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A structured analysis of sustainability in Arctic transport studies

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Abstract

With climate change and the opportunity to exploit oil and gas reserves, the arctic has been the subject of numerous analyses in the former years. In the same time, IMO and Arctic coastal states are creating a more constrained framework to protect the environment, to limit the impact of human activities upon the flora and fauna and to better integrate local communities. From an analysis of 239 articles, we assessed how sustainability is considered within the literature over the past 30 years. Our result highlighted that, if there are numerous sustainable approaches according to the country, the subject is still under-represented.

Keywords: Sustainable, Arctic, socio-economic development, ecology, literature review.

1. Introduction

Former years saw an increase in the number of academic publications related to the Arctic (Lavissière et al, 2021; Theocharis et al, 2018, Lasserre, 2014). One of the main reasons for this increase is the melting in ice that opens a shortcut between Europe and Asia via the North-East Passage (NEP) and between North America and Asia via the North-West Passage (NWP).

Yet, if the changes in climatic and navigational conditions and its consequences are at the origin of this interest, it appears that sustainability issues related to the Arctic can still be considered as an emerging subject rather than a subfield in the academic field of Arctic transportation research. This is even though new environmental regulations applicable to Arctic navigation represent a major issue for private and public stakeholders in the Arctic area.

A recent illustration is the implementation of the IMO 2020 rule, which constrains vessels to use low Sulphur-content fuel. In the Arctic specifically, between 2024 and 2029, Heavy Fuel Oil shall be banned for shipping which suggest two elements. This first illustrates that coastal

states have or are developing a sustainable conscience which may have some impact on the attractiveness of the NEP and NWP. Second, the fact that the Canadian regulator has banned HFO before the Russian highlights a difference in the perception toward sustainability in the Arctic.

Additional concerns exist. For instance, for the cruise industry (Fedi et al. 2019), the worst scenario is related to a potential accident and underwriters consider that the question is not when will it happen but rather, will we be ready when this event occurs? As stressed by Cajaiba-Santana et al (2020) and Têtu et al (2019), the cruise activity in this area skyrocketed over the last few years.

Ports are also impacted by the changes occurring in the Arctic, as they are one of the main pillars for the development of Arctic navigation (Ragner, 2000). Ports are considered as strategic for different reasons. First, from an economic perspective, they ease the exportation of raw materials and the supply of goods for the northern communities. Second, they act as Search and Rescue centers and provide a shelter for vessels in danger.

Yet, if in the academic literature in Arctic shipping, cruise and ports has been largely analyzed in recent reviews (Lavissière et al, 2021; Ng et al, 2021), none of them focus on how sustainability has been addressed in the existing literature. Thus, we investigate in this chapter the way sustainability is represented within the academic literature, from a geographic and a thematic point of view, by means of a lexical analysis.

The remainder of this chapter is organized as follow. We present our methodology, followed by our results and discussion and finally some concluding remarks.

2. Methodology

2.1. Construction of the database

To define the way environmental issues have been analyzed in the former years we used the dataset from a recent literature review (Lavissière et al. 2020) and analyzed it through the sustainability lens. We made this choice as it is the most recent literature review and authors had a convenient geographic and thematic approach. Regarding the geographic approach, we classified the papers in three areas: Northwest Passage (NWP), Northeast Passage (NEP), or Arctic in general, if no specific area was evident.

Looking at the themes, there are numerous activities within the Arctic: tourism (Cajaiba-Santana et al, 2019), and all freight transport activities related to raw materials exploitation and exportation to Europe and Asia (Faury et al, 2021) or supply of the local communities. Therefore, we kept all the themes from Lavissière et al (2020): dealing with “Shipping”, “Transport”, “Maritime”, “Port”, “Hinterland”, “Tourism” and “Cruise”. The database contains 239 articles published between 1991 and 2019.

As our objective is to define the relationships amongst the different topics, we considered articles with abstracts covering at least one theme and one geographical area. As articles covering several themes and areas are counted in each field of table 1, the total observed occurrences are higher than the number of papers. This approach allows us to define the significance of an area and theme compared to others.

Table 1 : Number of articles per geographical area and theme

Cruise	Tourism	Hinterland	Port	Transport	Maritime	Shipping	Total occurrences
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Arctic	6	6	1	10	21	33	58	135
NWP	7	7	1	6	7	9	19	56
NEP	10	9	2	23	50	71	87	252
Total occurrences	23	22	4	39	78	113	164	443

Source: Authors (2021)

We created two sub-databases concentrated on the geographical area for one and on the themes for the other.

From the 239 abstracts, we extracted 79 words that we considered relevant in our analysis, and we gathered them in 13 groups. The criteria for placing each word within a specific group was the expert perspective of the authors. The groups are: “*sustainability*”, “*geography*”, “*infrastructures*”, “*economy*”, “*shipping*”, “*tourism*”, “*governance*”, “*energy*”, “*month*”, “*social*”, “*industry*”, “*risk management*” and “*technical*” (annex 1). As argued previously, the purpose of this chapter is to tackle the gap of how the emerging attention to sustainability with the Arctic shipping literature. The group “*sustainability*” captures the climatic and environment specific issues of sustainability concerns. The purpose is to consider those words that relate to any of the effects of the shipping activity into the natural environment (to the air, water or biology).

2.2. Process

We carried out a topic modelling analysis (Schöggel et al., 2020) by integrating the Arctic shipping thematic analysis methodologies of Lavissière et al. (2020) and the statistical application for text analysis, Correspondence Analysis (CA) (Greenacre and Blasius, 2006).

CA is an exploratory multivariate technique; it is used for the analysis of count (positive) data in graphical form. CA has its origins in applications to texts (Greenacre and Blasius, 2006), its applicability in the field of text analysis underlies in a qualitative assessment of how closely used are certain terms in a corpus of document (for example a set of scientific abstracts).

First, we used the correspondence analysis in R package CA (Nenadic and Greenacre, 2007). This analysis is carried out according to our two perspectives, geographic and thematic as represented in table 1. Second, we looked at how the 13 groups and 79 words interact in the main database represented in table 1. Then we repeated this process by geographical area and theme. The aim is to define which themes are analyzed in priority according to the geographical area. Third, we defined the “*centrality*”, or the coverage, of each abstract, by looking at how many words among the 79 are present in the abstract of each article. Then, we have a deeper look at the most central articles to understand if and how they tackle the sustainability issues.

Finally, we provide a deeper analysis of the articles which abstracts have words belonging to the sustainability group.

2.3. Tools

We include in annex 2 the script of the package CA used to generate the CA biplots. The count data for CA is prepared in the form of a matrix, in which the rows represent the variables (keywords) and the columns represent a classifying category. The value in the matrix is thus the frequency in which certain keyword appears according to the classification. The matrix data is then represented graphically. The principle behind CA, lies in representing the maximum variance in a map of multiple dimensions (Greenacre and Blasius, 2006), in this

paper we do it in two dimensions or axis. Interpretation of the graph lies in a visual assessment of how the categories lie relative to one another.

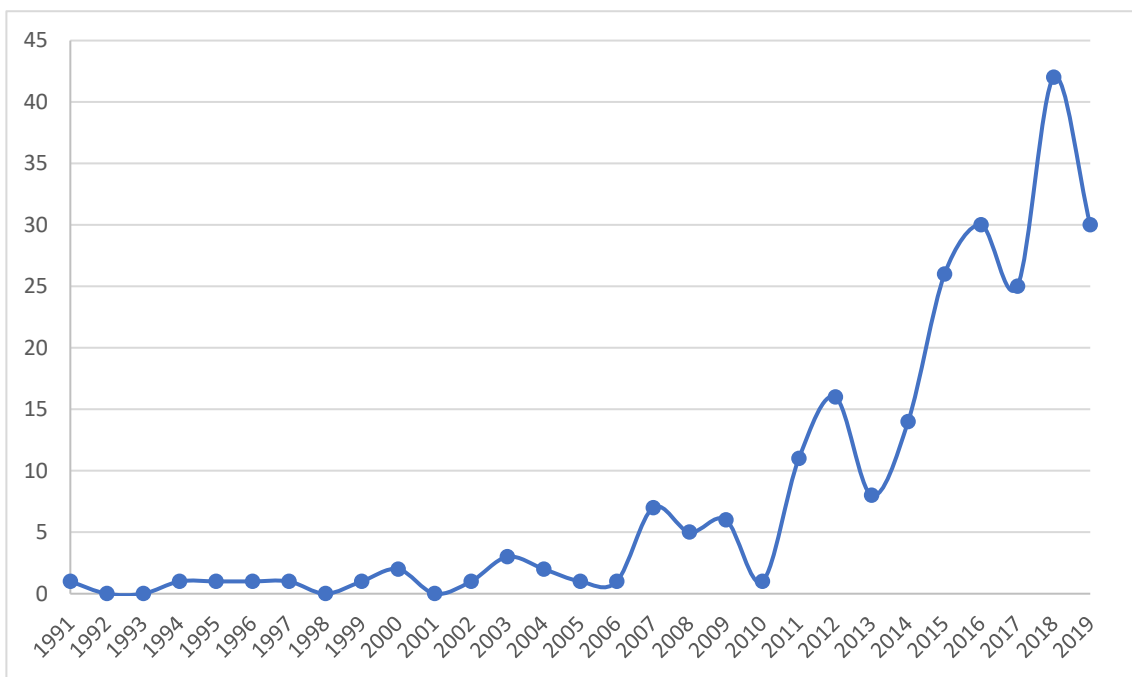
The column variables are conventionally used for classification (e.g. zones or themes) which act as explanatory variable, while the row variables present the keywords -acting as “response variables”, this is known as “contingency table” in CA. As result we are interested in the relationship between both sets. We generated one contingency table per CA biplot (Annex 3). The values in the table represent the frequency in which the keyword appears in the abstracts previously classified according to one of the “explanatory variables” (zones, themes).

3. Results

We first look at the main groups composed of the 79 words, their occurrence, the distance of the 79 words with the three main areas (NEP, NWP, Arctic) and their occurrence within abstracts. Then, we concentrate on words composing the sustainability group. Firstly, we look at the distance of these words with the areas, their occurrence. Secondly, we analyze the share of sustainability words in the main articles of this group versus the other groups and the publication of these article over-time.

3.1. General results

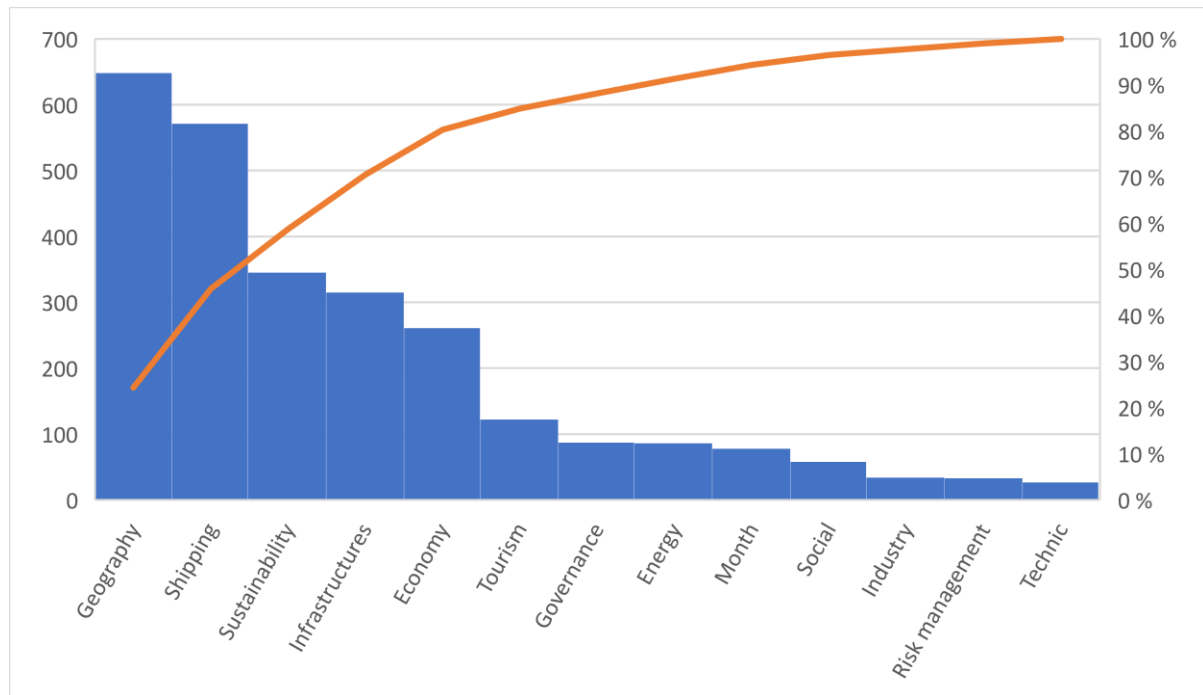
Figure 1: Academic production per year



Source: Authors based on Lavissière et al (2020).

Figure 1 shed a light on the evolution of the research within our scope over the last 30 years. Since 1991, research about can be divided in two parts, the first one before 2006 and then after 2006. Coincidentally, in 2006, the IACS adopted the Unified Requirement (UR), defining seven ice-class and the IMO enacted the “Guide to cold water survival », (IMO Doc. MSC 1/Circ. 1185, 2006) (Fedi et Faury, 2015). In 2007, the cruise vessel M/V Explorer sunk in the Antarctic, stressing the importance of legal framework and a risk management framework for such operations.

Figure 2: 'Total word count of the main 13 groups, extracted from the abstracts. Dataset of 443 occurrences (Table 1)



Source: Authors (2021)

When we look at the content of this academic production, we can see from figure 2 that words related to the groups “geography” and “shipping” are the most used ones, which is in line with Lavissière et al (2021) and Panahi et al (2021). Words belonging to “sustainability”, “infrastructures” and “economy” constitute the other most used terms in abstracts, overall.

Geography appears as the main group analyzed by academics, mainly due to the use of words such as “ice” (199) and “Arctic” (348). When analyzing the most central abstracts for this theme, it appears that the ice issue and climate change are at the core of articles. Yumashev et al (2017) used some ice prediction models to assess the impact of ice condition on the navigation cost. For their part, Stephenson and Pincus (2018) considered the prediction as a decision-making tool to help coastal states to define their strategies. We also find Fu et al (2018), who integrate the ice condition to assess the existing risk to render navigation in the Arctic safer. Finally, Smith (2011), look at the way Arctic states answer to ice and climate change. Hence, if the climate issue is the main topic of these article, the question seems to be more focused on how to react and predict, rather than to develop a sustainable economic development.

In second position of our analysis, we found the *Shipping* group, related to words such as “Transport” (146) and “Shipping” (256). The words “Transit” (70) and “Container” (53) follow in third and fourth position, what is in line with the Theocharis et al (2018) and Lasserre (2014), who explain that most of articles dealing with the Arctic are focusing on container and transit. This result can be explained by the 40% shortcut that the Arctic represents for container navigation. For example, Zhu et al (2018) defined the market share of the NSR and considered an environmental cost compared to the SCR. This comparison has been also done by Furuichi and Otsuka (2018), Cariou and Faury (2015) and Furuichi and Otsuka (2015). It appears that the sustainable issue is addressed as a factor impacting the NSR profitability.

In third position, with a significant gap from the previous groups, we find the *Sustainability* group. The two main words represented are “Environment” (110) and “Environmental” (84), as we will develop in the figure 5. The Arctic Ocean is highly sensitive to human activity and to

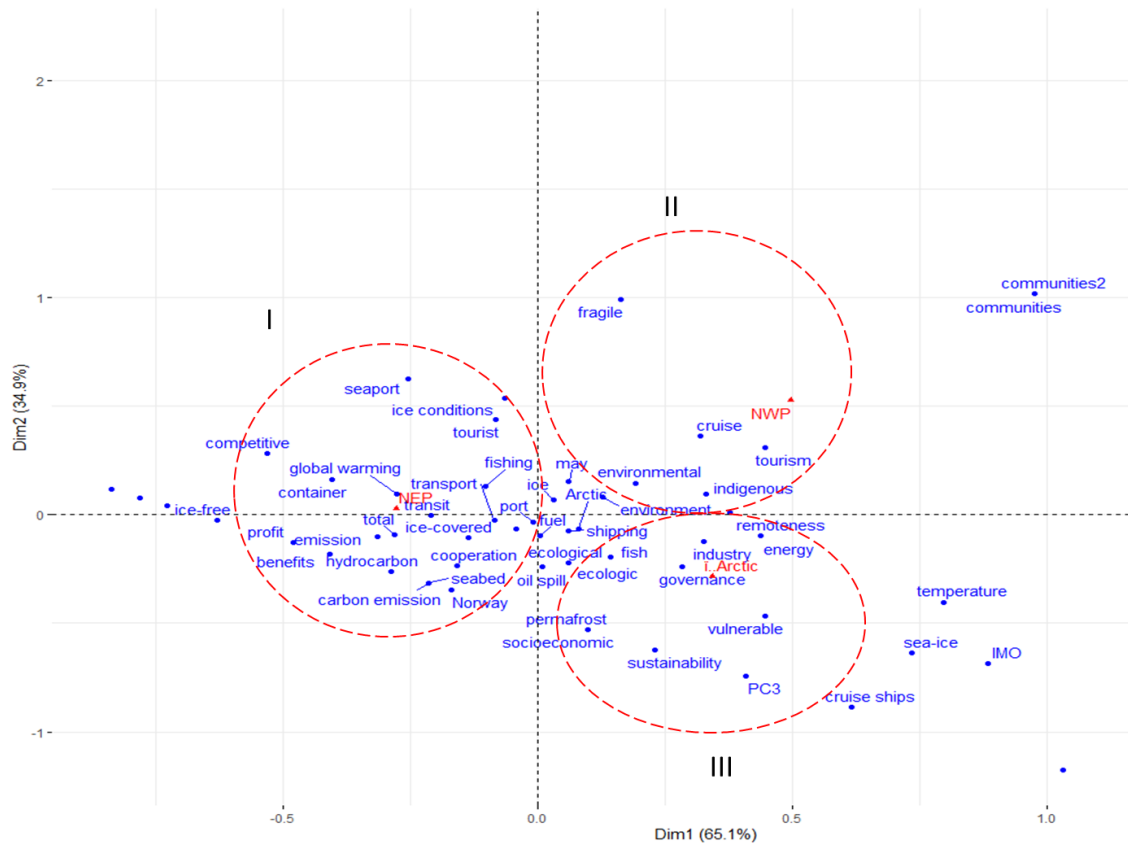
climate change, this is the reason why new regulations entered in force since 2000's, such as the Polar Code or the IMO 2020, involving the reduction of SOx and the ban of Heavy Fuel Oil in both Russian and Canadian Arctic. In this theme, most central abstracts, except for Lindstad et al (2016), address the environmental issue more as a part of an economic model (Yumashev et al, 2017; Zhao et Hu, 2017) or to assess state governance reaction (Edward and Evans, 2017; Yun, 2019).

Although - as also stressed by Panahi, et al (2021) - the group *Infrastructure* is not as analyzed as *Shipping*, the main word related to *Infrastructure* is "port" (304). The number of ports able to act as SAR represents a strong limitation for the development of this region (Kitigawa, 2000), and therefore a highly strategic topic. Ports in the Arctic can combine several functions: Search and Rescue center, terminals for the exportation of raw material or for the supply of communities which, due to the remoteness, are not always connected to the national network of infrastructures.

The last major group, *Economy*, is specific because the word composing the group (appendix 1) are represented in a balanced way. The most central abstracts of our database dealing with the *Economy* group are comparing the NSR versus the SCR for bulk (Faury et al, 2020, Cariou and Faury, 2015) and container (Zhao and Hu, 2016; Zhang et al, 2016). Notwithstanding, only two of them integrate a comparative study of the CO₂ emissions (Cariou and Faury, 2015; Zhao and Hu, 2016).

The *Tourism* group is less analyzed than the other ones. Out of the 122 words occurrences from this group, 44, 42 and 26 come from "Tourism", "Cruise" and "Tourist" respectively. The articles gathering the highest number of words related to the "Tourism" group deal with the way tourism can help to gather data (Taylor et al, 2019) or with the history of Arctic tourism (Barthelmess, 2017) while Dawson et al (2016) provide recommendation for the development of cruise activity within Canadian Arctic.

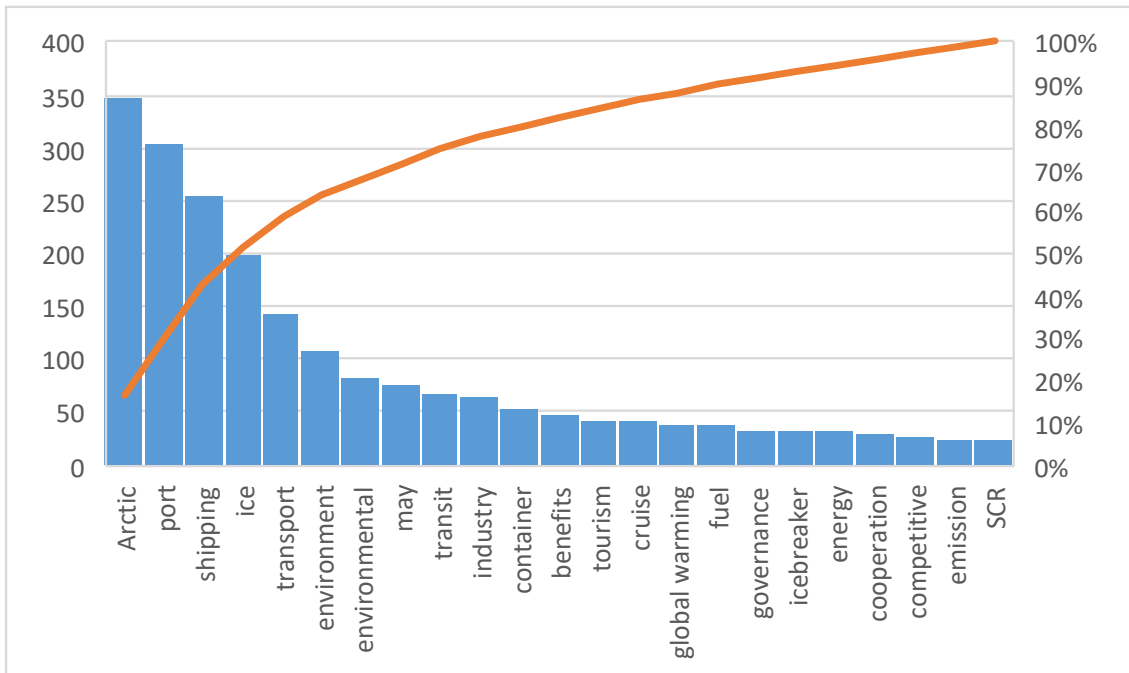
Figure 3: Relation of keywords and geographical focus of the articles: NEP (I), NWP (II) and Arctic (III)



Source: Authors (2021)

Figure 3 shows a biplot including all words in relation to the geographical scope of the article, which at the same time indicate three “clusters” of closely related words and geographical focus. From Figure 3 we can infer that research with focus on NEP (cluster I) is closely associated with issues such as global warming, “Transit” and ice-covered” among other words. The underlying narrative of this literature is that this literature is foremost looking into the connections between global environmental changes, increasing ship traffic and exploitation of oil and gas. The second cluster (NWP) is less dense compared to clusters 1 and 3. Here the literature has a stronger focus on cruise, tourism, and indigenous aspects. The underlying narrative of the NWP is therefore closely associated with Canadian concerns about how to make the increasing tourism in the region less damaging to local communities and the environment. The narrative underlying the third cluster (Arctic), is more diffuse as “governance” and “industry” appear as the core issues closely positioned to the geographical area, however an inference is that emerging industrial activities in the Arctic such as energy-related have implications to sustainability.

Figure 4 : Frequency of top 23 words

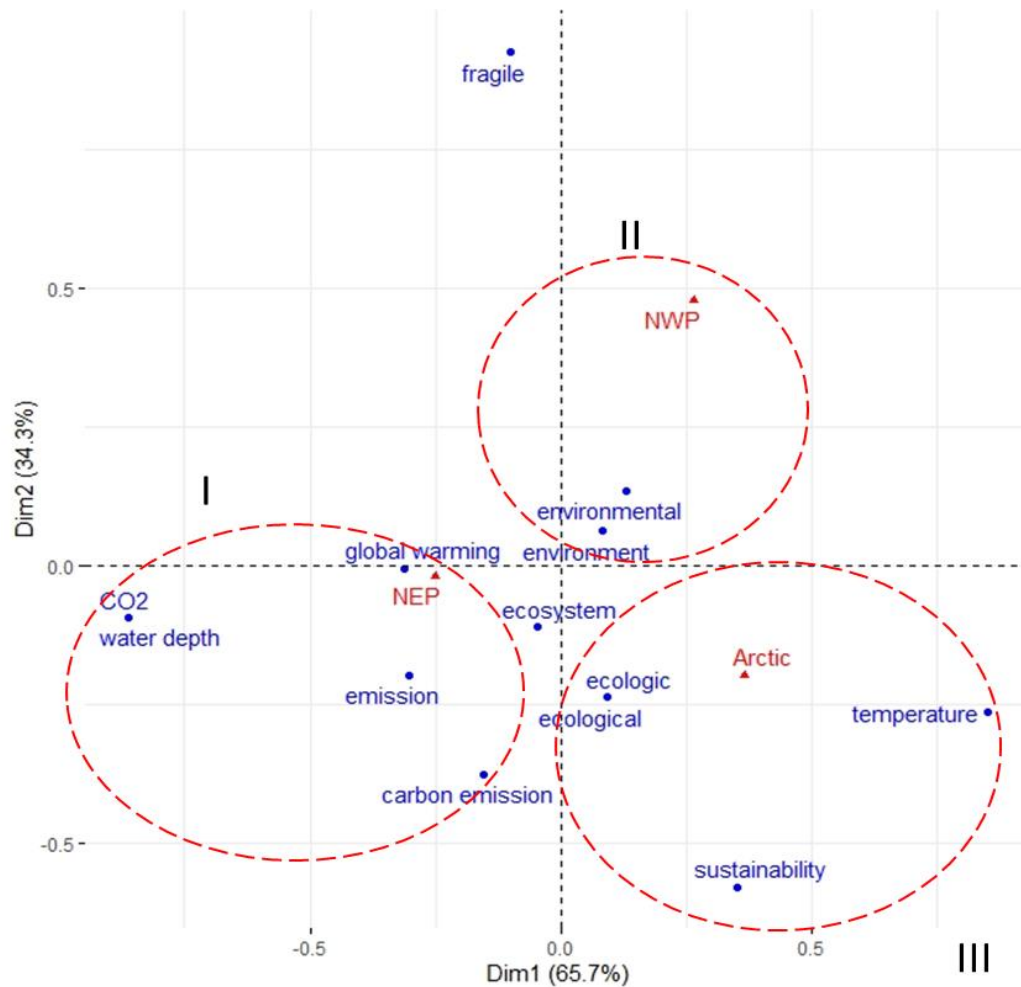


Source: Authors (2021)

To gain in readability, we assumed to look at the words that represent 80% of occurrences reason why the 80% of most quoted words represent 100% in the graph. Figure 4 shows that the top five words are related to geography, shipping, and infrastructures. Words from the group *Sustainability*, such as “environment” and “environmental” are only in 6th and 7th positions and no other word from this group appears after. This graph stresses the potential lack of detailed analysis focused on sustainability.

3.2. Focus on the “sustainability” group

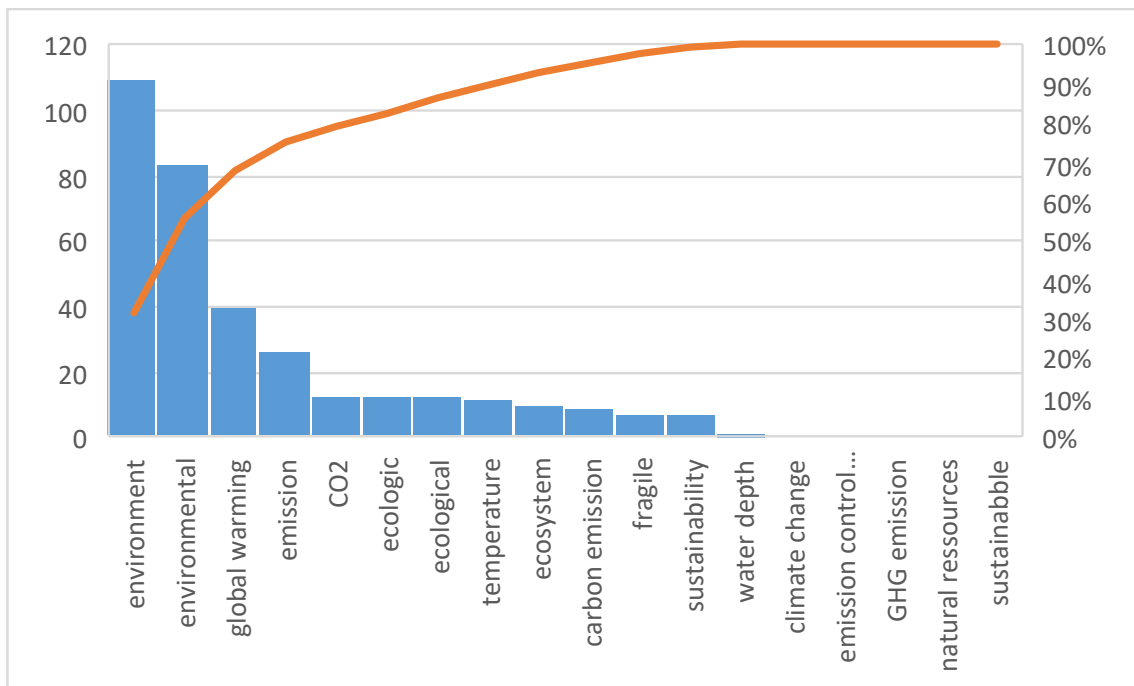
Figure 5: Relation between keywords about the group “sustainability” and the zones of interest for the research paper



Source: Authors (2021)

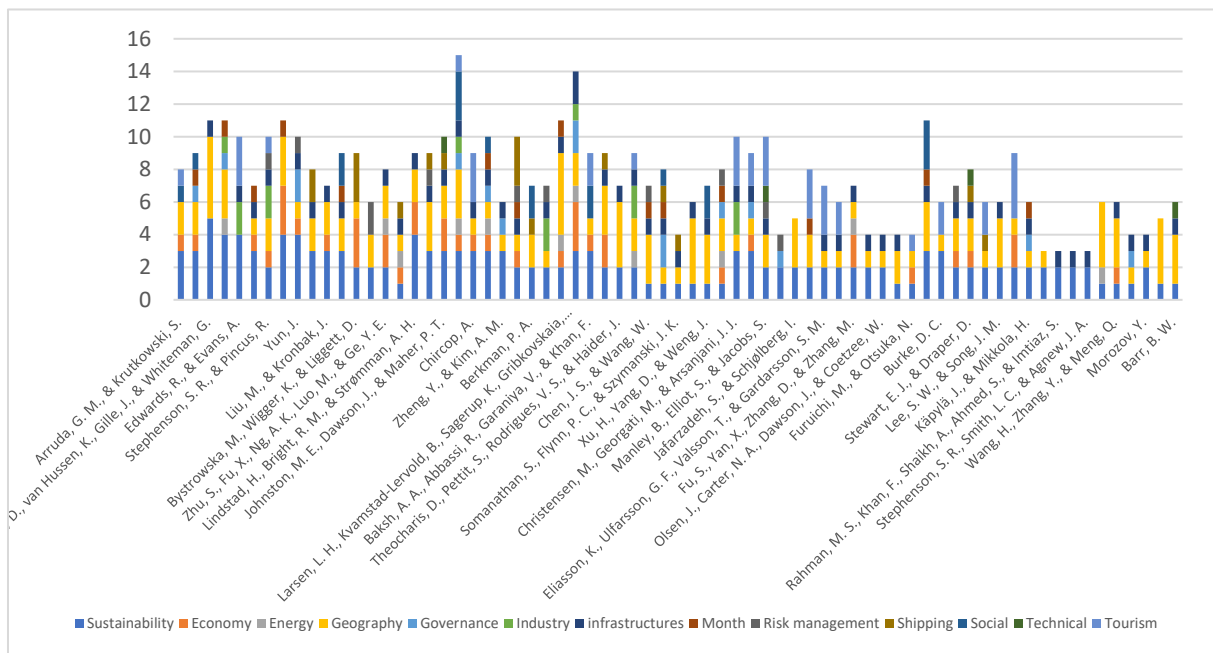
As figure 5 shows, three lexical clusters connect the geographical focus of the article with words about “sustainability”. Cluster 1 (NEP) connects global warming with (carbon) emissions and NEP, while cluster 2 loosely connects NWP with general concerns over the environment without further details. Finally, the third cluster, general Arctic concerns focus on ecological issues, temperature increase and sustainability.

Figure 6: words related to the “sustainability” group



Source: Authors (2021)

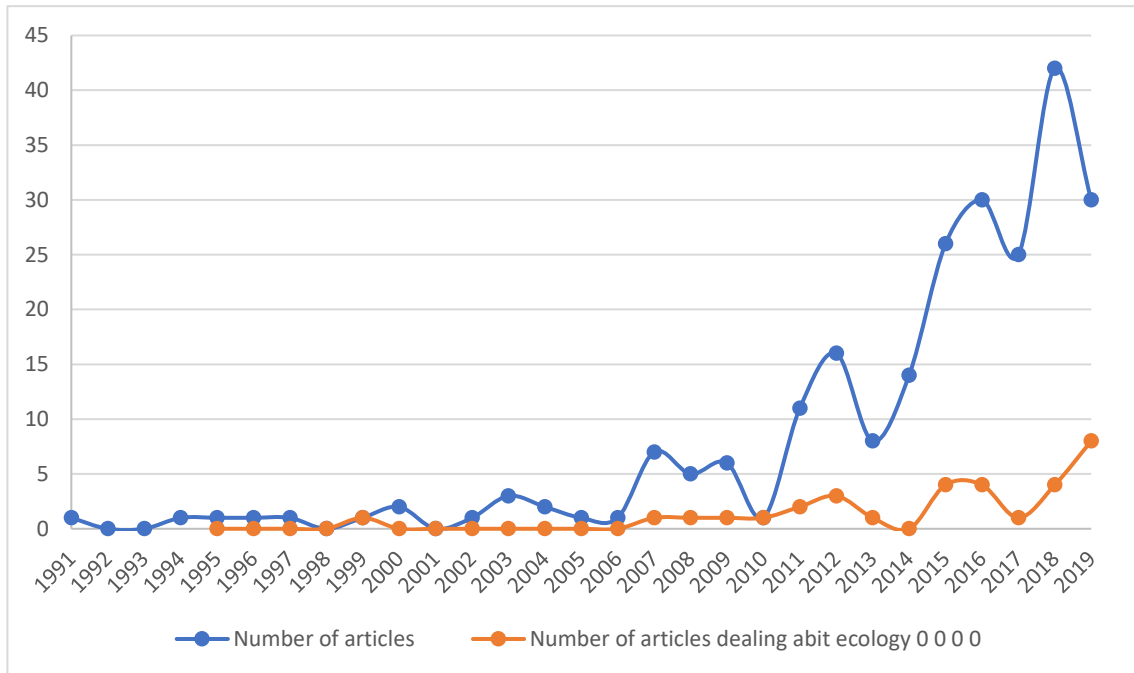
Figure 7: articles representing 80 % of the occurrence on sustainability group



Source: Authors (2021)

If figure 6 shed a light on the number of time words related to sustainability are used in our database, figure 7 focuses on articles representing 80 % of the occurrences on the sustainability group and the way all groups are represented within each paper. This figure highlights the strong link between the sustainability and geography groups: out of the 674 occurrences of the 77 words selected, 28% are dealing with *sustainability* and 26% with *geography* while *infrastructures* and *economy* only represent 10% and 8% and *Shipping* only 4%. This result let us suppose that most articles dealing with sustainability are not related to transportation, and that opens a way to further academic studies.

Figure 8: evolution of articles published and articles with at least one word related to sustainability.



Source: Authors (2021)

In the figure 8 we can see that although research about Arctic started in 1991, articles containing at least one word in their abstract that we considered as part of the sustainability group started in 1995 and remained marginal for a long time. In 2019, the last year of this analysis, only 8 out of the 30 published dealt with this theme.

Thus, this study demonstrates that articles focusing on environmental issues regarding Arctic shipping remain under-represented in the academic literature. This is even more critical when one considers that:

- Environmental issues are at the core IMO policies, regarding the reduction of SOx or the expected ban of Heavy Fuel Oil from both Canadian and Russian Arctic,
- The Arctic Ocean is highly sensitive to human activity,
- If an oil spill occurs, coastal countries do not have significant means to counteract the negative impact,
- The number of journeys offered by cruise companies, in this region, has increased during the last years.

4. Discussion

In this last section, we focus on identifying the main specificities in articles that belong to the sustainability group, and that were reported with the highest centrality score (top-10). The objective is to understand how they differ compared to articles with a focus on geography, shipping, and infrastructures.

One of the first differences is that these articles shed light on the regional and sectorial disparities that exist due to climate changes. According to Yumashev et al. (2017), the main gains from climatic changes are not equally distributed and they will mostly occur in Northern Europe and East Asia. The negative economic impacts from emissions from NSR shipping, on

the other hand, are expected to affect the poorer regions such as Africa and India that bear as much as two thirds of the global costs. Another source of future disparities is related to the possibility of marine accidents such as collision, foundering, and grounding. Baksh et al. (2018) stress that higher collision, foundering, and grounding probabilities exist in the East Siberian Sea, and with the ice effect being a dominant factor in accident causation, while other regions such as Chukchi, Laptev, Kara, and the Barents Sea have similar probabilities regarding grounding.

The existence of these regional disparities between economic benefits and costs of increased Arctic shipping, calls for more social science research to identify relevant policy options to address economic inequities. Therefore, similarly to the general trade model developed by Yumashev et al. (2017) that combines climatic and economic feedback effects of NSR, the integration of a variety of modelling approaches spanning across multiple disciplines is needed.

Edward and Evans (2017) also call for such a multi-disciplinary approach, to better consider how the sectorial differences from changes in the Arctic may lead to new types of conflicts. Their Marine spatial planning model accounts for climatic and geopolitical interactions to reflect differences in the demands on marine areas, both spatially and temporally. Under their setting, several users will compete for resources or space, to ensure that development is as sustainable as possible. The conflicts emerge from higher demand for hydrocarbon exploitation, shipping, and fisheries, within the context of the next 30 years of climate change. The paper highlights the need for cross-sectoral management tools that could potentially deal with a user–user or user–environment conflicts at a transboundary or Pan-Arctic scale.

Amongst the other sources of conflict analyzed is from differences in indigenous value. For instance, Hilmer-Pegram (2016) study on the spaces of confluence and divergence in Barrow, Alaska, reveals conflicting views about using subsistence hunting, fishing and whaling activities as tourism attractions. As stated by the authors, tourism can turn people, places and nature into commodities for market-based consumption and there is a need for a research agenda focused on exploring the relationship between the negative socio-economic impacts of capitalism and its alternatives within tourism destinations. This issue emerges as Arctic Canada has grown substantially since 2005 (Johnston et al. 2017), which raises concerns on the social, economic, and cultural opportunities associated with industry growth. Three areas of concern are significant: a complicated regulatory framework, a lack of data and monitoring capability, and insufficient control over tourist behaviors.

Tourism stakeholders' attitudes toward sustainability is also studied by Chen (2015). Arctic destinations are regarded as sacred and pristine places that are susceptible to the influx of tourists. In Arctic destinations, vigilant tourists are interested in a stewardship of preserving the nature, wildlife, and indigenous culture. Their survey however reveals that while tourists are apt to accept more sustainable operations in Arctic destinations, other stakeholders (industry players such as tourist operators) are less prone to consider this element as their priorities might be different (Dawson et al. 2016)..

Conflicts also arise from cultural differences amongst stakeholders towards the concept of sustainability, in a geopolitical context. The paper from Andreassen (2016) investigates how the concept of Arctic sustainability has developed in the politico-economic context of Russia. Ensuring energy security and sustainable development in the long term is considered regarding the development of energy on the Arctic continental shelf and northern territories

of Russia. Other states may have different priorities and view toward the Arctic. This is for instance the subject of investigation of Burke (2017), that questions the notion of Canada being the protector of the fragile Arctic, that would be part of the country's narrative about its relationship with the Arctic region and its national self-image. More generally, Canada should approach any amendments to the Arctic Waters Pollution Prevention Act (AWPPA) the potential future ratification of the Polar Code with caution.

These elements reinforce the view that the social impact of climate change on the Arctic areas should be better considered. Arruda and Krutkowski (2017) explore the socio-political implications of climate change as the melting ice ignites new debates over territorial sovereignty of Arctic coastal states. Indigenous communities in the resource-rich areas of the Arctic are increasingly exposed to severe climate change impacts as well as the external pressures of development advocated by governments and its industry partners. According to the authors, the Inuit do not regard the Arctic as an open and indeterminate space. This illustrates the importance of minimizing spatial disturbance to environment and related impacts to "place" that resource exploration and development in the Arctic inevitably brings.

Conclusion

Our results show that despite a recent surge in publications on Arctic shipping, there is a scarcity of academic studies covering environmental issues. This gap is even more concerning when we consider the forthcoming stakes identified in this area by the few papers covering this topic.

Academics agreed that there is not just 'one Arctic' but numerous ones, and thus there are various ways to implement a sustainable development. If the climate change opens new business opportunities, it also generates conflicts between private stakeholders and northern communities.

Besides, each coastal state has its own perception of a sustainable policy and development. One of the main functions of the Russian Arctic shore seems to be the extraction of hydrocarbons product for Europe and Asia, while Canada seems on a different pathway about the exploitation of its Arctic area. Notwithstanding, this maritime development is not riskless for both seafarer and environment.

To sustain this growth, the development of infrastructures is also very different when comparing the Russian and Canadian shores. Even within countries such as Russia, some regions are more developed than others, thus the way sustainable is perceived may change from one region to another. The development of tourism can also be a new source of conflict in any Arctic coastal state. If this "new" activity may have some positive impact on the development of Arctic regions, it must be developed in accordance with local communities, to respect their way of life, and to ensure they can reap the benefits of this industry. This balance remains an enduring question (Arruda and Krutkowski 2017). Prior to becoming a region of geopolitical interest, the Arctic has been primarily a homeland to many indigenous populations that should still be the primary stakeholders in the planning and decision-making concerning a range of social and environmental issues. As started in the pioneer work by Chircop (2007), any action in the Arctic will need to take heed of the Arctic Council and the views and interests of the indigenous peoples of the North.

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Annex 1

Groups	Words	Groups	Words	Groups	Words	Groups	Words
Sustainable	environment	Economy	attractiveness	Geography	Iqaluit	geography	russia
Sustainable	environmental	Energy	energy	Geography	Kara sea	Shipping	safe navigation
Sustainable	global warming	Energy	total	Governance	governance	Shipping	bulk carrier
Sustainable	emission	Energy	hydrocarbon	Governance	cooperation	Shipping	oil-tanker
Sustainable	CO2	Energy	LNG	Governance	IMO	Social	communities
Sustainable	ecologic	Energy	Yamal LNG	Governance	USA	Social	communities
Sustainable	ecological	Energy	offshore drilling	Industry	fish	Social	indigenous
Sustainable	temperature	Energy	oil & gas	Industry	fishing	Social	socioeconomic
Sustainable	ecosystem	Geography	Arctic	Infrastructures	port	Social	rural
Sustainable	carbon emission	Geography	ice	Infrastructures	infrastructures	Technic	ice-class
Sustainable	fragile	Geography	ice conditions	Infrastructures	seaport	Technic	PC3
Sustainable	sustainability	Geography	ice-free	Month	may	Technic	1A
Sustainable	water depth	Geography	ice-covered	Risk management	oil spill	Technic	open-water vessels
Economy	industry	Geography	competitive	Shipping	transit	Tourism	cruise operators
Economy	benefits	Geography	competitive	Shipping	container		
Economy	fuel	Geography	competitive	Shipping	SCR		
Economy	icebreaker	Geography	competitive	geography	north cape		
Economy	competitive	Geography	seabed	geography	northern scandinavian		
Economy	profit	Geography	permafrost	geography	norwegian sea		
Economy	competitiveness	Geography	inaccessibility	geography	pechora sea		

Annex 2- CA script in R used to generate the CA biplots

The following example is based on the relation between the themes and the Arctic keywords.

```
install.packages(c("FactoMineR", "factoextra"))
library("FactoMineR")
library("factoextra")
Contingency_arctic <- read.csv("~/R/Project_Arctic/data/Contingency_Arctic.csv", sep=";")
dt <- as.table(as.matrix(Contingencies_themes))
CA(dt, ncp = 5, graph = TRUE)
res.ca <- CA(dt, graph = FALSE)
print(res.ca)

fviz_ca_biplot(res.ca, repel = TRUE)
```

Annex 3 – Example contingency table to perform a CA

The following contingency table represents the relationship between the keywords grouped under the issue “Sustainability” and the Arctic zone under study.

Carbon emission	3	6	0
Climate change	0	0	0
CO ₂	0	13	0
Ecologic	5	7	1
Ecological	5	7	1
Ecosystem	3	6	1
Emission	6	19	1
Emission control area	0	0	0
Environment	33	58	19
Environmental	25	42	17
Fragile	0	4	3
GHG emission	0	0	0
Global warming	7	29	4
Natural resources	0	0	0
Sustainable	0	0	0
Sustainability	4	3	0
Temperature	8	2	2
Water depth	0	1	0