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1 **Transportation systems in the Arctic: a systematic literature review using textometry**

2

3 **Abstract**

4 Changes in the climatic conditions in the Arctic are opening new trading routes (**Northern Sea**
5 **Route & North West Passage**) in this area. There is a growing importance of this theme in the
6 conversation amongst transportation scholars. Indeed, the academic conversation about Arctic
7 transportation is becoming a field of research in itself. The aim of this study is to look at this
8 conversation and provide a state-of-the-art of Arctic transportation systems. The investigation
9 is based on a systematic literature review of peer reviewed articles dealing with transportation
10 and the Arctic. **The corpus composed of 386 articles about Arctic transportation is studied**
11 **from a textometric perspective and compared with professional press to identify gaps between**
12 **concerns of professionals and scholars' research.** Results show a growing body of research
13 with a strong node of experts. Their research covers operations and sustainable development
14 of shipping and port activities along the Arctic routes. **We also identify five major areas for**
15 **further investigation: the tactical perspective and management approach of issues in the field,**
16 **risk management in general, logistic systems to access to the Arctic routes, major clustering**
17 **projects development in the area and management of specific fleets required by the extreme**
18 **conditions.**

19

20

21 **Keywords**

22 Arctic, Northern Sea Route, North West Passage, Shipping, Ports, Hinterland, Tourism,
23 Literature Review.

24

1 **Transportation systems in the Arctic: a systematic literature review**

2

3 **1. Introduction**

4 One of global warming's effects is the melting of ice caps in Polar areas and especially in the
5 Arctic region. The Arctic is warming more than twice as fast as the rest of the planet, rapidly
6 increasing glacier and sea ice melt (Quinn, 2008). This ice melt makes shipping possible for a
7 certain period in the year along the coasts of Russia, with the Northern Sea Route (NSR) and
8 Canada with the North West Passage (NWP) (Lasserre and Faury, 2019). Moreover, the ice
9 melt influences the commercial viability of these routes (Bekkers, 2018). Potential
10 profitability comes from a reduction in distance for transcontinental shipping, and especially
11 the Asia-Europe shipping (Lasserre, 2014).

12 The ice melt has two main consequences for transportation. First, it opens a passage for
13 vessels crossing in the Northern American area (Chenier et al, 2016) and in the Eurasian area
14 (Solvang, 2018). These routes may not only be cheaper and faster solutions for
15 transcontinental transportation, but they could also become less-polluting routes overall
16 (Theocharis et al., 2018; Zhang et al., 2019). Second, this melt also enables easier exploitation
17 and transportation of resources to and from the Arctic area. It is especially true considering oil
18 fields (Remishevskaja et al., 2018) and liquefied natural gas fields (Ritz, 2019).

19 During the last few decades and with an increasing rate, studies have been performed by
20 private, institutional, and academic sectors. These studies cover transportation through, from
21 and to the Arctic area as well as infrastructures located in the Arctic. Transportation studies
22 cover tramping and oil transportation (Cariou and Faury, 2015), container shipping (Xu et al,
23 2018; Cheaitou and Cariou, 2012) and also cruise shipping (Webb and Gende, 2015; Kajan,
24 2014; Dawson et al., 2016). Infrastructures in the Arctic have been studied from the
25 perspective of ports with their capacity, development and specific requirements (Allen, 2015;
26 Krivoshchekov et al., 2018); from the perspective of the access to hinterland through the
27 different corridors and modes of transport (Alix, 2016; Antipov et al., 2017; Alklychev and
28 Zoidov, 2012); and from a free zone perspective (Lavissière and Faury, 2019).

29 In this short time, a complete field of research has emerged and structured itself around a few
30 major approaches. Not only are academic articles increasing in numbers, but books have also
31 been dedicated to transportation in the Arctic with its specific issues. Thematic literature
32 reviews have also been carried out. First, Lasserre (2014) looked at the studies that compared
33 the Arctic and non Arctic routes. He based his research on 26 academic papers dealing with
34 such comparisons. Then, Meng et al. (2017) carried out a literature review on the theme of
35 Arctic navigation and commercial opportunities. This literature review is based on 25
36 academic papers. A few years ago, Theocharis et al. (2018) completed a third literature review
37 on the different research methods used to compare the existing shipping routes and the Arctic
38 routes. This thematic literature review on methodology is based on 33 academic papers. While
39 these three major literature reviews focus on very specific aspects in the field of Arctic
40 transportation, there is currently no systemic literature review of concerning the whole field.

1 This leaves Arctic transportation scholars with no overall picture of the current academic
2 literature in their field.

3 The aim of the present paper is to bridge this gap. We present a systematic literature review of
4 the Arctic transportation field. We include academic articles treating the whole scope of
5 Arctic transportation: geographically with a coverage of NSR and NWP; in terms of
6 transportation with academic papers on ports in the Arctic; shipping in the Arctic; tourism;
7 and legal, institutional and geopolitical implications that the exploitation of the Arctic as a
8 transportation route creates. Moreover, we compare the concerns of the academic community
9 with the professional concerns that professional press about this field addresses and exposes.

10 For this systematic literature review, we take a textometric approach. This linguistics-based
11 method has been used in other management studies (Macke and Genari, 2019), but also in
12 maritime studies (Mandjak et al. 2019; Fedi et al. 2019) in order to obtain an overall picture of
13 the literature published in the field.

14 **2. Method**

15 *2.1. Characteristics of a systematic literature review*

16 Systematic literature reviews began in medical science and then diffused to psychology,
17 information technology, and social sciences (Senivongse et al., 2017). They cover a specific
18 topic in the academic literature in an exhaustive manner. The first aim is to build a state of the
19 art. Such reviews also enable academic communities to find new topics for research and to
20 identify specific gaps to fill while summarizing knowledge on the specific topic. In the field
21 of transportation, several types of systematic reviews can be identified: methodological (Woo
22 et al., 2011), emerging topics (Moros-Daza et al., 2020) or syntheses of large existing
23 literature (Mandjak et al., 2019).

24 A systematic literature review “*is based on a clearly formulated question, identifies relevant*
25 *studies, appraises their quality and summarizes the evidence by use of explicit methodology. It*
26 *is the explicit and systematic approach that distinguishes systematic reviews from traditional*
27 *reviews and commentaries” (Khan et al., 2003: 118).*

28 In order to carry out the systematic literature review on Arctic transportation systems, we
29 followed the steps suggested by Durach et al. (2017) and commonly accepted in management
30 science and economy (Tranfield et al., 2003; Mandjak et al., 2019). These six steps are the
31 following: (1) defining the research question, (2) determining the required characteristics of
32 primary studies, (3) retrieving a sample of potentially relevant literature, (4) selecting the
33 relevant literature, (5) synthesizing the literature, and (6) reporting the results.

34 *2.2. Steps in defining the relevant literature base*

35 Step 1: Research question

36 Literature suggests that the topic of a systematic literature review, as well as the research
37 questions, should be chosen before starting to perform the review (Boell and Cecez-
38 Kecmanovic, 2015; Khan et al., 2003). This approach led us to three main research questions:

- 39 • QR1: what is the state of the art of Arctic transportation?
- 40 • QR2: does academic research on Arctic transportation match with professional
41 concerns about the topic?

- 1 • QR3: what are the perspectives of future research in the field?

2 Step 2: Required characteristics of primary studies

3 Our literature review is **composed of three textometric analyses. The first textometric analysis**
4 **is** restricted to academic work published **in English** in peer review journals. We chose this
5 type of research document because it is the most representative of current research that is
6 approved by the academic community researching transportation. We systematically searched
7 for and included these articles. We did not include books, book chapters written by scholars,
8 articles selected for publication in conference proceedings, Masters or Ph.D. dissertations, or
9 reports.

10 **The second textometric analysis concerns four** academic books fully dedicated to Arctic
11 transportation that were published **recently. These four books constitute our second corpus.**
12 **For these books, we therefore performed a parallel analysis. These books were included in a**
13 **parallel corpus because they were published by** academic editor, written exclusively by
14 scholars, were peer reviewed and edited by authors we identified as key authors of the topic.

15 **During the analysis of our results, as a comparison, we also performed a textometric analysis**
16 **of professional press articles. Through this analysis, we were able to ascertain the**
17 **convergence or divergence of concerns between academia and the business world. While the**
18 **review of professional press is not, strictly speaking, commonly part of a systematic literature**
19 **review, we also aimed to identify sectorial themes that are salient in professional**
20 **communication and not addressed in the academic literature.**

21 Step 3: Sample of potentially relevant literature

22 We conducted a keyword research on EBSCO **and SCOPUS**, two of the most renowned and
23 used academic databases in order to identify a first set of academic articles dealing with our
24 topic. We limited our research to 30 years from 1990 to 2019 included. We then performed a
25 research in February 2020 to include the any recently published articles. Five articles were
26 included at this stage. **These two databases are complementary since only 47 articles were**
27 **duplicates out of the 386 articles which composed the corpus for the review.**

28 Following the methods of Mandjak et al. (2019) the EBSCO **and SCOPUS** research was
29 performed on two axes of keywords. One for the geographical approach to studying the Arctic
30 and a second for the maritime-related transportation in the area. In order to select the
31 keywords, we first surveyed and listed the potential keywords. Then we contacted a group of
32 experts, who first individually gave us their feedback. Finally, we shared feedback to reach a
33 consensus on the keywords. For the geographical axis, we excluded *Arctic Bridge* and *Polar*
34 as keywords and retained *Arctic*, *Northern Sea Route* (and *NSR*), *Northeast Passage* (and
35 *NEP*) *North West Passage* (and *NWP*). For the transportation axis, we selected *Shipping*,
36 *Transport*, *Maritime*, *Port*, *Hinterland*, *Tourism*, and *Cruise*. **To verify the quality of this**
37 **method, when we had the final database, we also looked at smaller scale geographical areas to**
38 **check if they were present in the corpus. We looked for Svalbard (842 occurrences),**
39 **Greenland (1026), Siberia (274), Nunavut (476), Alaska (591), Baffin (114), Beaufort (240),**

1 Barents (793), Bering (610), Yamal (226), Hudson (69), Kara (267), Laptev (153), Naress (3),
 2 Norwegian (1137).

3 Table 1a: Matrix of articles collected initially with EBSCO

Keywords	Arctic	NEP	NSR	NWP	Sum
Shipping	401	219	794	235	1649
Transport	940	417	1415	409	3181
Maritime	472	189	693	216	1570
Port	540	393	1181	405	2519
Hinterland	42	50	227	35	354
Tourism	408	182	593	178	1361
Cruise	120	41	151	71	383
Sum	2923	1491	5054	1549	11017

4

5 Table 1b: Matrix of articles collected initially with SCOPUS

Keywords	Arctic	NEP	NSR	NWP	Sum
Shipping	221	3	82	9	315
Transport	624	17	39	13	693
Maritime	219	3	42	2	266
Port	63	1	18	1	83
Hinterland	2	0	2	0	4
Tourism	138	10	1	0	149
Cruise	73	0	2	0	75
Sum	1340	34	186	25	1585

6

7 The search for articles was conducted with all combinations of keywords of the geographical
 8 axis with those of the transportation axis. We performed the search on Titles, Abstracts and
 9 Keywords. The result were two matrices, one for EBSCO and one for SCOPUS, of 28 lists of
 10 academic articles (the combination of 4 keywords by 7 keywords). The combined total
 11 number of academic articles was 11,017 articles for EBSCO and 1 585 for SCOPUS. The lists
 12 did not have the same length and some articles figured more than once in the total of each
 13 database. Table 1a and 1b show the number of articles found in each list. The first task was to
 14 merge the lists in each database and exclude duplicates. The second task was to exclude
 15 articles that were not related to the field of Arctic transportation such as academic articles
 16 dealing with conditions of use of USB (Universal Serial Bus) ports in Arctic conditions. We
 17 performed this task through a first round of elimination of clearly unrelated papers. Then the
 18 most expert author in the field performed a second verification of the articles. Finally, we
 19 verified both of our corpora by double-checking for any possibly missed articles directly on
 20 the websites of academic journals in the field. For this step, we used the same keywords as
 21 listed in Tables 1a and 1b.

22 Step 4: Selecting the relevant literature

1 After the collection and filtering out unrelated articles, 900 articles remained from the
 2 EBSCO database (Table 2a) and 445 articles from SCOPUS database (Table 2b). Several
 3 articles, however, appeared in more than one combination of keywords. After eliminating the
 4 duplicates, 204 articles relevant to the literature review remained in the EBSCO database.
 5 Four articles, however, were not academic articles as they were consulting reports published
 6 in an academic review (1), book chapters (1), and books (2). One article appeared in the
 7 proceedings from a renowned international conference and was highly cited as such. We first
 8 excluded the article and then discovered that the paper was published in a peer reviewed
 9 journal. We only included the peer-reviewed version in our database.

10 Table 2a: Matrix of articles collected and selected from EBSCO

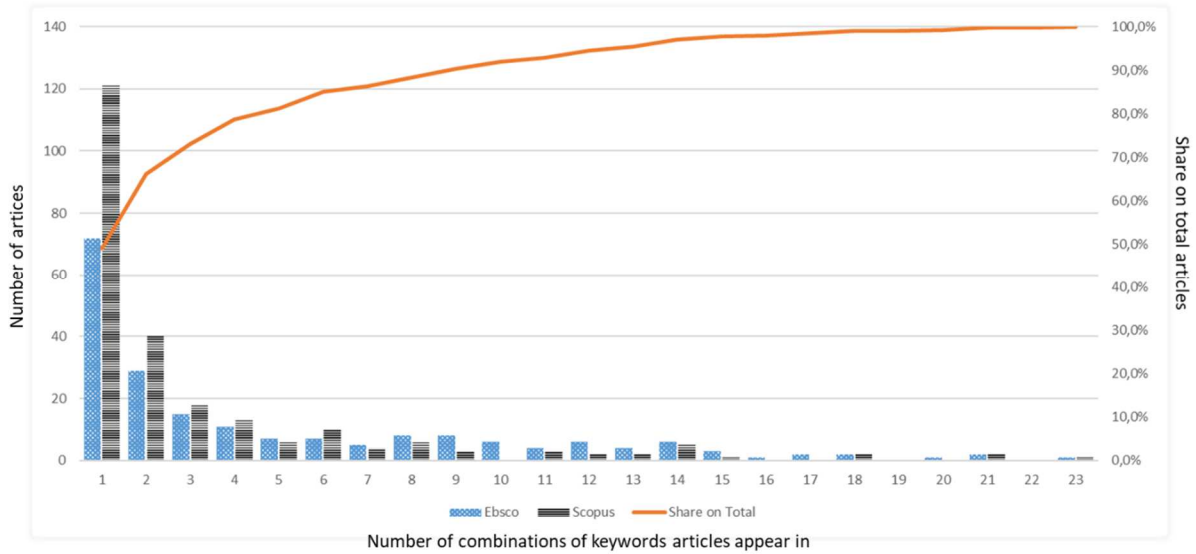
Keywords	Arctic	NEP	NSR	NWP	Sum
Cruise	18	9	9	13	49
Hinterland	4	2	3	1	10
Maritime	99	30	67	32	228
Port	49	17	31	23	120
Shipping	124	34	61	32	251
Tourism	33	8	7	12	60
Transport	81	25	52	24	182
Sum	408	125	230	137	900

11
 12 We used the same methodology to select 239 articles from the SCOPUS database. We
 13 excluded articles written in French (3) as well as in Russian (1). We also excluded book
 14 chapters (2). We finally merged both corpora and found 47 duplicates. The final total of our
 15 academic literature corpus was 386 academic peer reviewed articles in English.

16 Table 2b: Matrix of articles collected and selected from SCOPUS

Keywords	Arctic	NEP	NSR	NWP	Sum
Cruise	21		2		23
Hinterland	2		2		4
Maritime	82	1	30		113
Port	26		13		39
Shipping	100	1	58	7	166
Tourism	21		1		22
Transport	52		26		78
Sum	304	2	132	7	445

17
 18 From these 386 articles, 49% appear only with one combination of keywords, 81% appear
 19 with five or less combinations and only 10% appear with 9 or more combinations with one
 20 article appearing in 23 combinations in each database.



1

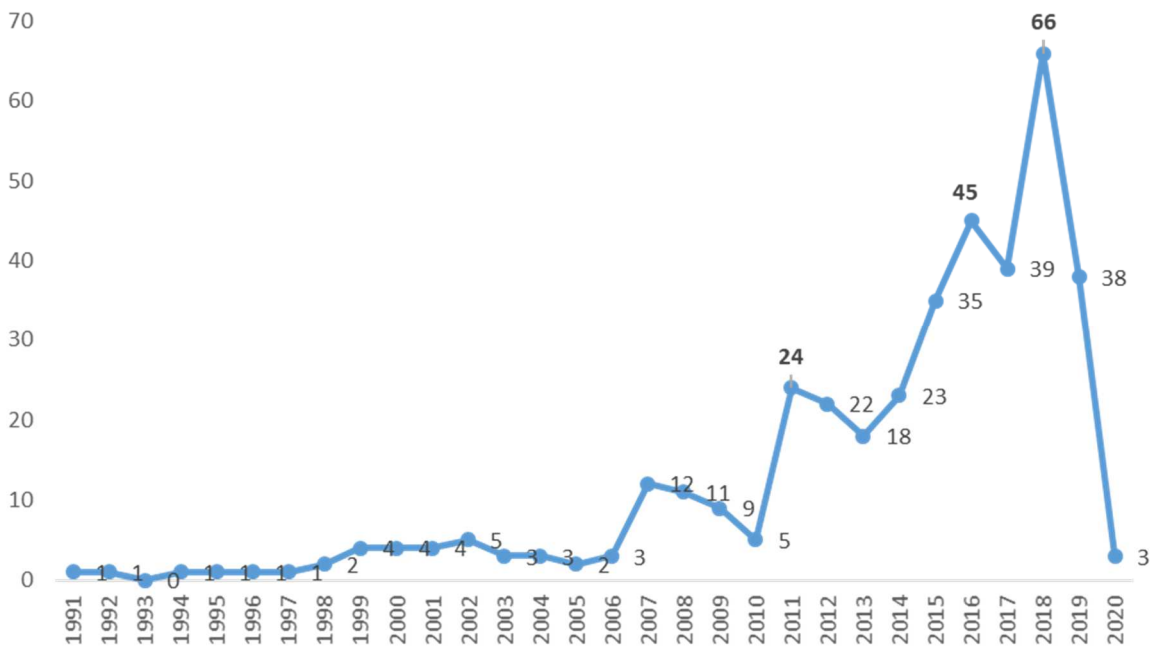
2

Figure 1: Distribution of articles of the corpus in the combinations of keywords

3

4 *2.3. Descriptive bibliographic results*

5 The corpus (Fig. 2) shows an increasing interest in the topic over time. There are less than 5
 6 articles per year from 1990 to 2006, then an increasing trend with three peaks in 2011 (24),
 7 2016 (45) and 2018 (66). Fig. 2 confirms the topicality of Arctic transportation and the
 8 relevance of a first systematic state of the art.



9

10

Figure 2: Distribution of articles of the corpus over time

11 Table 3 shows the most well-represented journals in the corpus. We can see that only journals
 12 cited at least two times in the corpus are presented in Table 3. There is a total of 181 different
 13 journals that appear in the corpus. The 12 most represented journals amount for more than a

1 third of the publications on Arctic transportation systems. Moreover, 26 journals, including
 2 Transportation Research Part A: Policy and Practice, represent 50% of the publications.

3 Table 3: Most represented journals in the corpus

Academic Journal	Number Articles	Share	Sum
Ocean Development and International Law	36	9%	9%
Review of European, Comparative and International Environmental Law	18	5%	14%
Maritime Policy and Management	17	4%	18%
Problems of Economic Transition	16	4%	23%
Journal of Transport Geography	9	2%	25%
International Affairs	7	2%	27%
Ocean Engineering	7	2%	28%
WMU Journal of Maritime Affairs	7	2%	30%
Coastal Management	6	2%	32%
Environmental science and technology	6	2%	33%
Europe-Asia Studies	6	2%	35%
Maritime Economics and Logistics	6	2%	37%
Tourism in Marine Environments	5	1%	38%
Transportation Research Part A: Policy and Practice	5	1%	39%
Current Issues in Tourism	4	1%	40%
Journal of Sustainable Tourism	4	1%	41%
Nordic Journal of International Law	4	1%	42%
Resources	4	1%	43%
Scandinavian Journal of Hospitality and Tourism	4	1%	44%
Strategic Analysis	4	1%	45%
Ambio	3	1%	46%
Energy Research and Social Science	3	1%	47%
International Journal of Shipping and Transport Logistics	3	1%	48%
J. Mar. L. and Com.	3	1%	48%
Journal of Borderlands Studies	3	1%	49%
Journal of Cleaner Production	3	1%	50%
Journal of Marine Science and Application	3	1%	51%
Mirovaya ekonomika i mezhdunarodnye otnosheniya	3	1%	52%
Polar Record	3	1%	52%
Ship technology research	3	1%	53%
Studies on Russian Economic Development	3	1%	54%
The RUSI Journal	3	1%	55%
Transportation Research Part D: Transport and Environment	3	1%	55%
Transportation research record	3	1%	56%
American University International Law Review	2	1%	57%
Annals of Tourism Research	2	1%	57%
Applied Ocean Research	2	1%	58%
Case W. Res. J. Int'l L.	2	1%	58%
Climatic Change	2	1%	59%
Energy Policy	2	1%	59%
Eurasian Geography and Economics	2	1%	60%
European Foreign Affairs Review	2	1%	60%
FOCUS on Geography	2	1%	61%
INCAS Bulletin	2	1%	61%
International Environmental Agreements: Politics	2	1%	62%
International Journal of Offshore and Polar Engineering	2	1%	62%
Journal of International Affairs	2	1%	63%
Marine Policy	2	1%	63%
Nature Climate Change	2	1%	64%
Polar Research	2	1%	65%
Science of The Total Environment	2	1%	65%

Scientific reports	2	1%	66%
The Asian Journal of Shipping and Logistics	2	1%	66%
The Brown Journal of World Affairs	2	1%	67%
Transport Policy	2	1%	67%
Transport Reviews	2	1%	68%
Transportation Research Part E: Logistics and Transportation Review	2	1%	68%

1

2 Table 4 presents the authors who are most represented in the corpus with their country of
3 affiliation. We can see that only the 23 authors who appear at least three times in the corpus
4 are presented in Table 4. These authors are central to the topic and represent 10.7 % of the
5 total of authors of the corpus (751 authors). Authors' affiliations also provide interesting
6 information since most Arctic countries are represented (all except Iceland and Denmark).
7 The most prolific country is Canada with 3 authors in the top 24 authors. The 3 authors are
8 also in top 5 author. They have written a combined total of 21 articles. Surprisingly France
9 appears second in terms of cumulated publications (17) from these major authors (4 out of
10 24). Other non Arctic countries such as China (2 authors) and Singapore (2 authors who have
11 more than 3 articles) are also represented.

12

Table 4: Most active authors in the field of Arctic transportation

Authors	Nbr of Publications	Country of affiliation
Lasserre, F.	9	Canada
Dawson, J.	7	Canada
Faury, O.	6	France
Bennett, M.M.	5	Hong Kong
Khan, F.	5	Canada
Cariou, P.	4	France
Cheaitou, A.	4	France
Ehlers, S.	4	Germany
Smith, L.C.	4	U.S.A.
Stephenson, S.R.	4	U.S.A.
Stewart, E.J.	4	New Zealand
Zhang, Y.	4	Singapore
Berkman, P.A.	3	U.S.A.
Brubaker, R.D.	3	Norway
Chen, J.S.	3	U.S.A.
Erikstad, S.O.	3	Norway
Fedi, L.	3	France
Furuichi, M.	3	Japan
Hu, H.	3	China
Meng, Q.	3	Singapore
Moe, A.	3	Norway
Stokke, O.S.	3	Norway
Tarovik, O.V.	3	Russia
Yan, X.	3	China

13

14 *2.4. Textometric analysis procedure: textometric analysis with Iramuteq*

15 *2.4.1. Textometry as a method in systematic literature reviews*

1 Our systematic literature review harnesses the advances in textometric software. Textometric
2 software has been used for discourse analysis in linguistics (Longhi, 2020) and other social
3 sciences (Ratinaud and Marchand, 2015). Discourse analysis, however, primarily aims at
4 understanding language and social phenomena through the study of discourse (Partington et
5 al., 2013). While not sharing the same object of study, the methods used in some types of
6 discourse analysis, such as textometry, can be employed to enhance systematic literature
7 reviews. Indeed, the goal of these reviews is to provide “a critical component of advancing
8 knowledge” in a given field of study (Durach et al. 2017: 67). Because it automatizes the
9 coding phase and a part of the interpretation phase, textometry enhances knowledge about a
10 field of study by allowing for a larger volume and wider range of literature to be analyzed and
11 integrated during the review process. It also allows researchers to avoid some biases during
12 the analysis and integration phase of the review.

13 Given its potential, textometric analysis has recently been used in several systematic literature
14 reviews in management sciences. Macke and Genari (2019) use a textometric method in their
15 literature review about sustainable human resource management (SHRM). Their research
16 contributes to the knowledge about the evolution of research about SHRM in time.
17 Additionally, the authors use the textometric analysis results to build a theoretical model of
18 SHRM in the grounded theory approach. Mandják et al. (2019) carry out a systematic
19 literature review of ports research with Iramuteq. They observe that ports have long been
20 studied in terms of their operations, but that there is a need for further development of an
21 industrial marketing approach in the field. Textometric analysis is therefore a promising
22 method to understand the current academic conversations about transportation and the Arctic.
23 In addition, it has already been used in management science studies for systematic literature
24 reviews.

25 In this article, we use textometric analysis of the full text of the 386 articles and 4 books to
26 complete the fifth step of Durach et al.’s (2017:75-76) protocol for systematic literature
27 reviews in Supply Chain Management. In this step, Durach et al. (2017) recommend that the
28 researchers 1) “code the relevant data from primary studies” and 2) carry out the task of
29 “summarizing or cumulating the findings of different studies” through analysis and
30 integration. As Durach et al. (2017) highlight, there are risks associated with these substeps.
31 In substep 5.1, variability in manual coding can introduce bias into the review. In substep 5.2,
32 there is a risk of expectancy bias, by which researchers highlight information that conforms to
33 their expectations. Expectancy bias may also lead them to omit problematic information. This
34 introduces subjectivity into the analysis and integration of the different studies.

35 In order to minimize these biases and to include a much larger range and volume of research
36 about Arctic transportation, we chose to use textometry to complete step 5. In this case, the
37 manual coding of 5.1 is replaced by statistical calculation of the salience of content words
38 (nouns, verbs, adverbs, and adjectives), the strength of the connections between them, and the
39 statistic relationship of the contexts in which these content words appear. This method also
40 reduces bias in step 5.2, during the analysis and integration of the coding of the various
41 articles. While the interpretation of the results requires the insight of the researchers, the
42 different themes calculated by Iramuteq are salient because of their statistical strength in the
43 corpus, and not because of the researchers’ own expectations. Finally, as textometry analyses
44 the corpus of articles as a whole, it meets the goals of steps 5.1 and 5.2 as defined by Durach
45 et al. (2017: 75): 5.1) discover the “content and interrelationships” between the information in

1 the different articles and 5.2) “develop narrative propositions” that integrate “insights from
2 different methodological approaches and research settings.”

3 *2.4.1. Iramuteq: underlying theory and types analyses performed*

4 Textometric software programs allow researchers to carry out statistical analyses on content
5 words in a corpus. Simply put, the hypothesis underlying Iramuteq, and textometry in general,
6 is that the frequency with which a content word appears, the statistical relationships between
7 content words and their contexts all witness to thematic patterns specific to a corpus. These
8 patterns occur at a local level when content words are repeatedly used closely together. They
9 also occur at a more global level when the same content words occur in the same contexts
10 throughout the corpus. These latter trends the corpus form what Reinert calls “lexical worlds”
11 (1990). Reinert (1993) explains that these represent cognitive “common places” towards
12 which the authors of a corpus tend to gravitate.

13 The interest of this method for a systematic literature review is therefore threefold. First, the
14 method provides a statistically grounded representation the current academic conversations in
15 a given research field. Second, it also represents how these different conversations interlace or
16 remain isolated from each other. The analyses were carried out in the five steps. We describe
17 these five steps in following paragraphs.

18 First, the software lemmatizes content words such as nouns, verbs, adjectives and adverbs.
19 This means that grammatical information, such as the plural or verb tense, is removed from
20 the corpus. For example, the words *girl* and *girls* are counted as two occurrences of one *active*
21 *form, girl*. In the same way, the verbs *ran* and *run* are counted as two occurrences of one
22 active form, *run*.

23 Second, the software divides the corpus into *segments*. These segments become the basic unit
24 of context used in the statistical analyses. In our analysis, we chose the segment length of 26
25 words, as this corresponds to the average length of a sentence in English academic articles
26 (Deveci, 2019).

27 Third, the software performs a basic statistical analysis that calculates the following
28 information. First, the number of texts in the corpus. Second, the number of words in the
29 corpus. Third, the number of active forms in the corpus. Fourth, the number of hapaxes in the
30 corpus. Fifth, the mean number of words per text. In addition, at this step, the software creates
31 four tables:

- 32 1) *active forms*, ranked from most frequent to less frequent;
- 33 2) *supplementary forms* that include grammatical words such as *a, the, and for*. These forms
34 are not counted in the active forms category;
- 35 3) *hapaxes* that include words that occur only once in the corpus;
- 36 4) *total* that includes both active forms and supplementary forms.

37 Fourth, a similarity analysis performed by Iramuteq. It is based on graph theory (Flament,
38 1962). It creates a graph using the co-occurrences of forms in the segments and the strength of
39 their association (Longhi, 2018). This graph, therefore, represents the local connections that
40 authors make between forms, and therefore, concepts, used to speak about Arctic

1 transportation. Details about graph theory and the similarity analysis algorithm used in
2 Iramuteq are given in Marchand and Ratinaud, (2012).

3 Fifth, the software performs the Reinert analysis. Details about the algorithm can be found in
4 Reinert (1983, 1986, 1991) in addition to Ratinaud (2018) and Ratinaud and Marchand
5 (2012b). The Reinert analysis is a type of Descending Hierarchical Classification (DHC). It is
6 based on a correspondence analysis. Using the frequency tables created at the lemmatization
7 stage (step 1) and the segments into which the text was initially divided (step 2), the algorithm
8 repeatedly divides the corpus into homogenous sections according to the chi-squared
9 correlation between the categories and the frequency with which the active forms appear in
10 similar segments (Bart, 2011). This creates different *categories* or “lexical worlds” according
11 to Reinert (1990). It is important to underline that the categories created by the Reinert
12 analysis are composed of the texts of the complete corpus. In this way, the categories exist in
13 the entire literature of Arctic transportation as it is represented by the corpus. In addition to
14 the Reinert dendrogram, Iramuteq creates a graph of the correspondence analysis representing
15 the two factors that best explain the distribution of the corpus as axes.

16 We followed the above procedure for the analyses of the corpus of four books and the corpus
17 of professional press that we describe in section 3.5.

18 3. Results of the textometric analysis

19 3.1. Results concerning the frequency of the active forms

20 As explained above, the analysis in this study was performed on the full text of 386 articles.
21 These articles amount for 2,663,095 occurrences of the forms. Consequently, there is an
22 average of 6899 forms per article, which is consistent with results obtained in similar
23 textometric literature reviews (see for example Mandjak et al., 2019). 44,995 different forms
24 generate these occurrences, of which, 20,983 are hapaxes (0.79% of occurrences for 46.63%
25 of forms). 489 forms were supplementary forms. 44,525 active forms, therefore, were
26 included in the analysis.

27 We now can divide the corpus into five groups:

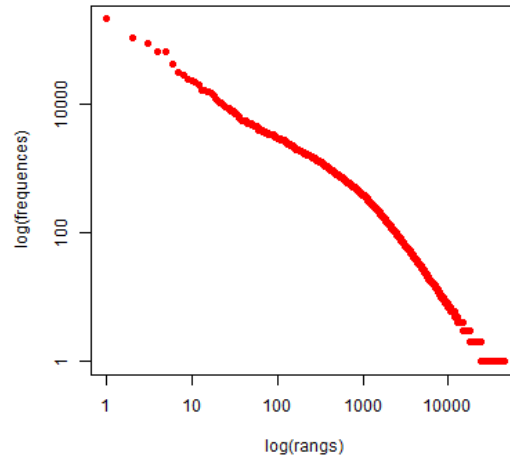
- 28 • Group 1: the word *Arctic* represents 1.63% of occurrences of forms in the whole
29 corpus, confirming its central position in our study. It represents 1.62% in EBSCO
30 only papers, which shows high consistency in the corpus.
- 31 • Group 2: five more forms, *state*, *ship*, *sea*, *ice* and *international*, together with *Arctic*,
32 represent 0.013% of the different forms of the corpus, but 5.23 % of the total
33 occurrences in the corpus.
- 34 • Group 3: fifteen more forms, *route*, *area*, *region*, *vessel*, *water*, *development*, *nsr*,
35 *cost*, *law*, *include*, *time*, *port*, *russian*, *new*, *increase*, and *oil* represent together with
36 the previous five forms 10.12% of the corpus’s occurrences.
- 37 • Group 4: 47 more forms represent, with the previous forms, 20% of the occurrences.
- 38 • Groupe 5: 106 more forms represent, with the previous forms, one-third of the
39 occurrences.
- 40 • Group 6: the rest of the forms (99.6%) represent two-thirds of the corpus.

41 The concentration of forms in the occurrences shows the consistency of our corpus since the
42 authors of the 386 articles use the same vocabulary to discuss Arctic transportation. Fig. 3

1 shows the logarithmic distribution of active forms in the overall corpus. Concerning the
 2 keywords used to select articles for the corpus, not all of them are present in the top
 3 occurrences of active forms in the corpus itself. This confirms that the authors whose articles
 4 were included are mainly concerned with shipping and ports along the Northern Sea Route.

5 **Table 5: Ranking of active forms in the corpus according to frequency of occurrence**

Form	Rank
Arctic	1
Shipping	2
NSR	13
Port	18
Maritime	31
Transport	27
Tourism	34
Cruise	45
NWP	659
NEP	1093
Hinterland	2253



6
7 **Figure 3: Distribution of forms in the corpus**

8
9 **3.2. Similarity analysis**

10 We performed the similarity analysis on the Group 2, Group 3 and Group 4 of words. We did
 11 not include Group 1 which is composed of *Arctic*, because the centrality of this concept
 12 masked other connections. Secondary connections appear more clearly without Group 1. In
 13 addition, we did not include Group 5 in order to focus on the **0.15% of forms that represent**
 14 **20%** of the corpus occurrences, i.e., the heart of the corpus. Then, we performed the similarity
 15 analysis without the form *ship* that was too central on to part of the graph.

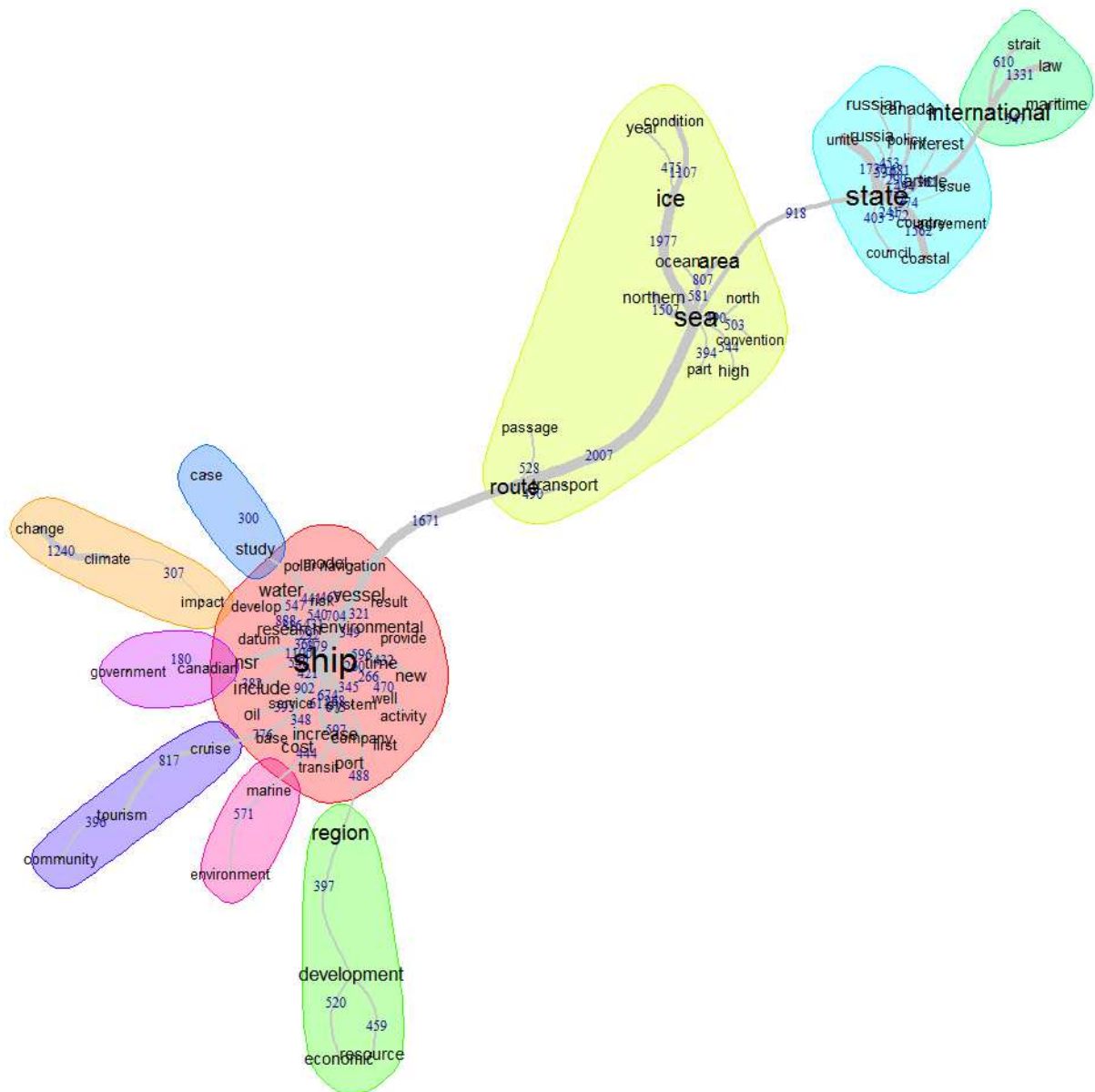


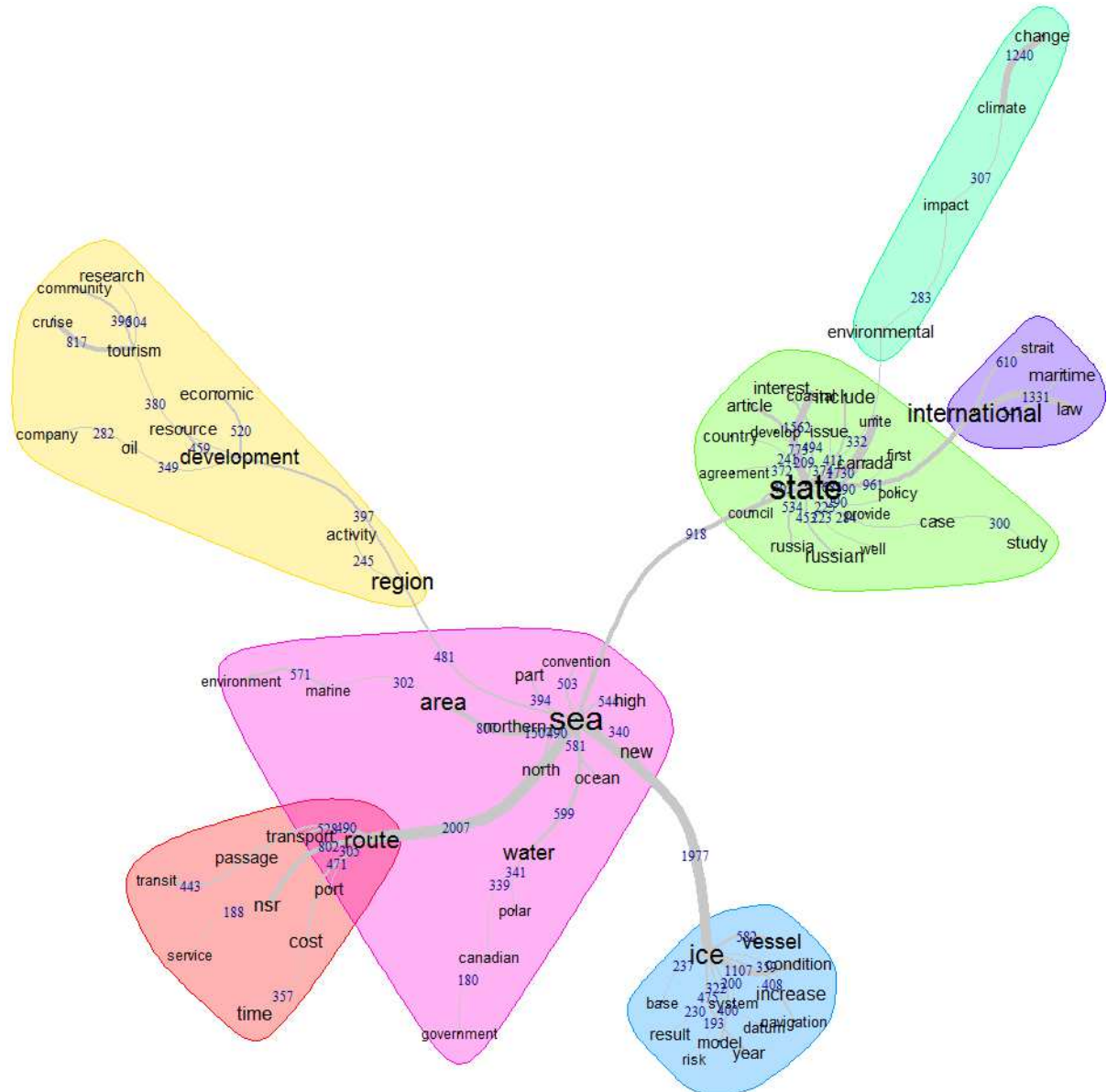
Figure 4a: Similarity analysis of the corpus (Groups 2, 3 and 4)

Figure 4a shows the results of the similarity analysis, with ten clusters of interrelated forms. Four clusters are multibranches linked to *sea*, *state*, *international* and *ship*. The cluster centered on *ship* is linked to six linear clusters: *region development*, *marine development*, *cruise tourism*, *Canadian government*, *impact climate change*, and *case study*. When we exclude the form *ship*, in order to analyze other relationships between concepts, Figure 4b shows an opposition between the *state* cluster and *sea* cluster. Each of them is linked to other clusters. These two main clusters and linked clusters include:

- 1) the concept of *sea*, which attracts a geographical cluster (*area*, *north*, *ocean*, *route*, *polar*, *water*, *Canadian*, etc.) with also *marine environment* branch, and concepts of *government* and *convention*; then minor clusters related are:
 - a. the concept of *route*, which starts inside the main *sea* cluster then opens to several branches which are *transport*, *passage*, *transit*; then *nsr* and *service*, and then *port*, *cost* and *time*;

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- b. the concept of *ice*, related to *sea* through *new* and that splits toward several small branches. These include *ice vessel*, *ice base*, *ice condition*, and then a group of forms around *model*, *system*, *increase*, *risk* and *result*.
 - c. the concept of *region activity*. This concept evolves toward *oil company*, *economic development*, *resource* and *tourism* with *cruise* and *community*
- 2) The concept of *state* with names of countries (*Canada*, *Russia*, *country*), institutional words (*policy*, *agreement*, *border*, *council*, etc.), a few other words concerning the role of state (*unite*, *provide*, *include*, *develop*, *well*), and *case study*. ; then minor clusters related are:
- a. the concept *international* with *international strait*, *international law* and *maritime*
 - b. the linear concept of *environmental impact climate change*.



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Figure 4b: Similarity analysis of the corpus (Groups 2, 3 and 4 without *ship*)

1 3.3. Reinert analysis

2 To avoid bias, the categories of dendrogram and the axes of the factorial analysis were named
3 using an iterative method, as described by Mandjak et al. (2019). A linguist and a port
4 economist first named the categories separately. In a second step, they compared their results
5 and reached a consensus about the categories' names.

6 The dendrogram (Figure 5) shows two meta categories with each four categories. The
7 categories of the first meta category deal with governance. The categories of the second meta
8 category are related to Arctic operations.

- 9 • Category 1 is **legal governance** with semantic fields of *law (convention, claim, treaty,*
10 *right, etc.)* and *territories (state, coastal, delimitation, territorial, etc.)*.
- 11 • Category 2 is **tourism governance** with semantic fields of *cruise (tourist, tour,*
12 *operator, visitor, cruiser, expedition...)* and the *local governance (resident,*
13 *community, attitude, Nunavut, wildlife...)*
- 14 • Category 3 is **outsider's geopolitics governance** with semantic fields of *disputes*
15 *(military, war, nato...)* the *Asian countries (China, Chinese, Korean, Japan, official,*
16 *...)* the *E.U. (E.U., European, Union, ...)*
- 17 • Category 4 is **political governance** with semantic fields of *sustainable development*
18 *(social, environment, resource, develop, governance...),* and *policy (government,*
19 *political, institution, region, strategy...)*.
- 20 • Category 5 is **ice conditions for operations** with semantic fields of *conditions*
21 *(temperature, thickness, concentration, melt, cover, multilayer, surface, wind, sea,*
22 *average...)* and *seasonality (season, summer, winter, warm...)*
- 23 • Category 6 is **modelization of operation factors** with semantic fields of *risk*
24 *(probability, collision, accident, etc.)* and the field of modeling (*datum, variable,*
25 *parameter, simulation, method, result, distribution, algorithm*).
- 26 • Category 7 is **shipping routes of operation** with semantic fields of *shipping (teu,*
27 *container, vessel, route, ship, fuel, cost, fee, insurance, etc.)* and the field of *routes*
28 *(nsr, suex, canal, transit, icebreaker, panama, ...)*.
- 29 • Category 8 is **Arctic trade operations** with semantic fields of market (*gas, lng, oil,*
30 *million, ton, cargo, ore, volume, freight, etc.)* and the field of logistics (*export, import,*
31 *transport, port, shipment, east, Europe, etc.)*.

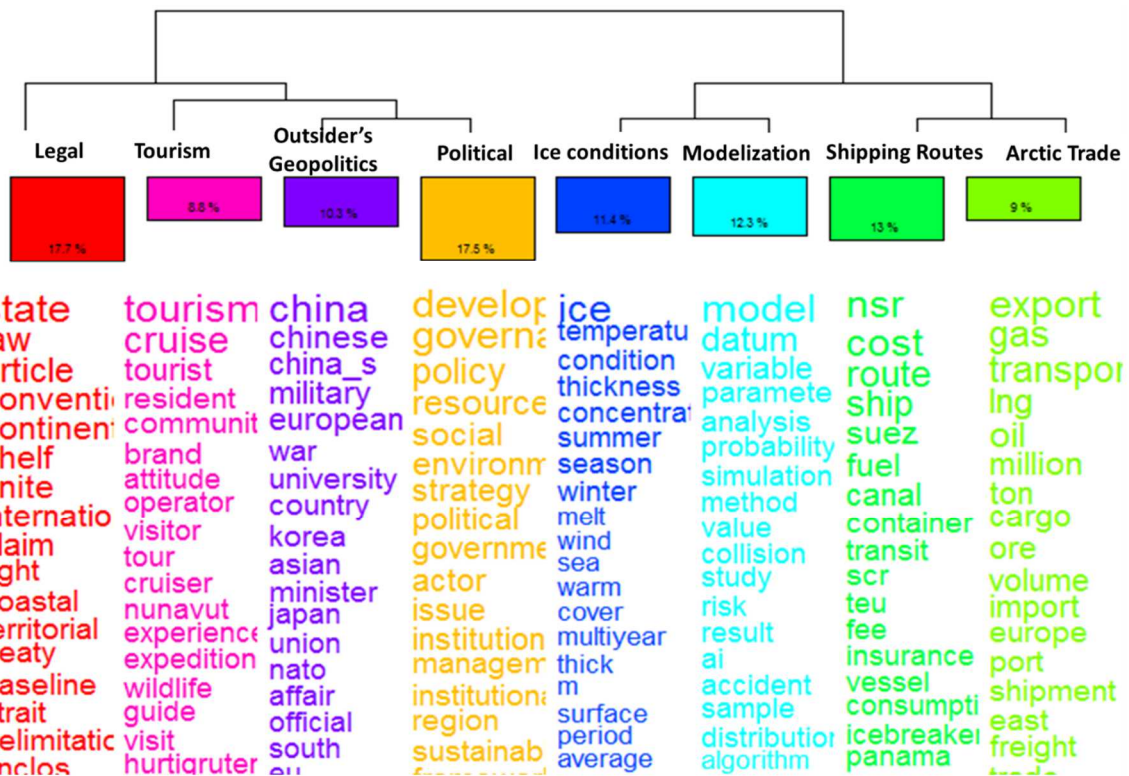


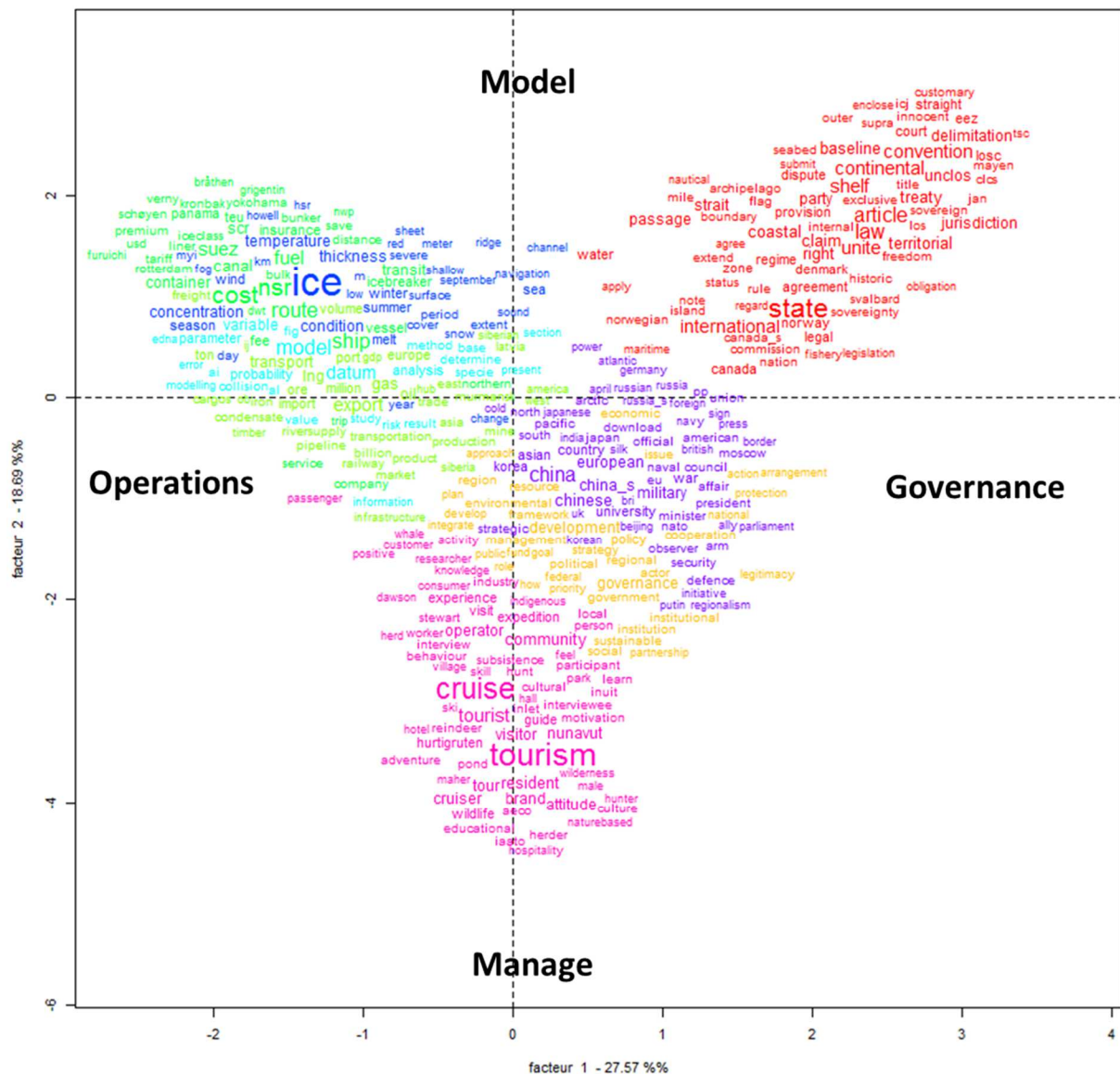
Figure 5: dendrogram of the corpus Reinert analysis

Figure 6 shows a correspondence analysis of the eight categories. They are represented on two axes. Next to the center of the two axes, we find the word *arctic*. This representation confirms the distinction between the two branches of the dendrogram. The horizontal axis divides the corpus from *operations* to *governance* in the Arctic. We interpret the second axis as ontological, in the sense that it refers to the levels of abstractions: one side (top) represents the *modelization* of issues in the Arctic, while the other represents the *management* of these issues. This means that on the governance side, from management to modelization (bottom to top) there is an evolution from the cruiser's experience and marketing toward local communities management (category 2), then political issues (category 4) and geopolitical issues (category 3) and at last legal frameworks and international conventions (category 1) that are legal models. On the operation side, from management to modelization (bottom to top), there is an evolution from tourist management (Category 2), to the market (category 8), to factors of operations (category 6) and ice conditions (category 5) toward international routing (category 7) that is a model of shipping operations.

This interpretation opens an interesting perspective. The top of Figure 6 is much more densely filled than the bottom. Apparently, there is more research done on modelization than on management of arctic issues. Statistically, *management* appears in Group 6 of active forms, thus not a salient active form in the corpus. In Figure 6, the governance side is filled with forms from the tourism category (Marketing Management) and with political and geopolitical forms. On the operation side, however, there are only a few forms. Some of them are marketing concepts like *service* and *value* or refer to specific areas of logistic management like *information* management.

In addition to this first observation, there is a large gap between legal models and economic models. There is a gap around the top middle of Figure 6 between $x=-1$ and $x=1$ and $y=0$ and $y=2$. We interpret this gap as being the modelization of risk, which is conceptually between

- 1 operations and governance/compliance. *Risk* is also an active form that is present in the
- 2 corpus, but again, it is not among the most frequent forms.



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4 Figure 6: graphic representation of the corpus's correspondence analysis

5 *3.4. Comparative analysis of recently published books on Arctic shipping*

6 In the past five years, there has been an increase in research on Arctic shipping (see Figure 2)
7 and four academic books have been published in English on Arctic issues (Table 5). These
8 books included works by leading scholars and were also edited by top scholars identified in
9 our literature review.

10 Table 5: corpus of academic books

Authors	Year	Title	Editor
Keupp	2015	The Northern Sea Route. A Comprehensive Analysis	Springer
Pastusiak	2016	The Northern Sea Route as a Shipping Lane. Expectations and Reality	Springer
Vestergaard, Kaiser,	2018	Arctic Marine Resource Governance and	Springer

Fernandez and Nymand Larsen		Development	
Lasserre and Faury	2019	Arctic Shipping: Climate Change, Commercial Traffic and Port Development	Routledge

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2 We carried out the same analyses as we did for the corpus of 386 academic articles.

3 The Reinert analysis results in six categories for Keupp’s book and only four for the three
4 other books (see Table 6 and details in Figure 7). For all the books, these categories are spread
5 in three groups on the two axes of the correspondance analysis graph (Figure 7). We first
6 observe that the categories of these books cover all the categories of our main corpus of
7 academic articles, except for *Tourism*. Second, we observe that in all four books, there are
8 categories dealing with the maritime transport aspect (trade, operations and shipping; routes
9 and vessels; infrastructures and business; and transport geography and trade ports). Moreover,
10 three categories are often together in the graphic representation. Third, we observe that in all
11 books except Pastusiak (2016) there is a category dealing with governance-related themes
12 (Governance and politics; governance; Legal) and in all books except Vestergaarde et al.
13 (2018), there are technical categories dealing with factors of analysis (weather; ice conditions,
14 shipping economy).

15 Table 6: Categories in correspondence analysis of forms for each book analyzed

Authors	Keupp (2015)	Pastusiak (2016)	Vestergaard, Kaiser, Fernandez and Nymand Larsen (2018)	Lasserre and Faury (2019)
Cat 1	Weather	Vessels	Sustainability	Shipping Economy
Cat 2	Trade	Routes	Infrastructures	Transport Geography
Cat 3	Operations	Ice Conditions	Business	Trade Ports
Cat 4	Shipping	Geography	Governance	Legal
Cat 5	Governance			
Cat 6	Politics			

16

17 There is therefore a comparable architecture of topics. In addition, all the graphic
18 representations have a propeller-like shape (see Figure 7). What is interesting is the central
19 form for most books in these representations is *sea*. In opposition, we do not identify the
20 lexical field of land transport. We interpret the propeller shape with categories going from the
21 center to develop outside as the community’s push to move research toward developing
22 themes.

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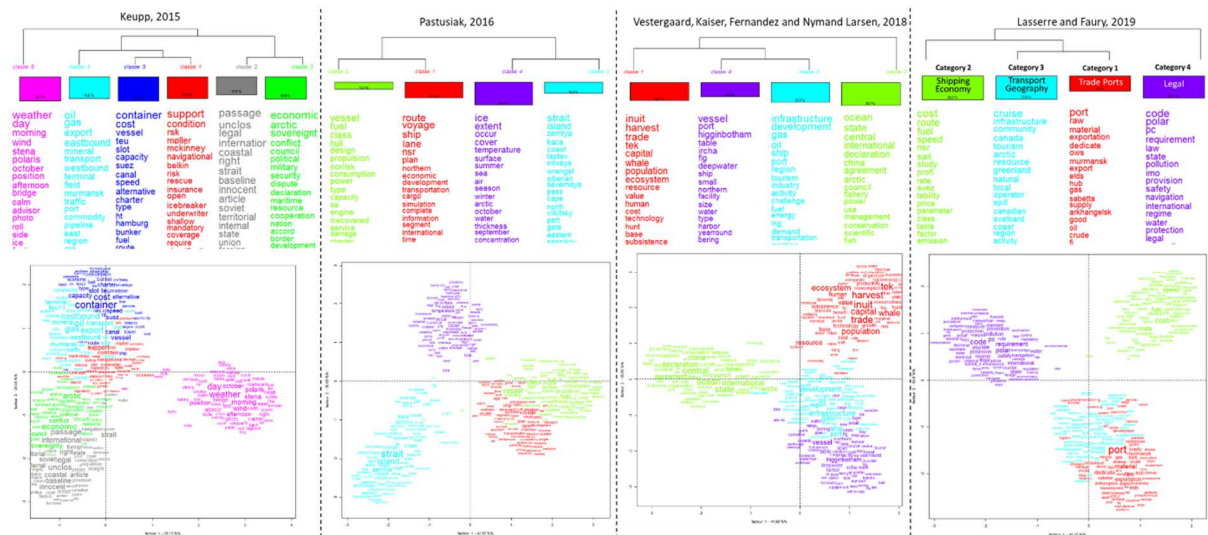
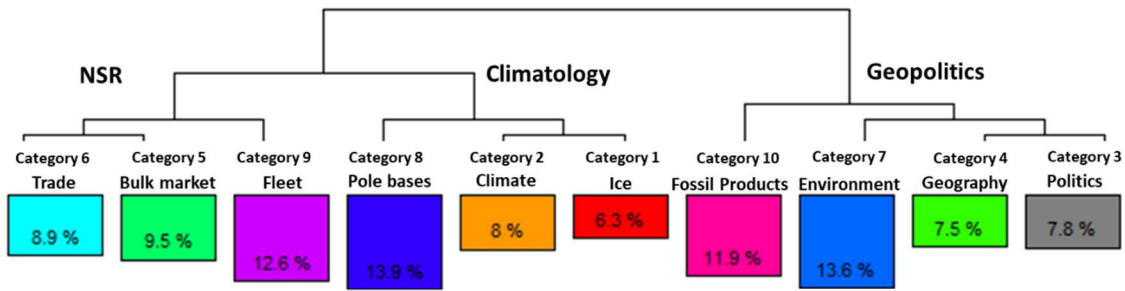


Figure 7: graphic representations of the books' correspondence analysis

3.5. Comparative analysis with professional press

In order to compare the state of research with the realities of the field, we carried out a similar textometric analysis on professional press dedicated to Arctic transportation systems. In order to do this, we contacted experts of the field and asked them about the main professional press for Arctic transportation in English. They agreed on two titles: *The Independent Barents Observer*, and *GCaptain*. The former is specialized about the topic while the latter is more general geographically. We included all articles of the former that were available online and selected articles from the latter with the keywords used to select the academic articles.

The Reinert analysis of this professional press corpus provides us with 10 categories that can be grouped into three meta-categories (NSR, Climatology, Geopolitics) as Figure 8 shows. From these results, we can underline that professional press in logistics covers a wider range of topics than the academic articles. The density of the graphical representation of the correspondence analysis (Figure 9) confirms this observation. Importantly, we can observe that there are areas of research that academics should deepen. We can identify three such domains. **First**, there is the logistics of access to the Arctic routes. These different types of logistics include hinterland access for markets (Category 6), for logistics of people (Category 8), including researchers and emerging tourists, and for logistics of resources (Category 5). **Second**, Category 5 clearly shows the link between fossil fuel extraction projects and shipping in the Arctic, as well as previously mentioned access to hinterland. Research focusing on these structuring projects (i.e. Yamal, Sabetta, Murmansk, etc.) needs to be developed. **Third**, Category 9 shows active forms that rarely appeared in the academic literature review such as *icebreaker*, *construction*, *vessel class*, etc. There is a wide field of research to develop in order to be in phase with these industry concerns.



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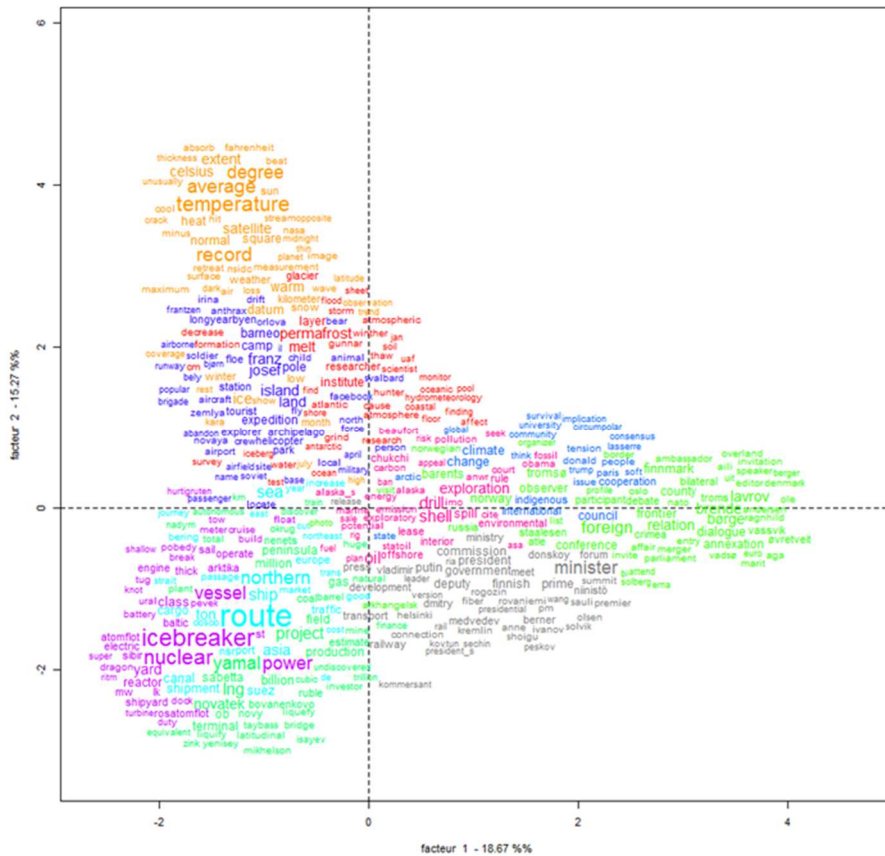
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Figure 8: dendrogram of the press correspondence analysis



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Figure 9: graph representation of the press correspondence analysis

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4. Research Findings and Implications

The results presented in the study enable us to provide clear answers to our three research questions.

- QR1: what is the state of the art considering Arctic transportation?

First, there is a large body of research on the topic, with 386 articles found and studied. This is comparable to similar studies on port marketing with 369 articles over 40 years on a major and worldwide topic (Mandjak et al., 2019). Moreover, research about Arctic transportation is experiencing a growing trend. There are leading scholars in the field who work together in collaborations. Some of them collaborated to deepen the topic through recently published academic books.

In terms of content, the research on Arctic transportation systems covers the three pillars of sustainable development. Environmental issues are addressed, especially greenhouse gas emissions. Social issues are also treated, from both the legal aspects of compliance, international negotiations, or conventions, and the consequences of development of shipping and trade in the Arctic on local people.

Of course, trade development and economic issues for the industry are also at the heart of the concerns of scholars in the field. There is a concentration on economics of the shipping routes, compared to other options as well as on how climatic conditions influence feasibility. Port strategy and industrial clusters are also identified as emerging topics. We notice a larger number of papers on the NSR than on the NWP.

- QR2: does academic research on Arctic transportation match professional concerns on the topic?

Professional concerns, summarized in our study by two of the main press journals on the field, match well with academic research. This means scholars are close to field issues that professionals find important. For this reason, researchers probably provide answers to professional issues. However, we observe a few topics that are not covered in depth by scholars. These could be developed in further research. The professional press also covers the topic from two perspectives that are different from scholars' concerns: climate change research and geopolitical and military issues. These two aspects are included in some research papers we studied, but they are not the core of the papers.

- QR3: what are the perspectives of future research in the field?

From the textometric analysis of the academic literature on Arctic transportation, the recently published books and the comparison with professionals' concerns, we identified five subfields of research to develop in the future. These fields are the following:

- The first major area to be developed in research on Arctic transportation systems is management. There is research on governance as well as on operation, but there is a gap in between these two aspects that corresponds to the management issues. What is at stake on tactical and strategic levels for companies? What are the marketing, corporate strategy, business models associated with this emerging market for logistics? What are the management constraints in the specific conditions of Arctic region?

- 1 ○ The second area is risk management. There are only a few studies that mention
2 risk while this appears to be a wide area to explore once we know what the
3 issues are, the legal context and the constraints on business. Risk and
4 compliance to rules are important stakes. This area is also related to
5 management since risk management in the Arctic deals with environmental
6 issues, technical and industrial issues, but also with the management of human
7 resources.
- 8 ○ The third area concerns access to the shipping routes of the Arctic. This
9 concern is a wider topic than just the hinterland. Systems of transportation to
10 access the ports of the Arctic as well as feeding routes are mentioned in the
11 corpus from an outside the Arctic perspective with ports in China or in the
12 North Range. There are a few articles dealing with developments of railroads,
13 routes, or even barges and dry ports.
- 14 ○ The fourth area is related to the previous one with a large representation in the
15 press of the logistic and industrial projects in the Arctic region. Only the
16 Yamal project is mentioned several times in our academic corpus. There are,
17 however, other projects. In addition, there could be studies do on the
18 feasibility, profitability of such projects as well as decision models or best
19 practices linked to such projects. This is also true from a supply chain
20 management, business-to-business and business network perspective.
- 21 ○ The fifth area concerns vessel management. The fleet of ice class vessels is
22 specific and needs not only technical research but also organizational research.
23 Indeed, icebreakers figure importantly in the professional press, but this
24 concept does not appear frequently in academic research. Specifically,
25 professional press articles mention the influence of vessels on location of ports
26 as well as the mix in the fleet and the transshipment constraints it imposes on
27 operations. Lasserre and Faury (2019) also mention this aspect.

28 **5. Conclusion**

29 The textometric approach of the literature review allowed us to have a systematic overview of
30 386 academic articles dealing with Arctic transportation systems. These articles were selected
31 using keywords that refer to the geography of the Arctic and maritime-related transportation
32 in the Arctic. We were also able to compare this corpus of articles with corpora of recently
33 published books on this topical issue and with a sample of the professional press. Such
34 comparison helps us to answer our research questions on the state of research on Arctic
35 transportation system, on this state in comparison with professional concerns and therefore to
36 identify research areas to develop in the future.

37 Five areas are recommended for further research: 1) a management approach to Arctic
38 transportation in addition to the legal, economic and geopolitical ones; 2) a risk management
39 approach that deals, in particular, with conditions of operations for people, organizations, and
40 also the consequences for the environment; 3) a logistics approach to the access to the Arctic
41 routes, including transportation modes and dry ports; 4) an approach that studies the
42 clustering projects in the Arctic area; 5) research on fleet management.

43 Our research is based on an innovative method using textometric software that allows for a
44 systematic literature review of 386 articles, representing a large volume and wide breadth of

1 literature related to Arctic transportation. There are, however, certain limits. Iramuteq cannot
2 analyze a corpus with more than one language. For this reason, literature in French and
3 Russian could not be included. Finally, while the software is able to show crucial statistical
4 connections across articles, it may miss finer connections and argument development
5 contained in individual articles.

6

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