuhata, M; Dessouky, M; Ordonez, F; Brunet, M-E; Wang, Xiaoqing; Koenig, S	2013	6	38.67
42	232	Degradable transport network: Travel time budget of travelers with heterogeneous risk aversion	Lo, HK; Luo, XW; Siu, BWY	2006	13	17.85
43	229	A learning-based transportation oriented simulation system	Arentze, TA; Timmermans, HJP	2004	15	15.27
44	228	Designing efficient stated choice experiments in the presence of reference alternatives	Rose, John M; Bliemer, MCJ; Hensher, DA; Collins, AT	2008	11	20.73
45	220	Continuous equilibrium network design models	Abdulaal, M; LeBlanc, LJ	1979	40	5.50
46	218	The crane scheduling problem	Daganzo, CF	1989	30	7.27
47	216	The multi-class, multi-criteria traffic network equilibrium and systems optimum problem	Yang, H; Huang, HJ	2004	15	14.40
48	211	Network with degradable links: Capacity analysis and design	Lo, HK; Tung, YK	2003	16	13.19
49	206	Properties of a well-defined macroscopic fundamental diagram for urban traffic	Geroliminis, N; Sun, Jie	2011	8	25.75
50	204	The generalized nested logit model	Wen, CH; Koppelman, FS	2001	18	11.33

Abbreviations: R = Rank; TC = Total citations; TS=Time span; TC/TS= Citations per year; *Time span* refers to the duration from the year of publication to 2019.

Note: As the quantity of document citations is still increasing, the TC in this table were last gathered from WoS on February 15, 2020 (Beijing time).

Table 2 provides the listing of the top papers published in *TR-Part B* with the most number of citations. A reverse issue of interest is to identify those papers and books that have received the most number of citations by the 2,697 papers published in *TR-Part B*. Table 3 shows the top 30 such publications, of which 22 (73.4%) are articles (A) published in academic journals, four (13.3%) are books or monographs (B), and four (13.3%) are proceedings papers (P). Note that each of the 2,697 papers in *TR-Part B* could only cite a specific existing reference once in the reference list, so the indicator *TC/2697* could be used to measure the average citation frequency of a publication in Table 3 being cited by the 2,697 papers. The manuscript most frequently cited by *TR-Part B* was the paper entitled *Shock waves on the highway* by Richards (1956) published in the journal *Operations Research,* with a total of 208 citations. The *TC/2697* value of this manuscript is 7.71%, indicating that almost one out of every thirteen papers among the 2,697 *TR-Part B* papers cited the work of Richards (1956). The manuscript following Richards (1956) is Wardrop (1952) with 178 citations by *TR-Part B*. Yosef Sheffi's representative book *Urban Transportation Networks* (Sheffi, 1985) ranks the third with 166 citations. The fourth most frequently cited document by *TR-Part B* is Daganzo (1994) on the cell transmission model. Also of note is that the research works of Carlos Daganzo appear six times in Table 3, reinforcing the pioneering contributions of Carlos Daganzo to the transportation profession.

A further dissection of the 30 manuscripts in Table 3 indicates that 11 (36.7%) are papers from *TR-Part B* (or *TR* before 1979) itself, which implies that, to some extent, there has been a self-perpetuating and self-reinforcing effect in the development of *TR-Part B* over the forty-year period. However, *TR-Part B* is an interdisciplinary journal that draws on knowledge from diverse disciplines, with five entries in Table 3 representing economics-related journals (from *the American Economic Review*, *Networks and spatial economics*, and *the Journal of urban economics*), and five others representing journals hosted by the Institute for Operations Research and the Management Sciences (INFORMS) (*Transportation Science* and *Operations Research*). In addition, the journal *Environment and Planning A* contributed one paper (Williams, 1977) to the list.

Table 3. The 30 most frequently cited documents by the 2,697 academic papers in *TR-Part B* (1979–2019).

R	Year	Cited documents by *TR-Part B* (only first author)	Types	TC	TC/2697
1	1956	Richards P. I, 1956, oper res, v4, p42 (Richards, 1956)	A	**208**	**7.71%**
2	1952	Wardrop J. G, 1952, p i civil eng, v1, p325 (Wardrop, 1952)	P	**178**	6.60%
3	1985	Sheffi Y, 1985, urban transportation networks (Sheffi, 1985)	B	**166**	6.15%
4	1994	Daganzo C. F, 1994, transport res b-meth, v28, p269 (Daganzo, 1994)	A	144	5.34%
5	1969	Vickrey W. S, 1969, am econ rev, v59, p251 (Vickrey, 1969)	A	144	5.34%
6	1955	Lighthill M. J, 1955, proc r soc lon ser-a, v229, p317 (Lighthill and Whitham, 1955b)	P	143	5.30%
7	1995	Daganzo C. F, 1995, transport res b-meth, v29, p79 (Daganzo, 1995)	A	139	5.15%
8	1956	Beckmann M, 1956, studies ec transport (Beckmann et al., 1956)	B	131	4.86%
9	1993	Newell G. F, 1993, transport res b-meth, v27, p281 (Newell, 1993)	A	116	4.30%
10	1982	Small K. A, 1982, am econ rev, v72, p467 (Small, 1982)	A	95	3.52%
11	1985	Ben-akiva M, 1985, discrete choice analysis (Ben-Akiva and	B	88	3.26%

		Lerman, 1985)			
12	1971	Dial R. B, 1971, transport res, v5, p83 (Dial, 1971)	A	77	2.86%
13	1993	Friesz T. L, 1993, oper res, v41, p179 (Friesz et al., 1993)	A	75	2.78%
14	1979	Smith M. J, 1979, transport res b-meth, v13, p295 (Smith, 1979)	A	74	2.74%
15	2008	Geroliminis N, 2008, transport res b-meth, v42, p759 (Geroliminis and Daganzo, 2008)	A	71	2.63%
16	1955	Lighthill M. J, 1955, proc r soc lon ser-a, v229, p281 (Lighthill and Whitham, 1955a)	P	67	2.48%
17	1978	Merchant D. K, 1978, transportation science, v12, p183 (Merchant and Nemhauser, 1978)	A	64	2.37%
18	1977	Daganzo C. F, 1977, transportation science, v11, p253 (Daganzo and Sheffi, 1977)	A	63	2.34%
19	2002	Newell G. F, 2002, transport res b-meth, v36, p195 (Newell, 2002)	A	61	2.26%
20	1975	LeBlanc L. J, 1975, transport res, v9, p309 (LeBlanc et al., 1975)	A	60	2.22%
21	1993	Arnott R, 1993, am econ rev, v83, p161 (Arnott et al., 1993)	A	59	2.19%
22	1994	Patriksson M. p i civil engineer, 1994, traffic assignment p (Patriksson, 1994)	B	58	2.15%
23	2007	Daganzo C. F, 2007, transport res b-meth, v41, p49 (Daganzo, 2007)	A	58	2.15%
24	1977	Williams H. C, 1977, environ plan a, v9, p285 (Williams, 1977)	A	57	2.11%
25	2005	Daganzo C. F, 2005, transport res b-meth, v39, p187 (Daganzo, 2005)	A	56	2.08%
26	2001	Peeta S, 2001, netw spat econ, v1, p233 (Peeta and Ziliaskopoulos, 2001)	A	53	1.97%
27	1980	Dafermos S, 1980, transport sci, v14, p42 (Dafermos, 1980)	A	52	1.93%
28	1978	Mcfadden D, 1978, spatial interaction, p75 (McFadden, 1978)	P	51	1.89%
29	1990	Arnott R, 1990, j urban econ, v27, p111 (Arnott et al., 1990)	A	50	1.85%
30	1989	Spiess H, 1989, transport res b-meth, v23, p83 (Spiess and Florian, 1989)	A	50	1.85%

Notes on document types: A: article; B: book; P: proceeding paper.

3.2 Leading authors, organizations, and countries/regions

This section identifies the authors, organizations, and countries/regions with the most number of academic papers in the lifetime of *TR-Part B* from 1979 to 2019. Additionally, to explore the temporal evolution of contributions to *TR-Part B*, the *TR-Part B* lifetime was divided into four decades (1979–1989, 1990–1999, 2000–2009, and 2010–2019) or two stages (1979–1999, and 2000–2019) for the analysis below as appropriate.

3.2.1 Leading authors

Aided by the VOSviewer software, this section identifies the authors with the most number of *TR-Part B* publications, as listed in the *Core Collection Database* of WoS. After correcting author names, the top 50 authors are tabulated in Table 4 (the list has 52 names, because the last six authors all have the same number of publications and so had to all be listed).[4] The table lists the authors' full names, their documented current or latest affiliations (abbreviations), the countries or regions to which they are affiliated, the number of total papers (TP) in *TR-Part B* lifetime (1979–2019) and in each half-life period (1979–1999, 2000–2019), total citations (TC) in lifetime (1979–2019), and average citations per paper (TC/TP). Two additional important indices presented are the *h*-index of *TR-Part B*, which indicates all *h* papers of a scholar published in *TR-Part B* that have been cited *h* times, together with the distribution of citation structures. When more than one author has the same TP value, the author who achieved a higher TC value is ranked first.

In terms of total publications over the *TR-Part B* lifetime (TP in Table 4), Hai Yang, Carlos Daganzo[5] ("Carlos F. Daganzo" in Table 4), and Chandra Bhat are ranked as the top three authors in the list. Hai Yang solely authored or co-authored 74 academic papers, followed by Carlos Daganzo with 71 papers, and Chandra Bhat with 58. These three authors also ranked highest in the list for TC and *h*-index of *TR-Part B* as the only authors with TC exceeding 4000 and *h*-index exceeding 35. When TC/TP is considered, the 71 papers of Carlos Daganzo received 7,902 citations, resulting in 111.30 citations per paper, which is the highest TC/TP number for all contributors to *TR-Part B* in the forty-year period. This is followed by David Hensher with 85.22 citations per paper. Other authors with high TC/TP exceeding 60.00 include Gordon Newell (84.67), Nikolas Geroliminis (74.78), Chandra Bhat (74.62), Michael Bell (68.59), Hai Yang (65.38), and Gilbert Laporte (63.96).

The last few columns of Table 4 provide the number of papers with citations *N* pertaining to specific ranges. For example, the column "≥300" indicates the number of *TR-Part B* papers by an author that have been cited more than 300 times, and the column "≥200" indicates the number of *TR-Part B* papers by an author that have been cited more than 200 times, and so on. Carlos Daganzo and Chandra Bhat have five and three papers, respectively, with over 300 citations. In terms of the number of papers with more than 200 citations, Carlos Daganzo has the most with eight papers, followed by Chandra Bhat with four, and Hai Yang, Hong Kam Lo, Nikolas Geroliminis and David Hensher with three each. For the number of papers over 100 citations, Carlos Daganzo (with 19 papers), Hai Yang (with 18) and Chandra Bhat (with 11) have the highest numbers. And these three authors remain at the top three when considering the number of papers receiving over 50 citations – Hai Yang with 39, Carlos Daganzo with 33, and Chandra Bhat with 31.

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[4] Note that this table is strictly focused on *TR-Part B* papers, and does not immediately provide an indication regarding paper contributions and associated details at the overall transportation field level.

[5] Under the premise of not causing ambiguity, for brevity, in the remaining text of this paper, we would leave out the "Middle name (if have)" of an author shown in the column "Authors' full name" in Table 4 and just use the format of "Given name + Family name."

Table 4. The 50 authors with the most number of papers published in *TR-Part B* (1979–2019).

R	Authors' Full Name	Current/Latest Affiliation	Country/Region	TP			TC	TC/TP	*h*-index	Number of papers with *N* citations			
				1979–2019	1979–1999	2000–2019				≥300	≥200	≥100	≥50
1	**Hai Yang**	Hong Kong Univ Sci & Technol	Hong Kong, China	**74**	16	58	4838	65.38	42	0	3	18	39
2	**Carlos F. Daganzo**	Univ Calif Berkeley	USA	**71**	31	40	7902	111.30	39	5	8	19	33
3	**Chandra R. Bhat**	Univ Texas Austin	USA	**58**	10	48	4328	74.62	36	3	4	11	31
4	Sze Chun Wong	Univ Hong Kong	Hong Kong, China	**44**	10	34	2137	48.57	27	0	0	6	17
5	Hong Kam Lo	Hong Kong Univ Sci & Technol	Hong Kong, China	**42**	1	41	2205	52.50	21	0	3	9	13
6	Michael H. Zhang	Univ Calif Davis	USA	**40**	4	36	1744	43.60	24	0	1	2	12
7	William H. K. Lam	Hong Kong Polytech Univ	Hong Kong, China	**35**	9	26	1636	46.74	21	0	0	6	12
7	Terry L. Friesz	Penn State Univ	USA	**35**	11	24	992	28.34	21	0	0	0	5
9	Qiang Meng	Natl Univ Singapore	Singapore	**33**	1	32	1302	39.45	19	0	0	2	9
9	Yanfeng Ouyang	Univ Illinois Urbana-Champaign	USA	**33**	0	33	950	28.79	17	0	0	2	7
11	Nikolas Geroliminis	Ecole Polytech Fed Lausanne	Switzerland	**32**	0	32	2393	74.78	22	1	3	8	14
12	Yu (Marco) Nie	Northwestern Univ	USA	**31**	0	31	989	31.90	17	0	0	1	6
12	Wen-Long Jin	Univ Calif Irvine	USA	**31**	0	31	550	17.74	12	0	0	0	3
14	Hai-Jun Huang	Beihang Univ	China	**30**	6	24	1379	45.97	18	0	1	4	11
14	Xuesong Zhou	Arizona State Univ	USA	**30**	0	30	1106	36.87	18	0	0	2	10
16	Michael G. H. Bell	Univ Sydney	Australia	**29**	7	22	1989	68.59	21	0	2	7	17
16	Wai Yuen Szeto	Univ Hong Kong	Hong Kong, China	**29**	0	29	989	34.10	17	0	0	3	5
18	Jorge A. Laval	Georgia Inst Technol	USA	**27**	0	27	1160	42.96	18	0	1	2	8
18	Ziyou Gao	Beijing Jiaotong Univ	China	**27**	1	26	1009	37.37	16	0	0	2	9
20	Yafeng Yin	Univ Michigan	USA	**25**	0	25	1015	40.60	15	0	1	1	9
20	Shuaian Wang	Hong Kong Polytech Univ	Hong Kong, China	**25**	0	25	567	22.68	13	0	0	0	3
22	Gilbert Laporte	HEC Montreal	Canada	**24**	1	23	1535	63.96	14	1	2	5	9
22	David P. Watling	Univ Leeds	England	**24**	5	19	643	26.79	13	0	1	2	2

24	David A. Hensher	Univ Sydney	Australia	**23**	5	18	1960	85.22	17	1	3	4	12
24	Michel Bierlaire	Ecole Polytech Fed Lausanne	Switzerland	**23**	1	22	1133	49.26	17	0	1	3	7
24	Xiaopeng Li	Univ S Florida	USA	**23**	0	23	620	26.96	14	0	0	1	3
24	Anming Zhang	Univ British Columbia	Canada	**23**	1	22	595	25.87	15	0	0	0	2
28	Mike (Michael) J. Smith	Univ York	England	**22**	13	9	1095	49.77	14	1	1	2	8
28	Anthony Chen	Hong Kong Polytech Univ	Hong Kong, China	**22**	0	22	871	39.59	14	0	1	3	3
28	Henry X. Liu	Univ Michigan	USA	**22**	0	22	778	35.36	18	0	0	0	5
28	Erik T. Verhoef	Vrije Univ Amsterdam	Netherlands	**22**	0	22	510	23.18	10	0	0	1	3
32	Malachy Carey	Ulster Univ	North Ireland	**21**	9	12	772	36.76	13	0	0	0	7
33	Michael J. Cassidy	Univ Calif Berkeley	USA	**19**	2	17	1135	59.74	15	1	1	4	6
33	Harry J. P. Timmermans	Eindhoven Univ Technol	Netherlands	**19**	1	18	958	50.42	14	0	1	2	6
35	Michiel C. J. Bliemer	Univ Sydney	Australia	**18**	0	18	648	36.00	10	0	1	2	5
35	Mogens Fosgerau	Univ Copenhagen	Denmark	**18**	0	18	638	35.44	14	0	0	1	5
35	Srinivas Peeta	Georgia Inst Technol	USA	**18**	0	18	362	20.11	10	0	0	0	2
38	Agachai Sumalee	Hong Kong Polytech Univ	Hong Kong, China	**16**	0	16	828	51.75	13	0	0	3	6
38	Hani S. Mahmassani	Northwestern Univ	USA	**16**	5	11	630	39.38	13	0	0	0	6
38	Ludovic Leclercq	Univ Lyon	France	**16**	0	16	547	34.19	12	0	0	1	4
38	Xuegang (Jeff) Ban	Univ Washington	USA	**16**	0	16	335	20.94	10	0	0	0	1
42	Gordon F. Newell	Univ Calif Berkeley	USA	**15**	14	1	1270	84.67	11	2	2	3	6
42	Wilfred W. Recker	Univ Calif Irvine	USA	**15**	4	11	509	33.93	13	0	0	0	2
42	Lixing Yang	Beijing Jiaotong Univ	China	**15**	0	15	473	31.53	10	0	0	0	4
42	Ke Han	Imperial College London	England	**15**	0	15	330	22.00	11	0	0	0	1
46	Sergio R. Jara-diaz	Univ Chile	Chile	**14**	7	7	338	24.14	9	0	0	0	3
47	Michael Florian	Univ Montreal	Canada	**13**	9	4	765	58.85	10	1	1	2	4
47	Soyoung Ahn	Univ Wisconsin Madison	USA	**13**	0	13	427	32.85	9	0	0	0	4
47	Zhi-Chun Li	Huazhong Univ Sci & Technol	China	**13**	0	13	373	28.69	9	0	0	1	2
47	Andre de Palma	Univ Paris Saclay	France	**13**	4	9	354	27.23	6	0	0	1	2
47	Jiuh-Biing Sheu	Natl Taiwan Univ	Taiwan, China	**13**	0	13	271	20.85	8	0	0	0	1
47	Baibing Li	Loughborough Univ	England	**13**	1	12	184	14.15	8	0	0	0	0

Note: The data presented in this table were last updated on February 21, 2020 (Beijing time).

To describe the temporal evolution, the top ten authors with the most number of papers by each of the four decades are listed in Table 5. From the perspective of quantitative contributions by the four decades of *TR-Part B*, Carlos Daganzo (1979–1989, 1990–1999, 2000–2009), Hai Yang and Chandra Bhat (1990–1999, 2000–2009, 2010–2019) were each ranked in the list of top ten scholars in three separate decades, followed by Hong Kam Lo, Sze Chun Wong, Michael Bell, and Gordon Newell who were each ranked in the list of top ten scholars in two separate decades.

Table 5. The top 10 authors with the most number of *TR-Part B* papers by each of the four decades.

R	1979–1989		1990–1999		2000–2009		2010–2019	
	Authors	TP	Authors	TP	Authors	TP	Authors	TP
1	Carlos F. Daganzo	17	Hai Yang	16	Chandra R. Bhat	22	Hai Yang	37
2	Marc J. I. Gaudry	10	Carlos F. Daganzo	14	Hai Yang	21	Yanfeng Ouyang	29
3	Mike J. Smith	10	Sze Chun Wong	10	Michael H. Zhang	19	Nikolas Geroliminis	29
4	Terry L. Friesz	9	Chandra R. Bhat	10	Carlos F. Daganzo	19	Hong Kam Lo	27
5	C. S. Fisk	8	William H. K. Lam	9	Sze Chun Wong	14	Xuesong Zhou	27
6	Warren B. Powell	8	Gordon F. Newell	8	Hong Kam Lo	14	Chandra R. Bhat	26
7	Michael Florian	7	Malachy Carey	7	Harry J. P. Timmermans	10	Qiang Meng	26
8	Randolph W. Hall	6	Yasunori Iida	6	Michel Bierlaire	10	Wen-Long Jin	26
9	Joel L. Horowitz	6	Hai-Jun Huang	6	David A. Hensher	9	Yu (Marco) Nie	26
10	Gordon F. Newell	6	Michael G. H. Bell	6	Michael G. H. Bell	9	Shuaian Wang	25

3.2.2 Leading research organizations

The aggregation effect of globally renowned scholars gradually forms an influential research organization in a particular academic domain. After establishing the prolific individual contributors to *TR-Part B*, this study then focused on how these individuals grouped together to develop leading research organizations or universities that contributed most to the journal in the forty-year study period. Primarily based on the *Core Collection Database* of WoS, Table 6 reports the top 30 organizations ranked by the number of total papers (TP) in *TR-Part B*, along with their region or country affiliations. The top five universities contributing most in TP to *TR-Part B* were (1) University of California, Berkeley (UC Berkeley, i.e., "Univ Calif Berkeley" in Table 6),[6] (2) The Hong Kong University of Science and Technology (HKUST, i.e., "Hong Kong Univ Sci & Technol"), (3) University of Montreal (i.e., "Univ Montreal"), (4) The University of Texas at Austin (UT Austin, i.e., "Univ Texas Austin"), and (5) The Hong Kong Polytechnic University (HKPU, i.e., "Hong Kong Polytech Univ"). Although organizations from Hong Kong took two positions in the top five as the USA did, the USA dominated the top 30 prolific organizations with 14 universities listed, followed by China (if Hong Kong is included) with six, the Netherlands and Canada with two each; this is helpful for the readers to understand the academic differential in *TR-Part B* publications between other regions/countries and the USA in organization-level rankings. Other organizations, such as the University of Leeds ("Univ Leeds" in Table 6, England), École Polytechnique Fédérale de Lausanne (EPFL, i.e., "Ecole Polytech Fed Lausanne," Switzerland), the University of Sydney (i.e., "Univ Sydney," Australia), and the National University of Singapore (i.e., "Natl Univ Singapore,"

[6] Under the premise of not causing ambiguity, in the remaining text of this paper, we would use the full names of the universities (e.g., "University of California, Berkeley") in the text, and use abbreviated names (e.g., "Univ Calif Berkeley") in the tables, **unless otherwise noted** (e.g., "UC Berkeley").

Singapore), are the only entries from their countries in the list.

Table 6. The top 30 organizations contributing the most number of papers to *TR-Part B* (1979–2019).

Rank	Organization	Country/Region	TP	TC	TC/TP	*h*-index
1	Univ Calif Berkeley	USA	162	12163	75.08	51
2	Hong Kong Univ Sci & Technol	HK, China	122	6848	56.13	50
3	Univ Montreal [1]	Canada	98	4331	44.19	33
4	Univ Texas Austin	USA	97	4916	50.68	38
5	Hong Kong Polytech Univ	HK, China	87	2522	28.99	30
6	Univ Hong Kong	HK, China	76	2791	36.72	30
7	Univ Calif Irvine	USA	68	2671	39.28	28
8	Univ Leeds	England	65	2088	32.12	25
9	Beijing Jiaotong Univ	China	64	1784	27.88	27
10	Massachusetts Inst Technol	USA	63	2373	37.67	26
11	Northwestern Univ	USA	63	2346	37.24	28
12	Univ Calif Davis	USA	61	2706	44.36	29
13	Ecole Polytech Fed Lausanne	Switzerland	54	2838	52.56	31
14	Delft Univ Technol	Netherlands	53	2121	40.02	25
15	Univ Sydney	Australia	52	2614	50.27	22
16	Univ Illinois Urbana Champaign	USA	51	1615	31.67	24
17	Natl Univ Singapore	Singapore	48	1217	25.35	21
18	Tongji Univ	China	47	1270	27.02	21
19	Penn State Univ	USA	47	1241	26.40	22
20	Purdue Univ	USA	47	1103	23.47	20
21	Georgia Inst Technol	USA	41	1165	28.41	20
22	Univ Minnesota twin cities	USA	37	2399	64.84	26
23	Univ Florida	USA	37	1646	44.49	22
24	Univ Chile	Chile	37	1112	30.05	18
25	Univ British Columbia	Canada	37	689	18.62	16
26	Beihang Univ	China	36	1336	37.11	18
27	Univ Maryland College Park	USA	36	1218	33.83	19
28	Vrije Univ Amsterdam	Netherlands	36	753	20.92	12
29	Arizona State Univ	USA	34	961	28.26	18
30	Univ Lyon	France	32	1186	37.06	19

Notes: 1. Recall that the papers affiliated with HEC Montreal and Polytechnique Montreal were counted in the total number of papers with Univ Montreal in the study period 1979–2019.

2. The data presented in this table were last updated on February 18, 2020 (Beijing time).

One interesting observation from Table 6 is that three of the top four most contributing universities to *TR-Part B* (i.e., UC Berkeley, HKUST, and UT Austin) correspond to the affiliations of the three most contributing individuals in Table 4. As might be expected, there is an association of the affiliation of the authors in Table 4 with the universities appearing in Table 6. Indeed, the 162 papers contributed by UC Berkeley involved all the 71 papers of Carlos Daganzo (71/162=43.8%) and all the 19 papers of Michael Cassidy (11.7%) reported in Table 4 (including three papers coauthored by Daganzo and Cassidy). Similarly, of the 122 academic papers affiliated to HKUST in *TR-Part B*, 69 papers (56.6%) were authored by Hai Yang and 41 (33.6%) papers by Hong Kam Lo (including two papers coauthored by Yang and Lo). Of the 97 academic papers contributed by UT Austin, 53[7] (54.6%) were contributed by Chandra Bhat. In terms of total citations (TC) and *h*-index, these same three institutions come out on top.

The fifth placement of HKPU in Table 6 is a result of the combined individual contributions of William H. K. Lam, Anthony Chen, Shuaian Wang, and Agachai Sumalee. Clearly, there is much more spread among individuals in the contributions from HKPU. In fact, HKPU ranks first in terms of the number of individuals (four authors listed in Table 4) from a single institution appearing in the top 50 authors, followed by UC Berkeley and University of Sydney with three authors each. Also of note is the high TC/TP of UC Berkeley (75.08, thanks to the high TC/TP of Carlos Daganzo [111.30] and Gordon Newell [84.67]), University of Minnesota Twin Cities (64.84, thanks to the works of Nikolas Geroliminis and Henry X. Liu), HKUST (56.13, thanks to Hai Yang [65.38] and Hong Kam Lo [52.50]), EPFL (52.56, thanks to Nikolas Geroliminis [74.78] and Michel Bierlaire [49.26]), UT Austin (50.68, thanks to Chandra Bhat [74.62]), and the University of Sydney (50.27, thanks to David Hensher [85.22] and Michael Bell [68.59]).

The top ten organizations with the most number of papers by each of the four decades are reported in Table 7. The University of Montreal and UC Berkeley contributed the most in the first decade of the *TR-Part B* lifetime. They are also the only two organizations that are listed in each of the four decades over the forty-year period. Other prolific organizations which held a place in the top rankings for three decades include HKUST, UT Austin, HKPU, and the University of Hong Kong (HKU, i.e., "Univ Hong Kong" in Table 7). Besides, in the latest decade (2010–2019), Beijing Jiaotong University ("Beijing Jiaotong Univ"), University of Leeds ("Univ Leeds"), EPFL ("Ecole Polytech Fed Lausanne"), and National University of Singapore ("Natl Univ Singapore") were found to be among those top contributors to *TR-Part B* for the first time.

[7] Note that the data herein is less than that (58 papers) reported in Table 4 because of the fact that five early papers of Chandra Bhat published in *TR-Part B* (one each in Dec. 1995, Jun. 1996, and Dec. 1996, and two in Feb. 1997) were solely affiliated with his former employer, University of Massachusetts, Amherst.

Table 7. The top 10 organizations with the most number of *TR-Part B* papers by each of the four decades

R	1979–1989		1990–1999		2000–2009		2010–2019	
	Organizations	TP	Organizations	TP	Organizations	TP	Organizations	TP
1	Univ Montreal	34	Univ Calif Berkeley	30	Univ Calif Berkeley	37	Hong Kong Univ Sci & Technol	74
2	Univ Calif Berkeley	28	Hong Kong Univ Sci & Technol	11	Hong Kong Univ Sci & Technol	37	Univ Calif Berkeley	67
3	Massachusetts Inst Technol	23	Hong Kong Polytech Univ	9	Univ Texas Austin	32	Hong Kong Polytech Univ	66
4	Univ Penn	12	Univ Hong Kong	8	Univ Calif Davis	24	Beijing Jiaotong Univ	60
5	Linkoping Univ	11	Univ Massachusetts Amherst	8	Univ Calif Irvine	20	Univ Hong Kong	53
6	Northwestern Univ	10	Kyoto Univ	7	Delft Univ Technol	14	Univ Texas Austin	52
7	Univ York	10	Massachusetts Inst Technol	7	Univ College London	14	Univ Leeds	45
8	Princeton Univ	8	Purdue Univ	7	Univ Hong Kong	14	Ecole Polytech Fed Lausanne	44
9	Univ Illinois Urbana Champaign	8	Univ Montreal	7	Univ Montreal	13	Univ Montreal	44
10	Univ Minnesota Twin Cities	8	Univ Texas Austin	7	Hong Kong Polytech Univ	12	Natl Univ Singapore	40

3.2.3 Leading countries/regions

A national-level analysis of the prolific countries or regions with the most number of papers in *TR-Part B* is next conducted. As stated in Section 2.1.2, the Hong Kong organizations (including HKUST, HKPU, and HKU, etc.) were categorized as an individual region to measure the exclusive contributions of Hong Kong to *TR-Part B*. The same process was undertaken for Macau and Taiwan, China. According to the WoS, the resulting 30 top countries/regions with the most number of papers contributing to *TR-Part B* are displayed in Table 8.

Table 8. The top 30 countries/regions contributing most to *TR-Part B* in terms of number of papers (1979–2019).

R	Country/Region	TP	TC	TC/TP	*h*-index
1	USA	1227	49807	40.59	100
2	China [1]	349	8549	24.50	48
3	Hong Kong, China	271	11101	40.96	61
4	Canada	231	7658	33.15	46
5	England	227	8331	36.70	51
6	Australia	160	6733	42.08	40
7	Netherlands	148	5599	37.83	42
8	Italy	87	2855	32.82	30
9	France	85	2225	26.18	28
10	Japan	81	3072	37.93	29
11	Singapore	80	1733	21.66	24
12	Switzerland	78	3484	44.67	38
13	Sweden	73	2400	32.88	26
14	Chile	71	2489	35.06	29
15	Germany [2]	68	2020	29.71	27
16	Taiwan, China	58	2210	38.10	29
17	Israel	55	1703	30.96	21
18	Belgium	49	881	17.98	17
19	Spain	44	1351	30.70	21
20	Denmark	34	903	26.56	16
21	South Korea	34	1280	37.65	19
22	New Zealand	34	747	21.97	15
23	Turkey	28	841	30.04	13
24	Saudi Arabia	17	330	19.41	11
25	Greece	15	1431	95.40	11
26	Scotland	15	437	29.13	12
27	Portugal	14	405	28.93	9
28	North Ireland	13	491	37.77	10
29	Norway	13	387	29.77	7

30	Brazil	12	347	28.92	7
31	U Arab Emirates	12	288	24.00	7

Notes: 1. The data counted all academic *TR-Part B* papers with at least one author being affiliated with any organization in mainland China.

2.The seven papers from the *Fed Rep Germany* during 1979－1989 were counted in the dataset.

3.The data presented in this table were last updated on February 21, 2020 (Beijing time).

USA is, by far, the country/region with the most number of academic papers (1,227) in the journal, and also nearly 50,000 citations, followed by China (mainland) with 349 papers and 8,549 citations, and Hong Kong (China) with 271 papers and 11,101 citations. It is evident that the USA is far ahead of other countries/regions with respect to the total number of papers and citations, which accords with the results in Table 6. Although China (mainland) is in second place in terms of papers, China's influence when measured by citations per paper (TC/TP=24.50) places it below Switzerland (44.67), Australia (42.08), Hong Kong (40.96), and USA (40.59), but higher than Singapore (21.66) and Belgium (17.98). Interestingly, the TC/TP of Greece is extremely high at 95.40 from 15 papers in the forty-year study period that nonetheless achieved 1,431 citations. Of course, all the discussions here must be taken with a "grain of salt" because the data can be "sliced and diced" in different ways. For example, if the TC/TP per capita were considered after controlling for the population of each country, or after controlling for the number of transportation academics in each country, the listing in Table 8 would be quite different.

The top ten countries/regions with the most number of papers by each of the four decades are reported in Table 9. Generally, the USA dominates in each of the four decades over the lifetime of *TR-Part B* with the most number of papers. Following the USA, Canada and England led the development of *TR-Part B* in the first two decades (1979–1999). During 2000–2009, Hong Kong moved up to the second place with a total of 60 papers. In the latest decade (2010–2019), the rankings of USA, China (mainland), Hong Kong, England, Canada, Australia, and Netherland were unchanged as the top seven regional contributors to *TR-Part B*. However, there is a clear trend of internationalization of *TR-Part B* contributions in the latest decade, with more balanced contributions from different countries in the world.

Table 9. The top 10 prolific countries/regions with the most number of *TR-Part B* papers by each of the four decades

R	1979–1989		1990–1999		2000–2009		2010–2019	
	Country/Region	TP	Country/Region	TP	Country/Region	TP	Country/Region	TP
1	USA	197	USA	152	USA	237	USA	641
2	Canada	55	England	32	Hong Kong, China	60	China (mainland)	313
3	England	37	Canada	27	England	40	Hong Kong, China	184
4	Australia	27	Hong Kong, China	26	Netherland	33	Canada	119
5	Italy	13	Japan	14	China (mainland)	30	England	118
6	Israel	12	Germany	9	Canada	30	Australia	104
7	Sweden	12	Italy	9	Taiwan, China	25	Netherland	103
8	Fed Rep Germany	7	Australia	8	Japan	22	Singapore	70
9	Japan	6	Sweden	8	Australia	21	France	63
10	Chile	5	Netherland	7	South Korea	18	Switzerland	62

3.3 Units citing *TR-Part B* papers most

As stated in Section 2.1, a total of 2,697 papers were published in *TR-Part B* from 1979 to 2019. In this section, we examine the authors, organizations, and journals that have cited the 2,697 *TR-Part B* papers the most, and the temporal evolution of world-wide academic (journal) publications citing the 2,697 papers.

The data for this section were downloaded from WoS on February 18, 2020 (Beijing time) (WoS counts the citing publications as those papers indexed by *Citation Indexes* and *Chemical Indexes*). Since 1979, a total of 37,713 academic publications (i.e., articles, proceedings papers and reviews) have cited at least one of the 2,697 *TR-Part B* papers in their reference lists. These 37,713 publications form the sample for all the analyses presented in this section.

3.3.1 Leading authors and organizations citing TR-Part B most

The top 15 scholars who have cited the 2,697 *TR-Part B* papers the most are reported in Table 10. Not surprisingly, all of these scholars have their primary affiliation in the transportation field. In relation to the most prolific authors in *TR-Part B* (in Table 4), it can be surmised that, although *TR-Part B* is not the frequent outlet journal for Serge P. Hoogendoorn (151) and Markos Papageorgiou (135), these two scholars are among the authors who most cite *TR-Part B* papers.

Table 10. The top 15 scholars with most academic publications (1979–) citing the 2,697 *TR-Part B* papers.

R	Authors	Current/Latest Affiliation	WoS Publications
1	Hai Yang	Hong Kong Univ Sci & Technol	292
2	Ziyou Gao	Beijing Jiaotong Univ	251
3	Sze Chun Wong	Univ Hong Kong	225
4	Hai-Jun Huang	Beihang Univ	218
5	William H. K. Lam	Hong Kong Polytech Univ	214
6	Chandra R. Bhat	Univ Texas Austin	166
7	David A. Hensher	Univ Sydney	164
8	Serge P. Hoogendoorn	Delft Univ Technol	151
9	Anthony Chen	Hong Kong Polytech Univ	143
10	Hong Kam Lo	Hong Kong Univ Sci & Technol	142
11	Qiang Meng	Natl Univ Singapore	142
12	Markos Papageorgiou	Tech Univ Crete	135
13	Hani S. Mahmassani	Northwestern Univ	129
14	Gilbert Laporte	HEC Montreal	121
15	Michael H. Zhang	Univ Calif Davis	121

Next, we turn to the organization-level to investigate which organizations have published the most papers that have cited at least one of the 2,697 *TR-Part B* papers. The top 15 organizations are listed in Table 11. Beijing Jiaotong University ("Beijing Jiaotong Univ") has published up to 1,441 publications citing *TR-Part B* since 1979. At a country-level, researchers from China have published the most number of academic papers that cite the 2,697 *TR-Part B* papers.

Table 11. The top 15 organizations with most publications (1979–) citing at least one of the 2,697 *TR-Part B* papers.

Rank	Organizations	Country/Region	WoS Publications
1	Beijing Jiaotong Univ	China	1441
2	Delft Univ Technol	Netherlands	912
3	Tongji Univ	China	734
4	Univ Calif Berkeley	USA	681
5	Hong Kong Polytech Univ	Hong Kong, China	636
6	Southeast Univ	China	621
7	Univ Texas Austin	USA	545
8	Beihang Univ	China	541
9	Tsinghua Univ	China	516
10	Chinese Academy of Science	China	483
11	Hong Kong Univ Sci & Technol	Hong Kong, China	480
12	Massachusetts Inst Technol	USA	477
13	Univ Montreal	Canada	460
14	Univ Maryland College Park	USA	454
15	Univ Hong Kong	Hong Kong, China	432

3.3.2 Annual number of publications citing TR-Part B

Figure 2 depicts the temporal evolution of the annual number of academic publications citing the 2,697 *TR-Part B* papers. By decade, the number of citations increased from 597 in 1979–1989, to 1,239 in 1990–1999, to 6,368 in 2000–2009, and finally to 29,509 in 2010–2020 (including papers published in 2020 until February 18, 2020). The increasing trend of citations of *TR-Part B* articles is clear from the figure and the decade-by-decade statistics, starting from a low of four citations in 1979 to 4,706 citations in 2019. *TR-Part B* has had an increasing academic influence on the global transportation research and related journals: it took thirty years (1979–2008) for the academic citations to exceed 1,000 (1,013 in 2008), but this timespan shrank to only five years (2009–2013) for exceeding 2,000, two years (2014–2015) for exceeding 3,000 and three years (2016–2018) for exceeding 4,000. Of course, these figures can be somewhat misleading in terms of *TR-Part B* influence because the increase in cites may simply be a result of the increasing number of *TR-Part B* papers published over time (see Figure 1). For example, the four citations in 1979 is simply because there were only 32 papers *TR-Part B* published in 1979 that formed the pool for possible citation in 1979. On the other hand, the 4,706 cites in 2019 in Figure 2 had a total possible citation pool of 2,697 *TR-Part B* papers. Even so, the implication is that the total cites to the pool of *TR-Part B* publications available for citing (that is, a measure of cites per published paper) increased from 0.125 (4/32) in 1979 to 1.74 (4706/2697) in 2019. This does suggest the increasing knowledge value of *TR-Part B* papers, though this increase is surely also related to the overall increase in the volume of academic papers published over time (that has the effect of increasing cites more than the number of published papers in any one journal).

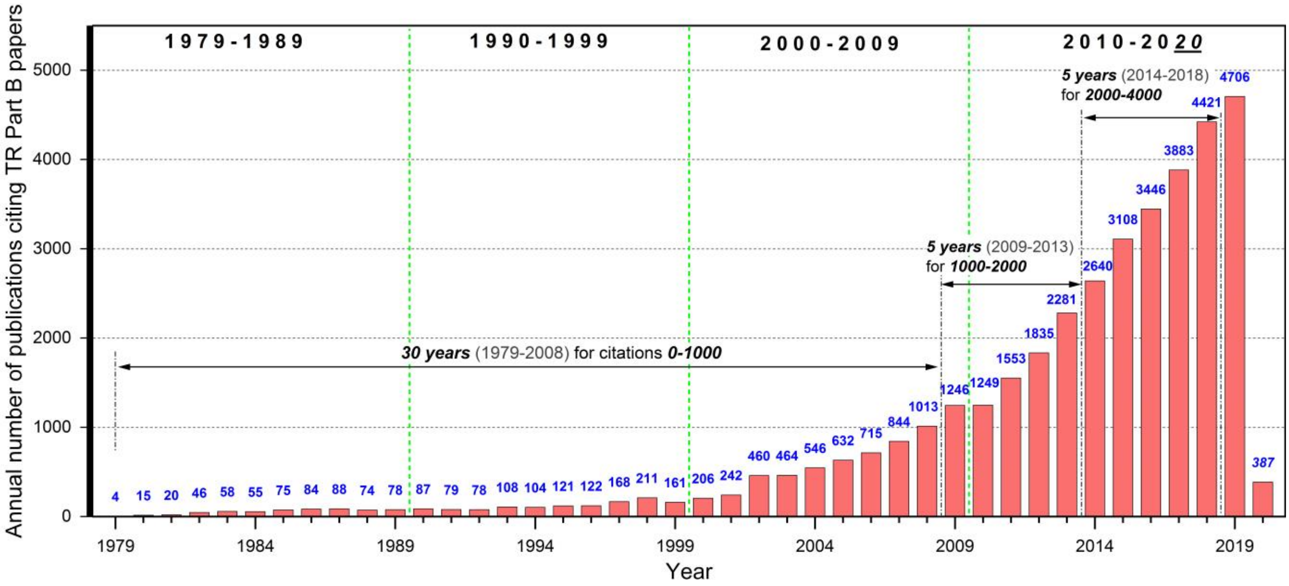

Figure 2. Annual number of publications citing the *TR-Part B* papers (1979-2020)

3.3.3 Leading journals citing TR-Part B most

To investigate which journals have cited the 2,697 *TR-Part B* papers the most, we once again made use of the WoS dataset of 37,713 academic publications. Among these publications in various journals, the top 25 journals with most publications (1979–) citing *TR-Part B* papers (1979–2019) were identified and are presented in Figure 3. Not unexpectedly, *TR-Part B* itself is the journal citing the 2,697 papers most. Up to date, *TR-Part B* has published 2,705 academic papers since 1979 (i.e., including 8 papers published in the period between January 1 and February 21, 2020), 2,197 of which (81.5%) cited at least one of the 2,697 papers. Beyond *TR-Part B*, the other journals to most cite *TR-Part B* papers are *Transportation Research Record* (*TRR*, 2,193), *TR-Part C* (1,269), *TR-Part A* (1,022), and *TR-Part E* (709), indicating that the journals in the *TR* series keep a close academic citation with *TR-Part B*. Outside the realm of traditional transportation journals, *the European Journal of Operational Research*, *Physica A*, *Sustainability*, *Computers & Operations Research*, and *Mathematical Problems in Engineering* are the top five journals citing *TR-Part B* papers.

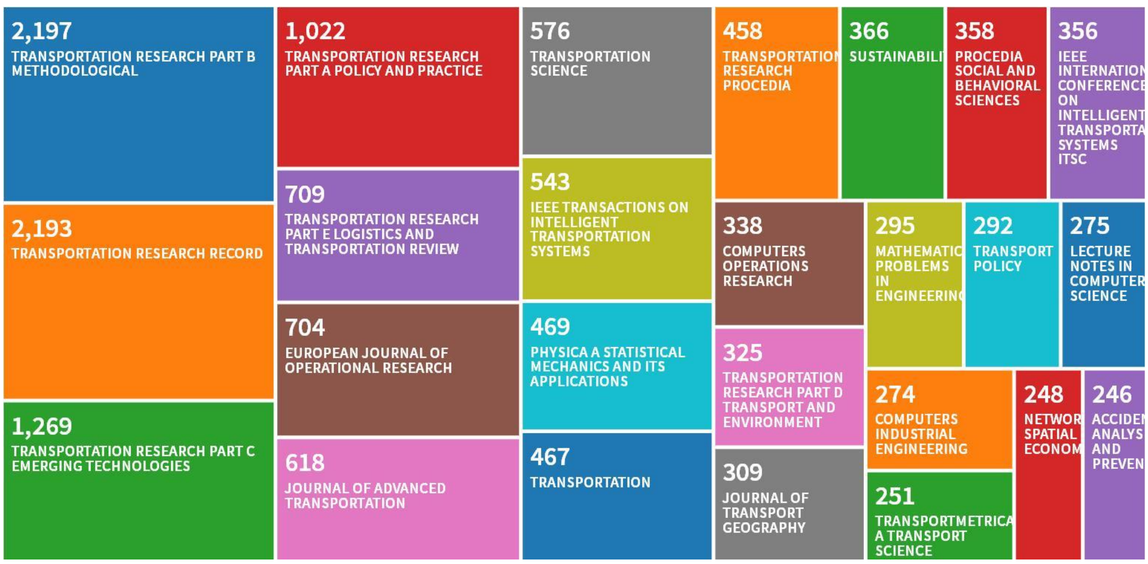

Figure 3. Top 25 journals with most academic publications (1979–) citing the 2,697 *TR-Part B* papers.

To address the *evolution* issue, a temporal analysis of individual journals citing *TR-Part B* is next undertaken. If we retain the top eleven journals (eleven in total in the first three columns of Figure 3) and merge *other journals* into one group, the temporal trends of journals citing *TR-Part B* papers may be analyzed. Figure 4 presents the results. As shown in Figure 4, *TR-Part B* and *TRR* maintain their status as the top two journals whose papers cite *TR-Part B* papers. *TR-Part C* has shown a substantial increase in citing *TR-Part B* papers in recent years, especially since 2013. It may also be observed in Figure 4 that, in the recent decade (2010–2019), the number of academic papers in *other journals* citing *TR-Part B* (denoted as bars filled with diagonals) has increased sharply. By contrast, the total citations from the aforementioned eleven top journals (denoted as bars filled with solid colors) have increased by a comparably smaller growth rate. So we may conclude from Figure 4 that the rapid growth of citations after 2009 is not solely due to citations in the eleven top journals, but also due to citations originating from *other journals*. This result suggests that the knowledge base represented by articles published in *TR-Part B* is having an increasing impact on a diverse set of journals in transportation and other fields.

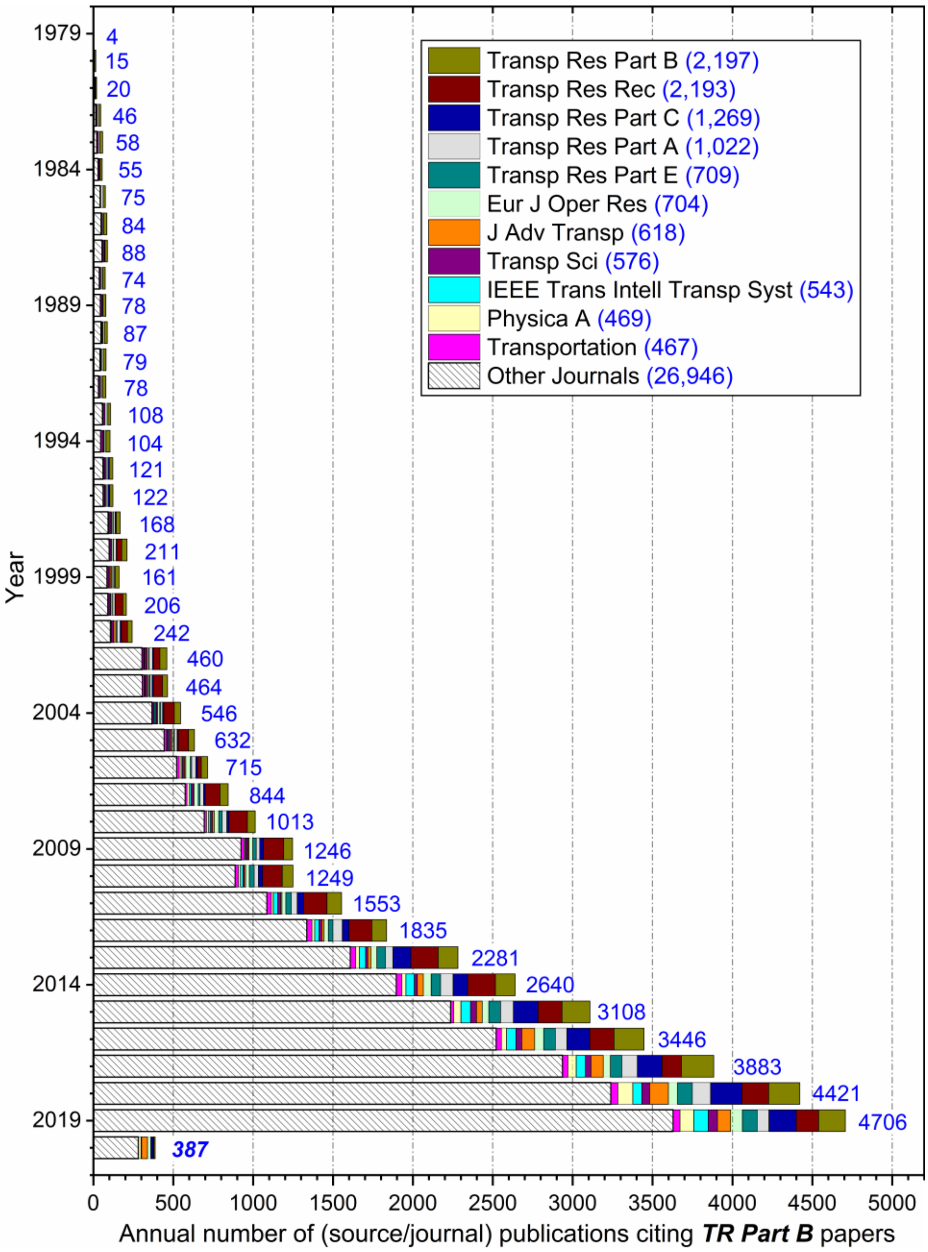

Figure 4. Temporal trend\s of journals with most academic publications citing *TR-Part B* papers.

4 Co-authorship and bibliographic coupling analysis

The previous section provided a statistical analysis of the publications and citations in *TR-Part B* during the past four decades. In this section, the VOSviewer software is employed to analyze and generate bibliometric maps in terms of co-authorship and bibliographic coupling. Analysis units (authors and organizations) are indicated by a label and, by default, also by a circle in a map. Note that a map may be freely rotated, and may be flipped horizontally or vertically, in the software, so more attention should be paid to the correlativity and connectivity details among the analysis units in the network, rather than a specific location of an individual analysis unit in the map. The color of a circle in a map (if there are different colors) refers to the cluster to which an analysis unit was assigned by the clustering technique (van Eck and Waltman, 2010). Units in the same cluster are more internally comparable with each other than with those units in other clusters, as will be explained later. A link represents the relationship between two connected units, and its thickness indicates the connection intensity between the two units, as measured by link strength. The total link strength (TLS) of an analysis unit is the summation of the strength of all links connecting a unit to other units. The TLS of a whole network is the summation of the strength of all links in the network.

4.1 Co-authorship network analysis

Co-authorship analysis continues to follow the order of authors, organizations, and countries/regions as in Section 3.2. A co-authorship occurs when at least two different units (i.e., authors, organizations, or countries/regions) cosign the same paper in a journal. For example, consider the analysis unit as being authors, and consider a simple scenario of three authors. Author A has one paper co-authored with Author B and two papers co-authored with Author C. Assume that authors B and C do not co-author any papers. In this case, the A-B link strength would be 1, the A-C link strength would be 2, and the B-C link strength would be zero. The TLS of A would be 3, the TLS of B would be 1, the TLS of C would be 2, and the TLS of the small network would be 3.

4.1.1 Authors

The author-level co-authorship in *TR-Part B* is analyzed first. According to the dataset used in this study, a total of 3,212 scholars were identified to have solely authored or co-authored the 2,697 academic papers, of which 79 met the threshold of having published ten papers or more in *TR-Part B* during 1979–2019. Excluding six authors who had no connections with others, the co-authorship network map among the remaining 73 authors is shown in Figure 5. The size of a circle in the map represents the number of papers an author has published in *TR-Part B* (i.e., corresponds to data in the TP column (1979–2019) in Table 4). The link connecting two authors indicates that the two authors co-authored at least one paper in *TR-Part B*. The more papers two connected author have co-authored in *TR-Part B* (that is, the higher the link strength between two connected authors), the thicker the line connecting them. It is possible for an author in Figure 5 to have a co-authorship with another author not shown in Figure 5 (because the other author did not meet the threshold of at least ten papers published in *TR-Part B*). But two visible authors without a link in this map indicate no co-authorship between them.

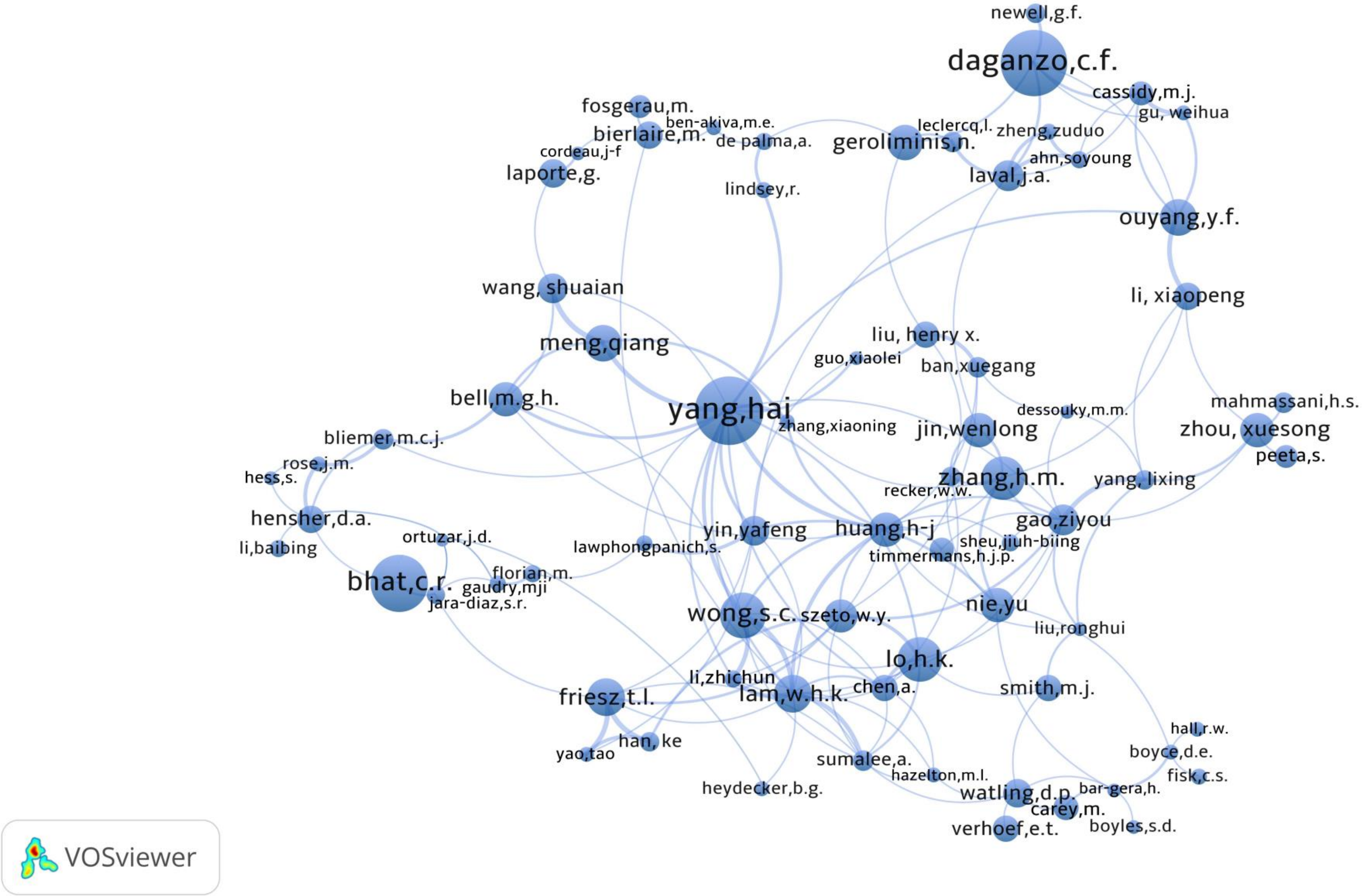

Figure 5. Co-authorship network map among the prolific authors in *TR-Part B* (1979–2019).

Figure 5 indicates that some authors, such as Hai Yang ("yang, hai" in the figure), William H. K. Lam ("lam, w.h.k."), Hai-Jun Huang ("huang, h-j"), and Sze Chun Wong ("wong, s.c."), have a number of links originating from their names, while other authors such as Chandra Bhat ("bhat, c.r.") and Carlos Daganzo ("daganzo, c.f.") do not have a high density of links originating from their circles. This indicates that the first set of authors have a higher intensity of co-authorship than the second set of authors. In fact, Hai Yang (links=17, TLS=58), William H. K. Lam (links=13, TLS=43), Hai-Jun Huang (links=13, TLS=31), and Sze Chun Wong (links=8, TLS=30), all of whom have contributed substantially to *TR-Part B*, are the top four scholars in terms of TLS (with a TLS higher than 30). The 17 links of Hai Yang indicate that he co-authored *TR-Part B* papers with 17 other prolific scholars (each with at least ten papers in *TR-Part B*). His total link strength (TLS) of 58 during the forty-year study period (which is higher than the number of links attributed to him) indicates that he co-authored multiple times with at least some of the 17 authors linked to him. On the other hand, despite the large number of paper contributions of Carlos Daganzo (71 papers, links=6, TLS=14) and Chandra Bhat (58 papers, links=2, TLS=3), both these authors have co-authored much less than the first set of authors. Further evidence of this is that 31 of the 71 papers (43.7%) involving Carlos Daganzo were sole-authored, and 20 of the 58 papers (34.5%) involving Chandra Bhat were sole-authored.

The top ten co-authorship pairings (based on link strength) among the set of 73 authors mapped in Figure 5 are reported in Table 12. The pairings involve a total of fourteen scholars, of whom five are affiliated with universities in Hong Kong (China), four with universities in the USA, three with universities in China (mainland), and one each with universities in Singapore and England.

Table 12. The top 10 co-authorship pairings between prolific authors in *TR-Part B* (1979–2019)

R	Co-author pairings	Co-authored link strengths	Affiliated country/region
1	Qiang Meng – Shuaian Wang	11	Singapore – Hong Kong
2	Terry Friesz – Ke Han	11	USA – England
3	Terry Friesz – Tao Yao	10	USA – USA
4	Hai Yang – Qiang Meng	9	Hong Kong – Singapore
5	William H. K. Lam – Sze Chun Wong	9	Hong Kong – Hong Kong
6	William H. K. Lam – Zhi-Chun Li	9	Hong Kong – China (mainland)
7	Ziyou Gao – Lixing Yang	9	China (mainland) – China (mainland)
8	Yanfeng Ouyang – Xiaopeng Li	9	USA – USA
9	Sze Chun Wong – Zhi-Chun Li	8	Hong Kong – China (mainland)
10	William H. K. Lam – Agachai Sumalee	8	Hong Kong – Hong Kong

The temporal evolution of co-authorship intensity across all authors is summarized Table 13. To construct the information in this table, we considered all co-authorship connections in each decade among scholars who have published at least five papers in *TR-Part B* during that decade. As per Table 13, during the first decade (1979–1989), 15 authors with five or more published papers during that decade contributed a total of 97 academic papers (N=97) during that decade. The co-authorship links across these authors in the co-authorship network was 5, with a network-level TLS of 10. Other entries may be similarly interpreted. The last column presents the ratio of network TLS to number of academic papers (TLS/N) during each decade. The larger this ratio, the more the co-authorship intensity. Specifically, if there is no collaboration whatsoever, and all *TR-Part B* papers published during the study period are sole-authored, it results that there is no link in the co-authorship network, and the ratio of *TLS/N* should be zero. If every paper published has exactly one co-author (i.e., two authors in total) in a co-authorship network, the ratio would be equal to one. Alternatively, the ratio can be greater than one. For example, if every paper published has two co-authors (i.e., a total of three authors in each paper), which would yield a *TLS/N* ratio of 3. According to Table 13, the *TLS/N* ratio is 0.10 for the first decade (1979–1989), and increases to 0.75 for the last decade (2010–2019). The trend is clear. As time has gone by, not only are the number of papers published increasing and the number of authors contributing to *TR-Part B* increasing, but so is the intensity of collaboration.

Table 13. Temporal evolution of the number of papers and co-authorship indices in the four decades

Four Decades	Number of authors with 5 papers or more	Corresponding number of academic papers *N*	Total links	Network-level *TLS*	*TLS/N*
1979-1989	15	97	5	10	**0.10**
1990-1999	15	98	9	17	0.17
2000-2009	33	210	32	73	0.35
2010–2019	166	1001	331	754	**0.75**

4.1.2 Organizations

In this section, we investigate the co-authorship network at the organization-level. Recall that if two organizations co-author a published paper, they are considered to have a mutually cooperative relationship. According to the dataset used in this study, a total of 942 organizations authoring the 2,697 papers in *TR-Part B* were identified by the VOSviewer software, of which 52 published no less than 20 papers. The co-authorship details of these 52 organizations are analyzed with use of the VOSviewer software. According to the co-authorship intensities, the VOSviewer groups these 52 organizations with 20 papers or more published in *TR-Part B* into three broad clusters, as reported in Table 14. The clustering algorithm is such that organizations within a cluster have a higher intensity of collaboration than organizations belonging to different clusters. Clearly, as may be observed from Table 14, universities in closer geographic proximity (in the same country or continent) tend to be identified in the same cluster, indicating that proximity still fosters more collaboration in this digital age (perhaps because of more opportunities for collaborators to meet in person when in relatively close proximity, even if the actual collaborative effort is done mostly virtually). For example, almost all the entries in Cluster #1 are US universities, and most organizations in Cluster #2 are from Asia. There is a little more diversity in Cluster #3, which includes European, North and South American, Australian, and Asian organizations.

Table 14. Co-authorship clustering results of the 52 prolific organizations in *TR-Part B*

Clusters (count)	Organizations (TLS)
#1 (19)	UC Berkeley (40), Univ Calif Davis (28), Arizona State Univ (25), UT Austin (24), Univ Illinois Urbana Champaign (24), Georgia Inst Technol (23), Univ Florida (21), Univ Minnesota Twin Cities (18), Univ Calif Irvine (16), Univ Wisconsin Madison (16), **Tsinghua Univ** (16), Northwestern Univ (15), Univ S Florida (15), Purdue Univ (13), Rensselaer Polytech Inst (13), Univ Michigan (12), Univ Massachusetts Amherst (8), Univ Maryland College Park (5), and Univ Penn (4).
#2 (12)	HKUST (67), HKPU (65), HKU (57), Beijing Jiaotong Univ (54), Tongji University (44), Beihang Univ (31), Huazhong Univ Sci & Technol (30), Natl Univ Singapore (29), **Penn State Univ** (25), **Imperial College London** (24), **Monash Univ (11)**, and Kyoto Univ (6).
#3 (21)	Delft Univ Technol (29), Vrije Univ Amsterdam (27), Ecole Polytech Fed Lausanne (25), **Univ Montreal** (24), **Univ Sydney** (23), Univ Leeds (23), **Univ Chile** (21), Tinbergen Inst (20), **Massachusetts Inst Technol** (19), **Univ British Columbia** (18), **Pontificia Univ Catolica Chile** (16), Swiss Fed Inst Tech (14), Tech Univ Denmark (13), Eindhoven Univ Technol (10), Katholieke Univ Leuven (10), KTH Royal Inst Technol (9), **Technion Israel Inst Technol (9)**, Univ College London (9), Univ Lyon (9), Univ York (5), and Univ Naples Federico II (3).

In terms of overall co-authorship intensity, the top ten institutions are HKUST, HKPU, HKU, Beijing Jiaotong University ("Beijing Jiaotong Univ" in Table 14), Tongji University ("Tongji Univ"), UC Berkeley, Beihang University ("Beihang Univ"), Huazhong University of Science and Technology ("Huazhong Univ Sci & Technol"), National University of Singapore ("Natl Univ Singapore"), and Delft University of Technology ("Delft Univ Technol"). Clearly, universities from China (Hong Kong and mainland) undertake substantial inter-university collaboration leading to papers published in *TR-Part B,* relative to universities elsewhere in the world.

The co-authorship details of representative organizations from these three clusters in Table 14 are shown in Table 15. The column N_{link} indicates the number of links (i.e., co-authored organizations) of an organization. The column $N_{i-c\ link}$ (%) indicates the number (percentage) of links connecting the organization with co-authored organizations in the same cluster as the organization. *TLS* indicates the total link strength (i.e., the number of co-authored papers) of an organization in the map, and the TLS_{i-c} (%) refers to the number (percentage) of papers the organization co-authored with another organization in the same cluster. All these statistics given in Table 15 are related to co-authorships among the 52 organizations with 20 papers or more published in *TR-Part B*.

Table 15. Co-authorship details of representative organizations in the three clusters

Clusters	Representative Organizations	Total number of papers	N_{link}	$N_{i-c\ link}$ (%)	TLS	TLS_{i-c} (%)
#1	**UC Berkeley**	162	**19**	**10 (52.6%)**	**40**	**23 (57.5%)**
	UT Austin	97	15	8 (53.3%)	24	14 (58.3%)
	Tsinghua Univ	23	**12**	**8 (66.7%)**	**16**	**12 (75.0%)**
#2	HKUST	122	20	9 (45.0%)	67	51 (76.1%)
	HKPU	87	18	8 (44.4%)	65	45 (69.2%)
	Penn State Univ	47	13	4 (30.8%)	25	13 (52.0%)
	Imperial College London	27	9	5 (55.6%)	24	18 (75.0%)
#3	Delft Univ Technol	53	15	10 (66.7%)	29	21 (72.4%)
	Univ Montreal	98	**14**	**9 (64.3%)**	**24**	**18 (75.0%)**
	Univ Leeds	65	14	7 (50.0%)	23	16 (69.6%)
	Univ Sydney	52	13	6 (46.2%)	23	14 (60.9%)
	Univ Chile	37	13	7 (53.8%)	21	13 (61.9%)
	Massachusetts Inst Technol	63	14	6 (42.9%)	19	12 (63.2%)

Cluster #1 in Table 15 indicates that UC Berkeley has co-authored papers with 19 other universities (organizations) (N_{link}=19) in 40 co-authored papers in *TR-Part B* (TLS=40). Of the 19 organizations that UC Berkeley has partnered with, 10 (52.6%) are in Cluster #1. And of the 40 co-authored papers from UC Berkeley, 23 (57.5%) are co-authored with organizations within Cluster #1. Other entries may be similarly interpreted. As indicated earlier, the clustering algorithm in the software attempts to group universities based on the intensity of collaboration. Curiously, Tsinghua University appears in Cluster #1, and is the only non-US university in Cluster #1. As an Asian university, Tsinghua University (N_{link}=12, TLS=16) co-authored with 12 organizations (with 20 papers or more) in *TR-Part B*, of which 66.7% (8/12) were partnerships with US universities in Cluster #1, contributing 75.0% (12/16) of Tsinghua's co-authored papers. Clearly, Tsinghua University holds a close collaboration with US universities, more so than with other Asian Universities in closer geographic proximity.

Cluster #2 in Table 15 mainly includes Asian universities, except for Pennsylvania State University (PSU, "Penn State Univ"), Imperial College London (ICL), and Monash University. As a US university, PSU (N_{link}=13, TLS=25) has collaborated with 13 organizations (with 20 papers or more) in its 25 papers in *TR-Part B*. Seven collaborators (53.8%) are US universities in Cluster #1, but this only generates 32.0% (8/25) of the collaboration intensity (8 co-authored papers). By contrast, 52.0% (13/25) of PSU's co-authored papers in *TR-Part B* benefit from collaboration with universities in Cluster #2. The same is the case for ICL (N_{link}=9, TLS=24). 55.6% (5/9) of ICL's partners are from universities in Cluster #2 (HKUST, HKPU, Tongji University, Kyoto University, and PSU), generating 75.0% (18/24) co-authored papers in *TR-Part B*. Therefore, PSU and ICL are classified into Cluster #2, to recognize their close co-authorship cooperation with Asia in *TR-Part B*.

Cluster #3 includes a diversity of countries and regions, though most of the universities (66.7%) in this cluster are European. As a Canadian organization bordering the USA, University of Montreal (N_{link}=14, TLS=24), however, has co-authored papers in *TR-Part B* with only three (21.4%) US universities (i.e., University of Maryland College Park, University of Florida, and University of

Massachusetts Amherst) in North America. By contrast, 64.3% (9/14) of its collaborations are with universities in this cluster (50% [7/14] are European cooperators including EPFL, The Technical University of Denmark, Delft University of Technology, and Eindhoven University of Technology, etc.), which generates 75.0% (18/24) of its co-authored papers (58.3% of its papers [14/24] result from the co-authorship with European universities). These statistics testify to the strong collaboration between University of Montreal and European universities. Other universities in this cluster, such as the University of Sydney ("Univ Sydney") and Universidad de Chile ("Univ Chile"), may be similarly interpreted.

The country/region-level co-authorship analysis provides insights similar to the organization-level co-authorship just undertaken, and so is not presented here.

4.2 Bibliometric coupling analysis

The previous section focused on co-authorship analysis. However, co-authorship analysis does not necessarily provide an indication of the closeness of the expertise areas of the co-authoring units. For example, at the author level, two co-authors may have expertise in pretty distinct areas in general, and they may bring their different expertise areas and different perspectives to bear and to address a common research challenge. In this section, we use a coupling analysis mechanism to identify researchers and organizations who have contributed in similar research areas. To do so, we use a similarity metric that counts the number of identical references cited by two papers. Thus, for an author level coupling analysis, consider the case of an author *a* (with paper A) and author *b* (with paper B) who co-cite a third document C in the reference lists of their respective papers. Then, we define that authors *a* and *b* have a coupling link (relationship), and the two scholars are more likely to have expertise in similar areas. The more identical references two *TR-Part B* papers co-cite, the thicker the link connecting the two authors, and higher is the probability that the two authors specialize in the same domain. Once the author-level links are determined, the results may be aggregated across authors to obtain coupling at the organization and country/region levels.

4.2.1 Authors

As indicated in Section 4.1.1, 79 of the 3,212 scholars have published at least ten papers in *TR-Part B* from 1979 to 2019. To investigate the coupling network among these scholars, the bibliographic coupling map of the 79 authors in *TR-Part B* is determined and shown in Figure 6, in which only the top 300 links with the most link strengths are presented. The size of a circle in the maps indicates the number of papers an author has published in *TR-Part B* (1979–2019). As may be observed, the software identifies four broad clusters (color-coded) based on the coupling intensity strength. These color coding may be used to identify and connect scholars who are deemed closer in their expertise areas and those not very close in their expertise areas (at least as determined by the strength of the couplings). The clusters and leading scholars in the bibliographic coupling map are displayed in Table 16.

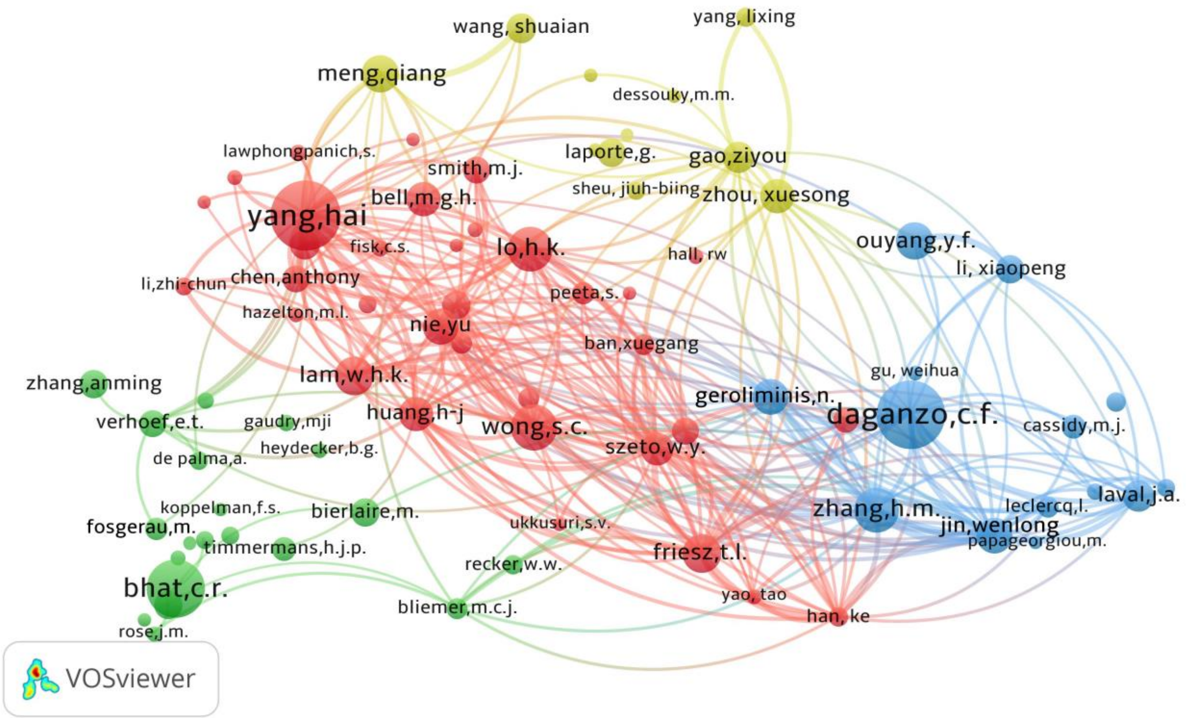

Figure 6. Bibliographic coupling network map of prolific authors in *TR-Part B.*

Table 16. Clusters and leading scholars in the bibliographic coupling map.

Clusters	Number of scholars (%)	Six dominant scholars in each cluster (number of *TR-Part B* papers)	Research fields in *TR-Part B*
#1-Green	20 (25.3%)	**Chandra R. Bhat (58)** David A. Hensher (23), Michel Bierlaire (23), Anming Zhang (23), Erik T. Verhoef (22), Harry J. P. Timmermans (19)	Travel demand and behavior, Transportation economics
#2-Red	34 (43.0%)	**Hai Yang (74)** Sze Chun Wong (44), Hong Kam Lo (42), William H. K. Lam (35), Terry L. Friesz (35), Yu (Marco) Nie (31)	Transportation network analysis
#3-Blue	14 (17.7%)	**Carlos F. Daganzo (71)** Michael H. Zhang (40), Yanfeng Ouyang (33), Nikolas Geroliminis (32), Wen-Long Jin (31), Jorge Laval (27)	Traffic flow theory, Public transportation
#4-Yellow	11 (13.9%)	**Qiang Meng (33)** Xuesong Zhou (30), Ziyou Gao (27), Shuaian Wang (25), Gilbert Laporte (24), Lixing Yang (15)	Marine transport, Distribution and Routing management, Railway transportation

As illustrated in Figure 6 and Table 16, scholars in Cluster #1 (green, 20 authors, 25.3%) are led by Chandra Bhat (58 *TR-Part B* papers), Michel Bierlaire (23), Anming Zhang (23), Erik Verhoef (22), and Harry Timmermans (19). The authors in this cluster are specialists in the field of travel demand, travel behavior, and transportation economics. Cluster #2 (red) includes the most number of authors of the 79 total authors (34 authors, 43.0%), and comprises scholars led by Hai Yang (74 *TR-*

Part B papers), Sze Chun Wong (44), Hong Kam Lo (42), William H. K. Lam (35), and Terry Friesz (35). The scholars in this cluster represent those who specialize in the field of transportation network analysis. In addition, as can be observed from Figure 6, the links in this cluster are found to be denser and thicker than those in the other three clusters, which indicates that more identical references are identified in the *TR-Part B* papers of the scholars in the area of transportation network analysis than in other areas. Carlos Daganzo (71 *TR-Part B* papers) dominates Cluster #3 (blue, 14 authors, 17.7%), with other prolific scholars including Michael Zhang (40), Yanfeng Ouyang (33), Nikolas Geroliminis (32), Wen-Long Jin (31), and Jorge Laval (27). These scholars are specialists in traffic flow theory and public transportation. As revealed in Figure 6, the authors toward the left of this blue cluster connect quite a bit with those in the red cluster, indicating the rich coupling association between those specialists in traffic flow theory and those in transportation network analysis (especially for dynamic traffic assignment). Finally, Cluster #4 (yellow, 11 authors, 13.9%) is led by Qiang Meng (33 *TR-Part B* papers), Xuesong Zhou (30), Ziyou Gao (27), Shuaian Wang (25), Gilbert Laporte (24), and Lixing Yang (15), and represents the domain of marine transport, distribution and routing management, and railway transportation.

4.2.2 Organizations

Analogous to bibliographic coupling of authors, organization coupling occurs when two organizations represented in two *TR-Part B* papers cite the same third document; this can be used to get a sense of the organizations that tend to undertake similar research (measured by co-citation of the same references). For an organization level coupling analysis, consider the case of a paper A (with organization *a*) and paper B (with organization *b*) who co-cite a third document C in the reference lists of their respective papers. Then, we define that organizations *a* and *b* have a coupling link (relationship), and the two organizations are more likely to have expertise in similar areas. The more identical references two *TR-Part B* papers (i.e., A and B) co-cite, the thicker the link (i.e., the larger the link strength) connecting the two organizations (i.e., *a* and *b*), and higher is the probability that the two organizations (i.e., *a* and *b*) specialize in the same domain. An extreme example is that, if the reference lists of the two papers (i.e., A and B) are totally identical, then we could infer that the two organizations (i.e., *a* and *b*) are working on the same domain.

The bibliographic coupling network of organizations in *TR-Part B* is depicted in Figure 7, in which 52 organizations that published no less than 20 academic papers in *TR-Part B* are considered and only the top 300 links with the most link strengths are presented. The size of a circle in the maps indicates the number of papers an organization has published in *TR-Part B* (1979–2019). A link connecting two organizations indicates the coupling relationship between the two organizations. As shown in Figure 7, the 52 organizations are categorized into three clusters (denoted by three colors) by the clustering algorithm in the software. The *TR-Part B* papers authored by those organizations in the same color cluster cite more identical references, thus (according to the definition of bibliographic coupling) these organizations in the same color cluster may be considered to be closer in research domain expertise with each other than with organizations in other clusters. For example, in Figure 7, HKUST ("hong kong univ sci & technol") and HKU ("univ hong kong") are classified in the same cluster (blue) by the clustering algorithm in the VOSviewer. Therefore, HKUST is believed to work on more close research topics with HKU by co-citing more identical references in their respective *TR-Part B* papers (link strength=2,771). Given that UC Berkeley is classified into a different cluster (red), as compared with HKU, HKUST is considered to address less identical research topics with

UC Berkeley (by co-citing less identical references in their respective *TR-Part B* papers, link strength=1,154). The number of organizations in each of the three clusters is: red cluster with 22, blue and green clusters with 15 each. As per Figure 7, the majority of components in the red, blue, and green clusters are those universities from the US (13/22=59.1%), Asia (8/15=53.3%), and Europe (6/15=40.0%), respectively. Interestingly, the universities in Hong Kong in Figure 7 all fall in the blue cluster, suggesting that the research domain expertise residing at these universities are similar. This is consistent with the finding from the author-level coupling analysis (see Table 16) that four of the most prolific scholars who have published in *TR-Part B* from Hong Kong all fall in the second cluster associated broadly with the research area of transportation network analysis.

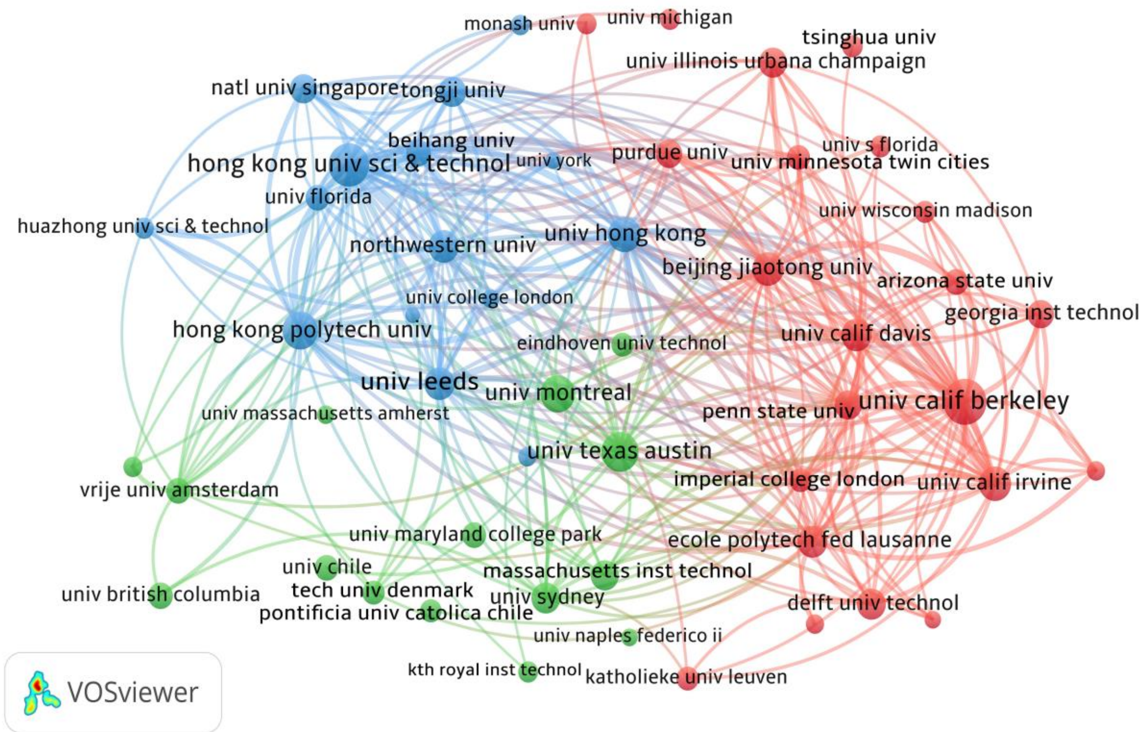

Figure 7. Coupling network map of the prolific organizations in *TR-Part B*.

Some earlier bibliometric studies in other fields (Cancino et al., 2017, Merigó et al., 2017) have suggested that organizations from the same countries or adjoining regions tend to work on closer technical topics or research areas. However, as per Figure 7, this seems not always the case. For example, about one half (8/15=53.3%) of the entries in the blue cluster are Asian universities, while the other half consists of three US, three European, and one Australian universities (7/15=46.7%). This indicates that the Asian universities are working on similar research topics with the organizations in other continents in *TR-Part B*. The same logic goes for the green cluster. Apart from the 40.0% (6/15) of European universities in the green cluster, other entries include four American (26.7%), two Chilean (13.3%), two Canadian (13.3%) universities, and one Australian (6.7%) university. This balanced diversity indicates that more universities from different continents of the world are now free from geographical constraints and addressing close research topics with each other in *TR-Part B*.

Overall, the organization-level coupling analysis indicates that, with the rapid development of the transportation discipline globally, the range of transportation research areas within universities is generally getting broader, and the organizations (from different continents) in the world are addressing more similar transportation issues. The country/region-level coupling analysis provides findings similar to that of the organization-level analysis, and so is suppressed here.

5 Conclusions

Motivated by the 40th anniversary of the top-tier journal *Transportation Research Part B: Methodological*, this study conducted a bibliometric analysis of the journal over the forty-year study period from 1979 to 2019. The data used in this study were derived from the *Core Collection Database* of WoS, involving the full records of a total of 2,697 academic papers (i.e., including articles and reviews only) published in *TR-Part B*. A comprehensive correction of data on author names and specific organizations or regions was undertaken to overcome the data inconsistencies.

This study presented the temporal trends of the publications in the lifetime of *TR-Part B* from 1979 to 2019 (Figure 1), indicating a rapid increase in publications in the 2010s. The citation structures of *TR-Part B* were analyzed according to several factors, including the 50 most frequently cited academic papers published in *TR-Part B* (Table 2), and the top 30 documents most cited by *TR-Part B* papers (Table 3). Also, the prolific authors, organizations, and countries/regions contributing most to the development of *TR-Part B* were investigated (Tables 4, 6, and 8). The top three authors in terms of *TR-Part B* paper contributions as well as many different citation metrics were Carlos Daganzo, Hai Yang, and Chandra Bhat, with the rank ordering among these three scholars varying based on the precise citation metric used. Carlos Daganzo was found to have 71 papers and the most citations globally, which testifies to the fact that he has greatly contributed not only to *TR-Part B*, but also to the development of modern transportation science. In terms of organization contributions, UC Berkeley had the most number of papers published in *TR-Part B* worldwide during the study period, and the academic gap between organizations from other countries and those from USA was evident. Besides, a temporal evolution analysis of the top ten authors, organizations, and regions with the most number of papers by each of the four decades in the forty-year lifetime of *TR-Part B* was also conducted (see Tables 5, 7, and 9). Moreover, this study also identified that Hai Yang (Table 10), Beijing Jiaotong University (Table 11) and *TR-Part B* itself (Figures 3 and 4) were the author, organization, and journal, respectively, who had cited the 2,697 papers in *TR-Part B* most.

To conduct an interactive analysis from a bibliometric perspective, the VOSviewer software was utilized to analyze and generate bibliometric network maps in terms of co-authorship and bibliographic coupling at the author-level, organization-level, and country/region-level, respectively. In terms of co-authorship analysis, this study identified the top ten co-authorship pairings in *TR-Part B* (Table 12). As time has gone by, not only are the number of papers published increasing and the number of authors contributing to *TR-Part B* increasing, but so is the intensity of collaboration (Table 13). This study also found that the organization-level co-authorship was more geographically clustered (Table 14). As with the bibliographic coupling analysis, the 79 top scholars with ten papers or more in *TR-Part B* were categorized into four research domains (dominant scholar) (Figure 6 and Table 16): (1) travel demand, travel behavior, and transportation economics (Chandra Bhat); (2) transportation network analysis (Hai Yang); (3) traffic flow theory and public transportation (Carlos Daganzo); and (4) marine transport, distribution and routing, and railway transportation (Qiang Meng).

Owing to the multi-disciplinary diversity of transportation research in the field, the analyses presented in this study for *TR-Part B* are by no means exhaustive. In the future, following the general bibliometric study of *Transportation Research* journals (*Part A-F*) conducted by Modak et al. (2019) and this specialized study on *TR-Part B*, analogous bibliometric studies on other *TR* journals, and other top-tier journals such as *Transportation Science*, could investigate the contributing features of these distinctive journals to the field of transportation research.

Acknowledgements

The work described in this paper was supported by the National Natural Science Foundation of China (No. 41571149), the Research Grants Council of the Hong Kong Special Administrative Region, China (No. R5029-18), and the Research Committee of the Hong Kong Polytechnic University (No. 4-ZZFY). The research was also partially supported by the Data-Supported Transportation Operations and Planning (D-STOP) Center (Grant No. DTRT13GUTC58), Tier 1 University Transportation Center sponsored by the U.S. Department of Transportation at The University of Texas at Austin. The authors are indebted to Professor Chi Xie from Tongji University for his valuable suggestions, comments and edits on the earlier version of this paper, and for his assistance in granting authors access to the full WoS dataset used in this study. The authors also extend their thanks to Dr. Jie Li from Shanghai Maritime University for his technical collaboration with the VOSviewer software.

Declarations of interest

None.

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