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RESEARCH ARTICLE

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The Arctic Environmental Responsibility Index: A method to rank heterogenous extractive industry companies for governance purposes

Indra Overland[1] | Anatoli Bourmistrov[2] | Brigt Dale[3] | Stephanie Irlbacher-Fox[4] | Javlon Juraev[5] | Eduard Podgaiskii[6] | Florian Stammler[7,9] | Stella Tsani[8] | Roman Vakulchuk[1] | Emma C. Wilson[9]

[1]Center for Energy Research, Norwegian Institute of International Affairs (NUPI), Oslo, Norway

[2]Nord University Business School, Nord University, Bodø, Norway

[3]Research Group for Environment and Society, Nordland Research Institute, Bodø, Norway

[4]School of Public Policy and Administration, Carleton University, Ottawa, Ontario, Canada

[5]School of Business and Economics, Westminster International University in Tashkent, Tashkent, Uzbekistan

[6]Faculty of Meteorology, Russian State Hydrometeorological University, Saint Petersburg, Russia

[7]Arctic Center, University of Lapland, Rovaniemi, Finland

[8]Department of Economics, University of Ioannina, Ioannina, Greece

[9]Scott Polar Research Institute, University of Cambridge, Cambridge, UK

Correspondence
Indra Overland, Norwegian Institute of International Affairs (NUPI), Hambros Plass 2D, 0130 Oslo, Norway.
Email: indra.overland@nupi.no

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Abstract

The Arctic Environmental Responsibility Index (AERI) covers 120 oil, gas, and mining companies involved in resource extraction north of the Arctic Circle in Alaska, Canada, Greenland, Finland, Norway, Russia, and Sweden. It is based on an international expert perception survey among 173 members of the International Panel on Arctic Environmental Responsibility (IPAER), whose input is processed using segmented string relative ranking (SSRR) methodology. Equinor, Total, Aker BP, ConocoPhillips, and BP are seen as the most environmentally responsible companies, whereas Dalmorneftegeophysica, Zarubejneft, ERIELL, First Ore-Mining Company, and Stroygaz Consulting are seen as the least environmentally responsible. Companies operating in Alaska have the highest average rank, whereas those operating in Russia have the lowest average rank. Larger companies tend to rank higher than smaller companies, state-controlled companies rank higher than privately controlled companies, and oil and gas companies higher than mining companies. The creation of AERI demonstrates that SSRR is a low-cost way to overcome the challenge of indexing environmental performance and contributing to environmental governance across disparate industrial sectors and states with divergent environmental standards and legal and political systems.

KEYWORDS

environmental governance, environmental responsibility, extractive industries, index methodology, mining, oil and gas

1 | INTRODUCTION

This article introduces the Arctic Environmental Responsibility Index (AERI) (see Table 1). The debates in the literature on similar rankings revolve mainly around the reliability of different methodological approaches (Maestas, 2016; Marquardt & Pemstein, 2018; Tofallis, 2014; Urueña, 2015) and the ability of such rankings to affect governance (Bullock, 2017; Prakash & Potoski, 2012; Shvarts et al., 2018).

This article deals with both issues but focuses on the former, providing a detailed description of the methodology and assessing the choices made in developing AERI.

Two critical methodological choices are made: the first is the use of expert perceptions to form the input for the ranking; the second is the use of the segmented string relative ranking (SSRR) technique to analyze the data. These approaches are combined in an effort to overcome known issues in the development of rankings, and the lessons learned from this experience can inform the development of similar rankings in the future, as well as provide insights into the relationship between ranking methods and the results that they produce, and by extension their influence.

The next section establishes the conceptual and contextual background for this exercise and reflects on the governance effects of such a ranking. Section 3 provides a detailed discussion of the methodology, and Section 4 presents the ranking results. Section 5 summarizes the key findings and lessons learned and reflects on possible applications of the ranking.

2 | RANKINGS AS A GOVERNANCE TOOL

Rankings can contribute to better governance of industrial activities by establishing norms, enhancing transparency, crediting high achievements, and discrediting poor practices (Amato & Amato, 2012; Broome & Quirk, 2015; Bullock, 2017; Cooley & Snyder, 2015; Shvarts et al., 2016; Towns & Rumelili, 2017; Urueña, 2015; Walker et al., 2013). They can contribute to governance through comparison, gamification, naming and shaming, and norm formation, but without formal rules and the exercise of governmental power. They can thus help improve practice without the red tape, corruption, or other risks commonly associated with environmental regulation by governments (Al-Najjar & Anfimiadou, 2012; Ghosal, 2015; Glachant, Schucht, Bültmann, & Wätzold, 2002; Heras-Saizarbitoria, Arana, & Boiral, 2016). The governance perspective has been applied to rankings at multiple levels, including rankings of countries (Davis, Fisher, Benedict, & Merry, 2012), universities (Fee, Hadlock, & Pierce, 2005; Osterloh, 2010; Siganos, 2008), and international development (Best, 2017; Honig & Weaver, 2019; Kelley & Simmons, 2019).

Rankings can contribute to environmental governance by engendering a "race to the top." A ranking such as AERI may function as an informal governance mechanism, influencing behavior not with rules or condemnation but rather through gamification: a competition in which some companies are more successful and others less so (Boer, 2003; Prakash, 2001). The more units a ranking covers, the greater competition it can potentially trigger. The SSRR method makes it possible to deal with highly disparate units and thus cover more units in one ranking (see Section 3.2). Companies are free to ignore a ranking, but it may still serve as a mechanism for establishing norms and competition (Fanasch, 2019). If a low-ranked company is investigated by the authorities or journalists, or sued by someone over an environmental issue, its low rank might put the company at a disadvantage, in terms of both legal processes and public relations. It is also theoretically possible that a company's rank may also influence its access to capital (Prakash & Potoski, 2012; Shvarts et al., 2016; Trumpp & Guenther, 2017). The petroleum and mining industries may be in particular need of such rankings, as the number of voluntary sustainability initiatives in the extractives sector grows, while their effectiveness is increasingly being questioned and scrutinized (MacInnes, Colchester, & Whitmore, 2017; Potts et al., 2018; Ranängen & Zobel, 2014).

Laws have absolute thresholds for what is counted as acceptable and unacceptable behaviors (Shvarts et al., 2015). By contrast, the competition generated by a ranking does not have a cutoff point. As a society develops, most companies may come to uphold a law or standard, and thus companies are not forced to continue improving their behavior. To achieve that, new laws must be passed, which requires initiative, time, and dedication. By contrast, a ranking always gives some companies higher scores and some lower, and thus it never stops chasing them towards greater environmental responsibility. With a ranking that is repeated at regular intervals, the sky is theoretically the limit for environmental standards. Conversely, if almost all the companies in a ranking are not in fact environmentally friendly, there is a risk that that relatively high ranks can be used for greenwashing purposes (Chen & Chang, 2013; Lyon & Montgomery, 2015; Martínez et al., 2020). It is therefore important to be cautious about how one interprets and uses rankings.

Two examples of rankings that are seen as contributing to governance are the Corruption Perceptions Index (CPI) of Transparency International and the Ease of Doing Business Index (EDBI) of the World Bank, both of which are believed to have stimulated improved performance on the part of states (Besley, 2015; Davis, Kingsbury, & Merry, 2012; Merry, Davis, & Kingsbury, 2015). By ranking governments according to the (perceived) level of corruption in their country, the CPI puts pressure on corrupt governments to recognize the magnitude of the problem and its reputational cost (Andersson & Heywood, 2009; Wilhelm, 2002). Similarly, the EDBI facilitates competition among states to have the best business climate.

The governance effect of rankings could be particularly beneficial in the Arctic extractive industries. Like the Amazon rainforest, the Arctic is a key component of the global ecosystem, and the environmental health of the Arctic is therefore of global importance (Koivurova, Molenaar, & Vanderzwaag, 2009; Storey, 2014). The area above the Arctic Circle makes up around 20 million km^2, a significant portion of the planet's surface. It spans three continents and eight countries and also draws the interest of many non-Arctic countries, as indicated by their observer status in the Arctic Council (including China, France, Germany, India, Japan, South Korea, and the United Kingdom). Around 30% of the world's remaining undiscovered gas and 13% of undiscovered oil is located in the Arctic; and the value of circumpolar Arctic mineral reserves has been estimated at USD 1 trillion (US Coast Guard, 2013; USGS, 2000). However, several factors—the remoteness of the Arctic from major centers of power (Gautier et al., 2009; Huskey, 2005), its division among eight states (Steinberg, Tasch, Gerhardt, Keul, & Nyman, 2015), and the resistance of these states to the intervention of non-Arctic countries in Arctic environmental management (Overland, 2010)—hinder the imposition of a unified system of environmental control in the Arctic (Chater, 2016).

The environmental responsibility rankings that have so far been developed for the extractive industries operating in the Arctic cover only one country and one industry, and often they cover both the Arctic and non-Arctic parts of the country in question.[1] For example, in Russia, two environmental rankings are potentially relevant to AERI—the Polar Index (Nikonorov et al., 2018a, 2018b) and the World Wildlife Fund/Creon ranking of environmental responsibility/transparency of oil and gas companies in Russia (Knizhnikov et al., 2017; Knizhnikov et al., 2018, 2019; Shvarts et al., 2016; Shvarts et al., 2018; WWF/Creon, 2014). There appears to be greater interest in extractive company rankings in Russia than in other Arctic countries. This may be because state-led and law-based governance is seen as less reliable in Russia. It may be for the same reason that the literature on rating systems for companies in developing countries is rich (Garcia et al., 2007; Hilson, 2012; Lodhia & Hess, 2014; Powers et al., 2011; Wang et al., 2004).

In the other Arctic states than Russia, it is harder to find such rankings, although other voluntary corporate responsibility frameworks do exist for extractive industry companies. The Mining Association of Canada has developed the Towards Sustainable Mining (TSM) initiative for Canadian companies. TSM has also been adopted by the Finnish Network for Sustainable Mining and the Norwegian mining association, Norsk Bergindustri.[2] The TSM Protocols include evaluation criteria resulting in ratings from C to triple A (following the logic of credit ratings), but these are not used to create rankings of companies. At the global level, there are initiatives such as the Global Compact, the Global Reporting Initiative (GRI), Integrated Reporting, the Equitable Origin responsible energy standard, the International Organization for Standardization (ISO) 14001 environmental management standard, the European Union Eco-Management and Audit Scheme (EMAS) certification, the Initiative for Responsible Mining Assurance (IRMA) standard, and the International Council on Mining and Metals (ICMM) Principles for Sustainable Development (see Roca & Searcy, 2012; Searcy & Elkhawas, 2012; Wagner, 2020). All of these serve to stimulate greater transparency and more responsible business practices, but they do not trigger direct comparison and competition among companies in the same way as a ranking does (Moran et al., 2014; Raufflet, Cruz, & Bres, 2014; Yadav et al., 2017).

In the context of Arctic resource extraction, a proper ranking focusing on environmental responsibility and spanning the whole circumpolar north and the major extractive industries is something new. The more industries and companies it covers, the greater the chance that such a ranking can help fill the governance gap by geographically widening and ramping up environmental competition among extractive companies. The purpose of this article is thus to create AERI, spanning the oil, gas, *and* mining industries *and* the entire Arctic. In doing so, we also seek to demonstrate how it is methodologically possible to create an index covering disparate countries and sectors at a low cost. If a unitary index can be made to cost-efficiently apply across the Arctic states and extractive industries, the same approach can be applied to other seemingly incongruent regions and sectors.

The aim of making AERI as broad as possible leads to some methodological challenges, which are dealt with in the next section, including how experts were recruited; how their input was processed; and how the companies to be included in the ranking were selected.

3 | METHODOLOGY

For the same reasons that a broad index can be useful for governance purposes, it is tricky: the different Arctic countries have different legal frameworks; environmental standards vary among the countries and sectors; and environmental issues vary from sector to sector and in different locations. For example, virtually all mining projects are located onshore, whereas oil and gas developments might be onshore or offshore, and they might require the construction of extended pipeline systems. The types of environmental risks and accidents they involve are different. Because of such differences, it is difficult to formulate objective, fact-based criteria that are meaningful across the companies extracting different types of resources in different parts of the Arctic. The alternative approach of asking companies to self-report is unreliable. And carrying out detailed fieldwork at all company sites would be prohibitively expensive.

To get around these challenges, two important elements were incorporated into AERI: it is based on an expert perceptions survey, and the expert input is processed using the innovative SSRR methodology. The basis for these methodological choices and their implications is discussed in the next two subsections.

3.1 | Perceptions as a basis for a ranking

Choosing an expert perceptions survey design made it possible to cover more companies spread over a greater geographical area than would have been possible if one were to inspect them individually. An important aspect of the AERI expert perceptions survey was the selection of the experts and ensuring that their perceptions were grounded in appropriate experience and expertise (see Section 3.6). Perceptions surveys involve a risk of subjectivity. However, the alternative methods for gathering information for rankings—including company self-reporting and review of other publicly available information—are not necessarily more objective or indeed sufficiently comprehensive in their coverage of "environmental responsibility." Published pollution figures and self-reporting of environmental conflicts alone cannot provide the full picture of environmental responsibility, which refers to a company's efforts to avoid harm to the natural environment and the livelihoods of local and indigenous peoples (see

[1]The ranking produced by Overland (2016) covers mining and oil and gas companies in all Arctic countries but focuses solely on those companies' policies on indigenous rights.
[2]In addition to Finland and Norway, TSM has also been adopted as a national-level framework in Argentina, Botswana, the Philippines, and Spain.

Section 3.5). Experts were recruited for the survey with many years of Arctic experience, including working within companies, being members of communities affected by company activity, or carrying out extensive field work in companies' regions of operations. Although data provided by these experts are always going to be subjective, they are nonetheless rich and valuable data that should not be dismissed lightly, especially given the lack of entirely objective or comprehensive data available from other sources.

Although perceptions inevitably involve an element of subjectivity, they can be useful, especially as far as the governance effect of a ranking is concerned. The CPI of Transparency International, discussed above, is an expert perceptions index (albeit one employing a different method to AERI), rather than a precise empirical measurement of the level of corruption in different countries—which would be impossible to achieve (Beddow, 2015; Lambsdorff, 2006; Treisman, 2007). Nonetheless, the CPI provides useful information for citizens, governments, and companies and has a powerful effect on the reputations of states (Serenko & Bontis, 2018; Steenbergen & Marks, 2007). Such surveys can be replicated, and if similar respondents are used, the surveys are likely to yield similar results. If properly executed, they can be informative and effective. In addition to the selection of experts, critical to the success of a perceptions survey approach is the form in which the input is provided and the way that it is subsequently analyzed. These are discussed in the next sections.

3.2 | Segmented string relative ranking

The SSRR methodology was first developed in Overland (2018), and an open-source computer-based algorithm was later developed by Overland and Juraev (2019), making it easier to apply to real-world cases. Using SSRR methodology to process the expert input for AERI makes it possible to cover diverse companies. This is because the SSRR methodology avoids the use of grades and uses only relativistic input. That is to say, experts rank those companies with which they are familiar in relation to each other, rather than ascribing absolute grades to them. As there are no grades or criteria, the SSRR methodology is versatile and can be applied to disparate units for which it would be difficult to develop uniform criteria—such as oil and mining companies, or companies operating under, for instance, the American and Finnish legal systems.

This also gives SSRR additional advantages over other expert-based ranking methodologies. Most expert-based rankings depend on experts giving items grades (Maestas, 2016). However, there is always a risk that some experts will be stricter than others in the application of grades (Marquardt & Pemstein, 2018). Differences in grading practices are particularly salient when different groups of units are graded by different experts (Tofallis, 2014). For example, if one expert assesses companies operating in Canada and another expert assesses companies operating in Russia, there is a risk that grades will be applied differently to companies operating in those two countries.

To limit this problem, detailed criteria can be developed for each grade. However, consistent grading is still not guaranteed. For example, the mining and metals company Teck, based in Canada and operating in Alaska, has scored highly in rankings such as in Overland (2016), which assessed companies' publicly reported formal mechanisms and institutional arrangements for indigenous rights protection. However, the company has been embroiled in environmental and indigenous rights conflicts and has been the target of lawsuits by indigenous groups. Notwithstanding the extensive work on formal criteria and gathering of data on Teck by Overland (2016), these weaknesses were not captured when the company was assessed. Similar problems apply to the Polar Index in Russia (Nikonorov et al., 2018a), which places Lukoil as the number one company for sustainability performance, despite the fact that its subsidiary, Lukoil-Komi, has been responsible for extensive and repeated oil pollution incidents in Russia's Komi Republic, resulting in widespread local protests (Loginova & Wilson, 2020; Stuvøy, 2011). By contrast, in AERI, Teck comes 60th out of 120 companies, whereas Lukoil comes in 37th place, below five other Russian companies (see Table 1).

Another problem with many criteria-based rankings is that many companies can get the same score and therefore have to be bunched together into groups. This makes rankings more ambivalent and difficult to communicate clearly to the public, which can in turn weaken their governance effect. Accordingly, another advantage of SSRR is that its strictly hierarchical approach ensures that every company has its own exclusive place in the ranking.

Finally, with a criteria-based approach, fewer companies can be compared, as few criteria apply across sectors and countries have different rules and regulations and gather different types of statistics. Again, a reduction in the number of companies covered would weaken the ranking's governance impact (Sharkey & Bromley, 2015). By contrast, in order to maximize the relevance of AERI, it was desirable to make it as broad as possible, for which SSRR is particularly suited. For more information about SSRR, see the computer code for the SSRR algorithm and a flowchart presentation of it in Appendices A, B, C, and D and a detailed technical discussion of its operation in Overland & Juraev (2019).

3.3 | Processing expert input

The experts providing input for AERI ranked only those companies they were familiar with, and only in relation to each other. Accordingly, their input came in the form: Company X is better than Company Y, which is better than Company Z. This input makes up a segment, and all the segments received from different experts were joined together into one long string, which constitutes the ranking. The result is a “pure” ranking that starts with ranking input and ends with a ranking, rather than starting with criteria, giving grades, and finally translating the grades into a ranking.

The experts were requested to rank companies they were familiar with, according to their perceptions of that company's environmental responsibility, based on their own experience and expertise. The

TABLE 1 The AERI ranking

Rank	Company	Country[a]	Rank	Company	Country
1	Equinor	NO	61	Marine Arctic Geol. Exp.	RU
2	Total	NO	62	Hilcorp	US
3	Aker BP	NO	63	Fortis Petroleum Corp.	NO
4	ConocoPhillips	US	64	Lime Petroleum	NO
5	BP	US	65	Auryn Resources	CA
6	Exxon Mobil	US	66	Nunaoil	DK
7	ENI	US	67	Norge Mineral Resources	NO
8	Anglo American	FI	68	Kovdorsky GOK	RU
9	Repsol	US	69	Arctic Marine Engineering-Geol. Exp.	RU
10	Royal Dutch Shell	US	70	Great Bear Petroleum	US
11	Baffinland Iron Mines Corp.	CA	71	Centrica Resources	NO
12	Chevron	CA	72	Nortec Minerals	FI
13	Gazprom	RU	73	Dragon Mining	FI
14	Arctic Slope Regional C.	US	74	Aurion Resources	FI
15	MMG Resources	CA	75	Concedo	NO
16	Arctic Gold Mining	NO	76	Rosneft	RU
17	Elkem	NO	77	Northgas	RU
18	Boliden	SE	78	Skaland Graphite	NO
19	Novatek	RU	79	Sibelco Nordic	NO
20	NANA Regional Corp.	US	80	Nenetskaya Neftyanaya Komp.	RU
21	Atlantic Petroleum	NO	81	Store Norske	NO
22	Kinross Gold	RU	82	Edison	NO
23	LKAB	SE	83	Noreco	NO
24	North Energy	NO	84	IronBark Zinc	DK
25	Wintershall	NO	85	Polymetal Int.	RU
26	Alyeska Pipeline Service Co.	US	86	Commander Resources	CA
27	Severstal	RU	87	Taranis Resources	FI
28	DEA Norge	NO	88	True North Gems	CA
29	Sydvaranger Gruve	NO	89	Tertiary Minerals	FI
30	Yamal LNG	RU	90	Gold Fields	FI
31	Capricorn Greenland Expl.	DK	91	Northern Cross Energy	CA
32	Achimgaz	RU	92	Vorkutaugol	RU
33	Petoro	NO	93	PhosAgro	RU
34	Imperial Oil	CA	94	Brooks Range Petroleum	US
35	Agnico Eagle Mines	FI	95	SK Rusvietpetro	RU
36	Norwegian Rose	NO	96	Caelus Energy	US
37	Lukoil	RU	97	Novourengoyskaya Burovaya Komp.	RU
38	Norilsk Nickel	RU	98	First Quantum Minerals	FI
39	Doyon	US	99	Magnus Minerals	FI
40	Leonhard Nilsen & S.	NO	100	RUSAL	RU
41	Hudson Resources	DK	101	Beowulf Mining	SE
42	Nordic Mining	NO	102	Vår energi	NO
43	Lundin	NO	103	Lovozerskiy GOK	RU
44	Yamalzoloto	RU	104	Surgutneftegas	RU
45	Omya Hustadm.	NO	105	CNPC	RU
46	OMV	NO	106	Komnedra	RU

(Continues)

TABLE 1 (Continued)

Rank	Company	Country[a]	Rank	Company	Country
47	Geo Mining	NO	107	Trust Arktikugol	NO
48	Bashneft	RU	108	TMAC Resources	CA
49	Tullow Oil	NO	109	The QUARTZ Corp.	NO
50	ENGIE	NO	110	Almazy Anabara	RU
51	Spirit Energy	NO	111	North-Western Phosphorous Co.	RU
52	Nussir	NO	112	EMX Royalty Corporation	SE
53	ALROSA	RU	113	Hannukainen Mining	FI
54	Bluejay Mining	DK	114	Arktikmorneftegazrazvedka	RU
55	Occidental Petr.	US	115	Sunstone Metals	SE
56	E.ON	NO	116	Dalmorneftegeophysica	RU
57	Platina Resources	DK	117	Zarubezhneft	RU
58	PGNiG	NO	*118*	*Eriell*[b]	*RU*
59	Greenland Resources	DK	*118*	*First Ore Mining Company*[b]	*RU*
60	Teck Resources	US	*118*	*Stroygaz Consulting*[b]	*RU*

Country codes: CA, Canada; DK, Denmark; FI, Finland; NO, Norway; RU, Russia; SE, Sweden; US, United States.
Abbreviation: AERI, Arctic Environmental Responsibility Index.
[a]Countries listed here are the main countries where companies have operations. Companies may also operate in other Arctic countries and may have their main base outside the Arctic.
[b]The three last companies are italicized because they share one rank.

ranking input/segment from each expert was fed into the algorithm, which strung them together into AERI. To make it possible to string together segments, they must include some common units. Figure 1 gives a simplified representation of how this works.

Inevitably, experts contradict each other—some may have had more experience of companies' relations with indigenous peoples, and others may have based their responses more on different companies' waste management and resource efficiency practices. The SSRR algorithm solves this problem by first calculating the interrelationships among all companies ranked by all experts and subsequently using a link analysis approach, similar to the Google PageRank algorithm, to work out the contradictions. This enables the rankings of companies in relation to each other to feed from one segment to another.

When carrying out link analysis, it is necessary to include a damping factor to avoid scores being passed on in endless, ever-escalating circles within the network. For AERI, sensitivity test runs were carried out with several different damping factors, and a choice was made to stick to the conventional damping factor of 0.85. Different damping factors did not generate significantly different results, and there was therefore little reason to depart from the convention.

3.4 | Identification of companies

Envisaging an Arctic environmental responsibility index, one might, for instance, picture an offshore oil platform of a well-known oil company somewhere in Arctic waters and assume that it is self-evident which companies should be covered by such a ranking. However, several definitional issues are encountered. Where, exactly, is the Arctic and what is its outer boundary? What kind of activities qualify a company as being an extractive company? How should subsidiaries and joint ventures be handled? The definitions applied in this article are the result of lengthy investigations and discussions in several workshops involving company, nongovernmental organization (NGO), and government staff in addition to academics.

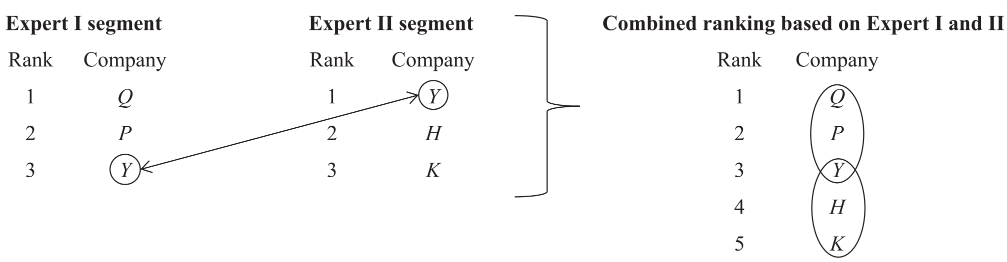

FIGURE 1 How input from different experts is combined into one ranking

In order to be included in the ranking, a company had to be involved in oil, gas, or mining activities above the Arctic Circle, regardless of where its headquarters are located. Some Canadians find this definition unjust, as there is much mining activity in Canada in areas with Arctic climatic conditions but located south of the Arctic Circle. However, the advantage of this choice is that it greatly eases the surprisingly difficult task of differentiating between Arctic and non-Arctic companies: one determines the locations of a company's operations, checks the geographic coordinates of those locations, and ascertains whether they are above or below the Arctic Circle. The location of the Arctic Circle is a fact no one disputes. Any other definition of the Arctic—and there are many—is more open to contention. It is important to note that, by extension of this methodological choice, we classify companies according to the Arctic country in which they operate, not where their global headquarters, owners, or non-Arctic operations are located.

A company's Arctic operations could be in exploration or extraction, and it could have operative responsibility or be a subcontractor or supplier of materials, equipment, or services. But it had to have its own website, not just a Facebook page or an entry in a Bloomberg database, as is the case for some small companies.

Subsidiaries were treated as a part of their parent companies rather than as separate entities. For example, Gazprom Dobycha Nadym was considered the same as Gazprom, and ConocoPhillips Canada as ConocoPhillips. However, as joint ventures have multiple parent companies, they were treated as separate companies. The most prominent case was Yamal LNG, a joint venture involving Russian Novatek, French Total, the Chinese Silk Road Fund, and China National Petroleum Corporation (CNPC), with a total value of over USD 20 billion (Praym Raskrytie, 2019). Another was Aker BP, which is a major oil company in its own right with its own history, although its largest shareholders are Aker and BP.

3.5 | Environmental responsibility

In the context of AERI, "environmental responsibility" is defined as seeking to avoid harm to the Arctic environment and the culture and livelihoods of Arctic peoples. Table 2 adds further detail to this definition. These points apply specifically to the activities of companies in the Arctic, not what companies do in other parts of the world.

As the focus of this study is the environmental aspects of upstream resource extraction specifically *located in* the Arctic, greenhouse gas emissions that will affect the Arctic indirectly via climate change are not covered by the ranking.

3.6 | Recruitment of experts for survey

Input was received from 173 experts. In order to encourage them to contribute, the International Panel on Arctic Environmental Responsibility (IPAER) was set up as a freestanding and independent international body (IPAER, 2018). Experts were then recruited as IPAER members. This meant that their contribution was formalized and given status. The aim was to make it more attractive for competent, busy experts to contribute to the ranking. Motivating respondents to contribute is one of the main challenges when carrying out surveys, and this approach might be useful for other surveys too.

TABLE 2 Definition of environmental responsibility

Aspect	Details
Damage	Minimizing damage to Arctic ecosystems (marine, freshwater, and terrestrial).
Species	Avoiding endangering Arctic species, both fauna and flora.
Toxins	Minimizing the release of toxic substances to the air, water, and soil.
Accidents	Minimizing the risk of accidents that could harm the environment.
Cleanup	Cleaning up any environmental damage.
Subcontractors	Ensuring that subcontractors behave in an environmentally responsible way.
Consent	Ensuring FPIC of local people.
Indigenous peoples	Avoiding disrupting the lives and livelihoods of Arctic indigenous peoples.
Legislation	Upholding national environmental laws and international legal instruments and guidelines.
Transparency	Transparency about industrial activities and environmental damage.
Reporting	Publishing annual environmental reports certified by a public or professional auditor.
Standards	Environmental reporting compliant with GRI guidelines and ISO 14001 environmental management certification.

Abbreviations: FPIC, free, prior, and informed consent; GRI, Global Reporting Initiative.

The recruitment of experts was laborious. Background checks were carried out, and some experts were also interviewed by telephone or email. This is one reason why this article has multiple coauthors, as the recruitment and engagement work was divided among several people familiar with different extractive industries and Arctic areas.

The aim was not to select a statistically representative sample of respondents but rather to select the most relevant and competent people. As all segments of expert input had to be connected with each other directly or indirectly for the SSRR algorithm to function, it was particularly important to recruit experts who were familiar with more than one Arctic country or extractive industry sector and could help link together the input on those countries or sectors.

On the one hand, the greater the number of experts, the more solid the survey. On the other hand, the stricter the selection of experts, the higher the quality of their input and thus the survey. It was therefore necessary to balance quantity and quality in the selection of experts. The experts were drawn from all seven Arctic states and included people with relevant expertise from another

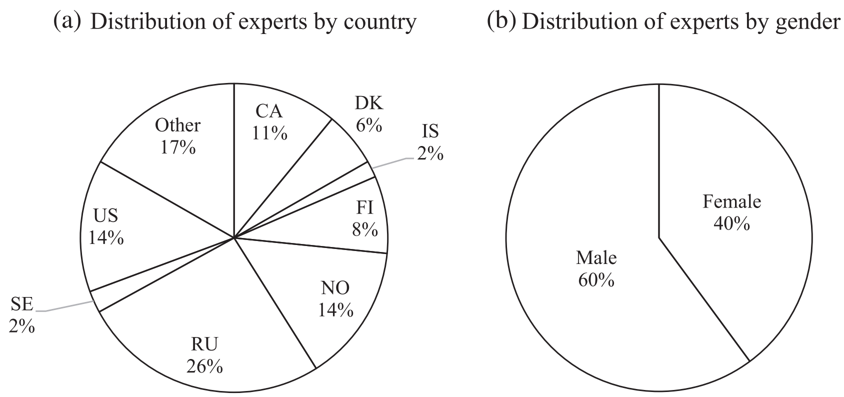

FIGURE 2 Composition of experts

10 non-Arctic countries. This geographical spread of experts made it possible to cover companies operating in all Arctic states (see Figure 2A). A balance was sought between female and male respondents, and a ratio of 40% female and 60% male experts was achieved (see Figure 2B).

To ensure multifaceted input, people were recruited from a variety of backgrounds, including academics, journalists, consultants, government officials, employees of NGOs, indigenous representatives, and residents of regions where the oil and gas or mining industries operate. The largest group of experts recruited was academics, mainly because more in-depth information about them was publicly available, making it easier to ascertain their competence, and partly because they were more likely to be neutral than, for example, company or community representatives. Some government officials and company staff declined to contribute to the index because they felt that it would not be appropriate for someone in their position.

The experts committed to acting impartially and disclosing any conflicts of interest. Their input was anonymized so that it would not be possible to trace it back to individual respondents.

4 | RESULTS

The final ranking is presented in Table 1. The three highest ranked companies are Western companies operating in Norway. However, companies operating in the United States (Alaska) had the highest average rank. The bottom of the ranking is dominated by companies operating in Russia. Overall, large companies are ranked higher than small companies; state-controlled companies are ranked higher than private companies; and oil and gas companies are ranked higher than mining companies. The results are discussed in further detail below.

The bottom three companies in the ranking—marked with italics—could not be ranked in relation to each other as there are no companies below them for the algorithm to feed off. They were left that way in order to keep the ranking methodology consistent. Another seven companies could not be included in the ranking at all because none of the experts had an opinion about them. These are listed in Appendix D.

4.1 | Large versus small companies

Many large companies do well in AERI, which corresponds with the findings of other researchers (e.g., Lee, 2015; Shvarts et al., 2016). For a company with a turnover of billions of dollars, the cost of having staff with competence on environmental and social issues and control systems for avoiding environmental damage and conflict may not be that high per dollar of revenue, whereas for a smaller company with a smaller income, the relative cost may be considerably higher (Blowfield & Murray, 2011; Lyons et al., 2016). Larger, more established companies are likely to have a greater interest in protecting their reputation, brand name, and market position;, and they may be under greater scrutiny from civil society, the media, and their shareholders and investors (Franks, 2015; Frynas, 2009). Larger companies also have more resources for self-promotion. Smaller and newer companies may have less confidence in future earnings and less of a brand name to protect, as well as an ability to operate below the radar of civil society and less resources for self-promotion. Thus, on the one hand, the fact that larger companies have higher positions in the ranking might indicate a possible bias in favor of individual large companies on the part of the experts (e.g., because they are better known). On the other hand, it can also be interpreted as indicating that the structural characteristics of large companies give them stronger incentives and capacities than small companies for sound environmental management, and therefore, it is possible that the perceptions of the experts adequately reflect reality on the ground.

4.2 | Highest and lowest ranked companies by sector and by country

Based on the complete ranking in Table 1, the perceived five best and five worst performing companies were identified in the oil and gas sector and in the mining sector, respectively (see Table 3). The three best and worst performing companies in each Arctic country were also identified (see Table 4). Equinor, Total, Aker BP, ConocoPhillips, and BP are seen as the most environmentally responsible extractive companies working in the Arctic, whereas Dalmorneftegeophysica, Eriell, First Ore Mining Company, Stroygaz Consulting, and

TABLE 3 Highest and lowest ranked oil and gas and mining companies (numbers represent rankings)

		Oil and gas companies		Mining companies
Top 5	1	Equinor (NO)	8	Anglo American (FI)
	2	Total (NO)	11	Baffinland Iron Mines Corporation (CA)
	3	Aker BP (NO)	15	MMG Resources (CA)
	4	ConocoPhillips (US)	16	Arctic Gold Mining (NO)
	5	BP (US)	17	Elkem (NO)
Bottom 5	114	Arktikmorneftegazrazvedka (RU)	111	North-Western Phosphorous Co. (RU)
	116	Dalmorneftegeophysica (RU)	112	EMX Royalty Corporation (SE)
	117	Zarubezhneft (RU)	113	Hannukainen Mining (FI)
	118	Eriell (RU)	115	Sunstone Metals (SE)
	118	Stroygaz Consulting (RU)	118	First Ore Mining Company (RU)

TABLE 4 Highest and lowest ranked companies by country of operation (numbers represent rankings)

	Canada	Denmark	Finland	Norway
Top 3	11 Baffinland Iron Mines	31 Capricorn Greenl. Expl.	8 Anglo American	1 Equinor
	12 Chevron	41 Hudson Resources	35 Agnico Eagle Mines	2 Total
	15 MMG Resources	54 Bluejay Mining	72 Nortec Minerals	3 Aker BP
Bottom 3	88 True North Gems	59 Greenland Resources	98 First Quantum Min.	102 Vår Energi
	91 Northern Cross Energy	66 Nunaoil	99 Magnus Minerals	107 Trust Arktikugol
	108 TMAC Resources	84 IronBark Zinc	113 Hannukainen Mining	109 The QUARTZ Corp.
	Russia	**Sweden**	**United States**	
Top 3	13 Gazprom	18 Boliden	4 ConocoPhillips	
	19 Kinross Gold	23 LKAB	5 BP	
	22 Novatek	101 Beowulf Mining[a]	6 Exxon Mobil	
Bottom 3	118 Eriell	101 Beowulf Mining[a]	70 Great Bear Petrol.	
	119 First Ore Mining	112 EMX Royalty Corp.	94 Brooks Range Petr.	
	120 Stroygaz Consulting	115 Sunstone Metals	96 Caelus Energy	

[a]AERI includes only five companies operating in Sweden, so Beowulf Mining is included both among the top 3 and the bottom 3.

Zarubezhneft are seen as the least environmentally responsible. There are fewer mining companies than oil and gas companies at the top of the table. The top three companies are operating in Norway, whereas the companies ranked 4–6 are operating in the United States (Alaska). Although companies operating in Russia dominate the lower ranks—the bottom five all operate in Russia—low-ranking companies (ranked between 100 and 118) are also operating in Canada, Finland, Norway, and Sweden.

4.3 | Average ranks by sector, ownership, and country

The average ranks of different categories of company were compared according to sector and country, and according to whether they were state controlled or private companies. The boxplots in Figures 3–5 show the mean rank, median rank, and quartiles of each category of company.

Figure 3 shows that oil and gas companies have higher average ranks than mining companies. This finding is similar to that of Overland (2016), who found that oil and gas companies performed better than mining companies on indigenous rights in the Arctic. Out of the 10 top-ranked companies, there is only one mining company:

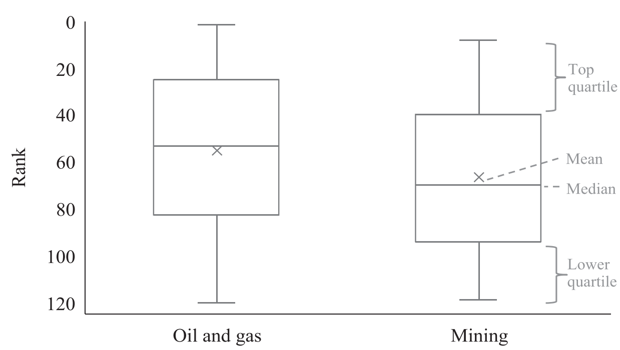

FIGURE 3 Average rank of oil and gas versus mining companies

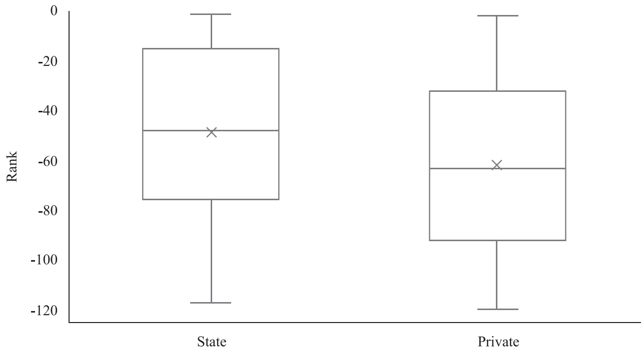

FIGURE 4 Average rank of state versus private companies

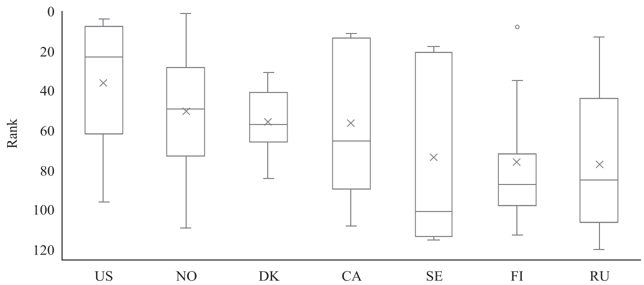

FIGURE 5 Average and median rank of countries

Anglo American, ranked eighth. Similarly, in a ranking of the quality of sustainability reporting by Vormedal and Ruud (2009), oil and gas companies achieved higher average scores than those from other sectors.

A possible reason for the higher ranks of oil and gas companies is that they have higher public profiles and better known brands and are therefore forced to be more conscious about environmental protection. This explanation fits with Rahman et al.'s (2020) finding that firms that perform better environmentally take larger market shares. Consumers choose among gas stations representing different oil companies, subjecting the companies to pressure over their environmental performance. By contrast, the products of mining companies are incorporated into other goods before they are sold to consumers, reducing consumer attention to mining companies. Few consumers know who supplied the steel for their car or the minerals used in their mobile phone. However, the growing popularity of Fairphones (with recycled and sustainably sourced components) and the increase in mineral-related voluntary sustainability initiatives, including Fairtrade Gold, the Aluminum Stewardship Initiative, the Fair Cobalt Alliance, and IRMA, suggest that sustainable sourcing of minerals is becoming increasingly important (Potts et al., 2018).

The higher rank of oil companies could also be related to the fact that mining operations are onshore and are more likely to have a direct impact on land and communities, whereas many oil and gas company operations are offshore. Further research would be needed to determine the reason for this disparity in perceptions of performance between mining and oil and gas companies.

Figure 4 shows that state-controlled companies have a higher average rank than privately controlled companies. For the purposes of this ranking, "state-controlled" is defined as companies where a majority of the shares are controlled by the state. The average rank of state-controlled companies in the ranking is pulled upwards by the ranks of Equinor (1) and Gazprom (13). However, both of these companies are partially privatized and actively traded on stock exchanges, which means that they actually confirm the rule.

Figure 5 shows that companies operating in the United States (that is to say, Alaska) have the highest average rank, followed by countries operating in Norway, Denmark (Greenland), Canada, Sweden, Finland, and Russia—in that order. Thus, although Thurner and Proskuryakova (2014) found already in 2014 that Russian companies were paying more attention to environmental protection than they did previously, their mean ranks in AERI indicate that they are still lagging behind their Western peers. However, if one looks at the median rather than mean rank, companies operating in Sweden come out the lowest, whereas Russian companies come out better than both their Finnish and Swedish peers. Using the mean ensures that all values are taken into account, whereas the median reduces sensitivity to broad data ranges and outliers.

At the 13th place, Gazprom came out significantly better than most of its Russian peers. This contrasts with the WWF/Creon ranking of environmental transparency of oil and gas companies, which ranks Gazprom sixth out of 22 Russian companies in 2018 and 10th out of 20 companies in 2019 (Knizhnikov et al., 2018, 2019). The WWF/Creon ranking also lists Zarubezhneft second in both 2018 and 2019, whereas the same company comes in at No. 117 in AERI. The AERI results may reflect a pro-Gazprom bias among the experts who provided input for the ranking. However, AERI is the result of input from both Russian and Western experts, who ranked other Russian and non-Russian companies in their inputs. Among those experts who ranked both Gazprom and other Russian companies, Gazprom was quite consistently ranked above its Russian peers, whereas those who ranked Zarubezhneft consistently ranked it below its Russian peers. It is therefore also possible that the disparity between the results of AERI and the WWF/Creon ranking reflects the difference between measuring environmental transparency through publicly available materials and perceiving environmental performance through the eyes of a diverse range of experts. However, this is a question for further research and debate.

Regarding countries of operations, Figure 5 can be compared with the results of the 2017 Klynveld Peat Marwick Goerdeler (KPMG) survey of corporate social responsibility disclosure and reporting practices among the 100 largest companies in each of 49 countries where the companies have offices (KPMG, 2017). If one looks up the Arctic countries in the KPMG survey, one finds that companies based in Denmark rank the highest, followed by the United States, Norway, Sweden, Canada, Finland, and Russia. Thus, whereas there are some differences between KPMG's results and AERI, the similarity is notable, considering that the KPMG survey covers the whole of these countries, not just their Arctic regions, and the two rankings employ entirely different methodologies.

Whereas AERI yields results that are comparable with other rankings (and diverges from others), the AERI methodology has arguably proven more sensitive to issues that are not captured in formal reporting. This can be seen in the case of Teck, the mining and metals company based in Canada and operating in Alaska, which was ranked No. 1 in Overland (2016)—which did not reflect its negative reputation on environmental and indigenous rights issues (see Section 3.2). Despite extensive gathering of publicly available data, and assessment of the data according to formal criteria, Overland (2016) did not capture these weaknesses. By contrast, in AERI—which is based on expert perceptions that extend beyond formal reporting—Teck comes out as 60th out of 120 companies. Similarly, the controversial Russian companies Lukoil and Norilsk Nickel—ranked first and third, respectively, in the Polar Index (Nikonorov et al., 2018a)—are ranked 37th and 38th, respectively, in AERI, behind five other Russian companies (see Table 1 and Section 3.2).

5 | CONCLUSIONS

This article has provided a detailed description of the methodology used to compile the AERI, along with an analysis of the key findings. The use of the new SSRR method to analyze expert perceptions has helped to avoid issues normally associated with perceptions surveys, such as the varying strictness of contributing experts. Moreover, because it is able to cover highly disparate units—in this case extractive industry companies of different sizes and types, operating in diverse sectors and geographical regions of the Arctic—it is able to cover more units in one ranking. AERI has also demonstrated how this is possible at a low cost—all of the expert inputs were voluntary, and no additional travel was required. The AERI approach could be applied to other contexts at a similarly low cost.

AERI is entirely relativistic. It does not imply that the environmental performance of companies is good or bad in absolute terms; it simply orders them in relation to each other. It is up to the reader to determine whether to think of the top-ranked companies as "good" and the bottom-ranked as "bad" in terms of their environmental responsibility, or all the companies as varying degrees of good or bad. In terms of governance, however, AERI's aim is to stimulate a desire among companies to rise in the rankings and to perform better than their peers.

One conclusion that we can draw from this exercise is that different ranking methodologies can yield different results. It is therefore important to make clear the type of data a ranking is based on—for example, by indicating that it is a perceptions survey or being clear on whether it is a ranking of environmental responsibility or transparency. It is also useful to triangulate the results with other sources: we found that the results of AERI are in line with other sources in many cases. The positions of individual companies and the relative performance of particular countries as they are reflected in the ranking will undoubtedly be questioned, and the results will be interpreted in various ways, but this is welcomed, given that one of the aims of the ranking is to generate discussion and debate.

Such a ranking might be an opportunity to draw attention to smaller, lesser known companies that are frequently overlooked, and thus act as an incentive for them to improve their performance. It could also spur research that critically assesses to what extent the actual performances of larger companies support their placements in the ranking, or to explore the reasons why oil and gas companies rank higher than mining companies—and whether this is likely to change over time in light of growing concern about mineral sustainability.

In its current form, AERI is thus an experiment in what could be called "governance without enforcement." It may trigger public debate and dialogue, internal corporate thinking, civil society activism, and—if repeated—an environmental race to the top among extractive industry companies. This could reduce some of the risks associated with relying heavily on environmental regulation by governments, such as red tape and corruption, different legal and regulatory frameworks, and variable environmental standards. This does not imply that the state is seen as unimportant for environmental governance in the Arctic. AERI is not meant to replace the governance roles of Arctic states or multilateral institutions but to complement them and perhaps stimulate improvements among them as well.

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ORCID

Indra Overland https://orcid.org/0000-0002-5955-4759

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APPENDIX A

Complete ranking table with company details

Rank	Company	Main Arctic country of operation	HQ country	Offshore only	O&G	Mining	50%+ state-owned	50%+ privately owned
1	Equinor	NO	NO		X		X	
2	Total	NO	FR		X			X
3	Aker BP	NO	NO	X	X			X
4	ConocoPhillips	US	US		X			X
5	BP	US	UK		X			X
6	Exxon Mobil	US	US		X			X
7	ENI	US	IT		X		X	
8	Anglo American	FI	UK			X		X
9	Repsol	US	ES		X			X
10	Royal Dutch Shell	US	NL	X	X			X
11	Baffinland Iron Mines Corporation	CA	CA			X		X
12	Chevron	CA	US	X	X			X
13	Gazprom	RU	RU		X		X	
14	Arctic Slope Regional Corp.	US	US		X			X
15	MMG Resources	CA	AU			X	X	
16	Arctic Gold Mining	NO	US			X		X
17	Elkem	NO	NO			X		X
18	Boliden	SE	SE			X		X
19	Novatek	RU	RU		X			X
20	NANA Regional Corporation	US	US			X		X
21	Atlantic Petroleum	NO	DK	X	X			X
22	Kinross Gold	RU	CA			X		X
23	LKAB	SE	SE			X	X	
24	North Energy	NO	NO	X	X			X
25	Wintershall	NO	DE	X	X			X
26	Alyeska Pipeline Service Company	US	US		X			X
27	Severstal	RU	RU			X		X
28	DEA Norge	NO	NO	X	X			X
29	Sydvaranger Gruve	NO	NO			X		X
30	Yamal LNG	RU	RU		X			
31	Capricorn Greenland Exploration	DK	DK	X	X			X
32	Achimgaz	RU	RU		X		X	
33	Petoro	NO	NO		X		X	
34	Imperial Oil	CA	CA		X			X
35	Agnico Eagle Mines	FI	CA			X		X
36	Norwegian Rose	NO	NO			X		X
37	Lukoil	RU	RU		X			X
38	Norilsk Nickel	RU	RU			X		X
39	Doyon	US	US		X			X
40	Leonhard Nilsen & Sonner	NO	NO			X		X
41	Hudson Resources	DK	CA			X		X

(Continues)

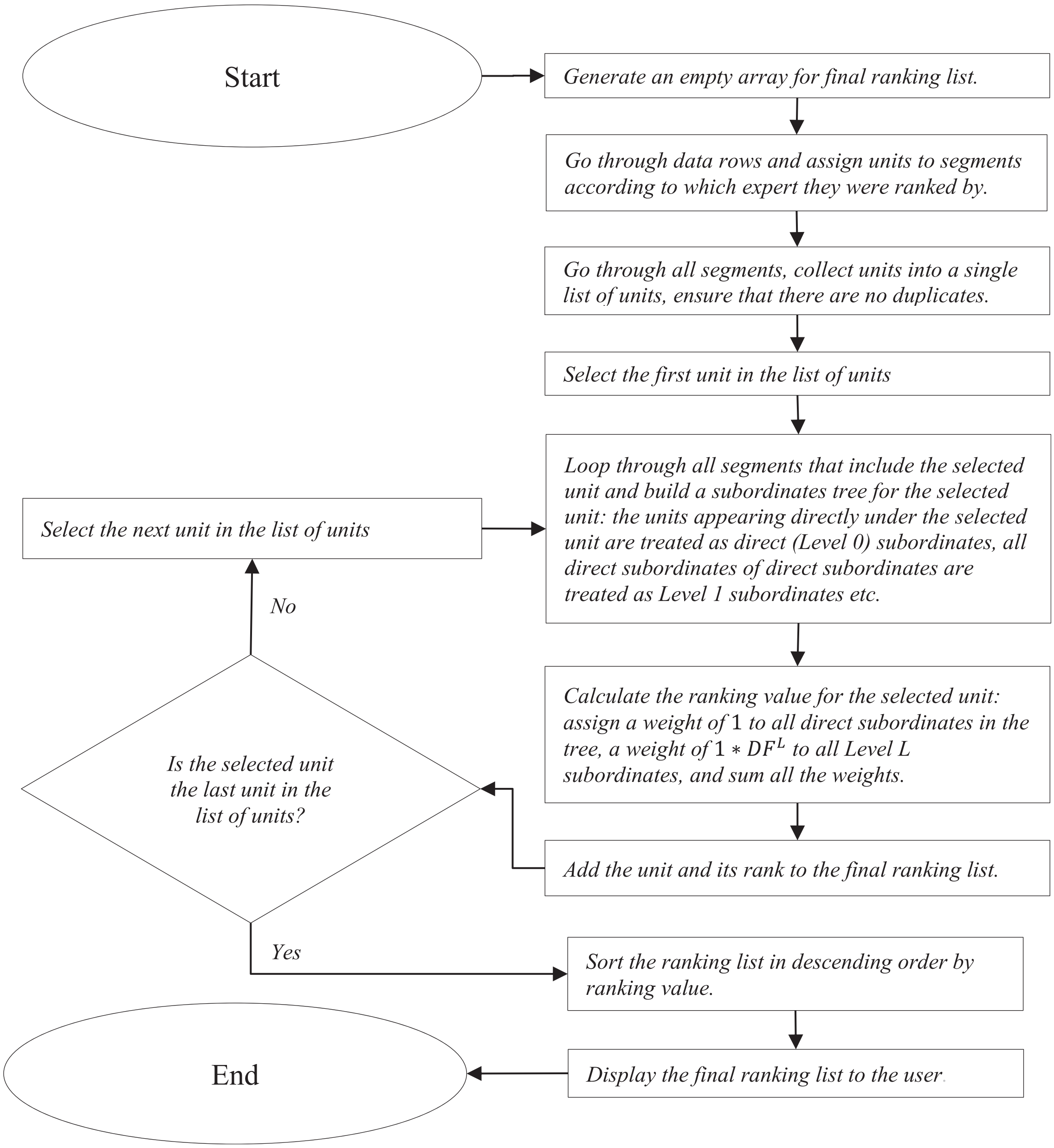
Rank	Company	Main Arctic country of operation	HQ country	Offshore only	O&G	Mining	50%+ state-owned	50%+ privately owned
42	Nordic Mining	NO	NO			X		X
43	Lundin	NO	SE	X	X			X
44	Yamalzoloto	RU	RU			X		X
45	Omya Hustadmarmor	NO	CH			X		X
46	OMV	NO	AT	X	X			X
47	Geo Mining	NO	NO			X		X
48	Bashneft	RU	RU		X		X	
49	Tullow Oil	NO	UK	X	X			X
50	ENGIE	NO	FR		X			X
51	Spirit Energy	NO	DE	X	X			X
52	Nussir	NO	NO			X		X
53	ALROSA	RU	RU			X	X	
54	Bluejay Mining	DK	UK			X		X
55	Occidental Petroleum	US	US		X			X
56	E.ON	NO	DE	X	X			X
57	Platina Resources	DK	AU			X		X
58	PGNiG	NO	PL	X	X		X	
59	Greenland Resources	DK	CA			X		X
60	Teck Resources	US	CA			X		X
61	Marine Arctic Geological Expedition	RU	RU	X	X			X
62	Hilcorp	US	US		X			X
63	Fortis Petroleum Corporation	NO	NO	X	X			X
64	Lime Petroleum	NO	NO	X	X			X
65	Auryn Resources	CA	CA			X		X
66	Nunaoil	DK	DK	X	X		X	
67	Norge Mineral Resources	NO	CH			X		X
68	Kovdorsky GOK	RU	RU			X		X
69	Arctic Marine Engineering-Geol. Expeditions	RU	RU		X			X
70	Great Bear Petroleum	US	US		X			X
71	Centrica Resources	NO	UK	X	X			X
72	Nortec Minerals	FI	CA			X		X
73	Dragon Mining	FI	AU			X		X
74	Aurion Resources	FI	CA			X		X
75	Concedo	NO	NO	X	X			X
76	Rosneft	RU	RU		X		X	
77	Northgas	RU	RU		X			X
78	Skaland Graphite	NO	NO			X		X
79	Sibelco Nordic	NO	BE			X		X
80	Nenetskaya Neftyanaya Komp.	RU	RU		X			X
81	Store Norske	NO	NO			X	X	
82	Edison	NO	IT	X	X			X
83	Noreco	NO	NO	X	X			X
84	IronBark Zinc	DK	AU			X		X
85	Polymetal Int.	RU	CY			X		X
86	Commander Resources	CA	CA			X		X

Rank	Company	Main Arctic country of operation	HQ country	Offshore only	O&G	Mining	50%+ state-owned	50%+ privately owned
87	Taranis Resources	FI	US			X		X
88	True North Gems	CA	CA			X		X
89	Tertiary Minerals	FI	UK			X		X
90	Gold Fields	FI	ZA			X		X
91	Northern Cross Energy	CA	CA		X			X
92	Vorkutaugol	RU	RU			X		X
93	PhosAgro	RU	RU			X		X
94	Brooks Range Petroleum	US	US		X			X
95	SK Rusvietpetro	RU	RU		X			X
96	Caelus Energy	US	US		X			X
97	Novourengoyskaya Burovaya Kompaniya	RU	RU		X			X
98	First Quantum Minerals	FI	CA			X		X
99	Magnus Minerals	FI	FI			X		X
100	RUSAL	RU	RU			X		X
101	Beowulf Mining	SE	UK			X		X
102	Vår energi	NO	NO	X	X			X
103	Lovozerskiy GOK	RU	RU			X		X
104	Surgutneftegas	RU	RU		X			X
105	CNPC	RU	RU		X			X
106	Komnedra	RU	RU		X			X
107	Trust Arktikugol	NO	RU			X	X	
108	TMAC Resources	CA	CA			X		X
109	The QUARTZ Corp.	NO	FR			X		X
110	Almazy Anabara	RU	RU			X		X
111	North-Western Phosphorous Company	RU	RU			X		X
112	EMX Royalty Corporation	SE	CA			X		X
113	Hannukainen Mining	FI	FI			X		X
114	Arktikmorneftegazrazvedka	RU	RU	X	X			X
115	Sunstone Metals	SE	AU			X		X
116	Dalmorneftegeophysica	RU	RU		X			X
117	Zarubezhneft	RU	RU		X		X	
118	*ERIELL*	*RU*	*RU*		*X*			*X*
118	*Stroygazconsulting*	*RU*	*RU*		*X*			*X*
118	*First Ore-Mining Company*	*RU*	*RU*			*X*		*X*

The three last companies are italicized because they share one rank.
Country codes: CA, Canada; DK, Denmark; FI, Finland; NO, Norway; RU, Russia; SE, Sweden; US, United States.

APPENDIX B

Algorithm flowchart



APPENDIX C

SSRR algorithm computer code

This is the hypertext preprocessor (PHP) open code for the automated SSRR algorithm used to process expert input data for AERI.

```php
<?php
header('Content-Type:text/html; charset=utf-8');

$units = array();
$experts = array();
$ranking = array();
$segments = array();

if(($handle = fopen('data.csv', 'r')) !== false) {
       while(($data = fgetcsv($handle, 0, ",")) !== false)
       {
              $units[] = $data[0];
              $experts[] = $data[1];
              $ranking[] = $data[2];
              unset($data);
       }
       fclose($handle);
}

foreach (array_unique($experts) as $e) {
       $segments[$e] = array();
}

foreach ($units as $k => $v) {
       $segments[$experts[$k]][$v] = array($ranking[$k]);
}

foreach ($segments as $k => $v) {
       asort($v);
       $segments[$k] = $v;
}

$units = array_values(array_unique($units));

function findChildren($parent, $unit, $children, $level) {
       global $segments;
```

```
        $generation = array();

        foreach($segments as $pool) {
                if (isset($pool[$unit])) {
                        $unitRank = $pool[$unit][0];
                        foreach($pool as $pk => $pv) {
                                if ($pk != $parent
                                && $pv[0] > $unitRank
                                && !isset($children[$pk])) {
                                        $children[$pk] = 1 * pow(0.85, $level);
                                        $generation[] = $pk;
                                }
                        }
                }
        }
        if (sizeof($generation) > 0) {
                $level++;
                foreach($generation as $child) {
                        $children = findChildren($parent, $child, $children, $level);
                }
        }

        return $children;

}

$rank = array();

foreach($units as $unit) {
        $children = array();
        $rank[$unit] = round(array_sum(findChildren($unit, $unit, $children, 0)), 5) * 100000;
}

arsort($rank);

$result = array();

foreach ($rank as $k => $v) { $result[$v][] = $k; }

$numberOfSegments = sizeof($segments);

$numberOfUnits = sizeof($units);

$notice = false;

echo  "<h4>Ranking  for  "  .  $numberOfUnits  .    "  units  in  "  .  $numberOfSegments  .  "
segments:</h4>";
echo "<ol>";
foreach ($result as $k => $v) {
        if ( sizeof($v) > 1) {
                $notice = true;
                echo "<li>";
                foreach($v as $vk => $vv){
                        echo (0 == $vk) ? "<span style='color: red;'>" . $vv . "</span>" : " |
<span style='color: red;'>" . $vv . "</span>";
                }
                echo "</li>";
        } else {
                echo "<li><span>" . $v[0] . "</span></li>";
        }
}
echo "</ol>";

if ($notice) {
        echo "<h2>Notice:</h2><hr><p>The above list contains units with equal ranking (colored
        red). These units have the same position in the final list. Please, consider providing
        extra data with ranking of these units relative to each other.</p><hr>";
}
?>
```

APPENDIX D

Companies that were included in initial database but omitted due to lack of expert input

Company	Country*
CGRG	DK
Idemitsu	NO
Lotos	NO
Northern Iron	NO
Northern Shield Resources	DK
Nytis Exploration	CA
Spike Exploration Holding	NO

* Country codes: CA, Canada; DK, Denmark; FI, Finland; NO, Norway; RU, Russia; SE, Sweden; US, United States.