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Socioeconomic Effects of Mining in the Arctic: Enhancing Benefits for Greenland

PhD dissertation

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Executive summary

The research agenda for mineral economics have traditionally emphasized the relationship between natural resource abundance and macroeconomic performance. However, the research on effects of mining on the regional and local scale with an emphasis on socioeconomic development is not particularly comprehensive. To alleviate this gap, this dissertation complements and contributes to the growing stream of research on local and regional effects by assessing micro-level socioeconomic effects of mining in the Arctic. This provides important insight and knowledge to inform Greenland as an emerging resource economy about the socioeconomic effects and business development opportunities of mining on host regions. It is valuable for Greenland to acquire knowledge from experiences of other Arctic regions that have encountered mining in order to manage their natural resources in a way that maximizes benefits for the Greenlandic society. For this purpose, it is important to investigate possibilities that can enhance capabilities of the Greenlandic business community in the mining industry.

To address the stated objectives, three research questions are formulated that in combination answer the primary aim of the dissertation:

> *RQ1: What are the micro-level socioeconomic effects of mining in the Arctic?*
>
> *RQ2: How can the Greenlandic business community overcome limitations of smallness and enhance local business development and application of Greenlandic businesses in mining projects?*
>
> *RQ3: How can a holistic assessment framework be developed that considers environmental, economic, and social dimensions and includes stakeholder values in order to evaluate mining projects prior to construction?*

These three research questions comprise four research papers, where RQ1constitutes two separate research papers under the following titles: *"Socioeconomic value creation and the role of local participation in large-scale mining projects in the Arctic"* and *"Mining in Arctic and Non-Arctic regions: a socioeconomic assessment"*. RQ2 constitutes a research paper under the title: *"Transitioning from an economic cluster to a collaborative community: mining projects in Greenland"* and RQ3 constitutes a research paper under the title: *"Multi-criteria decision analysis approach to a holistic assessment of a proposed mining project in Greenland"*. Following the approach of pragmatism, this research utilizes mixed methods to accommodate the complexity and

interdisciplinary nature of the subject and to provide comprehensive and meaningful answers to the research questions.

The first paper *"Socioeconomic value creation and the role of local participation in large-scale mining projects in the Arctic"* to address RQ1 (*What are the micro level socioeconomic effects of mining in the Arctic?*) is a comparative case study of two operating large-scale mining projects: the Red Dog Mine in Northwest Arctic Borough in Alaska and the Diavik Diamond Mine in Northwest Territories in Canada. A five-phase (exploration; planning; construction; operation; closure) life-cycle model for mining projects is outlined to serve as a framework for understanding and analyzing socioeconomic effects of mining. The comparative case study shows that direct employment is a significant socioeconomic benefit. Both mining projects provide education and training to the local workforce cooperatively with the local community, which is linked to employment opportunities and career advancements. Outsourcing of tasks creates indirect employment and business development opportunities derived from supporting industries, which has substantial effects on the local business communities. The derived business in supporting industries includes transportation and logistics services, catering and camp services, construction support, and supply services such as fuel, heavy equipment, and explosives.

The study reveals that mining is not the biggest direct employer. Hence, it is important to take stock of the indirect employment and growth in supporting industries when assessing micro-level socioeconomic effects. It is also important to note that mining contributes to the general economy of the host regions, where taxes and royalties are utilized to improve services and care to local residents.

An overarching observation is that both mining cases display is a high level of participation of local actors in the decision-making and negotiation processes throughout the planning phase concerning mine development and operation. The increased participation of stakeholders is established to have a positive influence on socioeconomic outcomes in the following phases of the mining project's life-cycle.

The second research paper *"Mining in Arctic and Non-Arctic regions: a socioeconomic assessment"* to address RQ1 (*What are the micro level socioeconomic effects of mining in the Arctic?)* is an econometric analysis, which empirically establishes the socioeconomic effects of mining on host municipalities in the Arctic regions of Norway, Sweden, and Finland. The analysis focused on the period three years prior to a mine opening to three years after the mine begins operation. The purpose is to capture the effects of mines during the construction and operation phases.

The results show significant and strong positive employment effects and a clear shift in the industrial structure in host municipalities. The employment effect accumulates to 364 persons in host municipalities, which means that an additional 364 new jobs are created compared to employment in municipality without mining activities. This effect persists and increases to 436 persons by the third year of operation. In additional, the number of people outside the labor force is reduced and unemployment is decreases. This point toward that people, who were previously not considered part of the labor market are now taking up jobs and entering the labor market. Mining does not have an effect on population size, which indicates that the positive employment effects remain local.

Mining has a strong influence of the industry structure in host municipalities. The employment share to the mining industry increases by 1.6 percentage points when the mine starts operation, and the effect increases to 3.1 percentage point in year three of operation. The increased employment share allocated to the construction industry is evident three years prior to mine opening, and is 2.1 percentage points higher than usual the year prior to operation and 1.5 percentage points higher the year the mine starts operation. In the following years the effect reverts back to normal. The employment share allocated to the primary sector increases by 2.4 percentage points and the effect persists throughout the period of investigation. There is a significant effect on the wholesale and retail industry. There are no significant effects on the employment share allocated to other industries, including transportation, manufacturing, electricity, gas, and water supply. Further, the results show a positive effect on the number of young people, 20–39 years old, in the municipalities and a significant drop in crime rates, which is evident two years prior to mine opening and persists. The study does not establish significant effects in the municipalities for gender composition, childbirth rates, or human capital distribution as a consequence of mine development.

The assessments of micro-level socioeconomic effects of mining in Canada, Alaska, and the Arctic regions of Norway, Sweden, and Finland addressed in RQ1 provide comprehensive insight about what happens to the host regions when developing mines, which is highly valuable to Greenland as an emerging resource economy. The remaining two research questions address topics with the purpose of maximizing value creation for the Greenlandic society.

The third research paper *"Transitioning from an economic cluster to a collaborative community: mining projects in Greenland"* addresses RQ2 (*How can the Greenlandic business community overcome limitations of smallness and enhance local business development and application of Greenlandic businesses in mining projects?*) is a single-case study based on data from interviews, to investigate the ability of cluster development and the collaborative approach to enhance capabilities of the Greenlandic business community in the mining industry.

The single-case study focuses on the recently established cluster, Arctic Cluster of Raw Materials (ACRM), which serves as a platform for firms relevant to extractive industries in Greenland. The purpose of ACRM is to strengthen competitiveness and increase opportunities of subcontractors to mining projects in Greenland. The study underlines that the Greenlandic business community is challenged by smallness, inadequate resources, lack of extensive experience with the mining industry, and subcontractor barriers. For this reason I analyze how a collaborative design can be a strategy to overcome the prevailing challenges because collaboration enables SMEs (small medium-sized enterprises) to gain economies of scale and mobilize a variety of resources, which gives competitive advantage and possibility to access new markets. The analysis directs toward a transition from a cluster relevant to extractive industries to a collaborative community in order to enable member firms to realize business development that the single member firm cannot achieve with own effort by being a part of a cluster.

The study emphasizes the facilitating role to manage the transition process, as a shared service provider is required in every collaborative community. The transition should be pursued as a deliberate attempt by ACRM, where ACRM has the ability to undertake the facilitating role. The analysis reveals that ACRM already conducts strategic initiatives but needs to perform the remaining activities of a shared service provider, which includes developing and providing core elements of the collaborative community design, such as infrastructure, protocols, and knowledge commons. It is important to consider the five proximity dimensions (cognitive, geographical, social, organizational, and institutional) in the transition process and in the activities assigned to a shared service provider, as they are mechanisms that influence linkages between firms. The analysis presents a conceptual model for the transition process from an economic cluster to a collaborative community, which is based on the core architectural elements of the collaborative community design. The conceptual model considers the five proximity dimensions both as enablers and barriers to the transition process and collaboration. The elements of the collaborative community have the possibility to mediate the proximity dimensions, as these elements can be tailored to fit the needs of the collaborative community.

Collaboration represents a new approach to organize small firms and business development in remote regions throughout the Arctic, including Greenland, with the purpose of enhancing local capabilities.

The fourth research paper *"Multi-criteria decision analysis approach to a holistic assessment of a proposed mining project in Greenland"* addresses RQ3 (*How can a holistic assessment framework be developed that considers environmental, economic, and social dimensions and includes stakeholder values in order to evaluate mining projects prior to construction?*) is based on a multi-criteria decision analysis to develop a holistic assessment framework, which is a practical instrument that can be applied by various stakeholders to evaluate proposed mining projects in Greenland.

The study is a quantitative approach to evaluation of mining projects prior to construction and includes environmental, economic, and social dimensions, and stakeholder values. The framework applies the weighted sum method (WSM) among the methods for multi-criteria decision analysis (MCDA) to assess alternatives. The framework integrates data assembled in environmental impacts assessments (EIA) and social impacts assessments (SIA) and translates these into a MCDA. The identified impacts in EIA and SIA reports comprise the criteria list.

MCDA includes stakeholders' weights to each criterion, which represents each stakeholder's perception of importance of each criterion. The results of the study demonstrate the applicability of the assessment framework by assessing the proposed mining project Isua iron ore mine in Greenland. Impacts identified by EIA and SIA which are prepared by independent consultants for the Isua project, comprise the criteria list and include 44 identified impacts originally scored as positive or negative low, medium, and high. In this study, this is converted into values from 1 (very high negative) to 10 (very high positive). The alternatives included in the assessment are Isua-mine and a zero-mine alternative. Four key stakeholder groups (community, government, business, and NGO) are selected, and their weights to each criterion from 1 (very low interest) to 5 (very high interest) are provided according to their generic interests.

The outcome of the assessment serves as an illustrative example of method application. The holistic assessment framework is a valuable evaluation method to support decision makers and increase local participation during the planning phase and to address sustainability and socioeconomic value creation of proposed mining projects.

Overall the three research questions are addressed using a variety of methods and both quantitative and qualitative data. The main conclusions are the positive socioeconomic effects on regional and local level from mine development, including significant direct employment, indirect employment derived from supporting industries, education, and the importance of participation in the decision-making and negotiation processes. In addition, the collaborative community design is a strategy to enhance capabilities of the Greenland business community in the mining industry.

Short summary in Danish

Forskningen indenfor minedrift har traditionelt fokuseret på sammenhængen mellem forekomsten af naturresurser og makroøkonomisk udvikling. Imidlertid er forskningen om effekterne af minedrift på regionalt og lokalt niveau med fokus på socioøkonomisk udvikling ikke omfattende. Denne afhandling bidrager til dette forskningsområde ved at analysere socioøkonomiske effekter af minedrift i Arktis. Dette tilvejebringer betydelig viden til at informere Grønland, som en kommende minenation, om socioøkonomiske effekter og muligheder for forretningsudvikling for værtsregioner på baggrund af minedrift. Det er værdifuldt for Grønland at tilegne sig viden på baggrund af erfaringerne fra andre arktiske områder med minedrift, for at forvalte naturresurserne på en måde, der øger værdiskabelsen for the grønlandske samfund. I dette henseende, er det vigtigt at undersøge tiltag, som kan forbedre mulighederne for the grønlandske erhvervsliv i mineindustrien.

Følgende tre forskningsspørgsmål er formuleret som afdækker afhandlingens genstandsfelt:

> *FS1: Hvad er de socioøkonomiske effekter af minedrift i Arktis på mikroniveau?*
>
> *FS2: Hvordan kan det grønlandske erhvervsliv overkomme begrænsninger forbundet med små virksomheder og styrke den lokale forretningsudvikling og anvendelsen af de grønlandske virksomheder i mineprojekter?*
>
> *FS3: Hvordan bør en helhedsorienteret vurderingsramme udarbejdes som anskuer de miljømæssige, økonomiske og sociale dimensioner samt inkluderer interessenternes værdier for at evaluere mineprojekter forud for opførelsen?*

Disse tre forskningsspørgsmål udgør fire artikler, hvor FS1 udgør to artikler med følgende titler: *"Socioeconomic value creation and the role of local participation in large-scale mining projects in the Arctic"* og *"Mining in Arctic and Non-Arctic regions: a socioeconomic assessment".* FS2 udgør en artikel med titlen: *"Transitioning from an economic cluster to a collaborative community: mining projects in Greenland"* og FS3 udgør en artikel med titlen: *"Multi-criteria decision analysis approach to a holistic assessment of a proposed mining project in Greenland"*.

Med en pragmatisk tilgang benytter denne forskning sig af blandende metoder for at rumme kompleksiteten og tværfagligheden af genstandsfeltet og for at bidrage med omfattende og meningsfulde svar på forskningsspørgsmålene.

Den første artikel *"Socioeconomic value creation and the role of local participation in large-scale mining projects in the Arctic"* afdækker det første forskningsspørgsmål (*Hvad er de socioøkonomiske effekter af minedrift i Arktis på mikroniveau)* er et komparativt casestudie af to storskala mineprojekter, Red Dog Mine i Northwest Arctic Borough i Alaska og Diavik Diamond Mine i Northwest Territories i Canada. En fem-fases livscyklusmodel for mineprojekter (efterforskning, planlægning, anlæg, drift, og lukning) er udarbejdet, som fungerer som en analyseramme for socioøkonomiske effekter af minedrift. Det komparative casestudie viser at direkte beskæftigelse i minerne er en væsentlig socioøkonomisk fordel. Begge mineprojekter tilbyder uddannelse til den lokale arbejdsstyrke i samarbejde med lokalsamfundet, som knytter sig til beskæftigelsesmulighederne. Udlicitering af opgaver skaber indirekte beskæftigelse og erhvervsudvikling i de afledte industrier, som har en betydelig effekt for det lokale erhvervsliv. De afledte forretningsudviklingsmuligheder omfatter transport og logistik, catering og lejr services, bygge- og anlægsvirksomhed, samt forsyning af brændstof, udstyr og sprængstoffer.

Analysen påpeger at minedrift ikke er den største direkte arbejdsgiver. Derfor er det vigtig at tage bestik af den indirekte beskæftigelse og vækst i de afledte industrier ved vurderingen af socioøkonomiske effekter på mikroniveau. Det er også vigtigt at understrege at minedriften bidrager til den generelle økonomi i værtsregionerne i form af skatter og royalties, som anvendes til at forbedre sociale ydelser til borgerne.

Analysen viser at der er en høj grad af deltagelse af lokale aktører i beslutnings- og forhandlingsprocesser i planlægningsfasen vedrørende anlæg og drift af minen i begge eksempler. En øget deltagelse af lokale aktører har en positiv indflydelse på socioøkonomiske værdiskabelse, som gør sig gældende i de efterfølgende faser af en mineprojekts livscyklus.

Den efterfølgende artikel *"Mining in Arctic and Non-Arctic regions: a socioeconomic assessment"* som afdækker det første forskningsspørgsmål (*Hvad er de socioøkonomiske effekter af minedrift i Arktis på mikroniveau)* er en økonometrisk analyse, der afdækker de socioøkonomiske effekter af minedrift på kommuneniveau i de arktiske områder i Norge, Sverige og Finland. Analysen fokuserede på perioden tre år før en mineåbning og de efterfølgende tre år med det formål at afdække effekterne af minedrift i anlægsfasen og i driftsfasen.

Resultaterne viser signifikante og særdeles positive beskæftigelseseffekter samt en industriel omstrukturering i værtskommunerne. Beskæftigelseseffekten opgøres til 364 personer i værtskommunerne, hvilket betyder, at der skabes yderligere 364 nye arbejdspladser i forhold til beskæftigelsen i kommunerne uden minedrift. Denne effekt er vedvarende og stiger til 436 personer i år tre af driftsfasen. Desuden reduceres antallet af personer uden for arbejdsstyrken samt et fald i ledigheden. Dette peger på at folk som tidligere ikke var betragtet som en del af arbejdstyrken, nu finder arbejde og kommer ind på arbejdsmarkedet. Minedrift har ikke en effekt på befolkningsstørrelsen, hvilket indikerer at de positive beskæftigelseseffekter forbliver lokale.

Minedrift har en stærk indflydelse på den industrielle struktur i værtskommunerne. Beskæftigelsesandelen til minesektoren stiger med 1,6 procentpoint, når minen påbegynder drift og denne effekt øges til 3,1 procentpoint i år tre af driftsfasen. Beskæftigelsesandel i byggebranchen er 2,1 procentpoint højere en normalt tre år før mineåbningen og 1,5 procentpoint højere end normalt i året hvor driften påbegynder. I de efterfølgende år vender effekten tilbage til normal. Beskæftigelsesandel i den primærsektor stiger med 2,4 procentpoint og er vedvarende i hele undersøgelsesperioden. Desuden er der en signifikant effekt på engros- og detailhandel. Der er ingen betydelige effekter på beskæftigelsesanden afsat til andre industrier, herunder transport, produktion, og el, gas og vandforsyning. Resultaterne viser en positiv effekt på andel af unge, 20-39 år gamle, samt et signifikant fald i kriminalitet, hvilket er tydelig to år før mineåbning og er vedvarende i de efterfølgende år. Analysen påviser ikke signifikante effekter i kommunerne vedrørende kønssammensætningen, fødselsrater, og uddannelsesniveau som følge af minedrift.

Det første forskningsspørgsmål afdækker socioøkonomiske effekter af minedrift i Canada, Alaska, og de arktiske områder i Norge, Sverige og Finland, hvilket giver et omfattende indsigt i og viden om, hvad der sker i værtsregionerne, når der etableres miner. Dette er et værdifuldt bidrag til Grønland som en kommende minenation. De efterfølgende to forskningsspørgsmål belyser emner, med det formål at øge værdiskabelsen for det grønlandske samfund.

Den tredje artikel *"Transitioning from an economic cluster to a collaborative community: mining projects in Greenland"* som afdækker det næste forskningsspørgsmål (*Hvordan kan det grønlandske erhvervsliv overkomme begrænsninger forbundet med små virksomheder og styrke den lokale forretningsudvikling og anvendelsen af de grønlandske virksomheder i mineprojekter?)* er et single-casestudie baseret på data fra interviews, for at undersøge dannelsen af klynger og en samarbejdstilgang til at øge kapaciteten for det grønlandske erhvervsliv i mineindustrien.

Casestudiet fokuserer på Arctic Cluster of Raw Materials (ACRM), som er en nylig etableret klynge, der fungerer som en platform for virksomheder med interesse i den grønlandske råstofsindustri. Klyngens formål er at styrke konkurrenceevnen og øge mulighederne for underleverandører til mineprojekter i Grønland. Analysen understreger at det grønlandske erhvervsliv er udfordret grundet små virksomheder, utilstrækkelige resurser og erfaringer med mineindustrien, samt underleverandører barriere. Med henblik på dette, analyseres der en samarbejdstilgang, som en strategi for at overkomme de aktuelle begrænsninger, da samarbejde muliggør stordriftsfordele og mobiliserer flere resurser for små og mellemstore virksomheder, hvilket giver konkurrencemæssige fordele samt adgang til nye markeder. Analysen peger på en udvikling og en overgang fra en klynge til en samarbejds-community, for at giver klyngens medlemsvirksomheder mulighed for at realisere forretningsudvikling, som den enkelte virksomhed ikke kan opnå ved egen indsat ved at være en del af en klynge.

Analysen lægger særlig vægt på den faciliterende rolle i overgangsprocessen, da en fælles tjenesteudbyder er påkrævet i enhver samarbejds-community. Overgangen bør gennemføres som et planlagt tiltag fra ACRM, hvor ACRM har evnerne til at påtage sig den faciliterende rolle. Analysen viser at ACRM allerede udfører strategiske tiltag, men som en fælles tjenesteudbyder skal der yderligere udvikles og leveres infrastruktur, protokoller samt vidensbank tilpasset til behovet. Det er vigtigt at tage højde for de fem nærheds-dimensioner (kognitive, geografiske, sociale, organisatoriske og institutionelle) i overgangsprocessen og i de aktiviteter, der er tildelt en fælles tjenesteudbyder, fordi disse mekanismer påvirker samarbejdet mellem virksomhederne. Analysen præsenterer en konceptuel model for overgangsprocessen fra en klynge til en samarbejds-community, som er baseret på elementerne fra et samarbejds-community design. Den konceptuelle model anskuer de fem nærheds-dimensioner både som katalysatorer og barrierer for overgangsprocessen og samarbejde. Elementerne fra et samarbejds-community design har mulighed for at mediere nærheds-dimensionerne, da disse elementer kan tilpasses til behovene i et samarbejds-community.

Samarbejde repræsenterer en ny tilgang til organisering af små virksomheder og forretningsudvikling i fjerntliggende områder i Arktis, herunder Grønland, med det formål at styrke den lokale kapacitet.

Den fjerde artikel *"Multi-criteria decision analysis approach to a holistic assessment of a proposed mining project in Greenland"* som afdækker det sidste forskningsspørgsmål (*Hvordan bør en* *helhedsorienteret vurderingsramme udarbejdes som anskuer de miljømæssige, økonomiske og sociale dimensioner samt inkluderer interessenternes værdier for at evaluere mineprojekter forud for opførelsen?*) er baseret på en multi-kriterie beslutningsanalyse for at udvikle en helhedsorienteret vurderingsramme, som er et praktisk redskab, der kan anvendes af interessenter til mineprojekter i Grønland.

Det er en kvantitativ tilgang til vurdering af mineprojekter før anlægsfasen, og som omfatter de miljømæssige, økonomiske og sociale dimensioner samt inkluderer interessenternes værdier. Vurderingsrammen anvender *weighted sum method* (WSM) blandt metoderne til multi-kriterie beslutningsanalyser (MCDA) for at vurdere alternativerne. Vurderingsrammen integrerer data, som er indsamlet i *environmental impact assessments* (EIA) og *social impact assessments* (SIA). De identificerede påvirkninger i EIA og SIA rapporterne udgør kriterielisten.

Multi-kriterie beslutningsanalyser omfatter interessenternes vægtning af hvert kriterium, hvilket repræsenterer interessenternes opfattelse af betydningen af de enkelte kriterier. Resultaterne demonstrerer anvendelsen af vurderingsrammen ved at fortage en vurdering af det foreslående mineprojekt Isua jernmalmminen i Grønland. De identificerede påvirkninger i EIA og SIA, som er udarbejdet af uafhængige konsulenter for Isua projektet, udgør kriterielisten og omfatter 44 identificerede påvirkninger, som oprindeligt er scoret som positiv eller negativ lavt, medium og højt. I dette studie er disse omdannet til værdier fra 1 (meget højt negativt) til 10 (meget højt positivt). Alternativerne som indgår i vurderingen er Isua-mine og en nul-mine. fire interessentgrupper er udvalgt (*community, government, business,* og *NGO*), og deres vægtning af hvert kriterium fra 1 (meget lav interesse) til 5 (meget høj interesse) er fastsat i henhold til deres generiske interesseområder.

Resultaterne af vurderingen er et illustrativt eksempel på anvendelse af metoden. En helhedsorienteret vurderingsramme er en værdifuld vurderingsmetode for at understøtte beslutningstagerne og øge den lokale deltagelse i planlægningsfasen samt at sikre socioøkonomisk værdiskabelse og bærdygtigheden af foreslående mineprojekter.

De tre forskningsspørgsmål er adresseret på baggrund af forskellige metoder og både kvantitativt og kvalitativt data. Hovedkonklusionerne er de positive socioøkonomiske effekter af minedrift på regionalt og lokalt niveau, som inkluderer betydelig direkte beskæftigelse, indirekte beskæftigelse afledt af støtteindustrierne, uddannelse, og vigtigheden af deltagelse i beslutnings- og forhandlingsprocesser. Desuden er et samarbejds-community design en strategi for at styrke det grønlandske erhvervsliv i mineindustrien.

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1 Chapter 1: Introduction

This chapter provides an introduction and motivation for my dissertation on Arctic mining and Greenland. First, I introduce the evolving research agenda for mineral economics and my focus of investigation within this theme. Then, I outline the contextual setting of investigation by introducing the Arctic and subsequently the emerging resource economy, Greenland. I provide three research questions and a brief thematic introduction to each, which constitute the four research papers of my dissertation.

1.1 Mining and socioeconomic development

The research agenda for mineral economics has traditionally emphasized macroeconomic issues, where resource abundance has been linked to macroeconomic performance (Sachs and Warner, 1995, 1999, 2001). Discussions have concerned the natural resource curse, which refers to the paradox whereby countries having high ratio of natural resources tend to have lower economic growth rates compared to countries without abundance of natural resources. Conversely, other researchers argue that the resource curse paradox is the exception rather than the rule, or that the evidence of the relationship between natural resource extraction and economic growth is contradictory (Davis, 1995, 1998, 2010). Studies have since challenged, reexamined, and revised the resource curse theory and the relationship between negative economic growth and resource abundance by considering alternative measures and providing possible explanations (Mainardi, 1997; Stijns, 2005; Brunnschweiler, 2008; Brunnschweiler and Bulte, 2008). Thus, discussions and different perspectives on the relationship between natural resource extraction and macroeconomic performance have produced a vast literature (Frankel, 2010; Davis and Tilton, 2005).

Recently, the research agenda for mineral economics has shifted focus. New concerns include effects of mining on indigenous and local communities, such as environmental effects, government policy, corporate responsibility, and the role of mineral exploitation in economic development (Gordon and Tilton, 2008). These areas of interests and concerns will persist over the foreseeable future and shape the research agenda of mineral economics (Gordon and Tilton, 2008).

While economists and researchers within other social science disciplines have extensively examined the macro-level effects of mineral development, research on the regional- and local-scale effects of mining operations, with emphasis on socioeconomic development, is not particularly comprehensive (McMahon and Remy, 2001; Rolfe et al., 2011; Gilberthorpe and Papyrakis, 2015). I complement and contribute to the emerging research agenda for mineral economics by studying micro-level socioeconomic effects of mining in the Arctic. Within this theme, I contribute to Arctic social science research by shedding light on the Arctic context of micro-level socioeconomic effect of mining. The geographical distribution of analysis includes Alaska, Canada, and the Arctic regions of Norway, Sweden, and Finland. By doing so, I provide important insight, which can inform Greenland as an emerging resource economy about the socioeconomic effects, including business development opportunities, of mining on host communities.

At local and regional level, the effects of extraction activities vary greatly. There is evidence of large-scale projects that are separated from the local socioeconomic environment and provide minimal benefits to local communities (Sandlos and Wiersma, 2000; Sandlos and Keeling, 2012). Nevertheless, other studies of socioeconomic effects of extractive industries, both within and outside the Arctic region, do show that extractive industries can boost economic growth considerably through direct and indirect employment, engage quite extensively with local communities and become the core of regional and local economies (AMAP, 2010; McMahon and Remy, 2001; Carrington, 1996; Aroca, 2001; Hajkowicz et al., 2011; Rolfe et al., 2011; Duhaime, 2004; McDonald et al., 2006). Hence, extractive industries can be vital to developing the Arctic region (Duhaime and Caron, 2006), and the Arctic states are often promoting extraction of natural resources as an essential strategy for creating local employment and securing national economic growth (Kullerud, 2011).

1.2 The Arctic and the extractive industries

The melting Arctic attracts renewed attention for natural resource development, which is driven by a growing pressure for resources. Mining activity across the regions of the Arctic is an important contribution of raw materials to the world economy and has become an important economic factor in remote regions (Huskey and Morehouse, 1992; Kullerud, 2011). Hence, the region has been opened to massive exploitation with the support of nation policies for industrial development or energy security (Duhaime and Caron, 2006). At present, considerable extractive activities are carried out in Scandinavian, North American, and Russian sections of the Arctic (Harsem et al., 2011). A great quantity of minerals are extracted in the Russian region of the Arctic, mostly on the Kola Peninsula and in Siberia, including copper, nickel, tin, apatite, platinum, gold, and diamonds. Mining in the Canadian Arctic is for copper, lead, zinc, gold, and diamonds (Huntington and Weller, 2005) and Alaska has one of the largest and richest zinc mines in the world (Capozza, 2005). Furthermore, Fennoscandia has a long history of mining and exploration in the Arctic region of Norway, Sweden, and Finland (FODD, 2012).

The Arctic, on the whole, is characterized by dependence on government transfer payments, export of natural resources, and subsistence activities (Duhaime, 2004; Aarsæther, 2004; Huskey and Pelyasov, 2015). Adding to this, consumable products are imported to the region, as there are limited local manufacturing and processing activities taking pace (Larsen, 2010). The Arctic economy represents two fairly distinct development models, which are either structured around exploitation of nonrenewable resources, such as minerals and hydrocarbons, or renewable resources, such as forestry or marine resources (Duhaime and Caron, 2006).

Mining in the Arctic is challenged by climate conditions, limited infrastructure, and remoteness (Southcott, 2009). Hence, in order to achieve economies of scale, projects must be large in scale to lower costs of operation (Southcott, 2009; Larsen, 2010). Nevertheless, resource extraction will continue to be essential to development of the Arctic in the future, due to the importance of the Arctic as a global resource supplier is expected to increase (Nuttall, 2009). Extractive industry is a high priority in many Arctic societies and is perceived as a guarantee for economic prosperity (Wilson and Stammler, 2016). Locally, hopes and expectations remain high for local employment in economically weak and remote regions, regardless of unrealized expectations and wasted opportunities in the past (Wilson and Stammler, 2016).

1.3 Greenland as an emerging resource economy

Similar to other Arctic regions, Greenland has received global attention in recent time as a new major frontier region of the Arctic due to the prospect of exploration and exploitation of significant mineral and hydrocarbon resources (Nuttall, 2012, 2013). The industrial structure in Greenland is similar to other Arctic economies, which is characterized by a large public sector, a block grant of 3,679 DKK million in subsidies from Denmark, and high dependence on fisheries that accounts for 90 percent of total exports (Økonomisk Råd, 2012; Larsen, 2010; Duhaime and Caron, 2006; Huskey and Pelyasov, 2015; Statistics Greenland, 2016). Variations in marine harvest, earnings, and export volume emphasize Greenland's economic vulnerability and the necessity of economic diversification. Natural resource extraction is considered a pathway to economic prosperity for the Greenlandic society (Government of Greenland, 2014). The Self-Government Act in 2009 gave Greenland full property right to dispose and exploit minerals in the Greenlandic subsoil (Inatsisartutlov, 2009).

Various interest groups, such as governmental bodies, business associations, and advisory groups argue that mining and hydrocarbon development is a pillar that can and should be developed in order to recover economic growth and improve economic conditions (Government of Greenland, 2014; Ministry of Foreign Affairs, 2011; Økonomisk Råd, 2012; The Committee for Greenlandic Mineral Resources to the Benefit of Society, 2014; Copenhagen Economics, 2012). As of 2016, 60 mineral exploration licenses and 6 mineral exploitation licenses have been granted in Greenland (MLSA, 2016a). The license areas are spread throughout the coast of Greenland. The majority of the firms that have obtained exploration licenses are from Australia, Canada, and the UK, and firms that are granted exploitation licenses are mainly from Canada, China, the UK, and Greenland (MLSA, 2016a). Greenland's key mineral resources include iron ore, zinc, copper, gold, gemstones, and rare earth elements. Rare earth elements are particularly important for modern technologies such as wind turbines and mobile phone, where China currently controls 90 percent of world reserves (Wilson, 2015).

Even though Greenland is articulated as a new frontier for natural resource development, there are several cases of mining throughout the history in Greenland with varying production lifetime. These include cryolite mining in Ivittuut from 1854 to 1987, graphite mining in Amitsoq from 1915 to 1924, marble mining in Maarmorilik from 1936 to 1940, and lead-zinc mining in Mestersvig in Central East Greenland from 1953 to 1959; coal mining in Qullissat from 1924 to 1972; and the Black Angel lead-zinc-silver mine in Maarmorilik, near Uummannaq in West Greenland from 1973 to 1990 (MLSA, 2016b; Nordregio, 2010). A common feature for these early mining activities is the relatively small-scale size with few direct employment opportunities and absence of Greenlandic labor. New surveys and drilling have been conducted throughout 2014–2015 for the old Black Angel Mine, in case a new ore is found the mine can be revitalized. Potential upcoming mining projects include the molybdenum deposit at Malmbjerg in East Greenland; iron ore at Isukasia in Western Greenland; Kvanefjeld and Kringlerne in South Greenland for rare earth elements (most likely the largest REE deposit in the world); and Aappaluttoq for ruby and pink sapphire at Fiskenaesset in West Greenland (MLSA, 2016b; Wilson, 2015).

A mining industry in Greenland represents an opportunity for economic growth and positive effects on local businesses and employment (Government of Greenland, 2014; Ministry of Foreign Affairs, 2011). Nonetheless, various interest groups stress that the Greenlandic business community is challenged by size limitations, lack of extensive experience with the mining industry, and necessary competencies, which can impede the realization of potential business development provided by the mining industry (The committee for Greenlandic mineral resources to the benefit of society, 2014; Copenhagen Economics, 2012; Økonomisk Råd, 2012). Hence, it is important to investigate possibilities that will enhance capabilities of the Greenlandic business community in the mining industry.

As an emerging resource economy, it is highly relevant for Greenland to turn its attention toward other Arctic regions where mining operations are taking place, for learning and knowledge building purposes, in order to manage their resources in a way that maximizes benefits for the Greenlandic society. This leads to the initial research question:

RQ1: What are the micro-level socioeconomic effects of mining in the Arctic?

I address this research question by outlining the life-cycle with its distinct phases of a mining project based on life-cycle theory (Stark, 2011; Kotler and Keller, 2006; McGahan et al., 2004; Terzi et al., 2010; Cusumano et al., 2006). By doing so, I create a framework for understanding and analyzing socioeconomic effects of mining that takes account of variations of effects throughout distinct phases such as construction and operation of a mine. At the micro level, mining is found to have effects on direct employment at the mine; indirect employment through derived industries such as transportation, logistics, construction, service, and supply; and training and education (McMahon and Remy, 2001; Rolfe et al., 2007; Rolfe et al., 2011; Aroca, 2001; Hajkowicz et al., 2011; MMSD, 2002; Clements et al., 1996; Loveridge, 2004; Ivanova; 2014). I analyze socioeconomic effects of established mining operations in Alaska, the Canadian Arctic, and the Arctic regions of Sweden, Norway, and Finland. I distinguish between direct and indirect effects and between the construction and operation phases of the life-cycle of a mining project. This forms two research papers presented in two separate chapters: a comparative case study of two large-scale mining projects in Alaska and Canada, and an econometric analysis of mining in Arctic Scandinavia (Norway, Sweden, and Finland).

The initial research question provides important insight and knowledge to inform Greenland about effects of mining on host regions. The following two research questions address ways to maximize benefits for the Greenlandic society in the mining industry by enhancing capabilities of the local business community in the mining industry and by developing a holistic assessment framework to evaluate proposed mining projects.

RQ2: How can the Greenlandic business community overcome limitations of smallness and enhance local business development and application of Greenlandic businesses in mining projects?

I address RQ2 by investigating the ability of cluster development and the collaborative approach to enhance local business development and application of Greenlandic businesses in mining projects. Clusters are concentrations of interconnected companies and institutions in a specific geographic region that are linked by commonalities and complementarities in a particular field (Singh and Evans, 2009; Porter, 1998, 2000; Ketels, 2003; Porter et al., 2004). Formation of a cluster is based on grouping of related suppliers of services, inputs, products, equipment, expertise, and know-how. As such, a new organization form is emerging based on a collaborative community design (Fjeldstad et al., 2012; Miles et al., 2010; Snow et al., 2011; Snow, 2012; Snow et al., 2009; Bøllingtoft et al., 2012; Miles et al., 2005). Collaboration among small firms can be an advantageous strategy to overcome resource limitations, achieve competitive advantage by joining resources, gain economies of scale, and accomplish more at a faster rate than they can on their own (Franco, 2003). I focus on the recently established cluster relevant to extractive industries in Greenland, Arctic Cluster of Raw Materials (ACRM), and on a linkage between cluster development and collaboration, where clusters evolve and transition into collaborative communities. The transition process emphasizes the facilitating role of a shared service provider (Bøllingtoft et al., 2012) and the five proximity dimensions (cognitive, geographical, social, organizational, and institutional) that influence linkages between firms (Belso-Martinez, 2016; Molina-Morales et al., 2015; Boschma, 2005).

RQ3: How can a holistic assessment framework be developed that considers environmental, economic, and social dimensions and includes stakeholder values in order to evaluate mining projects prior to construction?

I address RQ3 from a Greenlandic perspective, as proposed mining projects have not entered the construction phase. As an emerging resource economy, Greenland must assess the potential negative and positive effects of proposed mining projects across the environmental, economic, and social dimensions with the purpose of maximizing benefits for the Greenlandic society. This framework supports decision-making throughout the planning phase of a mining project's life cycle.

Impact assessments such as environmental impacts assessment (EIA) and social impact assessment (SIA) follow a prospective logic, are widely adopted in the mining industry, and can be used as a means of directing decision-making toward sustainable development (Fonseca et al., 2013; Hacking and Guthrie, 2008; Vanclay, 2004). These particular assessments, EIA and SIA, are also common practice in Greenland as two separate units of assessment. Integrated appraisal of impacts across environmental, economic, and social dimensions, and of all values and possible alternatives, is helpful throughout the planning and decision-making process (Bond et al., 2001; Slootweg et al., 2001). Multi-criteria decision analysis (MCDA) also follows a prospective logic (Fonseca et al., 2013) and is widely applied in evaluation of environmental, ecological, industrial, economic, and social systems and in the context of mining operations (Wang et al., 2009; Wibowo, 2013; Govindan et al., 2014; Kommadath et al., 2012; Marinoni, 2009; Esteves, 2008a; Esteves, 2008b; Huang et al., 2011; Keisler and Linkov, 2014). MCDA promotes the role of participants in decision-making, provides solutions to complex problems, and allows more logical and scientifically defensible decision-making (Linkov and Moberg, 2012; Linkov, 2014).

I focus on the development of a holistic and inclusive assessment framework that comprises environmental, economic, and social dimensions by translating the results of EIA and SIA into a MCDA that includes stakeholder values. This provides suitable structure and analytics to a quantitative approach for evaluation of proposed mining projects and comparison of alternatives such as zero-mining.

The structure of the dissertation is as follows. The introduction is followed by a methodology section that elaborates on the choice of paradigm, the research design, and methods regarding each research activity. This is followed by the four research papers, where I address the three research questions. Lastly, I provide a concluding chapter, where I present and synthesize the main findings of the four research papers and implications for further research.

The timing to explore, investigate, and analyze Arctic's past, present, and future relevant to extractive industries is impeccable. The global plunge in commodity prices since 2014 (Nasdaq, 2016; Infomine, 2016) has created a pause in the rush for Arctic's resources, which provides a window of opportunity to take advantage of this pause to utilize research with the objective to learn and prepare for future industry upswing (Sidortsov, 2016). Toward a future that provides socioeconomic value creation for an emerging resource economy, Greenland.

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2 Chapter 2: Methodology

This chapter outlines the methodological approach of the study and the associated research activities. First, I elaborate on the conceptual framework applied. Second, I present the research design and provide a detailed overview of the design of approach used in each of the four papers.

2.1 Conceptual framework

Pragmatism offers a very practical and applied research philosophy (Tashakkori and Teddlie, 2003). The world is not seen as an absolute unity and truth is what works at the time (Creswell, 2009). Pragmatism is not committed to one system of philosophy and reality. The characteristic idea of pragmatism is efficacy in practical application (Crotty, 1998; Creswell, 2009). Tashakkori and Teddlie (2003, p. 713) define the pragmatism paradigm as *"…a deconstructive paradigm that debunks concepts such as "truth" and "reality" and focuses instead on "what works" as the truth regarding the research question under investigation. Pragmatism rejects the either/or choices associated with the paradigm wars, advocates for the use of mixed methods in research, and acknowledges that the values of the researcher play a large role in interpretation of results."*

Pragmatist researchers consider the research question to be most important with a focus on the *what* and *how* rather than the methods applied (Tashakkori and Teddlie, 2003). Pragmatism utilizes a pluralistic approach by applying multiple data collection methods in practice to derive knowledge about the research problem (Johnson and Onwuegbuzie, 2004; Creswell, 2009). It employs the idea of "what works" and values both objective and subjective knowledge (Teddlie and Tashakkori, 2009; Creswell and Clark, 2011). Philosophical pragmatism views knowledge as being both constructed and based on the reality of the world we experience (Johnson and Onwuegbuzie, 2004). Theories are view instrumentally; they become true and are true to different degrees, which are based on their current workability. Pragmatism endorses practical theory that informs effective practice. Hence, truth, knowledge, and meaning are tentative and change over time.

The pragmatist paradigm is considered the most useful philosophy for mixed methods research as it supports the use of both quantitative and qualitative research methods in the same research study (Tashakkori and Teddlie, 2003; Creswell and Clark, 2011). It provides an epistemological justification and logic for utilizing multiple approaches and methods (Johnson et al., 2007) and enables researchers to embrace a pluralistic stance of collecting all types of data to best answer the research questions (Creswell and Clark, 2011). Pragmatists apply different kinds of methods because the complexity of the context demands multiple methods. Pragmatism opens the door to different worldviews, multiple methods, and different assumptions for the mixed methods researcher (Creswell, 2009).

2.2 Mixed methods research design

In this study, I explore micro-level socioeconomic effects of mining in the Arctic, particularly how to enhance benefits for the Greenlandic community. This favors research that emphasizes the research question and applies all available approaches to understand the subject and to address complexity and the interdisciplinary nature of research (Creswell, 2009). I have chosen a mixed methods approach, as I utilize different methods to accommodate the interdisciplinarity and complexity of the study and to answer research questions as multiple approaches are inclusive and complementary rather than restrictive and constraining (Johnson and Onwuegbuzie, 2004). Mixed methods research enables the use of all tools of data collection available rather than using only the tools typically associated with qualitative or quantitative research (Creswell and Clark, 2011).

Mixed methods research is a practical synthesis that considers multiple perspectives and recognizes the importance of traditional qualitative and quantitative research in social science and business research (Johnson et al., 2007; Johnson and Onwuegbuzie, 2004; Creswell, 2009; Bryman and Bell, 2007). It applies multiple methods to address the research problem; rejects the either-or in the choice of methods; allows the use of both numbers and words; and combines deductive and inductive logic (Teddlie and Tashakkori, 2009; Creswell and Clark, 2011). The combination of qualitative and quantitative research provides a fuller picture and an expanded and more elaborated understanding of the research problems. Including standpoints of quantitative and qualitative research produces defensible, comprehensive findings and more meaningful and useful answers to research questions (Creswell, 2009; Johnson et al., 2007).

Application of mixed methods research design requires acquaintance with both quantitative and qualitative data collection and analysis techniques (Creswell and Clark, 2011), which in itself, naturally, is a comprehensive part of my research process.

I apply the *partially mixed sequential equal status design* typology as proposed by Leech and Onwuegbuzie (2009) according to their three-dimensional typology of mixed methods designs. The level of mixing (a) is partial as qualitative and quantitative data sets are collected and analyzed separately. Time orientation (b) is sequential (Johnson and Onwuegbuzie, 2004; Creswell, 2009) as data collection and analysis for each research question occur one after the other. Both qualitative and quantitative approaches have equal emphasis (c) (Johnson et al., 2007; Creswell, 2009) as I address two papers with a qualitative approach and two papers with a quantitative approach.

2.3 Research methods

I address RQ1 with both a qualitative and a quantitative approach, which constitute paper 1 and paper 2 of the dissertation. Initially, I apply a qualitative approach for paper 1, which is sequentially followed by a quantitative approach for paper 2. I address RQ2 with a qualitative approach, which constitutes paper 3, and subsequently RQ3 with a quantitative approach, which constitutes paper 4. In Table 1, I provide an overview of the mixed methods research design that I apply for the study. A detailed elaboration on methods applied to address each research question is provided in the following subsections.

	RQ1		RQ2	RQ3
Approach	Qualitative	Quantitative	Qualitative	Quantitative
Method	Comparative case study	Econometric analysis	Single-case study	Multi-criteria decision analysis
Mode of inference	Inductive	Deductive	Abductive	Deductive
Output	Chapter 3 (Paper 1)	Chapter 4 (Paper 2)	Chapter 5 (Paper 3)	Chapter 6 (Paper 4)

Table 1 – mixed methods research design overview

2.3.1 Comparative case study

I address RQ1, "*What are the micro-level socioeconomic effects of mining in the Arctic?*" from a qualitative perspective by conducting a comparative case study (Yin, 2014) with a *typical-case* approach to case selection (Gerring, 2007). The typical cases serve an exploratory role to provide insight and some general understanding of a phenomenon (Gerring, 2007). I choose two mining operations: the Diavik Diamond Mine in Northwest Territories in Arctic Canada (construction 2001–2002, operation began in 2003), and the Red Dog Mine, a zinc-lead-silver mine in Northwest Arctic Borough in Alaska (construction 1986–1989, operation began in 1989). Both mines are still in operation. These mines share similar socioeconomic and geographic features, and they are both large-scale operations and developed in recent times. The socioeconomic variables include data on employment, business creation, multiplier effects, training and education, infrastructure creation, and taxes. In this study, I include the community relations and citizen participation variable to investigate the role of local participation in the decision-making process throughout the planning phase of the life-cycle. The socioeconomic effects are identified within the life-cycle framework throughout the construction and operation phases.

2.3.2 Econometric analysis

In paper 2, I apply a quantitative approach to address RQ1 in order to assess the micro-level socioeconomic effects of mining in the Nordic Arctic (Arctic regions of Norway, Finland, and Sweden). I apply (co-authored with Anders Frederiksen) an econometric framework that allows us to identify effects that occur prior to, during, and after the mine starts operation (Jacobsen et al., 1993). Hence, the study distinguishes between the construction and operation phases of the life-cycle. We use high-quality register data at the municipality level provided by Statistics Sweden, Statistics Norway, and Statistics Finland. This comprises 1,023 municipalities, 174 of which are located in the Arctic. Additionally, we apply data from the Fennoscandian Ore Deposit Database (FODD), which contains information about mines in region. There are 34 active mines across Sweden, Norway, and Finland, 24 of which are located in the Arctic region.

In this study, we use a large set of socioeconomic variables, dependent variables, to establish how municipalities in the Arctic and non-Arctic change prior and after mines start to operate. The variables are available from 1986 to 2013 and include population size, age groups, number of men, number of women, female proportion, and child births. The employment variables (available for the period 1995–2012) include employment, unemployment, and people outside the labor force. Additionally, we decompose employment data by industry to identify the indirect effects through the derived industries. Employment shares by industry (available for the period 1995–2012) comprise eight industries: primary sector; mining; manufacturing; construction; electricity, gas, and water supply; transportation; wholesale and retail; and other. We also include education variable (available for the period 1987–2012) and crime rates (available for the period 2007–2012). This comprehensive analysis allows us to estimate the total micro-level socioeconomic effects of mining (prior to and after operation start) in municipalities where mining activities occur.

2.3.3 Single-case study

I address RQ2, "*How can the Greenlandic business community overcome limitations of smallness and enhance local business development and application of Greenlandic businesses in mining projects?*" from a qualitative perspective and by applying a single-case study design based on qualitative data (Yin, 2014; Creswell, 2009). In this case study, I apply data from interviews, which I support with data from reports, research, and statistical sources, as multiple types of data increase the robustness of results through triangulation (Bryman and Bell, 2003; Yin, 2014). I follow the seven stages process of an interview inquiry: thematizing, designing, interviewing, transcribing, analyzing, verifying, and reporting (Kvale and Brinkmann, 2009). I conduct six semi-structured interviews with six key informants. Two key informants were from the Government of Greenland, Ministry of Industry, Labour and Trade (Gov GL); one was from Greenland Business Association (GA); one was from a local Greenlandic business with experience in the mining industry and member of ACRM (GL Bus); and two were from Arctic Cluster of Raw Materials and Confederation of Danish Industry (ACRM, DI). Arctic Cluster of Raw Materials is embedded within Confederation of Danish Industry and therefore the key informants cover both institutions.

The selected key informants contribute by their comprehensive experience and knowledge relevant to the societal aspects of mining in Greenland and business community perspectives. The interviews were characterized as elite interviews (Kvale and Brinkmann, 2009) as these persons are leaders or experts in their fields. I contacted the key informants by e-mail with an introduction to the research project and a request for interviews. The theoretical proposition guides data collection and analysis (Yin, 2014). I prepared an interview guide based on three topics: Greenland and the mining industry; cluster development; and a collaborative approach. I conducted five interviews during the fall of 2015 and one interview in spring of 2016. The form of each interview was selected based on the preference of the key informant. Key informants located in Denmark chose between face-to-face, telephone, and Skype interview. Key informants located in Greenland chose between telephone and Skype interview due to the geographical distance (Creswell, 2009). I conducted four telephone interviews, one Skype interview, and one face-to-face interview. All interviews were recorded and transcribed with the interviewee's consent. I based the coding process of transcripts on meaning condensation (Kvale and Brinkmann, 2009), where I compressed statements intro briefer statements and rephrased them into few words and identified empirical themes. I conducted the analysis by applying a theoretical lens (Yin, 2014; Kvale and Brinkmann, 2009) according to the theoretical propositions.

An example of the meaning condensation process is provided below in its original language form, where the natural "meaning unit" of the transcript as expressed by the subject, is restated as simply as possible. Each transcript follows this coding process, where at the end the central themes of all interviews are tied together into descriptive statements.

Natural meaning unit	**Central theme**
"90% af virksomhederne er jo virksomheder med under 10 ansatte. Så hvis man skal gøre sig gældende i en større kontekst, så er det vejen frem. Man	Hvis man skal gøre sig gældende som

bliver nødt til at indgå i nogle samarbejder, hvor man siger vi kan ikke gøre det her alene, men vi kan gøre det sammen. Og hvis man skal gøre sig lækker overfor større internationale spillere, så skal man ud og gør sig synlig. Det er nok nemmere at sige jeg er medlem af et netværk eller en sammenslutning af virksomheder, og så har vi hver især en ekspertise eller en kompetence der er brugbart for jer, der køber denne typer af ydelser."	SME i en større kontekst, så er samarbejde vejen frem.

All interviews were conducted in Danish, and therefore transcripts and the coding process are also in Danish. However, quotations provided throughout paper 3, presented in chapter 5, are translated to English. All key informants were aware of that they are participating and contributing with their knowledge and perspectives to a research project and all remain anonymized.

2.3.4 Multi-criteria decision analysis

I address RQ3, "*How can a holistic assessment framework be developed that considers environmental, economic, and social dimensions and includes stakeholder values in order to evaluate mining projects prior to construction?*" from a quantitative perspective. The holistic assessment framework applies the weighted sum method (WSM) among the multi-criteria decision analysis (MCDA) approaches for evaluating alternatives against the criteria and the weight of each criterion by stakeholders (Linkov, 2014; Linkov and Moberg, 2012; Mateo, 2012; Pohekar and Ramachandran, 2004; Wang et al., 2009).

$$A_{WSM}^{*} = Max \sum_{i}^{j} a_{ij} w_j$$

a_{ij} is the actual value of the i alternative in terms of j criterion and w_j weight of importance of the j criterion. The total value of each alternative equals the sum of the products, where the best alternative A^*_{WSM} is the one with maximum score (Wang et al., 2009). The framework integrates data assembled in the environmental impact assessment report (EIA) and the social impact assessment report (SIA) and translates these into a multi-criteria decision analysis with the weighted sum method.

I apply the method (co-authored with Igor Linkov) to conduct a holistic assessment of the proposed Isua iron ore mine in Greenland. The Isua-mine is one of the two alternatives to be scored, and a zero-mine is the other. In a zero-mine alternative the conditions remain unchanged as the mine is not developed. The environmental impact assessment (EIA) for the Isua-mine has been conducted by an independent consultant, Orbicon A/S, on behalf of London Mining Greenland A/S according to the Government of Greenland's guidelines for preparing an environmental impacts assessment (EIA) report for mineral exploitation in Greenland (EIA of the Isua Iron Ore Project, 2013; BMP, 2011). Correspondingly, the social impact assessment report (SIA) for the Isua-mine has been produced by Grontmij A/S on behalf of London Mining Greenland A/S according to the Government of Greenland's guidelines for social impacts assessments (SIA) for mining projects (SIA of the Isua Iron Ore Project, 2013; BMP, 2009).

The context-specific impacts identified by the environmental impact assessment report (EIA) and the social impact assessment report (SIA) for the Isua-mine form the criteria list for the assessment, which includes a total of 44 impacts. These impacts have been originally scored by the independent consultants as negative or positive low, medium, and high. In the holistic assessment framework, they are converted into values from 1 to 10 (Wibowo, 2013), where 1 is very high negative and 10 is very high positive. Negative very high (-VH): 1; negative high (-H): 2; negative medium (-M): 3; negative low (-L): 4; negative very low (-VL): 5; positive very low (+VL): 6; positive low (+L): 7; positive medium (+M): 8; positive high (+H): 9; positive very high (+VH): 10.

Four key stakeholder profiles relevant to the mining industry (Azapagic, 2004) are selected for the assessment and include the *community*, *government*, *business*, and *NGOs*. The generic interests of each stakeholder group are used to weight the criteria against which the alternatives are assessed. The level of interest, none (-), some (+), and strong (++) according to Azapagic (2004) is converted into: very low interest: 1; low interest: 2; medium interest: 3; high interest: 4; very high interest: 5.

As an example of the logic, "caribou" (*"disturbance and noise by the presence of vehicles, machines, buildings, personnel and other project infrastructure, which might cause displacement of caribou"*) is identified and assessed as a medium negative (-M) impact according to the EIA for the Isua-mine. The weight of the impact "caribou" is defined as very important according to the *community* stakeholder group. Hence, the medium negative (-M) is converted to the value of 3 and the weight is converted to the value of 5. The score of the impact "caribou" according to the *community* stakeholder group is: 3 (j criterion) * 5 (w_j weight of importance of the j criterion). Stakeholder weights are normalized in the actual assessment. Therefore, the calculation is as follows: j criterion * w_j weight of importance of the j criterion = 3 * 0,035 = 0,105. This logic proceeds according to all four stakeholder groups for each of the 44 identified impacts for both alternatives. The assessment outcome serves as illustrative example of a quantitative approach to conduct holistic assessments that considers relevant stakeholders' perspectives in a pre-mining context.

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3 Chapter 3: Socioeconomic value creation and the role of local participation in large-scale mining projects in the Arctic

Paper published in The Extractive Industries and Society [1]

By Maja Due Kadenic

3.1 Abstract

This paper examines socioeconomic value creation and the role of local participation in decision-making and negotiation processes during the planning phases of two operational large-scale mining projects: Red Dog Mine in Alaska and Diavik Diamond Mine in Canada. The analysis is conducted using a proposed life-cycle framework adapted for mining projects. Local socioeconomic value creation is realised through direct employment, training, integration of supporting industries, and taxes and royalties. Further, at both mines, there was a high level of local participation during the planning phase. The phases of the life-cycle model are interrelated, and thus actions and the level of participation in the early phases have influenced socioeconomic value creation later in the life cycle. The participation of communities throughout the planning phases of mining projects is a key to facilitating sustainable development outcomes at the local level.

Key words: Arctic, extractive industries, mining, socioeconomic value creation, participation, life-cycle

3.2 Introduction

The melting Arctic presents new opportunities and challenges for mineral exploration. Considerable natural resource extraction is currently being carried out in its North American, Scandinavian, and Russian sections (Harsem et al., 2011). Industrially, the region, on the whole, is characterized by limited market economics, a dependence on government transfer payments, subsistence activities, and the export of natural resources (Aarsæther, 2004; Duhaime, 2004; Duhaime and Caron, 2006). At the same time, there are limited manufacturing and processing activities taking place locally in Arctic communities; consumable products are imported to the region (Larsen, 2010).

Resource development in the Arctic is characterized by high costs: development projects must be large in scale to lower the costs of operation in order to achieve economies of scale (Larsen, 2010). The importance of the Arctic region as a supplier of resources to the rest of the world is expected to

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increase. Resource extraction will therefore continue to be essential to the development of the region in the coming decades (Nuttall, 2009). All of the states located in the Arctic now promote the extraction of natural resources as an essential strategy for securing national economic growth and creating employment (Kullerud, 2011).

In recent years, the research agenda for mineral economics has evolved and shifted focus toward producing countries. The new set of concerns it has raised includes environmental effects, the role of government policies, social responsibility, effects on local and indigenous communities, and the role of mineral exploitation in economic development (Gordon and Tilton, 2008). The agenda has traditionally emphasized macroeconomic issues, analyzing the mining sector's benefits or lack of benefits to the national economy: discussions have focused on the "natural-resource curse." The natural-resource curse refers to the paradox of countries with high ratio of natural resources tend to have lower economic growth rates compared to resource poor countries (Sachs and Warner, 1995, 1999, 2001).

At the same time, research on the regional and local effects of mining operations, with particular emphasis on socioeconomic development, has not been particularly comprehensive (McMahon and Remy, 2001).

This paper supports and contributes to this new research agenda by providing an extended analysis of the effects of mining on local communities in the Arctic. Research has shown that local communities can experience significant and often rapid social and economic changes in regions where natural resources are extracted (Stammler and Wilson, 2006). Nevertheless, these industries have also provided development opportunities to local societies. This paper uses a life-cycle framework to broaden understanding of the socioeconomic effects of mining on local communities. It does so by identifying the key aspects and main concerns of each phase of operation, and the interrelation between these phases from a community-based business-development perspective.

The article proceeds as follows. First, the life-cycle of a mining project is introduced as a framework for understanding and analyzing socioeconomic value creation. Next, a review of the socioeconomic effects of extractive industries and the role of local participation are provided. Then, the socioeconomic value creation and the role of local participation of two operational large-scale mining projects in the Arctic are evaluated. The two case studies explored are the Red Dog Mine in

Alaska and the Diavik Diamond Mine in Canada. The presentation of the case studies is followed by a discussion and conclusion.

3.3 Life-cycle framework

The life-cycle concept has existed for many years in various industries (Stark, 2011). Vernon (1966) was the first to apply the idea to products, with the aim of explaining observed patterns of trade and investment as new industries evolved (Klepper, 1997). Product life cycle (PLC) entails predicting the course of an industry's evolution, which passes through a number of stages (Porter, 2008). Each product is managed across its life cycle, from product inception until the product is disposed of – in other words, "from cradle to grave" (Stark, 2011). Since its initial conceptualization, life-cycle theory has been further refined into more specific ideas such as PLC, industry life cycle (ILC), and product life-cycle management (PLM). The central idea is now accepted widely, and has become conventional wisdom in business (McGahan et al., 2004).

The interdisciplinary approach to life-cycle theory stretches to include studies of technological changes and technical performance, strategic challenges that are unique to each stage, entrepreneurship, and economics (McGahan et al., 2004). Cusumano et al. (2006) introduced the service parameter in firm and industry evolution, where products generate service opportunities in a variety of industries. The products are defined as the core elements, and services are defined as complementary elements. The holistic role brings products, services, processes, activities, skills, practices, techniques, and standards together (Terzi et al., 2010). There are different viewpoints on life cycles that contribute to variations in life-cycle interpretation (Stark, 2011). These include the market-oriented approach, comprised of four stages, *introduction*, *growth*, *maturity*, and *decline*; the five-stage manufacturer approach, *imagination*, *definition*, *realization*, *support*, and *retirement*; and the industry approach, *fragmentation*, *shakeout*, *maturity*, and *decline* (Stark, 2011; Kotler and Keller, 2006; McGahan et al., 2004). Essentially, the cycle has three main stages: beginning of life (BOL), middle of life (MOL), and end of life (EOL) (Terzi et al., 2010).

The basis for defining a mining project's life cycle is adapting the three main stages – BOL, MOL, and EOL – to a mining project. It begins with an exploration stage, which is the BOL. When the project matures, it enters the exploitation stage, or the MOL. Eventually, the mineral deposit becomes exhausted or is no longer feasible for exploitation, which leads to its closure or the mining project's EOL stage.

However, the three essential stages of a mining project's life cycle can be further subdivided (Storey and Hamilton, 2003; Moon and Evans, 2006; AMAP, 2010; GEUS, 2013). There is a two-level distinction, namely the core level and the complementary level, as proposed by Consumano et al. (2006). Together, these comprise all elements relating to a mining project's life cycle. Thinking in terms of life-cycle processes is important for identifying where outputs that will affect socioeconomic value creation may occur, such as direct and indirect employment and interaction with supporting industries. It is necessary to distinguish between the output that creates value for the local community where resources are extracted and the output that creates value outside of the community. The duration of each stage varies widely from project to project (Porter, 2008). The duration of the project's life, therefore, depends strongly on the specific project and the mineral commodity. The proposed life-cycle model for a mining project is illustrated in Figure 1.

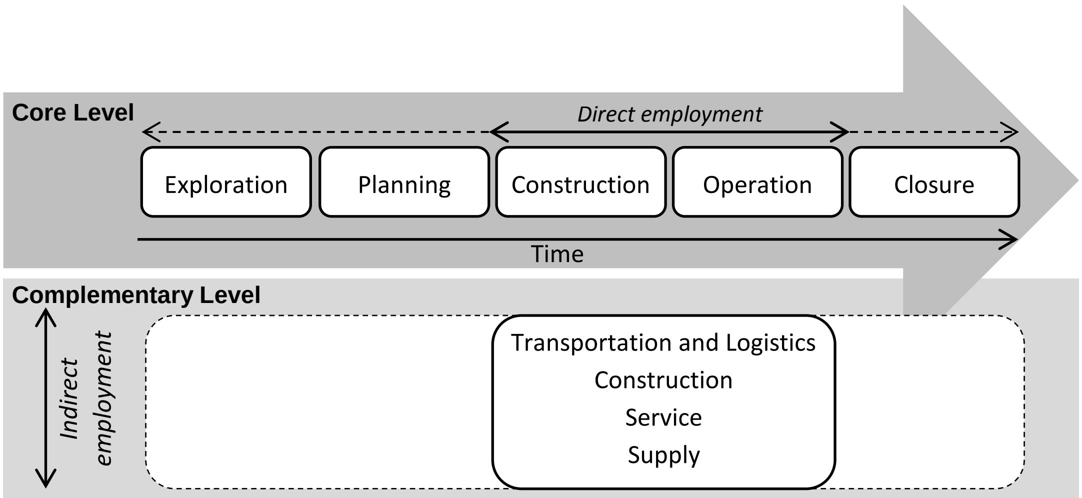

Figure 1 – Life-cycle of a mining project

The core level includes five phases, which, in combination, constitute the life cycle of a mining project. The *exploration* and *planning* phases are the BOL. The *construction* and *operation* phases are the MOL, and finally the *closure* phase is the EOL. The initial life-cycle phase is exploration, which includes activities such as geological mapping, drilling, testing and sampling. The following phase is recognized as the planning phase, with a focus on feasibility studies and a regulatory approval process. It includes technical studies and cost analysis to prove the commercial viability, the environmental and social effect assessments for the regulatory application and review process, and community hearings. Emphasis is placed on identifying potential effects and management strategies to assist decision makers. The local communities are often allowed to participate in the dialogue and negotiations between the mining company and local or regional authorities during the planning phase. The entire project is designed and prepared during this phase. This phase is followed by construction, during which infrastructure related to mineral production is established, and production facilities and camps are constructed. The next phase in the life-cycle model is operation, during which the raw material is physically extracted. Throughout the operation phase, several material processing activities occur, which may take place on site or in another region or country. These include milling, separation, smelting, refining, and storage. After years of operation, when extraction is no longer feasible, the mining project reaches its final phase, which is closure. It is necessary to have a closure management strategy in place before the project has reached the EOL. It must include provisions for remediation of the site, land reclamation and restoration, provide details of the cost of employee downsizing, and highlight social and community implications. There can be a need for local labor throughout the initial phases and the final phase. However, the greatest employment and business development effect is most likely to occur during the construction and operation phase.

Additional activities have been added to the life-cycle model that can be characterized as integration of supporting industries. These are considered complementary-level activities because they provide a service to the mine, whether it is transportation, construction, food provision, cleaning, or supply of machinery. Additional activities, comprising *transportation* and *logistics*, are vital in remote regions of the Arctic. They include air transportation, shipping, and ice-road-trucking. The *service* and *supply* industries provide the necessary support to production facilities, including food, energy, and equipment. The activity level and integration of support industries and local capabilities may vary greatly from project to project. However, it is necessary to take stock of the potential for business creation through supporting industries. As Moon and Whateley (2006) explain, one direct job in a mine can create additional indirect and induced jobs in the community. The ratio between direct jobs and generation of indirect jobs also differs from project to project. The extracted product will eventually reach the market, which can be far away from the extraction facilities. It will most likely create value outside of the region from where it is extracted on a national level or even globally. The extracted product is seen as raw material supply for processing in other industries that will lead to the development of various consumer products.

3.4 Effects of extractive industries and the role of participation

Where extraction activities are taking place, the effects on regions and local communities vary greatly. Some large-scale projects are separated from the local socioeconomic environment, and therefore provide minimal benefits to local communities. However, other projects engage quite extensively with local communities (Duhaime, 2004; McDonald et al., 2006), which can generate numerous positive local-level economic benefits. The latter is a key to developing the Arctic region (Duhaime and Caron, 2006).

The World Bank and the International Development Research Centre of Canada (IDRC) have used a case study approach to examine the effects of mining operations on local communities (McMahon and Remy, 2001). Each case study presented analyzes the benefits and costs of the mining operation on local communities from a multidimensional perspective, with the aim of disseminating important knowledge and sharing lessons with other countries (McMahon and Remy, 2001). In addition, AMAP (2010) investigates the socioeconomic effects of extractive industries in the Arctic at the local, regional, and national levels, also using a case-study approach. What these studies show is that extractive industries can boost economic growth considerably (AMAP, 2010). The total effects of large-scale mining operations on regional and local employment can be substantial. The indirect-employment effects are particularly important, and they are often equal to or even greater than direct mine employment (McMahon and Remy, 2001). The indirect-employment effects include employment in subcontracted firms and supplier firms of goods and services related to the mine. In addition to the direct- and indirect-employment effects, the multiplier effect can be substantial. It includes all non-mine-related employment (McMahon and Remy, 2001). Resource-development industries can generate spin-off effects, where large-scale exploitation projects can become the core of regional and local economies. This can lead to a vast array of subsidiary activities, including transportation, retailing, housing, construction, and operation of infrastructure, such as roads, harbors, airports, and pipelines.

One very significant positive impact brought about by large-scale mining is infrastructural development. A mining company can play a proactive role in enhancing local business opportunities through outsourcing. The multiplier effects are much greater because local subcontracted workers often spend their money locally (McMahon and Remy, 2001). Local taxes contribute positively to regional gross domestic product (GDP) by catalyzing economic growth. However, the finite nature of resource deposits means that once operations begin to wind down, outmigration may occur if a new economic base is not established.

Economic growth can fuel migration and an increase in the regional population, as well as lead to improvements in public health care, and ultimately, increase life expectancy. But an economic stimulus can also have negative social effects, including increased drug and alcohol abuse, violence, and crime (McMahon and Remy, 2001; AMAP, 2010). Additional social problems may emerge with an influx of new workers, brought about by inadequate housing, infrastructure, and educational and medical facilities, as well as increases in the number of bars, prostitution, and the poor. Usually, the lifestyles and behaviors of foreign workers differ from those of locals and can have a disturbing effect on communities (McMahon and Remy, 2001). However, increased employment, wealth, and commerce associated with the establishment of mining operations, especially in depressed areas, can also lead to cultural revival. Revenues from extractive industries can be used to finance cultural programs, strengthen a sense of cultural identity, and protect local practices (AMAP, 2010).

In decision-making and planning processes for extractive industries development, there are typically three key parties: the mining company, the local or regional community, and the government (McMahon and Remy, 2001). The most important link of the triangle is the communication between the mining company and the local community. The latter can be represented by various groups, including municipal authorities, nongovernmental organizations (NGOs), universities, churches, landowners, and community-based organizations and associations (McMahon and Remy, 2001). As Moon and Whateley (2006) explain, it is important to keep the local population informed about the development progress and obtain their approval of any project.

It is no longer sufficient to obtain solely a legal license to operate. Mining companies must also 'secure' a social license, which depends on the level of participation, consultation, and trilateral dialogue (McMahon and Remy, 2001). The emphasis on trilateral dialogue is due to an evident lack of it in previous negotiations over mine planning. In the past, mine permissions were granted based on agreements or assessments between the relevant levels of government and the mining company. In such processes, the public involvement was limited: the government tended to represent the needs and goals of the affected communities. However, the benefits rarely found their way back to the affected communities. Instead, they found their way into government coffers (Horswill and Sandovik, 2000).

Typically, mining companies import skilled labor and supplies from outside of local communities, and thus, direct benefits related to employment, service, supply business, and infrastructure improvements do not always materialize. Pine Point Mine, a lead–zinc mine which operated during 1965–1987 in the Northwest Territories of Canada, is one such example. Pine Point Mine was promoted as a vehicle for local employment creation in the region and as an engine for development in the north in general. The mine is a substantial historical example of state and private capital shaping industrial modernization in an underdeveloped hinterland region (Sandlos and Keeling, 2012). However, neither company nor government officials made much of an effort to consult with nearby local communities (Sandlos and Wiersma, 2000). An entire town was constructed to house transient mineworkers and the service community for the mine, which had a population of 1800 at its peak (Locock et al., 2006). Few locals found employment at the mine, and many suffered immensely from the damaging effects on traditional trapping and hunting grounds in the Pine Point region (Sandlos and Wiersma, 2000). Eventually, Pine Point Mine was closed, and the town was completely removed from the landscape (Locock et al., 2006).

A new paradigm is emerging in most host countries that requires community participation in the assessment and approval processes, with an emphasis on transparency and fairness to the cost and benefit assessments of mining (Horswill and Sandovik, 2000). Community participation enables identification of shared objectives between the affected community and the mine owner, thereby enhancing the potential success of the operation (Horswill and Sandovik, 2000). The relationship between mining companies and communities has evolved from paternalism to partnership in Canada, where sustainable community development is the key objective of both sides. The indigenous and local communities in Canada had very low participation in the negotiation, decision-making, and design processes of mining projects until the 1990s. Now, the indigenous groups can demand training programs and obligations to buy locally to some degree (McMahon and Remy, 2001). The socioeconomic agreements are very important when dealing with indigenous people. These agreements should include information related to quotas or targets for employment, support for local business development, local procurement, training programs, and a work environment that is supportive of local and indigenous cultures. The case studies conducted by the World Bank and IDRC (2001), AMAP (2010), and the historic case of Pine Point Mine clearly show that there is potential for both negative and positive socioeconomic effects. Even though some rules can be applied to all large-scale mining projects, such as trilateral dialogue and negotiations and transparency, each has its own unique geographical, historical, social, and cultural characteristics (McMahon and Remy, 2001).

3.5 Method and case studies

Two cases were selected to address the research question (Yin, 2014): the Diavik Diamond Mine (Diavik) and Red Dog Mine (Red Dog). Both share similar geographic and socioeconomic features.

Diavik is located in the Arctic region of Canada, and Red Dog is located in the Arctic region of Alaska. Further, both mines are large-scale operations, were developed in recent times and are still in operation. The cases rely on multiple sources of evidence, including literature, company data, and regional statistics. Theoretical propositions guided the data collection and analysis (Yin, 2014). The evidence is based on a number of key socioeconomic variables related to local communities, equivalent to case studies conducted by the World Bank and AMAP (McMahon and Remy, 2001; AMAP, 2010). This includes data on employment, business creation and development, multiplier effects, infrastructure creation, taxes, training and education, community relations, and citizen participation. The term *local community* refers to the entire local population, indigenous and nonindigenous persons, who are affected by the mining operation directly or indirectly (Pascó-Font et al., 2001). A mining company can be characterized according to three parameters: the size of the operation, which can be small, medium, or large; daily production volume in metric ton(s) (MT); and the estimated operating life span (Pascó-Font et al., 2001). Community–company relations are determined by the mining company's approach to the community. Community–company relations are shaped further by the level of involvement by community organizations and/or the public (i.e., the variable citizen participation). Participation can vary throughout the different phases of the mining project's life cycle (Castillo et al., 2001). The analysis that follows examines local participation in the decision-making process and details the socioeconomic effects of each mining project.

3.5.1 Red Dog Mine

The Red Dog Mine (Red Dog) is located 171 km north of the Arctic Circle within the Northwest Arctic Borough (NWAB) in Alaska. Here, the city of Kotzebue acts as a regional center. By 2013, the total population of the region was 7685 residents (United States Census Bureau, 2014), of whom, 85% were indigenous people with roots stretching back 4000 years in the region. Most families are involved in a mixed economy of subsistence activities, such as hunting and fishing, and full-time or part-time employment (Prno, 2013). The aboriginal land claims of Alaska Natives were settled under the Alaska Native Claims Settlement Act of 1971.

The NANA Regional Corporation Inc. (NANA) was created to represent the Iñupiat people of Northwest Alaska. It made them shareholders to facilitate titling, including in the Red Dog Creek area known to contain a rich zinc deposit (Capozza, 2005; Haley, 2012). The area began to attract interest when the USGS published a report, in 1970, indicating the presence of a large mineral deposit there. By 1982, NANA had forged an operating agreement with the large Canadian mining company, Cominco Ltd., to develop the Red Dog Mine, a zinc–lead–silver extraction project (NANA, 2014). Construction began in 1986, and by December 1989, the mine entered the operation phase. The closure date is projected to be 2031 (Haley, 2012). The concentrate is stored at a port-site facility connected to Red Dog by an 80-km road. The concentrate is then shipped out to smelters in Europe, Asia, and Canada, during a 100-day annual window of open seas. Supplies are also shipped in to the site during the 100-day window (Ednie, 2002). The mine was developed at a total cost of US$415 million (Stinson, 1993). Cominco entered into an agreement with Teck in 1986, and in 2001, Teck acquired 100% of Cominco to form Teck Cominco Ltd. Both companies have operated mines for over 100 years. In 2009, the company was renamed Teck Resources Ltd. (Teck, 2014). Teck is now one of the largest producers of zinc in the world, producing 623,000 MT of zinc in concentrate in 2013, of which 551,300 MT originated from Red Dog (Teck, 2013). This makes Red Dog one of the largest zinc mines in the world. In 2013, the mine's revenue was US$ 874 million, and its gross profit before depreciation and amortization was US$ 418 million (Teck, 2013). Teck is the operator of Red Dog, and NANA is the landowner (Red Dog Mine, 2014).

Land ownership and thereby control of mineral rights has given NANA significant influence in the selection of a partner, negotiating the terms of the development, and ensuring that the mine is developed in line with regional aspirations (Storey and Hamilton, 2003). The key objectives of the agreement were profitable development of the zinc deposit and providing long-term benefits to the population of the region (Horswill and Sandovik, 2000). NANA sought to maximize benefits for the shareholders and the region, as well as minimize adverse impacts on subsistence activities and the environment – in other words, creating jobs in a modern economy while maintaining the traditional subsistence lifestyle (Horswill and Sandovik, 2000). The agreement gave Teck the rights to build and operate the mine, while NANA would receive royalties of up to a maximum of 50% share of the profit after the initial expenditures were recovered. NANA shareholders would also receive preferential employment selection for all Red Dog jobs (Storey and Hamilton, 2003; Haley, 2012; Prno, 2013).

The agreement is an example of a framework for how a mine should be constructed and operated. Teck financed the construction, and it markets the products and operates the mines. The agreement requires it to hire and train NANA's people, protect subsistence resources, and preserve local culture (Teck, 2008). Education and training initiatives are undertaken cooperatively by Teck and NANA, with the aim of building knowledge and capacity to enable regional residents to take up positions at the mine. These initiatives include scholarship programs for studies at universities that might lead to employment at the mine; power generation, electrical, millwright, and heavy mechanics apprenticeship programs; job-shadow programs, which allow students to understand various occupations at the mine; and school visitations by NANA shareholders and mine staff (Ednie, 2002). By improving educational standards and village infrastructure, NANA leaders are working toward reducing migration from the region (Ednie, 2002).

The agreement also guarantees NANA’s involvement in decision making related to the mine. This includes having representation in a management committee that reviews and approves plans, monitors implementation, and resolves issues. NANA is also represented on an employment committee that supports efforts to hire and train its shareholders. Residents from nearby villages are also represented in a subsistence committee, with the aim of protecting local subsistence resources (Prno, 2013) by ensuring that the mine complies with environmental and wildlife standards. The committee has the authority to close down the transportation road between the port facilities and the mine during the caribou migration. Further, the committee determines the shipping-season window based on whale migration patterns (Ednie, 2002). The agreement between NANA and Teck sets a new standard for cooperation between indigenous people and a mining company (Teck, 2013).

The mine had an immediate effect on the borough. The employment in the region grew significantly when the mine opened. Not only did Red Dog contribute to the creation of stable, year-around jobs, but also the income earned from these jobs created an increased demand for goods and services. During its first four years of operation, the service sector employment grew by 46% (Stinson, 1993). Private firms have employees working at Red Dog, providing transportation and other services. Hundreds of mining jobs are provided to the borough, and many supply vendors, support services, and contractors provide jobs to the borough in connection with the mine. In 1997, Red Dog payroll was the largest employer in the borough, accounting for 26.7% of jobs; other mining activities accounted for an additional 6.5% of employment, specifically the contractors brought in during an expansion project at the mine. The remaining employment in 1997 is broken down as follows: government payroll accounted for 26.2%; services 18.9%; transportation, communications, and utilities 10.3%; trade 5.6%; finance and insurance 4.3%; and construction 1.2% (Fried and Windisch-Cole, 1999). Further, the mine had an influence on wage level in the borough. The average wage in the borough was well below the state average prior to Red Dog’s opening. However, in 1997, the average wage level in the borough exceeded the state average, with an average monthly wage of US$ 3210, compared with the statewide monthly average of US$ 2732. This premium can be attributed mostly to the mine (Fried and Windisch-Cole, 1999). Nevertheless, the government, federal, state, and local account for 40% of employment in NWBT (Shanks, 2009).

In 2013, statewide local employment at Red Dog accounted for 80% of the total workforce. NANA employees accounted for 52% of the mine's total workforce (459 employees) in 2013 (Teck, 2013). However, Red Dog had yet to meet the goal of 100% NANA shareholder employees (Ednie, 2002). In addition to direct employment opportunities at the mine, a number of joint-venture opportunities have been established with NANA business partners. NANA contractors have secured a great share of the business supplying the mine, which includes transportation services, engineering and technical services, construction support, and catering services (Horswill and Sandovik, 2000). Teck has two major subcontractors: 1) NANA Management Services, which provides catering and other services to the mine; and 2) NANA Lynden, which provides transportation between the mine and the port facility on the Chukchi Sea (Haley, 2012). In 2013, Red Dog's spending on statewide locally-based suppliers accounted for 60% of the company's total spending. Of Red Dog's spending in 2013, 47% was with indigenous suppliers (Teck, 2013). Red Dog accounts directly or indirectly for about 20% of total employment in NWAB (Prno, 2013). The mine is the only taxpayer in the NWAB, and the 2013 payment was estimated at US$ 8.7 million (Red Dog Mine, 2014). The NANA royalty charge was US$ 120 million in 2013, which accounts for 30% of net proceeds of production. The royalty increases by 5% every fifth year to a maximum of 50% (Teck, 2013). The majority of the royalty payment is being redistributed by NANA to other regional and village corporations (RDC, 2014). The identified socioeconomic effects and community participation relevant to Red Dog are illustrated throughout the life cycle of the mine in Figure 2.

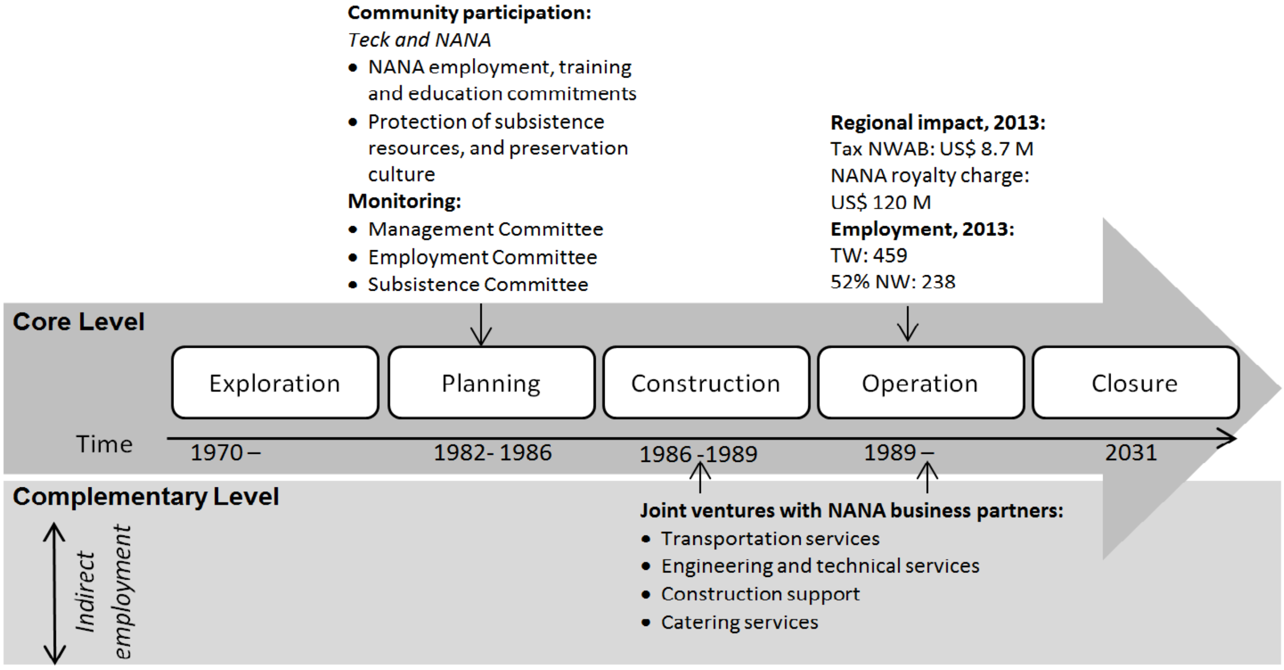

Figure 2 - Life-cycle of Red Dog[2]

In line with analysis presented by Prno (2013), it is clear that a 'strong' Social License to Operate (SLO) applies in the catchment area of Red Dog. As a result, the mine provides significant socioeconomic benefits to the region, its enhanced income facilitating improvements in infrastructure and public services, including emergency response, schools, economic development and planning (Haley, 2012). Red Dog has also made efforts to initiate communications with local communities, in an attempt to respond to their concerns more effectively. Mine representatives pay visits to communities to provide updates and elicit feedback. The mine's donation program also contributes to various community development initiatives (Prno, 2013).

Even though Red Dog has become a part of everyday life for many individuals, and has proved that it can provide long-term socioeconomic benefits to the region, as Haley (2012) and Prno (2013) explain, some individuals are critical of the mine. They have expressed concerns over, inter alia, the quality of drinking-water, and effects on human health and fish. In addition, "While income and employment have a generally positive effect on social and psychological health, there are also tradeoffs, including the strain on families and children of the prolonged absences of family members working at the mine" (Haley, 2012). An everyday life in a small remote community with one of the richest and largest operating zinc mines in the world (Capozza, 2005) as a neighbor may

[2] TW: total workforce, NW: northern workforce.

bring socioeconomic prosperity, but it will continuously raise concerns and there will always be room for improvement.

3.5.2 Diavik Diamond Mine

One of the main mineral exploration success stories of the 1990s was the major discovery of diamond deposits in the Canadian Arctic. This spawned the Diavik Diamond Mine (Diavik) in the remote, barren Lac de Gras area in the Northwest Territories (NWT). The mine is located 200 km south of the Arctic Circle on an island on Lac de Gras, which is 300 km from the regional center Yellowknife. By 2014, the total population of NWT was 43623 residents (NWT Bureau of Statistics, 2014). Approximately half of NWT's population is native. It is a population characterized by high unemployment, low incomes, and a significant reliance on welfare. Traditional business activities continue, but these do not generate sufficient incomes for many people (Ritter, 2001). The economy of the NWT is based on mining, government, and tourism (Government of Northwest Territories, 2014). The pristine Arctic environment was what discouraged many potential mineral explorers in the beginning (Moon, 2006; Cross, 2011). From 1989 to 1998, roughly US$ 510 million was invested in exploration activities. During this period, numerous kimberlites were discovered.

In the NTW region, diamond-bearing kimberlites were discovered in 1991, which led to the development of two diamond mines, Ekati and Diavik (Ritter, 2001). Ekati was the first mine to come into production. The North's second diamond mine is owned jointly by Diavik Diamond Mines Inc. (60% ownership) and Dominion Diamond Diavik Limited Partnership (40% ownership). The mine is managed and operated by Diavik Diamond Mines Inc. Both companies are headquartered in Yellowknife. Diavik Diamond Mines Inc. is a wholly owned subsidiary of Rio Tinto plc of London, England, is one of the largest mining and metals companies in the world, and has been in business for over 140 years (Diavik, 2014). Dominion Diamond Diavik Limited Partnership is wholly owned by Dominion Diamond Corporation, which is a Canadian diamond mining company. Besides having 40% ownership of Diavik, Dominion Diamond Corporation has an 88.9% controlling interest in the Ekati Diamond Mine (DDC, 2014). Between 1994 and 1998, Diavik studied the environmental and socioeconomic effects of the mine on the area and the well-being of the regional population (Ritter, 2001). In November 1999, the project was approved for permitting and licensing by the federal government (Rio Tinto, 2009). This paved the way for the next phase of the mine: construction. Diavik, Canada's largest diamond mine, commenced operation in January 2003. Each year, a 600-km-long ice road is constructed over frozen lakes. It is open roughly 10 weeks each winter for essential resupply to the mine. It is estimated that the mine will reach closure after 16 to 22 years of production, which would be between 2019 and 2025 (Rio Tinto, 2009).

By 1999, Diavik had forged a socioeconomic monitoring agreement (SEMA) with the five neighboring indigenous communities that would be most affected by the construction and operation of the diamond mine and the government of the NWT (Diavik, 1999). The primary purpose of the agreement is to facilitate meaningful engagement with the neighboring communities in order to catalyze sustainable economic development and capacity building locally (Missens et al., 2007). Diavik management asserts that it is committed to providing employment, training, and business opportunities to the North and to purchasing goods and services from northern businesses. Meanwhile, the government of the NWT claims it is committed to providing career counseling, training allowances, and training program delivery. Diavik management also claims it is committed to preparing annual business opportunities forecasts to enhance mine-related business and employment opportunities for northern businesses and to increase business capacity. For this purpose, the community advisory board was established, which includes representatives from the five communities, Diavik, and the government of the NWT. It aim is to monitor and review the socioeconomic effects of the project, provides recommendations to communities, and acts as a liaison between the parties and providing opportunities for public participation and involvement (Missens et al., 2007). Diavik has implemented negotiating participation agreements with each of the five neighboring indigenous groups (Diavik, 2001). These include cooperative agreements between communities and Diavik on training, employment, and business opportunities. The five communities agreed to assemble a human resource inventory and business registry and make them available to Diavik on an ongoing basis to achieve mutual objectives (Missens et al., 2007). The indigenous groups have committed to employing a representative to coordinate with Diavik on issues such as responsibilities, tasks, and timelines for reaching employment and business development targets (Diavik, 2001). Further, Diavik has conducted skill assessments within the communities to identify job skills and potential employees, for the purpose of putting together a skills database. Missens et al. (2007) have evaluated these agreements, which are guided by terms and conditions set out in the SEMA for the Diavik project. Their study highlights employment benefits as one of the most significant items negotiated. Annually, Diavik publishes socioeconomic monitoring, environmental monitoring, and sustainable development reports describing each year’s activities related to social and environmental responsibility (Diavik, 2014).

Already during the construction phase, Diavik has created significant employment-related business generation and training opportunities through its business policies and practices. The average employment level during the construction phase was approximately 800 employees, peaking at about 1500 employees. Northern employment accounted for 44% of the average workforce, of which half were indigenous northerners, thus surpassing the initial agreed goal of 40% of northern employment (Diavik SEMA, 2003). Diavik's spending during the construction was US$ 1.3 billion, of which 74% was with northern firms. The 74% spending amounted to US$ 900 million, of which US$ 600 million was with northern indigenous firms. Indigenous joint-venture companies, that is, partnerships between nonindigenous and indigenous companies, represented a major share (Diavik, 2001). Diavik actually surpassed the initial target of 38% spending throughout the construction phase, in which northern firms reached the 74% of total spending. The community-based training partnership with Diavik, the government, communities, educational institutions, and contractors provided training during construction, including classroom and hands-on training to 20 groups, creating 250 graduates. The majority of the graduates found employment with Diavik contractors, local community governments, at other mine sites, or by joining the operation workforce (Diavik SDR, 2003). Diavik enhances the business capacity among northern and indigenous business by outsourcing a significant share of its workload. This comprises a wide range of site services, such as heavy equipment, security staff, food and camp services, logistics, and explosives (Diavik SDR, 2003). By outsourcing and building business capacity, the northern firms may be better positioned to provide services to other mines and resource extraction projects, which can create additional opportunities for northerners (Diavik SDR, 2003). Diavik's business model seeks to achieve high performance in the total business equation, including core business deliverables of yield and cost, environment, indigenous and local participation, socioeconomic performance, and best practices. This balance is considered important to achieving sustainable mining outcomes (Diavik SEMA, 2003).

At the end of 2013, Diavik employed 997 persons, of which 485 were northerners, including 236 indigenous persons. The total northern workforce, including indigenous people, accounted for 49% of the total workforce at Diavik. The indigenous workforce accounts for 24% of the total workforce. However, Diavik has not yet reached the initial agreed goal of 66% northern employment, and of this, 40% of total indigenous employment. The remaining 51% of the total workforce is a southern workforce (Diavik SEMA, 2013). Approximately 60% of the total workforce is directly employed by Diavik, and the remaining 40% of the total workforce is employed by the subcontractors who provide a wide range of services to the mine. Davik provides a wide range of training for the workforce through safety training, various technical site-based training with certification programs, and apprenticeship programs. During 2013, Diavik supported 27 apprentices, surpassing the commitment to training 8–18 apprentices annually (Diavik SEMA, 2013). The total spending during 2013 amounted to US$ 362 million. The total spending with northern firms was US$ 261 million, which accounts for 73% of total spending in 2013, thereby surpassing the commitment of 70% of spending throughout the operation phase with northern firms. The spending with indigenous firms amounted to US$ 116, which accounts for 32% of total northern spending. The remaining 27% of total spending was with other Canadian firms, which amounted to US$ 101 million (Diavik SEMA, 2013). Outsourced labor constitutes the largest share of Diavik's spending by US$ 73.4 million. The remaining categories constituting Diavik's spending are as follows (in US$ million): consumables 64.6; construction 49.8; freight, cargo, and transportation 47.6; fuels and lubricants 47.2; passenger transport 10.4; professional services 10.3; accommodation 10; environmental services 5.6; telecommunication 4.5; drilling and blasting 4.3; and other 28.3 (Diavik SDR, 2013). The total construction and operation spending combined from 2000 to 2013 was US$ 6.0 billion, and of this, US$ 4.3 billion were with northern firms, which represents 72% of Diavik's entire spending. Of this, US$ 2.3 billion were with indigenous firms, which represents 38% of the total northern spending (Diavik SEMA, 2013). Besides spending with northern and indigenous firms, Diavik also contributed US$ 485,257 to community initiatives, including scholarships and cultural, educational, and health activities during 2013. Diavik seems committed to promoting cultural and community well-being through several initiatives by instituting policies to help indigenous employees cope with any effects. This includes mitigating negative aspects of working conditions by providing traditional food, permitting spousal visits, allowing cultural leave for ceremonial purposes, and implementing an indigenous-language-use policy (Missens et al., 2007). The identified socioeconomic outcome and community participation relevant to Diavik is captured throughout the life-cycle for Diavik in Figure 3.

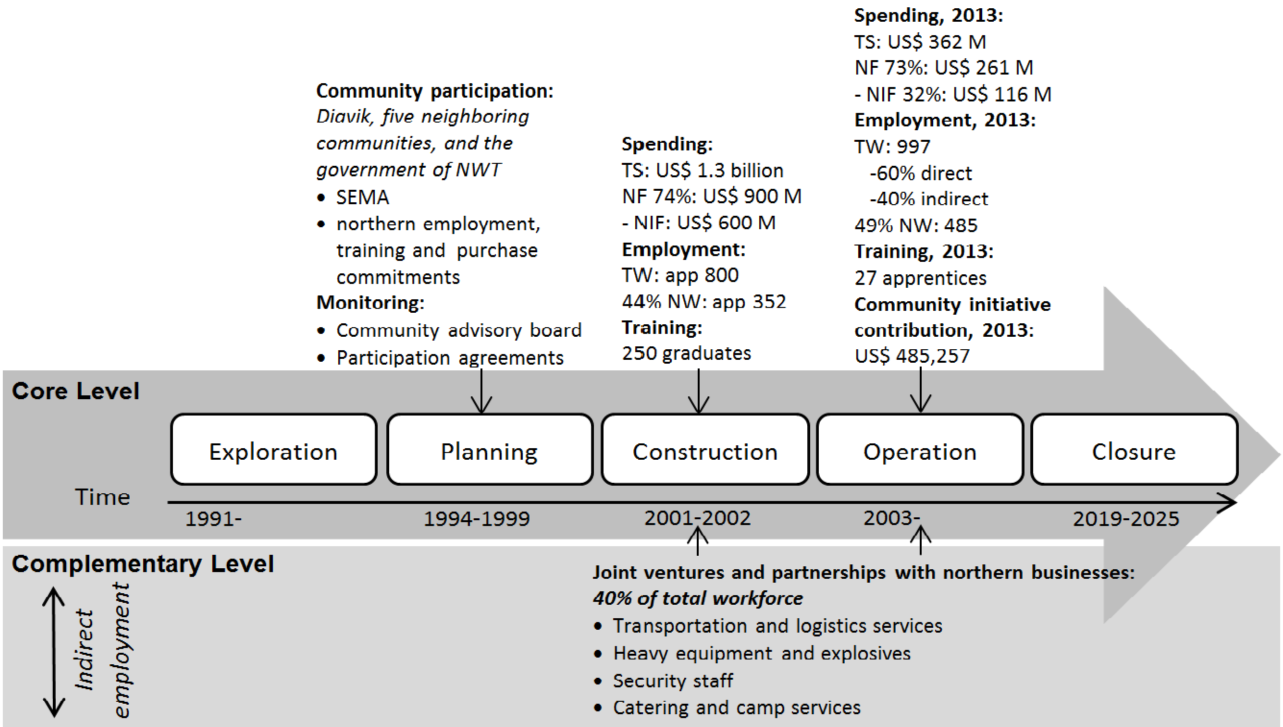

Figure 3 - Life-cycle of Diavik[3]

Mining has a great effect on the region. The total number of jobs in the NWT was 26,920 by 2010. The government is by far the biggest employer, which represents 35% of total employment, providing 9275 jobs. The main business-sector industries by number of jobs are construction with 3235 jobs; retail trade with 3010 jobs; mining with 2115 jobs; transportation with 1655 jobs; and accommodation and food services with 1530 jobs (ArcticStat, 2014a). Construction, transportation, and retail industries account for a significant number of jobs, whereas mining accounts for 8% of the total employment. However, these industries usually constitute the support industries in the life cycle of a mining project. Nevertheless, mining has the greatest economic effect on the region, accounting for 34% of its GDP, generating US$ 1027.3 million in 2010. The main business sectors contributing to regional GDP in US$ millions are government at 412.8, finance at 409, transportation at 220.3, and construction at 167.1 (ArcticStat, 2014b).

Mining at Diavik and Ekati has positioned Canada as a key player in the world diamond industry: the two mines account for 15% of global diamond production (Couch, 2002, Missens et al., 2007). This makes Canada as the third-largest diamond supplier in the world, by value. Missens et al. (2007) argues that Diavik is exemplary of ‘good’ mining strategy that goes beyond extraction, and includes supporting communities and their enterprises and being a good corporate citizen. However,

[3] TS: total spending. NF: northern firms. NIF: northern indigenous firms. TW: total workforce. NW: northern workforce.

O'Faircheallaigh (2007) claims that there remains considerable room for improvement in this part of the world, particularly in relation to indigenous participation in environmental agreements and management.

3.6 Discussion

The life cycle of a mining project spans several decades, depending on the mineral deposit. The life cycle of Red Dog is projected to be 61 years, while the life cycle of Diavik is estimated at 34 years. The duration of the initial phase, exploration, following the discovery of the mineral deposit, varied between the cases. Crucial during this phase was the willingness of mining companies with sufficient funding to make high investments to develop the mineral deposit into an actual mine. In both cases, the mining companies that developed the mines are foreign, and are among the largest in the world, with more than 100 years' experience of operating mines globally. The planning phase extends over 4–5 years in both cases, which is necessary because feasibility studies and environmental and socioeconomic assessments take several years to conduct before an exploitation license can be granted. The construction phase is the shortest phase throughout the entire life cycle, and it extends between two and three years in both cases. The duration of the operation phase depends on when the mineral deposit will be exhausted and extraction is no longer feasible, which is when the mining project enters the final phase. Because both mines are still in operation, it is not possible to discuss the actual effects of the closure phase. The life-cycle model can be applied to other mining projects because all mining projects will most likely undergo the suggested five phases of the life-cycle. The obvious variations will include the timeline, socioeconomic outcomes, and other case-specific effects.

In both the Red Dog and Diavik cases, there are signs that there will continue to be a high level of involvement of local actors. NANA had significant influence in negotiating the terms of development in the Red Dog case in relation to profit sharing, training, preferential employment, and business partnering. In the case of Diavik, partnership agreements were negotiated through SEMA with each one of the five neighboring communities, on training, employment, and business opportunities. The Diavik case provides clear evidence of trilateral dialogue, where both the local community and the local government participated in the negotiation process with the mining company. In both cases, there was a high level of transparency throughout the planning and decision-making process, which led to the identification of shared objectives. The local communities receive preferential employment, training, and local purchase. Cooperative agreements require commitment and continuous effort from all parties. In the cases of Red Dog and Diavik, the local communities have continuously been involved in decision-making processes concerning project operations. Community representatives are involved in monitoring and the reviewing of operations and plans, and act as a liaison between the parties. The level of local participation and the negotiated agreements during the planning phase has a continuous effect throughout the remaining phases of the life cycle. The planning phase can, in many ways, be considered the foundation for securing the future value creation of the mining project.

Although socioeconomic value creation can take place throughout the entire mine life-cycle, the most significant addition occurs throughout the construction and operation phases. The socioeconomic value creation in the cases of Red Dog and Diavik is manifested as direct employment: approximately half of the project's total workforce is sourced locally. Providing training programs is also a key aspect of the socioeconomic value creation, because it is linked to employment opportunities and career advancements. Whereas direct employment and training are key outcomes, the indirect opportunities and benefits derived from support industries must also be considered. An outsourcing of tasks has, in both cases, created business partnership opportunities between the mining companies and local businesses. The identified support industries where mining projects have a substantial effect are similar in both cases, and include transportation and logistics services, catering and camp services, construction support, and supply services such as heavy equipment, fuel, and explosives. Even though the mining industry is not the biggest direct employer in the two regions, the identified projects have an effect on growth and employment in other industries. It is important, therefore, to focus not only on direct employment and training quotas during the planning phase but also on the potential business development opportunities through derived industries. Both mining projects provide benefits to the general economy of the host regions. The income generated through taxes and royalties from the mining companies can be utilized to provide better services and care to local citizens, even for those who are not impacted by the mining project.

Increasingly, communities are demanding more benefits from local resource-development projects and greater involvement in decision making to ensure a responsible and safe mineral development (Prno, 2013). Communities seek to secure not only economic benefits from resource-development projects but also social equity and environmental protection through increased participation. They seek a greater share of economic benefits, such as employment opportunities, as well as to preserve their cultural roots. Sustainable development in this context requires striking a balance between environmental responsibility, social equity, and economic prosperity (Horswill and Sandovik, 2000). According to Fidler (2009), more sustainable mineral development can be achieved through greater community engagement in the design, operation, and closure of a resource-development project. This supports the key finding of this paper: that increased involvement and participation of local actors in decision-making and negotiation processes during the planning phase has a positive influence on significant socioeconomic value-creation outcomes throughout the remaining phases of the mining project life-cycle. Each phase of the life cycle model is both distinctive and interrelated. Moreover, actions in early phases can have effects on subsequent phases. The actions and level of participation during the planning phase will influence socioeconomic outcomes throughout the mine life-cycle. Previous mining operations had lower levels of local participation and did not require high levels of local labor use and business commitments.

Several challenges are evident in this research design, however. Asselin and Parkins (2009) discuss the comparative case-study design for social science approaches in Arctic research. First, there are challenges in conducting comparative analysis, which depends upon the complementarity of cases. The cases are selected based on their similar geography, demographic characteristics, and project size. However, there are still comparability concerns regarding differences between the two states, Alaska and Canada, in terms of geopolitics and cultural nuances between the local populations in each territory. Moreover, there are also concerns in relation to the use of published research and literature and secondary data for each case study. However, the case-study approach provides detailed and important insights and contextual aspects in each case, which may not be easy to capture in a conventional economic model. Even though there are comparison and generalizability concerns related to the qualitative case-study methods, the findings can still serve as knowledge building for local communities and actors who will be affected by future resource-development projects.

Regardless of the conditions of any planned resource-development project, it is essential for local actors to get involved in the decision-making and negotiations processes and seek to influence the terms and conditions of project development to ensure sustainable development for the community. In the Arctic, the paradigm is shifting toward sustainability and responsibility. The governance is increasingly shifting from governing authorities toward the civil society, which calls for greater public participation in decision-making (Prno, 2013). The new Arctic paradigm calls for industrial actors, companies, and organizations to adjust their operations, policies, and procedures, both to achieve social approval and to operate successfully in the setting.

3.7 Conclusion

This paper investigated the socioeconomic value creation and the role of local participation in two cases: the Red Dog Mine and the Diavik Diamond Mine. A life-cycle model for mining projects was proposed as a framework for examining effects. It consists of five distinct phases: exploration, planning, construction, operation, and closure. In both cases, there has been a high level of local participation in the decision-making and negotiation processes concerning mine development, as well as trilateral dialogue and transparency during the planning phase. Continuous effort and commitment from all parties has been a key to identifying mutual objectives and creating socioeconomic value.

The most significant socioeconomic value creation occurs during the construction and operation phase of the life-cycle model. Examples include direct employment, training, integration of local supporting industries in the value chain of the mining project, and contribution to regional economies through taxes and royalties. Business creation in the form of support industries, including transportation and logistics, construction, catering and camp services, and supply of heavy equipment, fuel, and explosives, can also be a significant source of socioeconomic benefits to the local communities. The phases of the life-cycle model are interrelated, and the level of local participation and negotiated agreements during the planning phase will influence the socioeconomic outcomes further long in the mine's life. There is a linkage between the level of participation and socioeconomic outcome in mining projects. Communities seek increased involvement to secure sustainable development, which requires balancing environmental responsibility, social equity, and economic prosperity. Local communities should maximize their level of participation in any future mining project.

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4 Chapter 4: Mining in Arctic and Non-Arctic regions: a socioeconomic assessment

Paper available as IZA discussion paper No. 9883, April 2016 [4]

By Anders Frederiksen[5] and Maja Due Kadenic

4.1 Abstract

In this paper, we study how mines change local societies in the Nordic countries with a particular focus on the Arctic region. Our study is based on register data at the municipality level from Norway, Sweden, and Finland for the period 1986 to 2013. The applied econometric model allows for identification of the total socioeconomic effects that occur throughout the mine's life-cycle. We find positive effects on local employment and reductions in unemployment and the number of people outside the labor force when a mine is opening up. We also detect significant shifts in the industry structure in the period around a mine opening and we find that mines attract young people and reduce crime rates. We do not find any effects on the local population size, the gender or education compositions, or fertility rates.

Key words: Mining, Arctic, socioeconomic effects, resource development, Nordic countries

4.2 Introduction

The Arctic region attracts renewed attention from extractive industries, oil companies, and governments from around the world. The rush to the Arctic is motivated by a growing pressure on existing resources, the receding ice cap, and technological advances that open up new opportunities in the Arctic. At present there are extractive activities in the Scandinavian, Russian, and North American sections of the Arctic (Harsem et al., 2011) and the Arctic states are promoting natural resource development as a strategy for creating local employment and national economic growth (Kullerud, 2011). Our intention with this paper is to broaden the perspective even further. We will do so by empirically establishing the socioeconomic effects of mining in the Arctic and by assessing how such effects differ from those observed in non-Arctic regions.

We focus our analysis on the unique Nordic setting where high-quality register data is available and where the countries have mining activities both in Arctic and non-Arctic regions. The detailed

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register data allow us to study a broad set of socioeconomic variables such as population size, employment, industry structures, the demographic composition (including fertility), educational composition, and crime rates. While our results are important to the Nordic countries (Sweden, Norway, and Finland) we study, they are also relevant to other countries such as Canada, the USA, and Russia who have mining activities in the Arctic region, and even to Greenland where there are limited mining activities at present, but where a large-scale mine often is suggested as the path toward economic growth.[6]

Extractive industries have been studied extensively outside the Arctic region where resource abundance has been linked to macroeconomic performance (Sachs and Warner, 1995, 1999, 2001). Sachs and Warner's (1995) prominent paper presents evidence which suggests that countries with a high ratio of natural resource exports tend to have lower growth rates. Other researchers argue, however, that the "resource curse" is the exception rather than the rule and the evidence about the relationship between economic growth and natural resource extraction is contradictory (Davis, 1995, 1998, 2010). While economists and researchers within other social science disciplines have examined the macro-level effects of mineral development, knowledge about the effects of extractive industries on regional and local development is more scarce (McMahon and Remy, 2001; Rolfe et al., 2011; Gilberthorpe and Papyrakis, 2015). Nevertheless, at this level extractive industries are commonly found to benefit local societies both within and outside the Arctic region through increased employment (AMAP, 2010; McMahon and Remy, 2001; Carrington, 1996; Aroca, 2001; Hajkowicz et al., 2011). Our analysis operates at this micro level with a focus on how mines influence local socioeconomic variables.

When assessing the effects of mines it is important to consider the mine's life-cycle (Kadenic, 2015). For example, a strict focus on the socioeconomic effects that result from a mine in operation would miss the effects on society that result from, say, the labor-intensive construction phase. Hence, to identify the total effects of a mine on the local society we apply the econometric model developed in Jacobson et al. (1993). This methodology is particularly suitable for the present analysis as it can be used to establish both the effects that occur prior to the official mine opening and the effects of the mine when it is in operation.

[6] This argument is promoted by several interest groups such as governmental bodies, advisory groups, and business associations. See Government of Greenland, 2014; Ministry of Foreign Affairs, 2011; Økonomisk Råd, 2012; The committee for Greenlandic mineral resources to the benefit of society, 2014; Copenhagen Economics, 2012; Nuttall, 2012.

Our empirical results, which are based on municipality-level register data from Norway, Sweden, and Finland from 1986 to 2013, show clear and positive employment effects in the municipality where a new mine is established. These employment effects start to show one year before the mine begins operation and they are persistent. In addition to the positive effect on employment, the opening of a new mine lowers unemployment and reduces the number of people who are outside the labor force. The reduction in unemployment coincides with the increase in employment, but the reduction in the number of people who are outside the labor force occurs much later. We do not find any effects on population size in response to a mine opening. Most importantly, these effects are similar for Arctic and non-Arctic municipalities.

Mines also have important effects on the industry structure and these effects differ between Arctic and non-Arctic municipalities. In the Arctic region the employment share allocated to the mining industry starts to grow in the year the mine starts production (and not earlier). Three years after the mine starts to operate it has increased the employment share in the mining industry by as much as 3.1 percentage points. This result for the Arctic municipalities stands in stark contrast to the results pertaining to non-Arctic municipalities, where a mine opening has no significant effect on the employment share allocated to the mining industry.

Furthermore, in Arctic municipalities the employment share allocated to the construction industry grows prior to and during the year the mine starts production and then again in year three after the mine opening. Non-Arctic municipalities only experience an increase in the employment share allocated to the construction industry in year three after the mine opening. The primary sector also grows in response to mining activities, but the pattern is different. For this sector the employment share increases by 2.4 percentage points in the year prior to the mine opening and it stays at this higher level thereafter in both Arctic and non-Arctic municipalities.

The mines attract young people. The positive effect of a mine opening on the number of people aged 20 to 39 can be detected up to three years before the mine starts production and it remains positive up to three years after the mine opening (but the effect is only statistically significant through the year where the mine starts operation). One could expect that this result was due to an inflow of young men, but that is not the case. The opening has no significant effect on the gender composition in the municipality. Further, we find no effects from a mine opening on birth rate or the level of human capital in a municipality. But, we do identify a reduction in crime rates.

The remainder of the paper is organized as follows. In the next section we present the Arctic region, which is followed by a discussion of the socioeconomic effects of mining in the Arctic and elsewhere. In Section 4 we present data on the mines and the register data applied in the empirical section of the paper. In Section 5 we discuss our empirical strategy, and our results are presented in Section 6. Implications are discussed in Section 7. Section 8 concludes.

4.3 The Arctic region

Arctic societies depend on export of natural resources, subsistence activities, and transfer payments (Aarsæther, 2004; Duhaime, 2004; Huskey and Pelyasov, 2015). The three pillars of the Arctic economy represent two different development models according to Duhaime and Caron (2006), which are characterized by exploitation of either renewable resources (marine resources or forestry) or nonrenewable resources (hydrocarbons and minerals).

The mining activities around the Arctic are presently an important contributor of raw materials to the world economy. The greatest quantity of these minerals is extracted by Russia, mostly on the Kola Peninsula and in Siberia, and they include copper, nickel, tin, apatite, platinum, gold, and diamonds (Huntington and Weller, 2005). Mining in the Canadian Arctic is for copper, lead, zinc, gold, and diamonds (Huntington and Weller, 2005), and Alaska has one of the largest and richest zinc mines in the world (Capozza, 2005). Adding to this is Scandinavia's long history of mining and exploration in the Arctic regions of Norway, Sweden, and Finland (FODD, 2012). Mineral extraction has also taken place in Greenland from the 1800s up to modern times (Nordregio, 2010). The Greenlandic mines, however, have been relatively small compared to mining activities in other parts of the Arctic region.

The Arctic economy is large compared to its share of population, with a GDP per capita of USD 45,360 in 2010, which is greater than most European countries but comparable to the United States (Huskey and Pelyasov, 2015). The total Arctic GDP was USD 442.8 billion in 2010. Furthermore, the Arctic had 0.15 percent of the world's population and produced 0.6 percent of world GDP in 2010. Hence the contribution to world output was four times the share of population (Huskey and Pelyasov, 2015). The total population of the Arctic is just above 4 million. According to the recent Arctic Human Development Report (AHDR, 2015), population growth was slowest between year 2000 and 2010 in the Scandinavian Arctic (Norway by 0.6 percent; Sweden -1.0 percent; and Finland 1.4 percent), with the exception of Russia, which accounts for the largest population decline of -5.3 percent. The Canadian Arctic, Alaska, and Iceland experienced relatively high population growth of roughly 13 percent during the same period.

Employment during the 2000 to 2010 period was increased in the Arctic regions of Norway by 7.8 percent, Sweden 3.8 percent, and Finland 8.2 percent, while the Canadian Arctic and Alaska had employment increases of 21.3 percent (Canadian Arctic) and 13.9 percent (Alaska). For more details, see Huskey and Pelyasov (2015). Both Iceland and the Russian Arctic experienced moderate employment growth of 6.8 percent (Iceland) and 5.3 percent (Russian Arctic), while the Danish regions of Arctic (Greenland and Faroe Islands) had an employment decline of -5.5 percent but a population growth of 3.1 percent (Huskey and Pelyasov, 2015).

Fertility rates of the Arctic regions of Norway, Sweden, and Finland are below the replacement level of 2.1, whereas Alaska, the Arctic region of Canada, and Faroe Islands have fertility rates above the replacement level. The Arctic has a relatively high male gender ratio due to an economy that is based on fishing and resource extraction (Heleniak and Bogoyavlensky, 2015). Furthermore, the Arctic regions of the Nordic countries have the highest median age, the smallest youth shares, relatively high portions of pension-age persons, and low proportions of people in the working age compared to the rest of the Arctic (Heleniak and Bogoyavlensky, 2015).

Finally, education, which is an essential part of human development and an important contributor to economic growth and well-being, is unequally spread across the Arctic region. Arctic regions of Scandinavia and Russia have relatively large shares of the population with post-secondary educations, while Alaska and the Canadian Arctic have relatively low levels (Hirshberg and Petrov, 2015).

4.4 Socioeconomic effects of mining

Mining features in the history of local community and regional development in several parts of the world. Examples are copper mining in northern Chile; 19th-century growth in Western Australia and the state of Victoria; silver and gold mining in the Rocky Mountain region in the United States; diamond and gold mines in Johannesburg in South Africa; and iron-ore mining in the region around Kiruna in northern Sweden (Eggert, 2001). Furthermore, studies show that the resource industry more generally has been a strong direct contributor to the economic development in remote regions (Rolfe et al., 2011).

The empirical literature on the effects of mining activities is very diverse. Some papers focus on economic and demographic aspects and study the relationship between resource abundance and regional economic and demographic effects throughout regions such as Chile, Australia, Sweden, US states, and Spain (Aroca, 2001; Rolfe et al., 2011; Ivanova 2014; Ejdemo, 2013; Papyrakis and Gerlagh, 2007; Domenech, 2008). Some of these studies identify how mines contribute to the GDP of a region; others take a more narrow focus and measure employment effects (Eggert, 2001; Rolfe et al., 2007). These employment effects can often be decomposed further by sector (Aroca, 2001; Loveridge, 2004; Clements et al., 1996). Cross-regional socioeconomic analyses of mining also include measures such as unemployment rates, population size, and educational attainment (Tonts, Plummer, and Lawrie, 2012; Hajkowicz et al., 2011).

It is important to stress that besides direct employment at the mine, additional indirect employment is created through contractor and service industries, and induced jobs are created through consumption spending (Rolfe et al., 2007; Ejdemo, 2013). Studies establish a link between employment effects in the mining sector and other sectors including the service sector, utility sector, transportation sector, wholesale and retail trade sector, and manufacturing sector (Hajkowicz et al., 2011; Aroca, 2001; Ejdemo, 2013). These linkages include purchase of inputs such as food and catering services, transportation services, electricity, and materials. For example, a related empirical study of the Alaskan labor during the development of the Trans-Alaska Pipeline System shows increases in population, employment growth, unemployment reduction, and labor demand increases in construction, transportation, services, retail trade, finance, insurance, and real estate; while the manufacturing industry and government sector were unaffected (Carrington, 1996).

A new trend that has arisen during the past two decades is that mining companies have shifted their way of operation by reducing the provision of mining towns toward outsourcing and a greater use of local contractors and business suppliers (MMSD, 2002; Rolfe et al., 2007). Outsourcing creates a new productive base of new small- and medium-size firms that start by providing their goods and services to the mining company and eventually expand their business to other sectors in the region and exploit markets outside the mining sector (Aroca, 2001). The regional suppliers of mining input extend the linkages by purchasing their own inputs within the region, which additionally stimulates regional economic activity. Further stimulation of the region’s economic activity is created when miners spend their household incomes on goods and services within the region (Eggert, 2001).

Mining activities have also proven to influence human capital. For example, a cross-regional study of 71 local government regions in Australia reports that mining activities are positively associated with educational attainment (Hajkowicz et al., 2011). This finding is also established by MMSD (2002). However, a macro-level study shows that natural resource abundance correlates negatively with educational measures, which relates to the explanation that natural resource–based industries often rely on low-skill labor (Gylfason, 2001).

An additional set of socioeconomic indicators affected by mining activities are developed by the Arctic Social Indicators (ASI) Project as a response to the Arctic Human Development Report (AHDR) to track changes in human development in the Arctic (ASI, 2010; AHDR, 2004). Amongst these indicators are several population indicators, including total population (broken down by age and gender when possible) and number of births. Finally, Carrington's Alaskan study shows that influx and presence of young single men led to increased crime (Carrington, 1996), a finding supported by McMahon and Remy (2001) and MMSD (2002).

The general picture arising from these prior studies is that extractive industries (and mines in particular) have a broad impact on local socioeconomic activities. These range from effects on population size, over employment and the employment structure, to crime rates. Adding to the complexity is the fact that these effects change over the life-cycle of the mine. The reason is that a mining project is initiated years before the mine starts operation and it goes through five phases (Cusumano et al., 2006; Kadenic, 2015; Storey and Hamilton, 2003; Moon and Evans, 2006). The first phase in a typical life-cycle of a mining project is *exploration*, which covers activities such as, drilling, geological mapping, sampling, and testing. This phase is followed by a *planning* phase, which focuses on feasibility studies and regulatory approval processes, including cost analyses and technical studies to prove the commercial viability, environmental and social impact assessments, and community hearings. Many of these preparatory studies can be and are done remotely by third-party consultants and have a minor effect on local economic activities. The following phase is *construction*. During this phase local activities are significant and involve construction of the production facilities and camps and setting up of appropriate infrastructure. Despite the direct relation to the mine, these activities may not necessarily be categorized as mining activities in official registers and may instead show up as increased employment in the construction and transportation industries, i.e., as indirect employment. The next phase is the actual commencement of operating the mine, the *operation* phase, where the raw material is extracted and processed. The final phase is *closure*, which includes remediation and restoration of site. A study of the socioeconomic effects of mines therefore should be sufficiently broad and flexible such that it can capture the diversity of effects and the fact that such effects may vary throughout the life-cycle of the mining project.

4.5 Data

In this section we describe the data used in the empirical analysis. We use register data provided by the statistical bureaus from the three Nordic countries: Norway, Sweden, and Finland. This information is complemented with data from the Fennoscandian Ore Deposit Database (FODD), which contains information about mines in the region, their location, mining history, tonnage, and commodity grades of deposits.

4.5.1 Nordic mines

Extensive exploration and large mining operations are currently taking place throughout Scandinavia (see Table 2). There are 34 active mines across Finland, Norway, and Sweden and 24 mines are located in the Arctic region. The mines are spread unequally across the three countries with 5 active mines in Norway, 13 active mines in Finland, and 16 active mines in Sweden.

The Arctic region of Norway comprises Nordland county, Troms county, and Finnmark county and contains 4 mines. The Arctic region of Sweden comprises Västerbotten county and Norrbotten county, where 12 mines are located. The Arctic region of Finland is made up of Lapland and Oulu, and these regions contain 8 mines. The Swedish mines are mainly extracting iron (Fe), zinc (Zn), and copper (Cu), the mines in Norway are primarily extracting iron (Fe), and the mines in Finland are mainly extracting nickel (Ni), zinc (Zn), copper (Cu), and gold (Au).

Mine	Country	County	Municipality	Lat. N	Long. E	When mined	Occurrence
Aitik	Sweden	Norrbotten	Gällivare	67.07	20.96	1968–	Cu, Au, Ag, Mo
Kirunavaara	Sweden	Norrbotten	Kiruna	67.83	20.19	1864–	Fe
Malmberget	Sweden	Norrbotten	Gällivare	67.18	20.67	1845–	Fe
Tapuli	Sweden	Norrbotten	Pajala	67.42	23.33	2012–	Fe
Garpenbergsfältet	Sweden	Dalarna	Hedemora	60.32	16.21	1876–	Zn, Pb, Ag, Au, Cu
Dannemorafältet	Sweden	Uppsala	Östhammar	60.20	17.86	1845–1992, 2012–	Fe
Zinkgruvan	Sweden	Örebro	Askersund	58.81	15.10	1849–	Zn, Pb, Ag,

							Cu
Björkdal	Sweden	Västerbotten	Skellefteå	64.93	20.59	1988–	Au
Kristineberg	Sweden	Västerbotten	Lycksele	65.06	18.57	1935–	Zn, Cu, Pb, Au, Ag
Renström	Sweden	Västerbotten	Skellefteå	64.92	20.09	1948–	Zn, Cu, Pb, Au, Ag
Gruvberget	Sweden	Norrbotten	Kiruna	67.65	20.99	1860–1892, 2010–	Fe
Maurliden Västra	Sweden	Västerbotten	Skellefteå	65.06	19.52	2000–	Ag, Au, Cu, Pb
Svartliden	Sweden	Västerbotten	Storuman	64.78	17.67	2005–	Au
Kankberg	Sweden	Västerbotten	Skellefteå	64.92	20.26	2012–	Ag, Au, Te
Maurliden Östra	Sweden	Västerbotten	Skellefteå	65.05	19.55	2010–	Ag, Au, Cu, Zn
Lovisagruvan	Sweden	Örebro	Lindesberg	59.72	15.17	1992–	Pb, Zn
Talvivaara	Finland	Kainuu	Sotkamo	63.99	28.06	2008–	Ni, Co, Zn, Cu,
Siilinjärvi	Finland	Northern Savonia	Kuopio	63.12	27.74	1979–	P2O5
Kevitsa	Finland	Lapland	Sodankylä	67.70	26.97	2012–	Ni, Cu, Au, Pd, Pt
Kemi	Finland	Lapland	Kemi-Tornio	65.79	24.71	1966–	Cr
Pyhäsalmi	Finland	Northern Ostrobothnia	Pyhäjärvi	63.66	26.05	1962–	Zn, Cu
Suurikuusikko (Kittilä Mine)	Finland	Lapland	Kittilä	67.90	25.39	2008–	Au
Laivakangas	Finland	Northern Ostrobothnia	Raahe	64.54	24.58	2011–	Au
Hitura	Finland	Northern Ostrobothnia	Nivala	63.85	25.05	1966, 1970–2008, 2010–	Ni, Cu, Co
Kylylahti	Finland	North Karelia	Polvijärvi	62.86	29.35	2011–	Cu, Au, Zn
Pahtavaara	Finland	Lapland	Sodankylä	67.63	26.41	1996–	Au
Kutemajärvi	Finland	Pirkanmaa	Orivesi	61.65	24.16	1990, 1994–2003, 2008–	Au
Jokisivu	Finland	Satakunta	Huittinen	61.12	22.62	2009–	Au
Pampalo	Finland	North Karelia	Ilomantsi	62.99	31.27	1996, 2002, 2010–	Au
Bjørnevatn	Norway	Finnmark	Sør-Varanger	69.65	30.03	1908–1996, 2011–	Fe

Ørtfjell (Kvannevann)	Norway	Nordland	Rana	66.42	14.68	1975–	Fe
Tellnes	Norway	Rogaland	Sokndal	58.34	6.42	1960–	Fe Ti
Fisketind Øst	Norway	Finnmark	Sør-Varanger	69.61	30.04	2012–	Fe
Kjellmannsåsen	Norway	Finnmark	Sør-Varanger	69.58	30.04	2009–	Fe

Ag: Silver, Au: Gold, Co: Cobalt, Cu: Copper, Fe: Iron, Mo: Molybdenum, Ni: Nickel, P2O5: Phosphorus Pentoxide, Pb: Lead, Pd: Palladium, Pt: Platinum, Te: Tellurium, Ti: Titanium, Zn: Zinc

Table 2 - Active mines in Fennoscandia (Norway, Sweden, and Finland)

4.5.2 Register data

The register data is obtained from publicly available databases at Statistics Norway, Statistics Sweden, and Statistics Finland or they have been acquired directly from these statistical bureaus. The data is thus of the highest possible quality.

To identify the effects of mines on local societies we use data at the municipality level. In our main sample (spanning 1995 to 2012) there are 1023 municipalities (see Table 3).[7] There are 174 municipalities located in the Arctic and 849 are non-Arctic municipalities. While the Arctic municipalities are relatively small with 9,000 inhabitants on average, the non-Arctic municipalities have an average size of 20,000 inhabitants. There is also some variation in municipality size across countries. The 290 municipalities in Sweden have on average 32,000 inhabitants. The 422 municipalities in Norway and the 311 municipalities in Finland are smaller and have on average 11,000 inhabitants.

	Number of municipalities	Municipality size: Population Mean (std. dev.)
All	1023	18,487 (45,206)
Arctic	174	9,288 (18,434)
Non-Arctic	849	20,367 (48,693)
Norway	422	10,794 (31,527)
Sweden	290	31,355 (60,139)
Finland	311	11,034 (21,237)

[7] We have deleted the smallest municipalities from our analysis. Hence, we focus our analysis on municipalities with at least 500 inhabitants. Throughout the sample period there has been multiple municipality mergers. We have accounted for this by merging data from the individual municipalities that merge in the time periods prior to the merge.

Note: We exclude the smallest municipalities from the analysis and thus focus on municipalities with 500+ inhabitants.

Table 3 - Municipalities by country and location

Motivated by the literature review, we will, in the empirical analysis, make use of a large set of dependent variables to establish how local municipalities in the Arctic and the non-Arctic regions change when mines start to operate in the area. Our focus will be on population size, employment, unemployment, and the people outside the labor force, but we will also assess to what extent mines influence the industry composition and the gender, age, and educational compositions, and to what extent mines change fertility and crime rates. An overview of the used dependent variables is presented in Table 4.

Dependent variable (all defined at the municipality level)	Time period used in the empirical analysis	Description
Population	1995–2012 or 1986–2013	Population size
Employment	1995–2012	Number of people employed
Unemployment	1995–2012	Number of people unemployed
Non-labor market	1995–2012	People not in the labor market, defined as: Population – Employment – Unemployment
Employment shares by industry (8)	1995–2012	Eight industry dummies are used: Primary sector; Mining; Manufacturing; Construction; Electricity, Gas, and Water supply; Transportation; Wholesale and retail; and Other
Age groups (5)	1986–2013	Five age groups are used: 0–19; 20–39; 40–59; 60–79; and 80+
Women	1986–2013	Number of women
Men	1986–2013	Number of men
Female proportion	1986–-2013	The proportion of females defined as: Women /Population
Child births	1986-2013	Number of children born
Education categories (5)	1987-2012	Four education groups are used: Basic schooling; Upper secondary; Tertiary (short); Tertiary (long)
Crime	2007-2012	The number of criminal offences reported to the police

Table 4 - Description of the dependent variables

The data series that we have obtained vary in length. Demographic variables such as population size, age, and gender are available in all countries from 1986 and we can use this information through 2013. Information on employment is available in all countries for the period 1995 to 2012 and information on education is available from 1987 to 2012. The shortest time series that we use are on crime and they span the period 2007 to 2012. The time periods used in regressions are presented in Table 3 and all regression tables contain information about the time period used.

4.6 Methodology

In the above section we stressed that it is important to take the life-cycle of the mine into account when assessing the effects of a mine on the local society. For example, a study that ignores activities prior to the opening date of the mine would leave out the important and labor-intensive construction phase. To accommodate this issue we apply a particular econometric framework developed in Jacobson et al. (1993). The advantage of this methodology is that it allows us to identify all effects from the mining activity—effects that occur prior to, during, and after the mine starts operation.[8]

4.6.1 The econometric model

The methodology developed in Jacobson et al. (1993) allows us to estimate the total effect the mine has on municipality-level outcomes (population, employment, etc.). These effects are identified as the differences between how the municipality would have progressed without the mine (the expected outcome) and how it is developing with the mine (the actual outcome).

To capture these effects we construct a set of dummies that will be included in the econometric model. Let the dummy D_{it}^{0}=1 if the mine in municipality *i* starts producing in year t and let the dummies D_{it}^{k}=1 if, in period *t*, the time distance to the opening of the mine in municipality *i* is *k* years. We use $k<0$ to denote periods prior to the mine opening and $k>0$ to indicate periods where the mine is producing. In our preferred specification we allow *k* to vary from *-3* to *3*.

In the econometric model the dependent variable y_{it} (e.g., the population in municipality *i* at time *t*) is explained using the dummies constructed above and a time trend intended to capture macroeconomic changes:

$$y_{it} = \alpha + \gamma_t + \sum_{k=-m}^{m} D_{it}^{k}\delta_k + \varepsilon_{it}.$$

[8] As will become clear below, we focus on the time period around a mine opening, i.e., the period that spans three years prior to a mine opening to three years after the mine starts operation. The "event" that we study is thus a mine opening. Had the data permitted it would have been natural to extend the period of study. We have also attempted to study the event of a mine closure, but it proved infeasible to conduct a proper statistical analysis due to the low number of mine closings in the sample period.

In this specification α is a constant term, γ_t are year dummies (i.e. the trend), and ε_{it} is an error term. The full effect of the mining activities is captured by the combined effects of the $\delta_k s$.

It is well known that municipalities may differ among themselves and that municipalities located in the Arctic region are different from other municipalities. Arctic municipalities are in general scarcely populated and, as discussed in AHRD (2015) (and supported by our data), they do not experience the same growth in population as non-Arctic municipalities. Ignoring such differences in levels and trends between Arctic and non-Arctic municipalities would provide misleading estimates of the effects of mines. Hence, to accommodate this, we extend the initial model along two dimensions. We introduce a municipality fixed effect (α_i) to account for level differences across municipalities, and we add municipality-specific trends $(\omega_i t)$:

$$y_{it} = \alpha_i + \omega_i t + \gamma_t + \sum_{k=-m}^{m} D_{it}^k \delta_k + \varepsilon_{it}.$$

This highly flexible model will produce unbiased estimates of the effects of mines on the dependent variable even if the decision to locate the mine in a particular municipality depends on fixed characteristics of the municipality (this could be its geographical location in terms of longitude, latitude, or distance to water) and previous trends in the municipality.[9,10]

A final adjustment to the model is made to accommodate the possibility that the effects of mines may be different between Arctic and non-Arctic municipalities. For this reason, we include interaction terms between the dummy variables described above and a dummy for being an Arctic municipality. Hence, our final econometric specification:

$$y_{it} = \alpha_i + \omega_i t + \gamma_t + \beta * Arctic_i + \sum_{k=-m}^{m} D_{it}^k \delta_k + Arctic_i * \sum_{k=-m}^{m} D_{it}^k \gamma_k + \varepsilon_{it},$$

Where $Arctic_i$ is a dummy variable taking on the value 1 if it is an Arctic municipality and 0 otherwise. The terms: $Arctic_i * \sum_{k=-m}^{m} D_{it}^k \gamma_k$ represents the interactions between Arctic municipality and the dummies introduced earlier. Now, the effect of the mine is captured by the

[9] For a detailed discussion of this, see the original paper by Jacobson et al. (1993).
[10] It can be noted from Table 1 that some municipalities have more than one mine. In such as case we estimate the effect of a new mine opening in the area conditional on the municipality fixed effect and trends. In a sensitivity study we have also included an additional variable reflecting the number of mines in a municipality and reassuringly all results were qualitatively equivalent to reported results presented below.

combined effects of the $\delta_k s$ and the $\gamma_k s$. Further, the $\delta_k s$ capture the "general" effect of a mine applicable to all municipalities whereas the $\gamma_k s$ identify to what extent the effect of mines are different for Arctic municipalities. That is, if all $\gamma_k s = 0$, then there is no difference in such effects between Arctic and non-Arctic municipalities.

4.7 Results

In this section we establish how mines change local societies and we focus on how these changes are different between Arctic and non-Arctic municipalities. We find significant employment effects and a clear shift in the industry structure toward mining-related activities—such effects appear stronger in Arctic municipalities. In addition to this, we establish that mines have a positive effect on the number of 20 to 39–year-olds in the municipality and that they tend to reduce crime rates. They do not alter the population size, the education or gender compositions in the municipality, or the childbirth rate.

4.7.1 Employment, unemployment, non-labor market, and population size

The first set of results focus on employment, unemployment, the number of people outside the labor force, and population size. The empirical results reveal strong positive and significant effects of a mine opening on employment (Model 1 in Table 5). The employment effects start to show in the years prior to a mine opening and in the year where the mine starts production the effect accumulates to 364 persons. That is, when compared to what employment would have been in the municipality had there been no mine, an additional 364 new jobs have been created in that municipality due to the mine opening.[11] This employment effect persists and even moderately increases over time such that the employment effect in year three after the mine opening is 436 persons. These effects are not statistically different between Arctic and non-Arctic municipalities as the interaction terms are insignificant.

The strong employment effect is accompanied by a clear drop in unemployment that coincides with the rise in employment (Model 2 in Table 5). This drop, however, is only about half the magnitude of the employment effect pointing toward the possibility that people who were not previously considered part of the labor force now enter the labor market to take up employment. In fact, there is some evidence that such an effect may be present (Model 3 in Table 5), as the point estimates in

[11] Note that we are measuring the number of employed people in the municipality where the mine is located. This number may differ from the total employment effect of the mine if people commute from other municipalities to work in the mine. See Rolfe et al. (2007) and MMSD (2002) for a discussion.

the model for "Non-labor market" are negative and large and in year three after the mine opening the effect becomes statistically significant.

The empirical results show that a mine opening has no effect on population size (Model 4 in Table 5). The main effects are insignificant and so are the interaction terms. In the year a mine opens the point estimate for the main effect is only 2 with a standard error of 144.

Thus, there are clear and positive economic effects in municipalities where new mines are established. Employment is clearly increasing and both unemployment and the number of people who are outside the labor market drop. Since there is no significant change in population size, this indicates that the positive employment effects are shared among the locals. To fully make this conclusion, however, a migration study is required, which is not permitted by the municipality-level data that we have available.

4.7.2 Industry composition

The mining industry is clearly expected to increase in importance when a new mine starts operation. This is confirmed empirically, but only for Arctic municipalities (Tables 6 and 7). In non-Arctic municipalities a mine opening is not a sufficiently big event to significantly shift the employment share in the mining industry. For Arctic municipalities, however, the shift in employment share is significant. In the year the mine starts operation the employment share in the mining industry increases by 1.6 percentage points. This effect persists and increases to 3.1 percentage points in year three after the mine opening. Hence, mines have a strong influence on the industry structure in Arctic societies.

Other industries are also influenced by mine openings. The construction industry in Arctic municipalities grows significantly as a result of a mine opening. The increase in employment share can be detected up to three years before the mine starts operation, which is only natural as the construction sector is a main contributor to the establishment of the mine. The year before the mine starts operation and in the year where the mine starts production the employment shares allocated to the construction industry are 2.1 percentages points and 1.5 percentage points higher than usual. In the years that follow the mine opening the construction industry reverts back to normal, but then a significant effect starts to show again in year three after the mine opening. This three-year effect is also present in non-Arctic municipalities.

The primary sector also grows as a result of mining activities. In the year before the mine starts production the employment share allocated to the primary sector goes up by a significant 2.4 percentage points and the effect stays at that level during the period we investigate (up to three years after the mine starts production). These strong effects are found for both Arctic and non-Arctic municipalities. We can also establish significant effects for the wholesale and retail industry. In non-Arctic societies the employment share allocated to wholesale and retail increases the year after the mine starts production, but then in year three after the mine starts operation there is a significant drop in the employment share in this industry. All other industries are either unaffected by the mine opening (manufacturing, electricity, transportation, and gas and water supply) or is negatively affected.

4.7.3 Demographic compositions

It has already been established that a mine opening does not alter the population size in a municipality. In the case of no migration this would naturally imply that we should not expect to see any effects on the age, gender, and human capital compositions following a mine opening. In the case of migration it is less clear what to expect. Our first set of results on this issue is presented in Table 8. We divide the population into five age groups: 0–19, 20–39, 40–59, 60–79, and 80+. The results show that mines have a positive effect on the number of young people in the municipality. Three years prior to the mine opening the number of young people (20–39 years old) starts to increase and the effect stays positive and significant through the year where the mine starts producing. After that the point estimates remain positive, but they turn insignificant. All other age groups are unaffected by the mine opening.

Another important dimension to look at is the gender composition in a society. One prior is that mining related employment is a male activity and therefore a new mine would attract more men to the municipality, but there is no evidence of such an effect in the data (Table 9). In fact, there are not significant effects for either men or women. If anything, there is weak evidence for an increasing female proportion when mines open up (see Model 4 in Table 9). The lack of change in the gender composition may also be the reason why we do not find an effect on childbirth rate as a consequence of a mine opening (Model 5 in Table 9).

4.7.4 Human capital and crime

Mines have traditionally relied on unskilled labor (Gylfason, 2001), but more recently mines have become larger and more technically complex, which increases the required skill levels of workers and decreases employment (MMSD, 2002). Hence, the skill composition in a society may likely change as a result of a mine opening. This, however, is not the case in our data, as Table 10 vividly shows. When we estimate our model for the four education levels—basic schooling, upper secondary schooling, tertiary education (short), and tertiary education (long)—we do not establish a single significant coefficient. The abundance of insignificant coefficients clearly shows that a mine opening has no significant influence on the human capital distribution.

Finally, we can establish one additional positive effect from a mine opening: crime drops. Two years before the mine starts production there is a significant drop in the crime rate of 1.1 percentage point. The point estimate stays at this level in the following years but it is statistically insignificant the following two years before it regains its significance in year three, four, and five. This finding contradicts previous findings by Carrington (1996), MMSD (2002) and McMahon and Remy (2001), who report higher crime rates in mine development areas. These studies also find a sizable inflow of workers from outside and link the two. In the Nordic countries a mine opening does not increase the population size significantly, and hence the lack of inflow of new workers may be the reason why we observe crime rates dropping and not increasing.

4.8 Discussion

The empirical analysis shows many positive effects from mining projects in the Nordic countries and more specifically in the Arctic regions of Norway, Sweden, and Finland. The mines create new jobs and as a result both unemployment and the number of people outside the labor force are reduced. The new jobs are established in the mining industry and as derived employment in both construction and the primary sector. We have also provided evidence showing that the number of young people aged 20–39 increases when mines arrive in the area and that crime is reduced. Hence, the overall assessment is that mines are good for local societies, at least in the Arctic regions of the Nordic countries.

An important question is to what extent these results can be transferred to other territories in the Arctic region. That the Nordic countries may be somewhat different from other areas in the Arctic is reflected in the empirical observations that population size is constant despite the opening of a new mine, gender composition is unaffected, and the education distribution in the municipality is unaltered. This indicates that both manpower and knowledge are present in the areas where mines are established, at least to some extent. In other parts of the Arctic this has not been the case. When the Trans-Alaska Pipeline System was built it created a huge labor demand, which resulted in an influx of skilled "pipeliners," where the majority came from the pipeline industry in Oklahoma and Texas (Carrington, 1996). The influx of non-Alaskans, a sense of transiency, and rapid changes led to pressure on social welfare: increased crime, accelerated divorce rates, alcoholism, gambling, prostitution, and overcrowded classrooms (Carrington, 1996). The Pine Point Mine in the Northwest Territories of Canada during 1965–1987, for example, was mainly operated by transient mineworkers based in a temporary mining town. Few locals found employment at the mine, but nevertheless they suffered from damaging effects on traditional hunting and trapping grounds in the region (Sandlos and Wiersma, 2000; Locock et al., 2006). Hence, mine openings in regions where societies lack either manpower or skills will experience additional dynamics to those observed in the Nordic countries.

The situation in Greenland deserves particular attention in this discussion. Greenland has received a lot of global attention in recent time as a new major frontier due to the prospect of exploration and exploitation of significant mineral and hydrocarbon resources (Nuttall, 2012, 2013). For years varying interest groups, such as governmental bodies, advisory groups, and business associations (Government of Greenland, 2014; Ministry of Foreign Affairs, 2011; Økonomisk Råd, 2012; The Committee for Greenlandic Mineral Resources to the Benefit of Society, 2014; Copenhagen Economics, 2012; Nuttall, 2012), have argued that extractive industries and in particular mining and oil development can be the path that Greenland should pursue to improve economic conditions and recover economic growth. Despite the fact that Greenland had mining activities from 1800s up to modern times in the 1990s (Nordregio, 2010; GEUS, 2013) they have been at a modest scale and at present there are limited operating mining activities in Greenland (MLSA, 2016). Hence, unlike the Arctic regions of the Nordic countries, which we study in this paper, it is not clear if Greenland has a workforce of a sufficient scale and with appropriate competences (experience) required to harvest the positive employment effects of a large scale mining project (Økonomisk Råd, 2012; Copenhagen Economics, 2012; The Committee for Greenlandic Mineral Resources to the Benefit of Society, 2014). If this is the case, then Greenland's experience may be more similar to the Nanisivik and Polaris mines in Nunavut, where some (but far below expectations) Inuit from Arctic Bay and Resolute found employment at the mines (Bowes-Lyon et al., 2009). For a detailed discussion of the Greenlandic case see The Committee for Greenlandic Mineral Resources to the Benefit of Society (2014).

In this paper we have identified positive socioeconomic effects from mining activities. We have not addressed the mines' influences on the environment or the consequences of potentially hazardous working conditions. We have also not addressed the often complex relationships between the mining industry and indigenous people. While there are good examples of how indigenous people and the mining industry cooperate, such as the Red Dog Mine in Alaska (Prno, 2013; Horswill and Sandovik, 2000) and Diavik Diamond Mine in Canada (Missens, et al., 2007; Ritter, 2001), there are also examples of limited local participation and socioeconomic value creation. See for example the discussion related to the Pine Point Mine in Canada (Sandlos and Wiersma, 2000). Naturally, these potential threats and costs should be internalized and dealt with to secure successful implementation of any mining project.

4.9 Conclusion

In this paper, we establish the socioeconomic effects of mining projects in the Nordic countries with a particular focus on the Arctic region. We find strong positive effects on local employment, a decrease in unemployment, and a reduction in the number of people who are outside the labor force. The positive employment effects can be found in the mining and construction industries and the primary sector, but the timing and magnitude varies in line with the life-cycle of the mining project. Our results also show that mines have a positive influence on the number of young people in the municipality and that they reduce crime rates.

Our results also show that the gender and education compositions are unaffected by local mining activities and we are unable to detect changes in population size when mines are established in the area. Further research should establish if this is a result that only pertains to Scandinavia and to what extent the Arctic regions of the Nordic countries are different from other Arctic territories. Such studies may, however, be challenged by the lack of high-quality data that has benefitted this study.

In conclusion, this study contributes to the scarce literature on the socioeconomic effects of mining activities in the Arctic. Better knowledge about this issue is warranted as the Arctic is likely to be the resource deposit of the future. It is difficult, however, to answer the important question how Arctic societies change when resource exploration becomes more prevalent in the region. One reason is that data about these territories is limited and the number of mines in the area is small. With this study, we hope to pave the way for more research that will shed light on these our most

Northern societies and how they can be expected to change when extractive industries enter the region.

4.10 Results and tables

This section includes all tables with results presented throughout section 4.7 and discussed in section 4.8.

4.10.1 Table 5: The effect of a mine opening on the population size, employment, unemployment and people not in the labor force

	Employment	Unemployment	Non-labor market (*residual*)	Population
Prior to opening				
t = -3	72.161	-8.912	-59.810	3.439
	(97.293)	(17.438)	(140.989)	(51.341)
t = -2	133.446	-29.289	-39.438	64.719
	(132.426)	(52.648)	(237.869)	(133.948)
t = -1	285.294*	-93.999*	-159.558	31.737
	(145.488)	(51.185)	(243.410)	(138.412)
Mine opening				
t = 0	364.115**	-137.978***	-223.961	2.176
	(158.136)	(45.961)	(251.636)	(144.274)
Post opening				
t = 1	367.208***	-131.018***	-208.786	27.405
	(108.563)	(39.608)	(197.446)	(125.537)
t = 2	374.967***	-108.974***	-253.069	12.924
	(101.832)	(39.189)	(185.068)	(107.709)
t = 3	436.195***	-70.124	-316.747**	49.324
	(113.873)	(55.533)	(148.554)	(102.875)
Arctic x Prior to opening				
t = -3	-69.989	-18.404	141.230	52.837
	(158.320)	(66.875)	(155.967)	(71.495)
t = -2	-205.376	28.774	173.883	-2.719
	(168.284)	(88.051)	(249.112)	(140.677)
t = -1	-185.387	-1.554	243.447	56.506
	(193.834)	(91.264)	(259.168)	(144.191)
Arctic x Mine opening				
t = 0	-82.269	-1.883	195.871	111.719
	(212.002)	(98.167)	(261.558)	(150.220)
Arctic x Post opening				
t = 1	-78.266	-14.510	205.571	112.796
	(176.290)	(101.448)	(209.663)	(134.655)
t = 2	-42.513	20.975	112.594	91.056
	(188.124)	(98.918)	(206.763)	(114.515)
t = 3	-147.754	9.539	208.195	69.981
	(221.794)	(110.914)	(177.924)	(104.278)
Municipality specific time trends	YES	YES	YES	YES
Observations	18,352	18,352	18,352	18,352

R-squared	0.878	0.511	0.344	0.946

Note: *** 1 percent significance, ** 5 percent significance, and * 10 percent significance. Regressions are based on the period 1995 to 2012. We use robust standard errors in all specifications.

Table 5 - The effect of a mine opening on the population size, employment, unemployment and people not in the labor force

4.10.2 Table 6: The effect of a mine opening on the employment share by industry

	Primary sector	Mining	Manufacturing	Construction
Prior to opening				
t = -3	0.014	-0.003	0.002	-0.004
	(0.009)	(0.003)	(0.005)	(0.003)
t = -2	0.012	-0.004*	-0.004	-0.001
	(0.011)	(0.002)	(0.007)	(0.004)
t = -1	0.024***	-0.002	-0.005	-0.005
	(0.007)	(0.002)	(0.007)	(0.005)
Mine opening				
t = 0	0.028***	0.001	-0.007	-0.004
	(0.009)	(0.004)	(0.007)	(0.006)
Post opening				
t = 1	0.023**	0.007	-0.007	-0.003
	(0.009)	(0.005)	(0.006)	(0.003)
t = 2	0.024***	0.004	-0.007	0.000
	(0.008)	(0.004)	(0.005)	(0.003)
t = 3	0.024***	0.001	-0.004	0.008**
	(0.006)	(0.002)	(0.004)	(0.003)
Arctic x Prior to opening				
t = -3	-0.014	-0.007	-0.003	0.006*
	(0.012)	(0.008)	(0.006)	(0.004)
t = -2	-0.009	-0.010	0.001	0.011*
	(0.015)	(0.008)	(0.009)	(0.006)
t = -1	-0.011	-0.004	-0.001	0.021***
	(0.013)	(0.008)	(0.009)	(0.008)
Arctic x Mine opening				
t = 0	-0.016	0.016**	-0.002	0.015**
	(0.013)	(0.007)	(0.009)	(0.007)
Arctic x Post opening				
t = 1	-0.010	0.017*	0.001	0.005
	(0.013)	(0.010)	(0.008)	(0.004)
t = 2	-0.008	0.024**	0.004	0.005
	(0.014)	(0.011)	(0.007)	(0.005)
t = 3	-0.005	0.031***	0.000	-0.004
	(0.013)	(0.012)	(0.009)	(0.004)
Municipality specific time trends	YES	YES	YES	YES

Observations	18,352	18,352	18,352	18,352
R-squared	0.579	0.555	0.710	0.647

Note: *** 1 percent significance, ** 5 percent significance, and * 10 percent significance. Regressions are based on the period 1995 to 2012. We use robust standard errors in all specifications.

Table 6 - The effect of a mine opening on the employment share by industry

4.10.3 Table 7: The effect of a mine opening on the employment share by industry

	Electricity, gas and water supply	Transportation	Wholesale and retail	Other
Prior to opening				
t = -3	0.003	-0.001	0.005*	-0.016**
	(0.003)	(0.002)	(0.002)	(0.008)
t = -2	0.003	-0.000	0.006	-0.012**
	(0.003)	(0.002)	(0.004)	(0.005)
t = -1	0.001	0.002	0.004	-0.019***
	(0.003)	(0.003)	(0.003)	(0.004)
Mine opening				
t = 0	0.002	0.002	0.002	-0.024***
	(0.005)	(0.002)	(0.004)	(0.007)
Post opening				
t = 1	-0.000	0.001	0.004**	-0.024***
	(0.003)	(0.001)	(0.002)	(0.009)
t = 2	0.000	0.001	-0.001	-0.022***
	(0.003)	(0.002)	(0.002)	(0.008)
t = 3	-0.001	-0.001	-0.005***	-0.021***
	(0.002)	(0.002)	(0.002)	(0.006)
Arctic x Prior to opening				
t = -3	-0.006	0.004	-0.002	0.023*
	(0.004)	(0.003)	(0.004)	(0.012)
t = -2	-0.002	0.002	-0.004	0.010
	(0.004)	(0.004)	(0.005)	(0.013)
t = -1	-0.001	-0.001	-0.005	0.002
	(0.003)	(0.005)	(0.005)	(0.015)
Arctic x Mine opening				
t = 0	-0.002	-0.005	-0.004	-0.002

	(0.005)	(0.003)	(0.005)	(0.014)
Arctic x Post opening				
t = 1	0.001	-0.006	-0.007*	-0.002
	(0.003)	(0.004)	(0.004)	(0.015)
t = 2	0.002	-0.007	-0.003	-0.017
	(0.003)	(0.004)	(0.004)	(0.016)
t = 3	0.004	-0.007	0.001	-0.021
	(0.002)	(0.004)	(0.005)	(0.019)
Municipality specific time trends	YES	YES	YES	YES
Observations	18,352	18,352	18,352	18,352
R-squared	0.551	0.547	0.490	0.602

Note: *** 1 percent significance, ** 5 percent significance, and * 10 percent significance. Regressions are based on the period 1995 to 2012. We use robust standard errors in all specifications.

Table 7 - The effect of a mine opening on the employment share by industry

4.10.4 Table 8: The effect of a mine opening on the age structure

	Age 0 to 19	Age 20 to 39	Age 40 to 59	Age 60 to 79	Age 80+
Prior to opening					
t = -3	-24.128	59.246**	-7.809	26.301	1.623
	(41.701)	(26.431)	(53.173)	(59.117)	(9.425)
t = -2	-10.653	79.282**	-13.632	29.806	9.667
	(54.474)	(36.076)	(60.151)	(56.260)	(10.977)
t = -1	-3.851	96.421**	-12.313	14.308	14.848
	(59.266)	(45.045)	(61.772)	(61.784)	(9.140)
Mine opening					
t = 0	12.710	95.387**	-31.312	-11.983	14.461
	(64.915)	(48.111)	(73.635)	(68.637)	(13.055)
Post opening					
t = 1	17.796	87.432*	-43.500	-21.716	17.967
	(69.926)	(47.574)	(71.466)	(65.518)	(12.417)
t = 2	38.801	74.473	-21.911	-42.319	24.951*
	(53.132)	(56.193)	(40.487)	(70.300)	(12.938)
t = 3	42.090	63.480	-27.821	-45.090	28.501*
	(50.914)	(48.881)	(45.128)	(54.591)	(15.927)
Arctic x Prior to opening					
t = -3	52.783	48.400	-70.202	-17.768	-16.400
	(63.816)	(59.991)	(108.005)	(88.518)	(13.256)
t = -2	63.647	35.818	-85.274	-34.293	-18.786

	(79.950)	(61.233)	(137.154)	(95.023)	(15.618)
t = -1	93.896	25.154	-95.824	-38.297	-16.174
	(92.422)	(70.981)	(160.938)	(105.580)	(17.195)
Arctic x Mine opening					
t = 0	112.022	34.451	-107.600	-25.982	-5.831
	(107.611)	(79.259)	(192.795)	(116.632)	(20.054)
Arctic x Post opening					
t = 1	143.817	34.141	-93.315	-39.635	-8.128
	(122.895)	(78.548)	(211.198)	(120.508)	(21.275)
t = 2	154.914	22.289	-165.343	-4.816	-3.853
	(124.788)	(85.807)	(240.725)	(125.568)	(25.451)
t = 3	75.043	-15.887	-5.378	-57.119	-19.047
	(77.053)	(70.030)	(121.235)	(116.951)	(24.860)
Municipality specific time trends	YES	YES	YES	YES	YES
Observations	28,466	28,466	28,466	28,466	28,466
R-squared	0.954	0.920	0.947	0.678	0.858

Note: *** 1 percent significance, ** 5 percent significance, and * 10 percent significance. Regressions are based on the period 1986 to 2013. We use robust standard errors in all specifications.

Table 8 - The effect of a mine opening on the age structure

4.10.5 Table 9: The effect of a mine opening on the population size, the gender distribution and child births

	Population[1]	Women	Men	Female proportion	Child births
Prior to opening					
t = -3	55.233	21.086	34.147	-0.001	-1.735
	(85.265)	(40.767)	(45.232)	(0.001)	(3.966)
t = -2	94.471	38.448	56.023	-0.001	5.249
	(115.724)	(58.483)	(58.636)	(0.001)	(9.087)
t = -1	109.413	49.949	59.464	-0.001	0.516
	(127.541)	(62.945)	(66.030)	(0.001)	(8.597)
Mine opening					
t = 0	79.263	39.445	39.818	-0.000	10.186
	(153.499)	(79.200)	(75.874)	(0.001)	(13.140)
Post opening					
t = 1	57.979	34.713	23.267	0.001	8.971
	(151.642)	(78.186)	(74.920)	(0.001)	(13.436)
t = 2	73.994	42.828	31.167	0.000	5.728
	(136.982)	(68.305)	(69.752)	(0.001)	(12.140)
t = 3	61.162	32.857	28.305	0.000	2.429
	(125.617)	(65.932)	(59.937)	(0.001)	(7.402)
Arctic x Prior to opening					
t = -3	-3.186	13.112	-16.298	0.002**	1.894

	(114.312)	(56.403)	(59.217)	(0.001)	(7.257)
t = -2	-38.888	-0.570	-38.318	0.002	-6.854
	(145.168)	(73.310)	(74.100)	(0.001)	(11.185)
t = -1	-31.245	14.514	-45.760	0.003*	1.751
	(162.456)	(81.355)	(83.994)	(0.002)	(9.729)
Arctic x Mine opening					
t = 0	7.060	37.626	-30.567	0.003	-13.176
	(181.780)	(92.595)	(92.600)	(0.002)	(14.390)
Arctic x Post opening					
t = 1	36.881	40.378	-3.497	0.001	-4.409
	(181.292)	(93.397)	(91.850)	(0.002)	(16.020)
t = 2	3.191	25.393	-22.202	0.001	-3.505
	(172.965)	(85.259)	(92.026)	(0.002)	(18.067)
t = 3	-22.388	3.161	-25.549	0.001	-1.234
	(173.825)	(87.805)	(88.606)	(0.002)	(10.536)
Municipality specific time trends	YES	YES	YES	YES	YES
Observations	28,466	28,466	28,466	28,466	28,466
R-squared	0.957	0.947	0.963	0.573	0.706

Note: *** 1 percent significance, ** 5 percent significance, and * 10 percent significance. Regressions are based on the period 1986 to 2013. [1] In contrast to the results presented earlier on population these span the longer time period: 1986 to 2013. We use robust standard errors in all specifications.

Table 9 - The effect of a mine opening on the population size, the gender distribution and child births

4.10.6 Table 10: The effect of a mine opening on the education level and crime

	Basic[1] schooling	Upper[1] secondary	Tertiary[1] (short)	Tertiary[1] (long)	Crime[2]
Prior to opening					
t = -3	-0.000	0.000	-0.001	0.000	0.005
	(0.002)	(0.004)	(0.001)	(0.002)	(0.010)
t = -2	-0.002	0.002	0.001	0.000	-0.011***
	(0.003)	(0.005)	(0.001)	(0.001)	(0.003)
t = -1	-0.002	0.003	0.000	-0.000	-0.011*
	(0.003)	(0.005)	(0.001)	(0.001)	(0.006)
Mine opening					
t = 0	-0.003	0.003	0.001	-0.000	-0.010
	(0.004)	(0.006)	(0.001)	(0.001)	(0.006)
Post opening					
t = 1	-0.003	0.004	0.001	-0.001	-0.011**
	(0.003)	(0.005)	(0.001)	(0.001)	(0.004)
t = 2	-0.003	0.004	0.000	-0.000	-0.011***
	(0.002)	(0.004)	(0.001)	(0.001)	(0.003)
t = 3	-0.002	0.003	0.000	-0.000	-0.004**

	(0.002)	(0.004)	(0.002)	(0.001)	(0.002)
Arctic x Prior to opening					
t = -3	-0.001	0.001	0.001	-0.000	-0.003
	(0.003)	(0.005)	(0.001)	(0.002)	(0.010)
t = -2	-0.001	0.000	0.000	0.000	0.000
	(0.003)	(0.006)	(0.001)	(0.002)	(0.005)
t = -1	-0.000	-0.001	0.000	0.001	0.002
	(0.004)	(0.007)	(0.001)	(0.002)	(0.009)
Arctic x Mine opening					
t = 0	-0.001	-0.000	-0.001	0.002	-0.000
	(0.005)	(0.008)	(0.001)	(0.002)	(0.010)
Arctic x Post opening					
t = 1	-0.001	0.000	-0.001	0.003	0.009
	(0.004)	(0.008)	(0.002)	(0.002)	(0.009)
t = 2	-0.002	0.002	-0.002	0.002	-0.006
	(0.004)	(0.007)	(0.002)	(0.002)	(0.006)
t = 3	-0.001	-0.000	-0.001	0.002	-0.003
	(0.004)	(0.008)	(0.003)	(0.002)	(0.005)
Municipality specific time trends	YES	YES	YES	YES	YES
Number of municipalities	1,023	1,023	1,023	1,023	1,022
Observations	26,446	26,446	26,446	26,446	6,122
R-squared	0.986	0.924	0.958	0.968	0.611

Note: *** 1 percent significance, ** 5 percent significance, and * 10 percent significance. [1] Regression is based on the period 2007 to 2012. [2] Regression is based on the period 1987 to 2012. We use robust standard errors in all specifications.

Table 10 - The effect of a mine opening on the education level and crime

4.11 References

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5 Chapter 5: Transitioning from an economic cluster to a collaborative community: mining projects in Greenland

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By Maja Due Kadenic

5.1 Abstract

This paper analyzes the Greenlandic business community and the recently established cluster relevant to extractive industries in Greenland, Arctic Cluster of Raw Materials (ACRM), to enhance local business development in mining projects in Greenland. The analysis directs toward a transition from an economic cluster to a collaborative community in order to increase business potential and to overcome limitations of smallness and inadequate competencies of the Greenlandic business community in the mining industry. Transitioning into a collaborative community creates more value by enabling member firms to realize business development that each single firm could not achieve with its own efforts by being a part of a cluster. Managing the transition process emphasizes the facilitating role for the reason that a shared service provider is required in every collaborative community. I develop a conceptual model for the transition from an economic cluster to a collaborative community based on the architectural elements of the collaborative community design. The conceptual model considers the five proximity dimensions that influence inter-firm linkages both as enablers and barriers to the transition process and collaboration. Collaboration represents a new approach to business and industrial development in remote regions of the Arctic, as challenges evident for Greenland can be found throughout the entire Arctic.

Key words: Cluster development, collaboration, collaborative community, proximity dimensions, Greenland, mining, Arctic

5.2 Introduction

In recent years, Greenland has attracted global attention as a frontier region of the Arctic for development of mineral and hydrocarbon resources (Nuttall, 2012). Similar to other Arctic economies, the industrial structure in Greenland is dominated by fishing and hunting of very few species (Duhaime and Caron, 2006; Larsen, 2010; Økonomisk Råd, 2012), which emphasizes the vulnerability of Greenland's economy. A mining industry represents an opportunity for economic growth and positive effects on local businesses and employment (Government of Greenland, 2014;

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Ministry of Foreign Affairs, 2011). Nevertheless, the Greenlandic business community is challenged by size limitations, lack of prior experience with the mining industry and necessary competencies (Copenhagen Economics, 2012; The committee for Greenlandic mineral resources to the benefit of society, 2014; Økonomisk Råd, 2012).

A cluster relevant to extractive industries in Greenland, Arctic Cluster of Raw Materials (ACRM), was established in 2013 by the Confederation of Danish Industry (DI), the Danish Industry Foundation (IF), Greenland Business Association (GA), and the Technical University of Denmark (DTU). The cluster serves as a platform for businesses with interest in the extractive industries in Greenland (Jakobsen and Lyne, 2013). The main purpose of ACRM is to strengthen competitiveness, increase possibilities for subcontractors to mining projects in Greenland, and raise awareness about mineral exploration in Greenland and the Arctic (Arctic Cluster of Raw Materials, 2016; Jakobsen, 2013).

Cluster establishment and collaboration is considered beneficial for the Greenlandic business community in order to increase business potential (The committee for Greenlandic mineral resources to the benefit of society, 2014). I therefore investigate the ability of cluster development and the collaborative approach to enhance local business development and application of Greenlandic businesses in mining projects. In this paper, I apply an in-depth single-case-study design (Yin, 2014) based on data from interviews and supported with secondary data sources such as reports, research, documents, and statistics.

Firms in various industries cohere together in different kind of clusters and networks. Industrial clusters are powerful engines to wealth creation (Mathews, 2012; Ghadar et al., 2012). They cut across traditional industry classifications and are concentrations of interconnected companies and institutions co-located in a specific geographic region and linked by commonalities and complementarities in a particular field (Ketels, 2003; Porter, 1998, 2000; Porter et al., 2004). This represents a new way of thinking about local economies (Porter, 1998, 2000). This is well recognized and object of increased attention (Mathews, 2012). Clusters represent a setting in which both traditional production activities and entrepreneurial and innovative activities take place (Mathews, 2012). Firms that form part of a cluster can accomplish many more activities by having access to more resources over the single, isolated firm, and expanding the market for their products and services (Mathews, 2012). Ultimately, a cluster is a system where interconnections among members result in a whole that is greater than sum of its parts (Porter, 1998, 2000). Firms within clusters do form linkages. Collaboration and linkages between organizations in clusters are influenced by five proximity dimensions: geographical, social, cognitive, organizational, and institutional (Belso-Martinez, 2016; Molina-Morales et al., 2015; Boschma, 2005). Limitation and excess of proximity may prevent successful inter-organizational linkages (Boschma, 2005).

In extension of cluster development, industries are rethinking their business processes (Daft et al., 2010). Firms are increasingly faced with competitive pressures due to continuous adaptation to a dynamic environment (Fjeldstad et al., 2012). In response to the pressing challenges, a new organizational form is emerging, based on a collaborative community design (Bøllingtoft et al., 2012; Fjeldstad et al., 2012; Miles et al., 2010; Snow, 2012; Snow et al., 2011; Snow et al., 2009). Collaboration is a process where at least two parties work together to achieve mutually beneficial outcomes, such as resolving a problem or creating a new business (Miles et al., 2005; Miles et al., 2000; Tencati and Zsolnai, 2009). Companies can achieve competitive advantage by joining resources and accomplish more at a faster rate than they can on their own (Bøllingtoft et al., 2012; Daft et al., 2010; Miles et al., 2005; Schilling, 2010; Snow et al., 2011). Collaboration among SMEs can be an advantageous strategy to overcome financial and resource limitations and strengthen their market position (Franco, 2003). Small companies are particularly motivated by competitive advantages, which include entering new markets; improving the level of innovation; sharing resources and competencies; achieving economies of scale; and increasing production capacity (Franco, 2003).

Firms within a cluster that face challenges and limitations, such as those of the Greenlandic business community, can achieve more through the act of collaboration than with own efforts within a cluster. Hence, there is a linkage between cluster development and collaboration, where clusters evolve and transition into collaborative communities for the reason that it will enable member firms to accomplish more business development. The transition from a cluster to a collaborative community is important as it represents an approach for continuous development and evolvement of clusters both from a theoretical and practical perspective. This is particularly interesting for small clusters such as ACRM. Collaborative community development is not always a result of an evolutionary process, but can also be a planned and purposeful process (Bøllingtoft et al., 2012). Therefore, the transition from a cluster to a collaborative community can also be a deliberate effort. For this reason, managing the transition process emphasizes the facilitating role of a shared service provider as this role is required in a collaborative community (Bøllingtoft et al., 2012). Adding to this, it is important to take account of the proximity dimensions in the transition process, as they are mechanisms that influence linkages between firms (Boschma, 2005).

In this paper, I develop a conceptual model for the transition from an economic cluster to a collaborative community, which is based on the core architectural elements of a collaborative community design and considers the proximity dimensions both as enablers and barriers to the transition process and collaboration.

The remainder of the paper is organized as follows. First, I provide the theoretical proposition of cluster development and collaborative communities. Then, I present the methodological approach. Thereafter, I investigate expectations and challenges associated with the mining industry in Greenland, which provides a contextual framework and thorough understanding of the subject to support further analysis. This is followed by the analysis, where I analyze cluster development and ACRM, and the collaborative approach to enhance local business development in Greenland. The analysis leads to a transition from ACRM as a cluster into a collaborative community relevant to extractive industries in Greenland. Here, I develop and outline the conceptual model for the transition from an economic cluster to a collaborative community. Lastly, I provide the discussion and a conclusion.

5.3 Cluster development

Grouping of related suppliers of services, inputs, products, equipment, expertise, and know-how leads to the formation of a cluster (Ketels, 2003; Porter, 1998; Singh and Evans, 2009). Clusters arise when business segments require specialization from multiple contributors. And these formations emerge unexpected places both in advanced countries and in developing countries (Ghadar et al., 2012; Mathews, 2012). For example, several countries have used natural resources (mineral and hydrocarbon resources) as a platform to catalyze economic potential by developing clusters of supporting industries, products, and services, such as the cluster around extraction and processing of copper ore in Chile and the Ontario Mineral Industry Cluster in Canada (Singh and Evans, 2009).

Clusters can increase competitiveness and drive innovation by their geographic concentration when bringing partners together and providing opportunities to share expertise and network (Porter, 2000; Singh and Evans, 2009). Clusters enable member firms to operate with a higher level of efficiency by sharing common technologies and infrastructure, and by accessing extensive information on market, technical and competitive matters (Delgado et al., 2014a; Ketels, 2003; Porter, 1998). Close interaction among firms leads to knowledge spillover, which creates new ideas, facilitates growth in entrepreneurship, and enables firms and research institutions to achieve higher levels of innovation (Delgado et al., 2010; Ketels, 2003). A high concentration of people who are working on similar problems in the same location can speed the progress, as collaboration that produces innovation is easier on the ground that in the cloud (Ghadar et al., 2012). Besides providing opportunities for innovation, clusters also provide the flexibility and capacity to act rapidly (Porter, 1998). Industries located in a strong cluster produce higher employment and patenting growth, which contributes to regional industrial growth (Delgado et al., 2014b).

5.3.1 Government support

While it is difficult to establish how clusters emerge, it is evident that government support is an important factor for cluster formation (Ghadar et al., 2012). Policy choices, public and private awareness, and investments can have a great influence in the process (Porter et al., 2004; Ghadar et al., 2012). Encouraged and aligned efforts by the private sector, government at all levels, and other institutions constitute an essential element in regional economic development. This is an evolutionary process combined with careful planning and investment to seize presented opportunities (Porter et al., 2004). Effort made by government or public institutions, including public spending for educational programs of local workforce or specialized infrastructure, has the ability to enhance productivity of local companies (Porter, 1998; Ghadar et al., 2012). Governments should reinforce and build on emerging and established clusters, and motivate and facilitate cluster development and collective action by the private sector (Porter, 2000).

5.3.2 Inter-firm linkages in clusters and the proximity dimensions

Clusters provide a platform to bring government, local institutions, and companies together in a constructive dialog for collaboration as a new way of organizing economic development beyond traditional efforts and to enhance the overall business environment (Porter, 2000). Interaction among cluster members, the strength of networks, and open collaboration within a region are key factors for economic success (Ketels, 2003).

Inter-organizational relationships, collaboration, in clusters depend on five proximity dimension: cognitive, social, institutional, organizational, and geographical (Belso-Martinez, 2016; Molina-Morales et al., 2015; Boschma, 2005). Studies provide evidence of proximities' influence on the formation of inter-firm linkages in clusters (Belso-Martinez, 2016; Molina-Morales et al., 2015). They are context specific and depend on the stage of the life-cycle of the cluster (Belso-Martinez, 2016). The cognitive proximity dimension refers to the similarity of actors' shared knowledge base, which eases collaboration. Common interpretive schemes are needed in order to understand each other, communicate meaningfully, and generate knowledge (Boschma, 2005). Limited cognitive proximity can lead to misunderstandings and impede performance, whereas too close cognitive proximity may reduce inter-firm knowledge exchange and learning opportunities (Belso-Martinez, 2016; Molina-Morales et al., 2015).

The social proximity dimension refers to socially embedded relationships between actors at the micro-level and such behaviors include friendship, kinship, and experiences (Boschma, 2005). Social links create trust and reduce the risk of opportunism. Trust emerges from frequent meetings and face-to-face interactions, which leads to cooperative behavior. This is linked to geographical proximity (Molina-Morales et al., 2015). However, a high level of social proximity may underestimate opportunistic behavior (Boschma, 2005). The institutional proximity dimension refers to formal rules, codes of conduct, norms, and conventions that provide stability and basic level of trust. High levels of institutional proximity can prevent knowledge transfer, awareness of new innovation, and provide no opportunities for newcomers (Boschma, 2005; Belso-Martinez, 2016; Molina-Morales et al., 2015). Organizational proximity refers to share of relations in an organizational arrangement, where more control and possibilities to regulate interactions leads to greater organizational proximity, which reduces uncertainty and opportunism (Boschma, 2005). However, too much organizational proximity can lead to lack of flexibility (Belso-Martinez, 2016; Molina-Morales et al., 2015). Geographical proximity refers to the physical closeness. Geographical proximity strengthens indirectly other forms of proximity, such as the formation of institutions, embeddedness, trust, and cognitive closeness (Belso-Martinez, 2016; Molina-Morales et al., 2015). Proximity dimension interrelate and affect network dynamics, where two or more forms of proximity can complement each other (Boschma, 2005; Molina-Morales et al., 2015).

5.4 Collaborative communities

The complexity and instability of the environment, and companies' weaknesses can push toward interorganizational relationships (Daft et al., 2010). Companies are changing the concept of what constitutes an organization by becoming involved in partnerships, breaking down boundaries, approaching with fairness, and adding value to both sides (Daft et al., 2010; Snow et al., 2009). The collaborative community design provides member firms the opportunity to mutually develop capabilities and increase effectiveness, efficiency, and productivity by mobilizing a wide variety of resources (Snow et al., 2011). Collaboration can reduce cost and risk, enhance flexibility, speed products to market, provide accessibility to new markets, and gain economies of scale without the fear of exploitation (Bøllingtoft et al., 2012; Fjeldstad et al., 2012; Schilling, 2010; Snow et al., 2011). Expanded availability and application of resources and knowledge can enhance innovation and wealth creation (Fjeldstad et al., 2012; Ketchen et al., 2007; Miles et al., 2000; Schilling, 2010). Effective collaboration is present when the involved parties value the contribution of each other and are concerned with equitable treatment (Miles et al., 2006). The underlying motives and beliefs of interacting parties point toward commitment to contributing to a shared set of goals and as well as achieving private benefits, which reduces the need for continuous assessment of trust (Alder et al., 2008; Miles et al., 2005; von Hippel and von Krogh, 2003). It is a behavior that can be learned (Miles et al., 2005).

5.4.1 The architecture of collaborative community design

The architectural elements and core ingredients of a collaborative community design include actors, protocols and infrastructure, and commons (Fjeldstad et al., 2012; Miles et al., 2010). Actors are individuals, firms, or governments, who have collaborative capabilities, knowledge, information, tools, and values. Protocols are codes of conduct used by actors in their collaborative activities, which deals with the division of labor, linking, and mobilization of actors for a specific project or task (Fjeldstad et al., 2012). Infrastructure allows actors to connect to each other and access the same knowledge, information, and resources (Fjeldstad et al., 2012). Protocols set the directions for their collaborative activities, whereas shared infrastructure enables members to connect with each other and access the same information. Commons are a repository of resources and knowledge, which are available to all actors (Fjeldstad et al., 2012; Miles et al., 2010). Actors can collaborate to find solutions to problems and pursuit opportunities through shared access to commons supported by protocols and infrastructure that facilitate the collaborative process (Miles et al., 2010).

Time, trust, and territory are three essential conditions for establishment of an effective collaboration process. All three are broad and interrelated (Miles et al., 2000). Investing time is a basic necessity of engaging in a collaboration process, which is important for development of trust among the involved parties (Miles et al., 2000). Trusting relationships create an environment where involved parties are more willing to expose views and ideas without the fear of being exploited (Miles et al., 2000). The concept territory refers to a sense of belonging and it implies real evidence, such as stock ownership and one’s efforts by which the outcomes of the collaborative process are achieved (Miles et al., 2000).

5.4.2 Governance structure

A collaborative community is managed by a philosophy of minimal organization, such as the use of protocols and self-management instead of hierarchical controls (Alder et al., 2008; Miles et al., 2005). Effective governance of a collaborative community design requires a facilitative management approach and flexible governance structure, which carries no connotation of hierarchy or ownership and allows the community to expand and accelerate (Bøllingtoft et al., 2012; Miles et al., 2005; Miles et al., 2010; Snow et al., 2009). There is a need for a shared service provider in every collaborative community (Bøllingtoft et al., 2012). Activities performed by a shared service provider include screening and selection of member firms, linking members, development of a knowledge commons, infrastructure and protocols that connect members, administrative services, and strategic initiatives to improve and expand the community (Bøllingtoft et al., 2012; Miles et al., 2005; Snow et al., 2011).

5.4.3 Challenges

The challenges associated with a collaborative design include ensuring commitment and necessary investments to the common goal, coordinating efforts of different contributors, and ensuring compatible solutions that fit together in the larger system (Miles et al., 2005; Miles et al., 2010; Miles et al., 2000; Schilling, 2010; Snow, 2012). Furthermore, collaboration faces barriers such as fear of exploitation, view that collaboration is too time-consuming, costs exceeding benefits, and reduction of own talent pool and capabilities (Schilling, 2010; Snow, 2012). Collaborating partners must have compatible objectives, whereas contradicting objectives can result in conflicts, wasted resources, and lost opportunities (Schilling, 2010). Collaboration is fundamentally a voluntary and self-managed process, which can only be facilitated and encouraged and cannot be imposed, manipulated, or closely controlled (Miles et al., 2006; Miles et al., 2000).

5.5 Method

The paper applies a single-case study design (Yin, 2014) and investigates opportunities and implications of the mining industry to the Greenlandic society and approaches to enhance local business development derived from the mining industry based on qualitative data (Creswell, 2009). The theoretical proposition guides data collection and analysis (Yin, 2014). The case study is based on data from interviews and is supported with data from documents, reports, research, and statistical sources, as multiple types of data increase the robustness of results through triangulation (Bryman and Bell, 2003; Yin, 2014).

The key informants relevant to the subject of inquiry include the Government of Greenland, Ministry of Industry, Labour and Trade; Greenland Business Association; Confederation of Danish Industry; Arctic Cluster of Raw Materials; and a local Greenlandic business with experience in the mining industry and member of ACRM. They represent the local community content, authorities, and the local business community. The interviews with the selected key informants within these organizations are characterized as elite interviews (Kvale and Brinkmann, 2009) as these persons are leaders or experts in their field. These key informants contribute by their comprehensive experience and knowledge relevant to the societal aspects of mining in Greenland and business community perspectives. Hence, persons with these characteristics are few in numbers. Six semi-structured interviews are conducted with six key informants, whereof two key informants are from the Government of Greenland, Ministry of Industry, Labour and Trade (Gov GL), one key informant from Greenland Business Association (GA); one key informant from a local Greenlandic business (GL Bus); and two key informants from Arctic Cluster of Raw Materials and Confederation of Danish Industry (ACRM, DI). Arctic Cluster of Raw Materials is embedded within Confederation of Danish Industry and therefore the key informants cover both institutions.

The process follows seven stages of an interview inquiry (Kvale and Brinkmann, 2009): thematizing, designing, interviewing, transcribing, analyzing, verifying, and reporting. The study includes three topics: Greenland and the mining industry, cluster development, and a collaborative approach. The initial introductory topic provides a framework and an understanding of the context, which supports the analysis of the two following topics that are based on the theoretical propositions.

Five key informants were contacted by e-mail with an introduction to the research project, a short outline of the three topics, and a request for interview. The key informant from GA recommended the local Greenlandic business and it's CEO as a key informant due to the company's experience with the mining industry and collaborative activities. The key informant from the local Greenlandic business was subsequently contacted by e-mail with an introduction to the research project and a request for interview. An interview guide was prepared based on the three topics. The interview form of each interview is selected based on the preference of the key informant. Key informants located in Denmark chose between face-to-face, telephone, and Skype interviews. Key informants located in Greenland chose between telephone and Skype interviews due to the geographical distance from the researcher (Creswell, 2009). Four telephone interviews, one Skype interview, and one face-to-face interview were conducted. All interviews were recorded and transcribed with the interviewee's consent. The coding process of transcripts is based on meaning condensation (Kvale and Brinkmann, 2009) where statements are compressed into briefer statements and rephrased into few words and empirical themes are identified. The analysis is conducted by applying a theoretical lens (Kvale and Brinkmann, 2009; Yin, 2014) according to the theoretical propositions.

Ethics: All key informants are aware of that they are participating and contributing with their knowledge and perspectives to a research project and all remain anonymized.

5.6 Greenland and the mining industry: current situation, expectations, and challenges

Greenland's economy is dominated by a large public sector, dependence on fishery (which accounts for 90% of total exports), a block grant of 3679 DKK million in subsidies from Denmark, and a negative growth rate (Statistics Greenland, 2016a). Greenland's current economic situation is considered vulnerable, with few sources of income and an increasing gap between expenditure and revenue. *"The economic situation is such, if you do not take any action, remain status quo, which is also a choice, then you simply aggravate the situation"* (key informant 1 Gov GL). There is a general awareness in Greenland about the necessity of economic diversification and business development according to key informants.

5.6.1 Expectations

Extraction of natural resources is considered as an industry that will make a difference to the society and provide economic prosperity (Copenhagen Economics, 2012; Government of Greenland, 2014; Ministry of Foreign Affairs, 2011; Nuttall, 2012; The committee for Greenlandic mineral resources to the benefit of society, 2014; Økonomisk Råd, 2012). *"The industry that can really make a difference and create an economic base and liberate Greenland's dependence on the two sectors* (fishery and block grant) *is natural resources"* (key informant 2 Gov GL). The extractive industry is stated from the political system and the business community as a pillar that can and should be developed in order to boost the economy (Bjørst, 2016; Government of Greenland, 2014; Tiainen; 2016). *"… it* (mining industry) *will contribute to the society by generating jobs, turnover, tax revenue, and that way it will generate growth for companies and the society as a whole"* (key informant 2 ACRM, DI). Additionally, *"… mining industry can be a catalyst to raise the educational level in Greenland"* (key informant GA).

Communities in other parts of the Arctic have realized socioeconomic development from the presence of the mining industry (Frederiksen and Kadenic, 2016; Kadenic, 2015; Missens et al., 2007; Prno, 2013; Ritter, 2001). *"... it* (mining industry) *especially creates jobs in the derived effects. Such as service tasks, mechanics, catering, transportation, logistics. And I believe that this is where the Greenlandic companies have potential"* (key informant GA). Linkages between the mining industry and other sectors include supply of food and catering services, transportation services, construction, utilities, and materials (Aroca, 2001; Ejdemo, 2013; Hajkowicz et al., 2011). The derived business opportunities deserve particular attention, since this is where the Greenlandic businesses will find a strong fit between local capabilities and the demand side of mining.

5.6.2 External challenges

Undoubtedly, there are great expectations that the mining industry will be beneficial to the Greenlandic society. Nevertheless, there are some challenges that can impede the establishment of a mining industry in Greenland. Among the external challenges, since 2014, prices for commodities such as crude oil (Nasdaq, 2016) and iron (Infomine, 2016) have fallen, reducing the business case for developing mines in Greenland at present time. *"...the problem is that the prices are not at their peak at the moment. And then they* (mining companies) *do not have a business case"* (key informant 2 ACRM, DI). A promising large-scale project in West Greenland, the Isua iron ore mine, is currently on hold as the company (London Mining Plc) behind the project was faced with financial problems, and the exploitation license has been transferred to the Hong Kong–based company General Nice Development Limited (Government of Greenland, 2015). Furthermore, Maersk Oil has postponed exploration activities in Baffin Bay due to low oil prices (Borsen, 2016).

Key informants elaborate that lack of funding also impedes development of a mining industry. Currently, there are no significant Greenlandic or Danish investments in Greenlandic mining projects. *"You not only need risky money, but plenty of really risky money to push some projects in progress"* (key informant GL Bus). Investing in the mining industry is associated with great risk, which typically does not appeal to public funding or pension funds, as these particular investors seek secure and long-term investments with reasonably guaranteed returns. *"... if they* (local investors) *do not invest in their own country, then the risk might be too high and therefore foreign investors are maybe holding back"* (key informant 1 ACRM, DI). However, key informants stress that there is a need for public Greenlandic and Danish funding to show commitment to the local mining industry and potentially attract private and foreign investments. These investments may not directly be in mining projects, but investments in local infrastructure and hydropower could strengthen the business case for investing in mining projects.

5.6.3 Internal challenges

Among the internal challenges, resource extraction in Greenland, as in other parts of the Artic, is challenged by the climate conditions, limited infrastructure, and remoteness (Hansen et al., 2016). Furthermore, primary school is the highest level of education for 63 percent of the Greenlandic population (Statistics Greenland, 2014). *"…we are also challenged on the skills of the workforce in Greenland, there is a gap between the needs, the technically advanced issues, and the competencies that are present"* (key informant 2 Gov GL). Besides uncertainties regarding necessary competencies, Greenland has a small labor force of 26,764 (Statistics Greenland, 2016a). As an example, the proposed large-scale mining project, Isua, requires a workforce of between 1,500 and 2,000 employees with a peak of up to 3,300 employees during a three-year construction phase (SIA of the Isua Iron Ore Project, 2013). This need cannot be met entirely by the local workforce. *"We cannot deliver full labor force for the construction of large mining projects. Small projects are no problem"* (key informant 2 Gov GL). Adding to this, the business community is dominated by SMEs (small medium-sized enterprises), where 75.1 percent of companies in Greenland are proprietorships (Statistics Greenland, 2016b). *"90 percent of businesses have fewer than 10 employees. So if you want to make yourself relevant in a larger context, then it* (collaboration) *is the way forward"* (key informant 2 ACRM, DI). Hence, collaboration appears to be a suitable strategy to pursue in order to strengthen local competitiveness and enhance local business development in the mining industry.

5.7 Analysis

This section presents key findings of the empirical work analyzed according to the theoretical perspectives. Further, the analysis directs toward a transition from ACRM as a cluster to a collaborative community.

5.7.1 Cluster development and Arctic Cluster of Raw Materials

ACRM represents 27 businesses ranging broadly from transportation and logistics companies to law firms and consultancies, which covers the entire life cycle of a mining project (Arctic Cluster of Raw Materials, 2016). Cutting across traditional industry classifications and including a variety of industries and companies is a key feature of cluster formation (Porter, 1998, 2000; Porter et al., 2004; Singh and Evans, 2009). Clusters allow members to access extensive market information

(Delgado et al., 2014a; Ketels, 2003; Porter, 1998), which is also a key contribution of ACRM to its members. *"We collect knowledge within our platform and disseminate knowledge to members by hosting various seminars, going on field trips to see how we can do it better, schedule meetings with companies from other mining countries such as Canada to hear more about their experiences, something we can learn by and also learn from each other"* (key informant 2 ACRM, DI). Key informants emphasize networking as a key benefit of being a member of ACRM. The opportunity to communicate and become familiar with other companies is highly valued by the members. In addition to knowledge sharing and networking, ACRM constitutes as a marketing platform for members. *"I believe that many companies need to have some kind of platform to promote them. Both promote Greenland as an investment object and themselves as a part of the industry"* (key informant 1 ACRM, DI).

5.7.1.1 Subcontractor barrier

It is very challenging to make yourself visible as a single Greenlandic company in a highly competitive mining industry without any prior experience as a subcontractor. Mining companies have typically established a network of subcontractors with proven track records, necessary certifications, and quality levels to work in the Arctic or the mining industry in general. Therefore, mining companies will primarily assign known subcontractors within their own network. *"There is a barrier in relation to not being inside or a known subcontractor, or how to qualify to get on the list of potential subcontractors"* (key informant 1 ACRM, DI). It is also difficult for Greenlandic SMEs to arrange a meeting with a mining company and get recognized as a potential subcontractor. In this regard, a cluster becomes valuable, as the whole is greater than each single company that comprises the cluster (Porter, 1998, 2000). ACRM address this problem by gathering members and arranging meetings with mining companies. This way, a group of potential subcontractors are represented in one place and the mining company becomes aware of them and their services. *"... and the client* (mining company) *tells that it is interesting for us* (mining company) *to meet all of them* (potential subcontractors, members of ACRM) *at once and know that there is an entrance door to subcontractors in Greenland, they* (mining company) *can find it here* (ACRM)*"* (key informant 1 ACRM, DI). Hence, ACRM takes on the facilitating role when it comes to establishing relations between its members and mining companies. According to key informants, size matters in order to become subcontractor to mining projects. Large mining companies are more likely to make a contract with one large subcontractor, who guarantees the delivery of large construction work rather than hiring several smaller subcontractors to do the same work.

5.7.1.2 A timing dilemma

Governments have the ability to support and motivate cluster development by initiating educational programs to enhance the productivity of local workforce and local companies (Porter, 1998, 2000; Porter et al., 2004). The Government of Greenland has financed a competency development program to improve qualifications of local workforce and local companies to prepare local companies for being positioned as service providers in the mining industry. Aligned efforts by the Government of Greenland indirectly support the purpose of ACRM, as they both aspire to strengthen the competitiveness of local businesses in a mining context. *"The past year has been characterized by companies in Greenland being reluctant towards the mining industry, not because they have anything against it, but because it has not turned into something big yet"* (key informant 2 Gov GL). Key informants stress that the downturn in the mining industry combined with lack of local project development at present time causes reluctance among local businesses to allocate resources from daily operations to participate in competency development programs. *"But it is very hard constantly to wait and get trained for something you do not know will be realized"* (key informant 1 ACRM, DI). This leads to uncertainty about when to improve qualifications of local workforce. Undoubtedly, preparing the local workforce and businesses for the next upswing will be advantageous. Nevertheless, local businesses are occupied by their daily operations and qualifying for an industry that is not fully established is difficult to prioritize. In this regard, it is worth drawing on perspectives from other mining projects in the Arctic. In the cases of Red Dog Mine in Alaska and Diavik Diamond Mine in Canada, education and training of local workforce is undertaken cooperatively by the mining company and the local community and is continuously provided throughout the construction and operation phases (Ednie, 2002; Kadenic, 2015; Missens et al., 2007). In both cases, agreements were made during the planning phase of the project life-cycle. This clearly shows that training and improvement of qualifications should not necessarily all take place in advance, but it is possible to reach a solution where the local community and the mining company jointly provide education and training programs for the local workforce.

Some key informants emphasize that collaborative agreements should be in place prior to a future upswing in the mining industry. *"And for the members that we have in the cluster* (ACRM), *when an upswing comes in the mining industry, you have to be ready, and you must have your strategic collaboration agreements in place…*" (key informant GA). Ultimately, collaborations should be established prior to development of large mining projects, otherwise it may be too late (Jakobsen and Lyne, 2014).

5.7.2 Toward collaboration

The Greenlandic businesses community can overcome prevailing challenges by engaging in collaboration, as collaboration enables SMEs to gain economies of scale (Franco, 2003), mobilize a variety of resources (Snow et al., 2011), achieve competitive advantage, and access new markets (Bøllingtoft et al., 2012; Fjeldstad et al., 2012). "*You need to engage in collaborations with the awareness about that we cannot do this alone, but we can do this together"* (key informant 2 ACRM, DI). Instability of the environment, companies' weaknesses (Daft et al., 2010) and competitive pressure (Fjeldstad et al., 2012) push toward a collaborative design (Bøllingtoft et al., 2012; Miles et al., 2010; Snow, 2012; Snow et al., 2011; Snow et al., 2009). *"…If we want the large contracts that cover many things, which makes it easier for the licensee to have fewer contracts to monitor, then we need to obtain skills that are not our core competencies, but which are necessary to have when bidding for a contract. That is why we are seeking partnerships"* (key informant GL Bus). The motivation to engage in collaboration arises from a necessity based on realization of firm's internal weaknesses and the external pressures in order to continuously adapt to the business environment.

5.7.2.1 Exploitative collaborations, a competitive environment, and the importance of trust

The key of successful collaboration is based on achieving mutual benefits (Miles et al., 2005; Miles et al., 2000), fairness (Snow et al., 2009), and breaking down boundaries. However, this is not always a part of the collaborating experience from the Greenlandic business community's perspective. Attempts to engage in partnerships often end up as a one-way benefit for Danish or foreign companies. *"I can say from my own experience that we often run into Danish and foreign companies that need Greenlandic companies, they do not want a real collaboration, they just need to have the collaborative agreement on paper"* (key informant GA). These collaborations are characterized as big-brother/little-brother relations with a lack of reciprocity and mutual benefits. Danish and foreign companies need collaborative agreements with Greenlandic companies to be considered within the local content quota in Impact Benefits Agreements (IBAs). Fear of exploitation (Snow, 2012) and contradicting objectives (Miles et al., 2010) are substantial challenges to a productive and effective collaborative design, which unfortunately is a part of the Greenlandic businesses' experience with collaboration. The Greenlandic businesses are not interested in engaging in exploitative collaborations; they want genuine collaborations where both parts contribute and operate under equal conditions. It is necessary to overcome these fundamental barriers by coordinating efforts and ensuring commitment to a mutual goal (Miles et al., 2010) and thereby creating transparency and synergy in collaborations.

The Greenlandic businesses are met with competition among themselves in a small community and a small market regardless of the extractive industries. In a small Greenlandic market, where everyone knows each other, businesses are constantly faced with their competitors as they are bidding for the same work and contracts. *"It is also difficult if you have five companies in a small community that have been in fierce competition with each other in the last 20–30 years and suddenly must look beyond these small local interests (...) so you have to look beyond some of these things and understand that these things are so large* (mining industry) *that you need to collaborate, otherwise they* (local businesses) *might end up standing as spectators"* (key informant GA).

Commitment and contribution to shared goals among collaborating parties reduces the continuous need for assessment of trust (Alder et al., 2008; Miles et al., 2005; von Hippel and von Krogh, 2003). Lack of those combined with years of competitive circumstances leaves a sense of skepticism and distrust among the Greenlandic business community. Trust, along with time and territory, are essential for establishment of a collaboration process (Miles et al., 2000). Trust is paramount for successful collaboration from a Greenlandic business perspective. *"If they try to go around us, then we cannot work with them, even when times are better. Once you have broken the trust, you are not getting back inside"* (key informant GL Bus). It takes time (Miles et al., 2000) to establish trusting relations, which requires that involved parties—Greenlandic, Danish, or foreign—take time away from their daily operations and invest time and commit to the collaboration, which eventually reduces the fear of exploitation.

Besides allocating time to the collaboration, establishment of trust needs attention, since it is perceived as an essential part of the collaborative process by the Greenlandic business community. Hence, the application of protocols becomes a valuable instrument when engaging in collaboration. By applying protocols, the Greenlandic businesses who engage in collaboration can secure the direction for the activities, mobilization, and linking of labor (Fjeldstad et al., 2012). *"You have to open up if you want a partnership, then you have to be able to trust each other (...) our business, the whole design, the set-up, they* (collaborating parties) *are a part of it. So if they are going to be a part of it, then they have to commit to us"* (key informant GL Bus). It is a way to ensure commitment toward a common goal and support the establishment of trust, when the foundation for collaboration is written in place. Protocols should be regarded as a step toward overcoming the big-brother/little-brother disputes, getting beyond local rivalry, and achieving genuine collaborations under equal conditions and ownership.

5.7.3 Transition from a cluster to a collaborative community

The arguments to engage in collaboration seem inevitable for the Greenlandic business community, as collaborative arrangements are an attempt to overcome liability of smallness and increase commercialization (Bøllingtoft et al., 2012). As clusters are geographic concentrations of companies in a particular field (Porter, 2000), companies within a cluster should be regarded as potential collaborators. Members of ACRM are businesses that share a common objective to accelerate in the mining industry, and in order to do so, collaborative arrangements are advantageous. Potential collaborators in this context are already interconnected through ACRM. Hence, the linkage between cluster and collaborative community development becomes apparent in order to overcome prevailing limitations and increase business potential by pursuing a collaborative approach.

5.7.3.1 Managing the transition

To manage the transition from a cluster to a collaborative community requires particular emphasis on the facilitating role. Bøllingtoft et al. (2012) argue the role of a shared service provider is crucial for the development of a collaborative community. In a study of three different collaborative communities—Blade.org, Kalundborg Industrial Symbiosis, and MG50 Bøllingtoft et al. (2012) emphasize the necessity and importance of a shared service provider in each collaborative community to provide services that enable members to self-organize and collaborate. Following activities are identified that are performed by a shared service provider according to Bøllingtoft et al. (2012, p 103): *"(a) screening and/or selection of member firms, (b) provision of infrastructure and protocols for members to connect with one another, (c) development of a knowledge commons, (d) administrative services, and (e) strategic initiatives to help the community to expand and improve."* The activities performed by a shared service provider vary according to the purpose and needs of each community. For example, Snow et al. (2009) also describe Blade.org, a collaborative community that consists of complementor firms (Fjeldstad et al., 2012) that together represent different capabilities. The design of Blade.org includes a "principal office," which provides administrative services, infrastructure, and strategic initiatives to operate and expand the community.

As a cluster is comprised of potential collaborators, the following step to manage the transition from a cluster into a collaborative community is identification of a shared service provider to perform activities that will enable cluster members to collaborate. In the case of ACRM, a "principal office" organizes various events provided to members. In this sense, the "principal office" of ACRM has the ability to undertake the facilitating role in a collaborative community. ACRM carries no connotation of ownership, which fits with the facilitative management approach (Miles et al., 2005). Among the identified activities by Bøllingtoft et al. (2012), ACRM already conducts strategic initiatives by providing a promotion platform for members and establishing relations between mining companies and members. Getting recognized with own efforts as a Greenlandic SME in the mining industry is considered very difficult, whereas being represented alongside other SMEs across industries displays professionalism.

ACRM in its current form does not perform the remaining activities of a shared service provider. Hence, in order to transition into a collaborative community, it is necessary to develop and provide suitable infrastructure, protocols, and knowledge commons tailored to fit the needs of the collaborative community in order to support collaborative relationships among members (Bøllingtoft et al., 2012; Miles et al., 2005; Snow et al. 2011). Current activities conducted by ACRM, such as continuous collection and dissemination of knowledge through seminars and field trips, and the accessibility of a cluster website, should be regarded as valuable components. These can be further developed as activities performed by the shared service provider in the transition process to a collaborative community. ACRM does not provide administrative services, help firms directly to collaborate, or screen and select firms to collaborate, which a shared service provider should do according to Bøllingtoft et al. (2012), Miles et al. (2005), and Snow et al. (2011). Furthermore, according to Snow et al. (2009), design features such as criteria for selecting the "right" member firms, IT infrastructure, and all-member meetings facilitate trust building. Hence, ACRM, as a shared service provider in a collaborative community, should be more selective when allowing new members in the collaborative community to secure the right fit. As a shared service provider in a collaborative community, ACRM needs to ensure commitment to common goals, secure direction for collaborative activities, and support the building of trust among collaborative actors.

Proximity dimensions are considered as mechanisms that can bring actors together (Boschma, 2005), which must be taken into account in the transition process. Too little and too much proximity may be harmful for effective inter-organizational linkages (Boschma, 2005; Molina-Morales et al., 2015; Belso-Martinez, 2016). Hence, these proximity dimensions are both enablers and barriers to collaboration. Therefore, it is important to consider the proximity dimensions in the transition process and in the activities assigned to a shared service provider.

Cognitive proximity in terms of a shared knowledge base is necessary for actors in order to communicate, understand, and process new information (Boschma, 2005). ACRM consists of a broad range of businesses from consultancies to transportation firms; therefore the cognitive proximity is not considered high, which may be an initial barrier. Hence, providing *knowledge commons*, as a key activity of ACRM as shared service provider, is important in order to sustain a close cognitive proximity in the collaborative community. Nonetheless, common and complementary capabilities among actors, a combination of cognitive distance and similar capabilities is advantageous for innovation (Boschma, 2005). While cognitive proximity is prerequisite for learning, the other four dimensions are mechanisms that can bring actors together (Boschma, 2005).

Social and geographical proximity enhance linkages and are important door openers to new linkages, as they foster a trustful atmosphere and facilitate interactions among local actors (Belso-Martinez, 2016). The social and geographical proximities are high in the Greenlandic business community, and therefore are regarded as important enablers in collaborations and in the transition process. However, these proximities may be lower regarding Greenlandic and Danish inter-firm relationships, which may explain previous negative collaboration experiences. High institutional proximity negatively affects the formation of linkages in advanced stages of the cluster life-cycle (Molina-Morales, 2015). However, ACRM is still in its early stages of a cluster life-cycle, therefore the institutional proximity is regarded low. Too little institutional proximity is harmful to collective actions due to a lack of common values and weak formal institutions (Boschma, 2005). According to Boschma (2005) Institutional proximity is an enabling factor, as it provides stable conditions. To this extent, it is important to emphasize *protocols* of the collaborative community design in the transition process as a key activity of ACRM as a shared service provider in order to reinforce the institutional proximity and reduce opportunistic behavior. Organizational proximity is not characterized as high due to a lack of actual collaboration. However, both social and organizational proximities as characterized by strong ties between actors, therefore organizational proximity may eventually increase over time.

The *infrastructure* of the collaborative community becomes an important element and activity of ACRM as shared service provider in the transition process. Infrastructure facilitates communication between actors and access to the same knowledge commons (Fjeldstad et al., 2012), which supports the social, geographical, and cognitive proximities.

Figure 4 illustrates the conceptual model for managing the transition process from a cluster to collaborative community. The five proximity dimensions as mechanisms that influence the linkage between firms in clusters are both enablers and barriers to the transition process and collaboration. The core elements of the collaborative community (infrastructure, protocols, and commons) have the possibility to mediate the proximity dimensions, as they can be tailored to fit the needs of the collaborative community. The transition process emphasizes the role of a shared service provider. Of course, collaborating actors are required, which is included in the conceptual model.

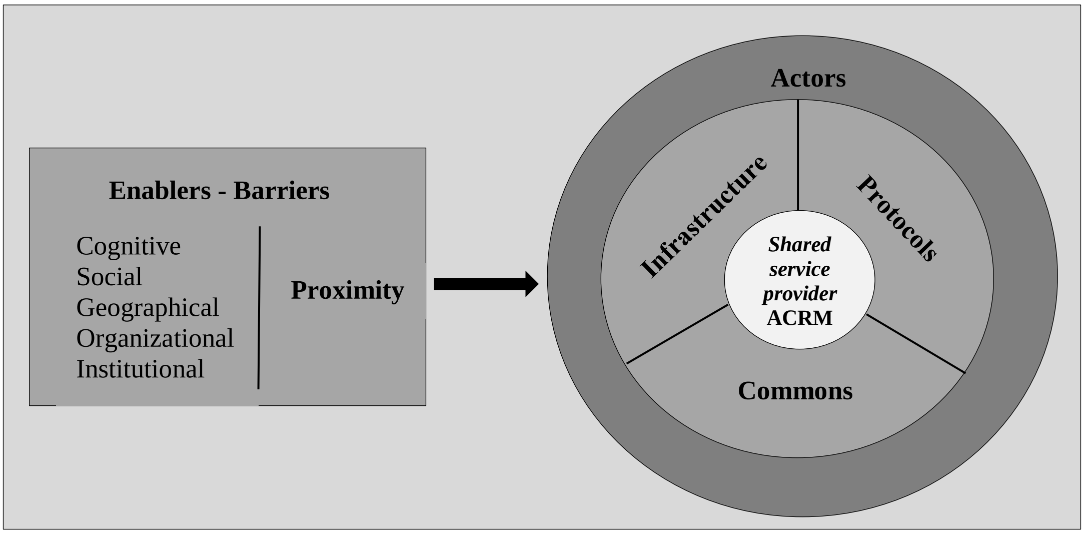

Figure 4 - A conceptual model - transitioning from a cluster to a collaborative community

To realize the transition to collaborative community for extractive industries relevant to Greenland requires great effort and commitment by ACRM in order to perform activities assigned to a shared service provider. Naturally, it also requires collaborating actors, current or new members of ACRM, who have collaborative capabilities (Fjeldstad et al. (2012) and voluntarily want to engage in a collaborative process (Miles et al., 2000).

5.7.3.2 Motivation for transition

Being a part of the cluster, a network of interconnected companies in the mining industry, will not solve the prevailing limitations of member firms. Evolving and managing the transition from a cluster into a collaborative community and adapting to the business environment, will create more value to members and fulfill the initial purpose for establishing ACRM. ACRM is not the result of an evolutionary process, but a purposeful attempt by funding institutions to gather a variety of businesses with the purpose to increase possibilities and competitiveness for subcontractors. Development of a collaborative community can also be a purposeful and planned process (Bøllingtoft et al., 2012). The transition to a collaborative community relevant to extractive industries in Greenland should be pursued as a deliberate effort by ACRM.

In transitioning from a cluster to a collaborative community, members of ACRM can achieve individual benefits (von Hippel and von Krogh, 2003) as well as shared goals (Miles et al., 2005) by pooling resources and knowledge and strengthen their position and competitiveness as subcontractors to mining projects. These benefits do not follow from being a concentration of interconnected businesses that comprise a cluster, but from transitioning into a collaborative community and pooling resources toward a common goal.

The process costs (Barnett and Carroll, 1995) associated with the changes and actions needed in order to transition from a cluster to a collaborative community are related to the necessary time and resources that need to be invested by the principal office of ACRM in order to undertake the facilitating role to manage the transition and perform activities of a shared service provider. Additionally, the transition process entails costs to member firms, as they too, must invest time and resources beside their daily operations to engage in the collaborative activities.

However, the content costs (Barnett and Carroll, 1995) associated with lack of change and remaining as a cluster entails only costs to members, as they continue to face the prevailing challenges and will not enhance their capabilities to be recognized and considered as potential subcontractors to mining projects. In this regard, ACRM carries no content costs as it continues to operate within the same scope of work and with the same time and resources allocated to do so.

The linkage between cluster development, particularly small clusters, and collaboration is advantageous as it represents an approach for continuous development and evolvement of clusters. This way, small clusters such as ACRM can become more powerful and enable members to realize business development that each single business could not manage with its own efforts in a cluster. Collaboration represents a new approach to organizing small businesses in remote regions, such as Greenland, in order to enhance their capabilities. Business environment in remote regions is typically weaker than in metropolitan regions due to lower population density, lack of quality of available workforce, and lower economic activity (Porter et al., 2004). These characteristics are not only evident for Greenland, but can be found throughout the entire Arctic (Duhaime, 2004; Duhaime and Caron, 2006; Huskey and Pelyasov, 2015). Hence, this represents a new way to think about industrial development and business development in remote regions throughout the Arctic.

5.8 Discussion

The current circumstances in Greenland are not preferential. Economic vulnerability, the necessity of economic diversification, and abundance of natural resources leads to great expectations that extraction of natural resources will provide economic prosperity to the society (Bjørst, 2016; Tiainen, 2016). Unfortunately, falling commodity prices reduce the business case for establishing mines in Greenland and do not attract investments in any mining activities. This leaves Greenland in a sense of standstill. Nevertheless, the effect of these external challenges on Greenland is unavoidable, and to overcome this may require other initiatives or enormous investments to push projects in progress regardless of market conditions. However, a future upswing in the industry should indeed boost the business case to the benefit for Greenland.

A collaborative design is a strategy to overcome the prevailing limitations of the Greenlandic business community and potentially increase application of Greenlandic businesses in mining projects. The willingness and motivation to engage in collaborations arise from recognition of the necessity to adapt to the business environment (Daft et al., 2010). However, engaging in a collaborative process might not be straightforward for Greenlandic businesses when considering some of the previous experiences with foreign and Danish collaboration partners and the internal competition in their home market. These experiences and conditions foster skepticism and distrust, which is very destructive for a collaborative design as trust is an essential element for successful collaboration (Miles et al., 2000). Geographical proximity stimulates social proximity, because short distances favor social interaction and trust building. These are particularly an enabling factor in the transition process and collaboration. However, the isolation of the region may lead to excess of social and geographical proximities, which can have adverse impact on innovation and learning and lock actors into established ways of doing things.

To manage the transition from a small cluster to a collaborative community emphasizes the facilitating role of a shared service provider, which is required in every collaborative community (Bøllingtoft et al., 2012). The transition from ACRM as a cluster to ACRM as a collaborative community significantly expands the role of ACRM. ACRM already conducts strategic initiatives, but it needs to take on additional activities assigned to a shared service provider in a collaborative community (Bøllingtoft et al., 2012; Miles et al., 2005; Snow et al., 2011; Snow et al., 2009), which supports a gradual development of trust. It is important to consider the proximity dimensions as they are mechanisms that influence linkages between actors. A key focus area in the transition process is the institutional proximity, which is considered low. High level of institutional proximity supports stability and a basic level of trust, which can be enhanced through the development of protocols. The potential collaborating actors can be found among the existing or new members, as they have an interest in working in the Greenlandic mining industry. Hence, it is advantageous to build on something already existing in order to pursue meaningful collaboration to enhance local business development derived from the mining industry. This may lead to innovation, entrepreneurship, or new collaborative start-ups in a future scenario (Franco, 2003). Nevertheless, this requires that ACRM continue to accelerate and retain its members throughout the current downturn in the industry and encourage and facilitate the collaborative process.

This provides a new perspective on cluster development, particularly small clusters, by suggesting that clusters can evolve from "just" being a concentration of interconnected companies by transitioning into collaborative communities and thus creating more value to members. Naturally, a transition process from a cluster to a collaborative community and the role of a shared service provider in the transition requires further research both in theory and practice. Moreover, this represents a new approach to accelerate business development in a business environment that faces limitations of smallness and inadequate resources, which is highly relevant in remote regions throughout the Arctic.

The case-study approach allows in-depth exploration (Creswell, 2009; Yin, 2014) in order to understand complex social phenomena and retain a holistic and real-world perspective (Yin, 2014), which is valuable in this context. The one-case selection in this study is a limitation to generalizability of the findings. Nonetheless, the intention of this study is not generalizability in the conventional sense, but rather the force of example (Flyvbjerg, 2006). The geographical isolation of Greenland may stimulate collaborative behavior not only due to a high geographical and social proximity, but also due to a lack of other options available in remote regions. What might appear as an advantageous strategy to pursue for Greenland may not necessarily apply to other Arctic communities dealing with extractive industries. Nonetheless, as experiences with extractive industries in other Arctic locations provide knowledge and perspectives to Greenland, studies of

Greenland can contribute learnings to other Arctic communities. The analysis is based on insights and perspectives of the selected key informants, which are considered most relevant with respect to the topics of investigation in this study. Nevertheless, if key informants from other institutions were chosen for the study, they might shed light on other topics and issues.

Continuous debates on how the development of extractive industries can be managed to maximize socioeconomic benefits to the Greenlandic society is important, as the development of these will inevitably influence the society in the future (Hansen et al., 2016). This study contributes with detailed insights and perspectives to shape the discussions about Greenland as a future mining nation and how to maximize local socioeconomic value creation and business development.

5.9 Conclusion

Natural resource extraction is considered a pathway to economic diversification and prosperity for the Greenlandic society. Nevertheless, Greenland's business community is challenged by size limitations, lack of necessary skills, and no extensive experience with the mining industry.

This paper examines the Greenlandic business community and the Arctic Cluster of Raw Materials, ACRM, to enhance local business development in mining projects in Greenland. However, a cluster of interconnected companies does not solve the prevailing limitations of the Greenlandic business community. Collaboration in this context is an approach to enhance capabilities and organize small businesses in remote regions. The analysis directs toward a transition from an economic cluster to a collaborative community. Hence, adapting to the business environment and managing the transition from ACRM as a cluster to a collaborative community enables member firms to realize business development that each single firm cannot achieve with own efforts. To manage the transition emphasizes the facilitating role, as every collaborative community requires a shared service provider. This expands the role of ACRM by undertaking the facilitating role and performing activities assigned to a shared service provider. In addition, it is necessary to consider the five proximity dimensions (cognitive, social, geographical, organizational, and institutional) as they are mechanisms that influence linkages between actors. This paper presents a conceptual model for the transition process to a collaborative community, which is based on the elements of the collaborative community design and considers the five proximity dimensions as both enablers and barriers to the transition process and collaboration. The transition should set the direction for the Greenlandic business community to engage in collaborations in order to overcome prevailing limitations and enhance local business development derived from the mining industry.

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6 Chapter 6: Multi-criteria decision analysis approach to a holistic assessment of a proposed mining project in Greenland

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6.1 Abstract

This paper presents a method for translating the results of environmental impact assessment (EIA) and social impact assessment (SIA) of a proposed mining project in Greenland, Isua Iron Ore Mine, into a multi-criteria decision analysis (MCDA) result. MCDAs that include economic and social with environmental considerations are more holistic and more inclusive. This paper demonstrates how MCDA provides suitable structure and analytics for a quantitative approach to more holistic assessments of mining projects based on integration of data assembled in EIAs and SIAs with technical judgment and stakeholder values. Explicitly addressing the environmental, economic, and social costs and benefits of mine development during the planning stage can result in operations that are more acceptable to relevant stakeholders than a zero-mining alternative. More holistic and inclusive assessments can be helpful for local communities and decision makers to address sustainability concerns of proposed mining projects by applying MCDA.

Key words: Mining, Greenland, multi-criteria decision analysis, MCDA, stakeholder engagement, sustainable development

6.2 Introduction

The mining industry is associated with sustainable development challenges. Depletion of nonrenewable resources poses disturbance and damage to the environment in the form of air emissions, effluents, waste, contamination, visual impacts, disturbance of natural habitat, and loss of biodiversity (Azapagic, 2004). Economic issues are related to economic benefits to society, including employment, business creation, multiplier effects, and tax and revenue distribution (Kadenic, 2015; McMahon and Remy, 2001). Social issues associated with mining include occupational health and safety, and wider social disturbance of the host community (McMahon and Remy, 2001). Nevertheless, the industry can also be a key driver to socioeconomic development of local communities, and represent the core of a community's economy (McMahon and Remy, 2001).

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Similar to other regions of the Arctic, Greenland has received global awareness in recent years. Greenland is being positioned and represented as a major new frontier for exploration and exploitation of mineral and hydrocarbon resources (Nuttall, 2012a, 2013). Geological mapping and reports about the potential for technically recoverable and undiscovered natural resources confirm that Greenland is a significant source of new hydrocarbon and mineral development. Common features of Greenland's previous mining activities are relatively small-scale mining, few employment opportunities, and absence of Greenlandic labor (GEUS, 2013; Nordregio, 2010). Today, Greenland's industrial structure is characterized by high dependence on fisheries and a large public sector (Larsen, 2010; Økonomisk Råd, 2012), which is a common feature of Arctic economies (Duhaime and Caron, 2006; Huskey and Pelyasov, 2015). Since the 1990s there have been periods of slow and negative economic growth that can be attributed to variations in marine harvest, earnings, and export volume, which emphasizes Greenland's economic vulnerability. A growth strategy for Greenland cannot be based solely on fisheries in a future perspective. Hence, there is a need for sustainable industrial development that creates jobs without overexploitation of natural resources or damaging the environment (Økonomisk Råd, 2012). A new mining industry in Greenland must be developed so it contributes to sound economic development, the creation of new jobs, and a maximum return to society, while strongly taking the vulnerable Arctic environment into consideration (Government of Greenland, 2014; Ministry of Foreign Affairs, 2011).

Finding sustainable solutions for the mining industry requires an integrated approach that acknowledges and minimizes the negative environmental and social impacts of mining and concurrently implements actions to enhance and contribute positive impacts (Giurco and Cooper, 2012; Han Onn and Woodley, 2014). Retrospective and prospective sustainability assessment frameworks have widely been adopted by the mining industry for reporting about previous years' performance on economic, environmental, and social issues or addressing potential effects of proposed projects (Fonseca et al., 2013). Integrated appraisal of impacts across economic, environmental, and social dimensions is likely to be helpful throughout the planning and decision-making process (Bond, et al., and Francis, 2001; Hacking and Guthrie, 2008).

This paper contributes to the sustainability discussion of mining projects by presenting a holistic assessment framework and method that includes environmental, economic, and social dimensions, with the goal of evaluating a proposed mining project in Greenland prior to the construction. We integrate metrics developed in the EIA and the SIA undertaken for the proposed iron ore mine, Isua, in Greenland (EIA of the Isua Iron Ore Project, 2013; SIA of the Isua Iron Ore Project, 2013). MCDA (Linkov, 2014; Linkov and Moberg, 2012) provides a means for analytically comparing Isua-mine impacts to a zero-mine alternative according to four key stakeholder groups' perspectives (community, government, business, and NGO). The zero-mine alternative is where conditions remain unchanged as the mine is not developed.

The remainder of the paper is organized as follows. In the next section we present sustainability assessment frameworks in the context of mining industry and their application with a focus on impact assessments and MCDA. Then, we present the case of the proposed Isua-mine and key outcomes of the EIA and SIA. This is followed by a methodology section, which includes aspects related to criteria identification, criteria scoring, and stakeholder selection and weights. Finally, the holistic assessment of the Isua-mine alternative opposed to zero-mine alternative is conducted and the results are presented, followed by a discussion and conclusion.

6.3 Sustainability assessment frameworks

Sustainable development directed assessments should comprehensively and equally consider the full range of relevant aspects, since stakeholders and decision makers should be informed of all relevant impacts associated with a proposed mining project (Hacking and Guthrie, 2008). A review of the published literature addressing sustainability reporting in the mining industry found a call for a more integrated approach of the various strands of sustainability reporting across economic, social, and environmental dimensions (Lodhia and Hess, 2014). According to Hacking and Guthrie (2008), the universally promoted feature of assessments directed toward sustainable development is comprehensive and equal considerations of impacts associated with a proposed project. *"The recognition that biophysical, social and economic systems are interconnected leads commentators to conclude that the pursuit of SD (sustainable development) requires the linkages and interdependencies to be considered by: exploring interrelationships between the themes; and presenting impacts across the themes in a comparable manner so as to reveal the existence of tradeoffs or 'win–win' outcomes."* (Hacking and Guthrie, 2008). Everything is inherently interconnected; some environmental changes can cause social impacts and social processes that occur due to social impacts can cause environmental impacts, hence the necessity of integration (Vanclay, 2004). A comprehensive and integrated assessment can provide a thorough understanding of all impacts. Furthermore, agencies can better manage integrated assessments and the multiple processes that are required when there are varied forms of assessments (Vanclay, 2004).

Within the mining industry, there is no agreement on how a sustainability assessment should be conducted (Fonseca et al., 2013). The different approaches to sustainability frameworks are not due to disagreements on the definition of sustainability, but rather about the assumptions and principles that should be used to measure it (Fonseca et al., 2013). While sustainability assessment frameworks vary in approach and scope, they have a shared purpose of informing decision makers about the effects of mining on the environment and on society. Assessments can guide decision makers about strategies to secure long-term economic benefits of mining, including environmental conservation programs, investment in social development, diversification of skills, and growth of other industrial sectors (Lederwasch and Mukheibir, 2013). Fonseca et al. (2013) categorize various frameworks for sustainability assessments, which are proposed to or applied by mining companies and industry associations (Hacking and Guthrie, 2008; Ness et al., 2007).

Some frameworks are widely adopted in the mining sector and promoted by mining associations, whereas others represent examples of theoretical frameworks without being applied. The frameworks also vary in terms of comprehensiveness with respect to indicators for measuring their sustainability performance, whether the focus is on organizational performance or the mining site performance and whether they follow a retrospective or prospective logic (Fonseca et al., 2013). The retrospective logic allows mining companies to report on past-year performance, whereas the prospective logic allows scenario building and forecasting about future projects (Fonseca et al., 2012). Impact assessments and MCDA are categorized amongst the prospective frameworks according to Fonseca et al. (2013).

Impact assessments follow a prospective logic and can be used as a means of directing decision making toward sustainable development (Hacking and Guthrie, 2008). A growing interest in the field of impact assessment has resulted in over 100 different types, where some refer to specific sectors and others are slight variations of other terms (Vanclay, 2004). Prospective methods for assessing the impacts of proposed projects are part of standard practice in the mining industry. Social impact assessments (SIA) and environmental impact assessments (EIA) are applied in connection with mineral extraction projects in Greenland (Hansen and Mortensen, 2013). The Mineral Licence and Safety Authority (MLSA) in Greenland, for example, provides guidelines to mining companies and requires that they include third-party, publicly available EIA and SIA with their applications for exploitation in Greenlandic, Danish, and English (Government of Greenland, 2015a, 2016). EIAs identify the potential environmental impacts of a proposed action, while SIAs identify the potential social consequences of a proposed action (Vanclay, 2003). SIA can either be a component of a broader EIA or a single unit of assessment. While separate SIAs are not common in the Nordic countries (the required impacts assessments cover both impacts upon the environment and society), SIA is not a part of EIA in Greenland, but a separate unit of assessment (Hansen and Mortensen, 2013), as the Ministry of Industry, Labour and Trade (MILT) holds responsibilities relevant to SIA and the Environment Agency for Mineral Resources Activities (EAMRA) holds responsibilities relevant to EIA. Nevertheless, there is a strong connection between the two units of assessments, as environmental impacts may have a negative effect on traditional hunting and fishing (Hansen and Mortensen, 2013). An integrated approach to EIA and SIA should be applied to fully understand the impacts of a proposed project and utilize a better project design (Slootweg et al., 2001). Application of EIA and SIA throughout the decision-making processes can become an important planning instrument by providing information about consequences and impacts of specific development activities. To this extent, decision making should be based on the assessment of all values, possible alternatives, and necessary mitigation measures to undesirable impacts (Slootweg et al., 2001). This can lead to improving the quality of the proposal, designing mitigation actions and measures, and reducing negative impacts (Slootweg et al., 2001; Bond et al., 2001).

MCDA methods follow a prospective logic and are widely accepted and applied to ecological, biological, agricultural, industrial, economic, and social systems (Wang et al., 2009). A sustainability assessment of a mining project is complex due to the numerous aspects that need to be evaluated, the multidimensional nature of the decision-making process, and the dependence on project-specific factors (Wibowo, 2013). There are various applications of methods under the MCDA umbrella that have been applied in the context of mining operations and sustainability assessments (Govindan et al., 2014; Kommadath et al., 2012; Linkov, 2014; Marinoni et al., 2009). MCDA can be applied to assist mining companies in the decision-making process about investments in social development projects within a sustainable development framework that creates value for both the community and company (Esteves, 2008a, 2008b). Wibowo (2013) address the evaluation of sustainability performance of mining companies from a MCDA perspective by determining the performance ratings and the environmental, economic, and social criteria weights of all available alternatives. MCDA can provide a better understanding of characteristics of the decision problem, promote the role of participants in decision-making, and provide solutions to complex problems. It allows more logical and scientifically defensible decision making (Linkov and Moberg, 2012). Furthermore, MCDA methods can improve the quality of decisions by making them more rational, efficient, and explicit (Pohekar and Ramachandran, 2004). Interest in applying MCDA tools for environmental evaluations is steadily growing (Huang et al., 2011; Keisler and Linkov, 2014).

6.4 The case: Isua Iron Ore Mine

Isua is the first large-scale mining project granted in Greenland. It is located 150 km north-east of Nuuk on the edge of the inland ice and is partially covered by glacier ice. An exploitation license has been granted to London Mining Greenland A/S (previously owned by the British company London Mining Plc., who suspended its payments in 2014; London Mining Greenland A/S is now owned by the Hong Kong based company General Nice Development Limited) for an area covering 290 km^2 at Isukasia (Isua) in West Greenland with a license period from year 2013–2042 (Government of Greenland, 2014, 2015b). The project is currently on hold. After 3 years of construction, the mine is expected to operate for 15 years and process and export 15 million tons of iron concentrate per year. The proposed operation is an open pit mine, since the ore body is close to the surface in one large formation (EIA of the Isua Iron Ore Project, 2013), which will comprise a mine pit 1800 m long, 800 m wide, and 400 m deep. The main components of mine infrastructure include a processing plant, slurry pipeline, dewatering and storage facility, deep-water port site, fuel storage and pipeline, a small plant near the mine for explosives used in blasting, administrative facilities, workers accommodation, potential airstrip, and a 105 km access road. Excavated ice and waste rock will be hauled to deposit areas. The tailings will be pumped to a deep glacier melt water lake, which will contain all the tailings during 15 years of operation (EIA of the Isua Iron Ore Project, 2013). The iron concentrate slurry is pumped through a 104 km pipeline from the processing plant to the dewatering plant at the port site. The dry iron concentrate is stored and eventually shipped away from Greenland. During the 3 years of construction phase, the workforce requirement is 1500–2000 employees with a peak of up to 3300 employees, which will mainly consist of foreign workers (SIA of the Isua Iron Ore Project, 2013). The accommodations and service facilities during the operation phase are provided for 465 employees at the process plant and 165 in the port area. The Government of Greenland expects the mining project to have significant effects on the local businesses and the development in the municipality, which can extend to the surrounding municipalities (Government of Greenland, 2013).

The EIA undertaken for the Isua project was carried out from years 2008–2011 (EIA of the Isua Iron Ore Project, 2013). The major impacts will be caused due to: landscape alterations, which will imply visual disturbance in the surrounding area; hydrological consequences in the tailings pond due to gradual filling with tailings; noise disturbance; disturbance and displacement of caribou; and increased CO2 emission (EIA of the Isua Iron Ore Project, 2013). The complete list of identified impacts is found in the appendix. The SIA for the Isua project was commenced in 2009 and completed in 2012 (SIA of the Isua Iron Ore Project, 2013). The major challenges addressed by the SIA include: pressure on public services; social conflicts with international workers; and health and safety conditions at mine site. The major contributions from the project are increased public revenue through fees and taxes; direct and indirect local employment; and education and training opportunities (SIA of the Isua Iron Ore Project, 2013). However, due to the lack of previous experience with projects of this magnitude in Greenland, there are uncertainties related to the multiplier factor and limited availability of local labor. The positive impacts on the local business community depend on the capacity of local businesses to provide services and products that meet the required quality at competitive prices (SIA of the Isua Iron Ore Project, 2013). The complete list of identified impacts is found in the appendix.

6.5 Methodology

An MCDA method is applied for analytically comparing the total identified impacts for the two alternatives: Isua-mine and zero-mine. An MCDA starts by identifying the problem. Then the alternatives and criteria are defined, where criteria are applied to select among the alternatives. The alternatives are scored against the criteria and the weight of each criterion by stakeholders (Linkov and Moberg, 2012). This paper applies the weighted sum method (WSM), the most commonly applied MCDA approach for single dimensional problems for evaluating *M* alternatives in terms of *N* criteria (Mateo, 2012). All data must be expressed in exactly same scale for applying the WSM (Pohekar and Ramachandran, 2004). The best alternative satisfies the expression:

$$A_{WSM}^{*} = Max \sum_{i}^{j} a_{ij} w_j$$

A^*_{WSM} is the score of the best alternative. a_{ij} is the actual value of the i alternative in terms of j criterion and w_j weight of importance of the j criterion. The total value of each alternative equals the sum of the products, where the best alternative is the one with maximum score (Wang et al., 2009). There are two alternatives in this assessment; A_1 is the Isua-mine alternative and A_2 is the zero-mine alternative. Each criterion (C_1, C_2, C_3,..) receives an impact score relative to Isua-mine alternative

(A_1) and zero-mine alternative (A_2), and each criterion has a weight (W_{C1}, W_{C2}, W_{C3}…) according to each key stakeholder group. When the WSM is applied, the calculation is as follows:

$A_{1WSM} = (C_1 * W_{C1}) + (C_2 * W_{C2}) + (C_3 * W_{C3}) + (C_4 * W_{C4})\ldots = \text{value}$

6.5.1 Criteria identification

Criteria for evaluating alternative actions depend on the specific context, location, and project (Wibowo, 2013). Criteria can vary across projects, meaning that not every criterion in one specific project might be relevant to a similar project in another location (Wibowo, 2013). The context-specific impacts identified by the EIA and SIA for the Isua-mine form the criteria for the MCDA-based assessment. The EIA for the Isua-mine has been conducted by an independent consultant, Orbicon A/S, on behalf of London Mining Greenland A/S according to the Government of Greenland's guidelines for preparing and EIA reports for mineral exploitation in Greenland (EIA of the Isua Iron Ore Project, 2013; BMP, 2011). Correspondingly, the social impact assessment report (SIA) for the Isua-mine has been produced by Grontmij A/S on behalf of London Mining Greenland A/S according to the Government of Greenland's guidelines for SIA reports for mining projects (SIA of the Isua Iron Ore Project, 2013; BMP, 2009).

The impacts are grouped according to environmental, economic, and social dimensions. Some impacts are identified in both the EIA and the SIA. Within the theme "Human presence and use of the environment" in the EIA, impacts relevant to *1) hindrance of other land use (hunting and fishing)* and *2) disturbance of culturally significant sites* are addressed. The same impacts are addressed within the theme "Cultural and natural values" in the SIA. This displays interdependency and interconnection between the biophysical environment and the human environment, where environmental changes may cause social impacts (Hacking and Guthrie, 2008; Hansen and Mortensen, 2013; Vanclay, 2004). A central feature of the indigenous peoples' culture is an inseparable relationship with the land and its resources (Sejersen, 2004). For the structure of the assessment, these particular impacts are only mentioned within the environmental dimension. Impacts related to *1) education and training* are categorized within the economic dimension. Education and training is a prerequisite for realizing the full potential of positive effects related to direct employment in the mine, which is an economic issue. However, it is highly recognized that education and training also have a great impact on the social dimension, which again displays the interconnection among impacts. The full description of the 44 identified impacts (environmental dimension: 21 impacts; economic dimension: 15 impacts; and social dimension: 8 impacts) and their impact score relative to the Isua-mine alternative and zero-mine alternative are found in the appendix.

6.5.2 Criteria scoring

In the EIA and SIA, the identified impacts have been originally scored by their respective authors, independent cunsultants, as negative or positive low, medium, and high. These terms of performance measures can be represented with numbers (Wibowo, 2013). Hence, they are converted into values from 1 to 10, where 1 is a very high negative impact and 10 is a very high positive impact. Negative very high (-VH): 1; negative high (-H): 2; negative medium (-M): 3; negative low (-L): 4; negative very low (-VL): 5; positive very low (+VL): 6; positive low (+L): 7; positive medium (+M): 8; positive high (+H): 9; positive very high (+VH): 10. The conversion of the impacts is important in order to conduct a measurable and quantitative assessment. The economic and social impacts are assessed throughout the entire scale, while the environmental impacts are assessed within the negative range of the scale. The impacts of the zero-mine alternative are assigned the equal opposite value of the scale. If an impact is assessed as high positive in the Isua-mine alternative, then it will be equally assessed as high negative in a zero-mine alternative, since the potential of a highly positive impact will be absent in a zero-mine alternative. Impacts that are assessed as being not relevant or not significant will not be included in the model.

6.5.3 Stakeholders and weights

Azapagic (2004) suggests a comprehensive list of stakeholders relevant to the mining industry. The industry stakeholders include local communities, authorities, governments, employees, trade unions, NGOs, contractors and suppliers, shareholders, customers, creditors, and insurers. The complexity arises from multiple stakeholder values and perspectives combined with impacts on communities, economics, and ecosystems across institutional and geographical scale (Giurco and Cooper, 2012). Based on Azapagic's (2004) stakeholder list, four key stakeholder profiles are selected to illustrate this assessment. These are *community*, which includes people, employees, and trade unions; *government*, which includes the Government of Greenland; *business*, which includes local companies, local suppliers, and contractors to the mine; and *non-government-organizations (NGOs)*. The *community* is directly affected by neighboring mines, as those community members that comprise the employees of the industry are particularly interested in a healthy working environment, training, job creation, and derived business opportunities (Azapagic, 2004; Loe and Kelman, 2016). The local population has strong interest in preserving the traditional livelihoods, including hunting and fishing, since indigenous identities, societies, and economies are inseparably tied to their traditional land and resources (Sejersen, 2004). However, the nearest settlement, Nuuk, is located 150 kilometers from the mine site. Trade unions are mainly interested in issues related to health, safety, equal opportunities and fair treatment (Azapagic, 2004). *Government* has a strong interest in the economic dimension (Bjørst, 2016; Tiainen, 2016) as well as the social and environmental dimensions, since it implements and enforces laws and regulations, distributes wealth, protects the right of the local communities, provides health services, and develops initiatives to mitigate social issues (Azapagic, 2004). *Business* is mainly interested in economic issues with no or some interest in environmental and social issues (Azapagic, 2004). However, since it is composed of potential local suppliers and contractors to the mine, it must be assumed that the local business has some interest in the social and environmental issues (Sejersen, 2004), since they are a part of the local community as well. *NGOs* are mainly concerned with protecting the environment and securing a socially responsible approach to mining (Azapagic, 2004; Bjørst, 2016). The interests of each stakeholder group are used to weight the criteria against which the alternatives are assessed. Level of interest: strong (++), some (+), and none (-), according to Azapagic (2004) is assigned and subsequently converted into quantitative values, where a strong interest level receives the value of 5, some interest receives the value of 3, and no interest or very low interest receives the value of 1. Very low interest: 1; low interest: 2; medium interest: 3; high interest: 4; very high interest: 5. Weights are derived from general interests and awareness areas as described by Azapagic (2004) and supported by other contributions about Greenland and Arctic communities (Bjørst, 2016; The Committee for Greenlandic Mineral Resources to the Benefit of Society, 2014; Copenhagen Economics, 2012; Loe and Kelman, 2016; Sejersen, 2004; Tiainen, 2016; Økonomisk Råd, 2012) with the purpose of providing illustrative examples of how various interests can be considered in the assessment. This offers a nuanced picture of a holistic assessment based on different viewpoint by different stakeholder groups and how the net potential impacts of the mine relates to a zero-mine alternative. The impact weights for each key stakeholder group are included in the appendix.

6.6 Results

The holistic assessment of the Isua-mine as compared to a zero-mine alternative based on the weighted sum method (WSM) is presented in Table 11. The table shows how the two alternatives perform on each dimension according to each stakeholder group's weight and the impact level. Here, as an example, "caribou" is an identified impact in EIA for the Isua-mine, which deals with *"disturbance and noise by the presence of vehicles, machines, buildings, personnel and other* *project infrastructure, which might cause displacement of caribou"* (EIA of the Isua Iron Ore Project, 2013; appendix). This particular impact is assessed according to the EIA as medium-negative (-M), which is converted to a value of 3 for the Isua-mine alternative. The weight of the "caribou" impact according to the stakeholder group *community* is assessed as very important (Sejersen, 2004) and converted to a value of 5. The score of the impact "caribou" according to the stakeholder group *community* is 0,105 ($C_x * W_{Cx}$ (stakeholder weight is normalized) = 3 * 0,035). This logic proceeds for each of the 44 identified impacts for both alternatives according to all stakeholder groups. The complete assessment of performance is found in the appendix. Criteria weights will differ across studies, depending on the specific context and relevant stakeholders, and result in different outcomes for the most suitable alternatives of a decision analysis. Therefore, this assessment also includes a combined weight of all four key stakeholder groups. An equal-weighted result for both alternatives is also presented.

	KEY STAKEHOLDER PROFILE	ISUA-MINE	ZERO-MINE
Environmental	Equal score	86	145
	Community	1,594	2,713
	Government	1,561	2,643
	Business	1,084	1,874
	NGOs	2,625	4,446
	All stakeholder groups	1,687	2,87
Economic	Equal score	104,5	60,5
	Community	3,129	1,563
	Government	3,169	1,736
	Business	4,197	2,366
	NGOs	1,085	0,585
	All stakeholder groups	2,949	1,588
Social	Equal score	37,5	50,5
	Community	0,853	1,147
	Government	0,828	1,064
	Business	0,664	0,815
	NGOs	0,951	1,308
	All stakeholder groups	0,824	1,308
Total WSM	Equal score	228	256
	Community	5,577	5,423
	Government	5,557	5,443
	Business	5,945	5,055
	NGOs	4,661	6,339
	All stakeholder groups	5,460	5,766

Table 11 - Total sum of impacts for Isua-mine and zero-mine alternative

Figure 5 illustrates the performance of the two alternatives based on an equal-weighted score. Initially, the results indicate that Isua-mine only outperforms the zero-mine alternative on the economic dimension and the total sum of impacts combining all three dimensions is higher for the zero-mine alternative.

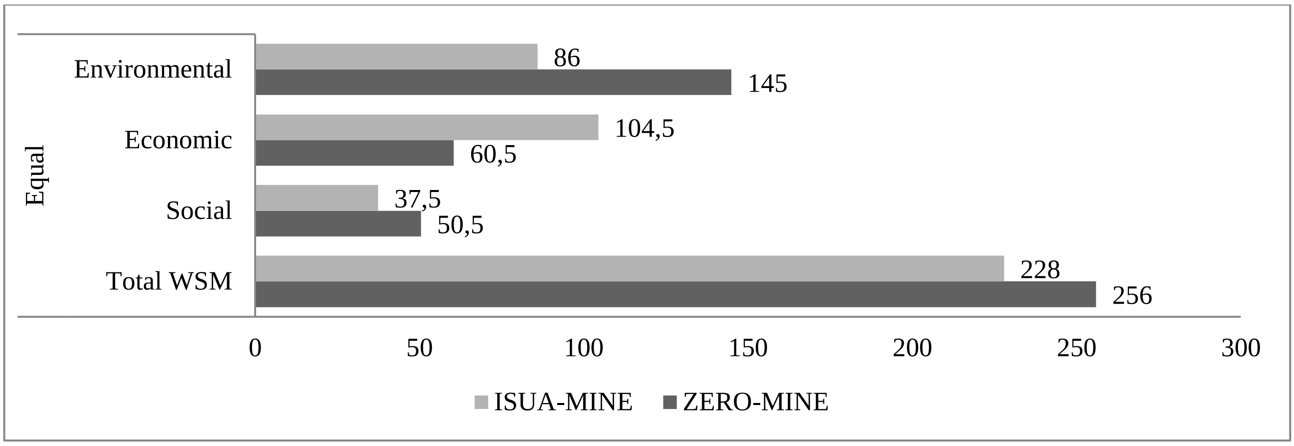

Figure 5 - Equal-weighted result

A similar distribution of performance between the two alternatives across the three dimensions is traceable throughout all stakeholder variations in Figure 6 as the equal-weighted result in Figure 5. While Isua-mine only outperforms the zero-mine alternative on the economic dimension, the performance of the environmental and social dimensions is in favor of the zero-mine alternative across all stakeholder groups.

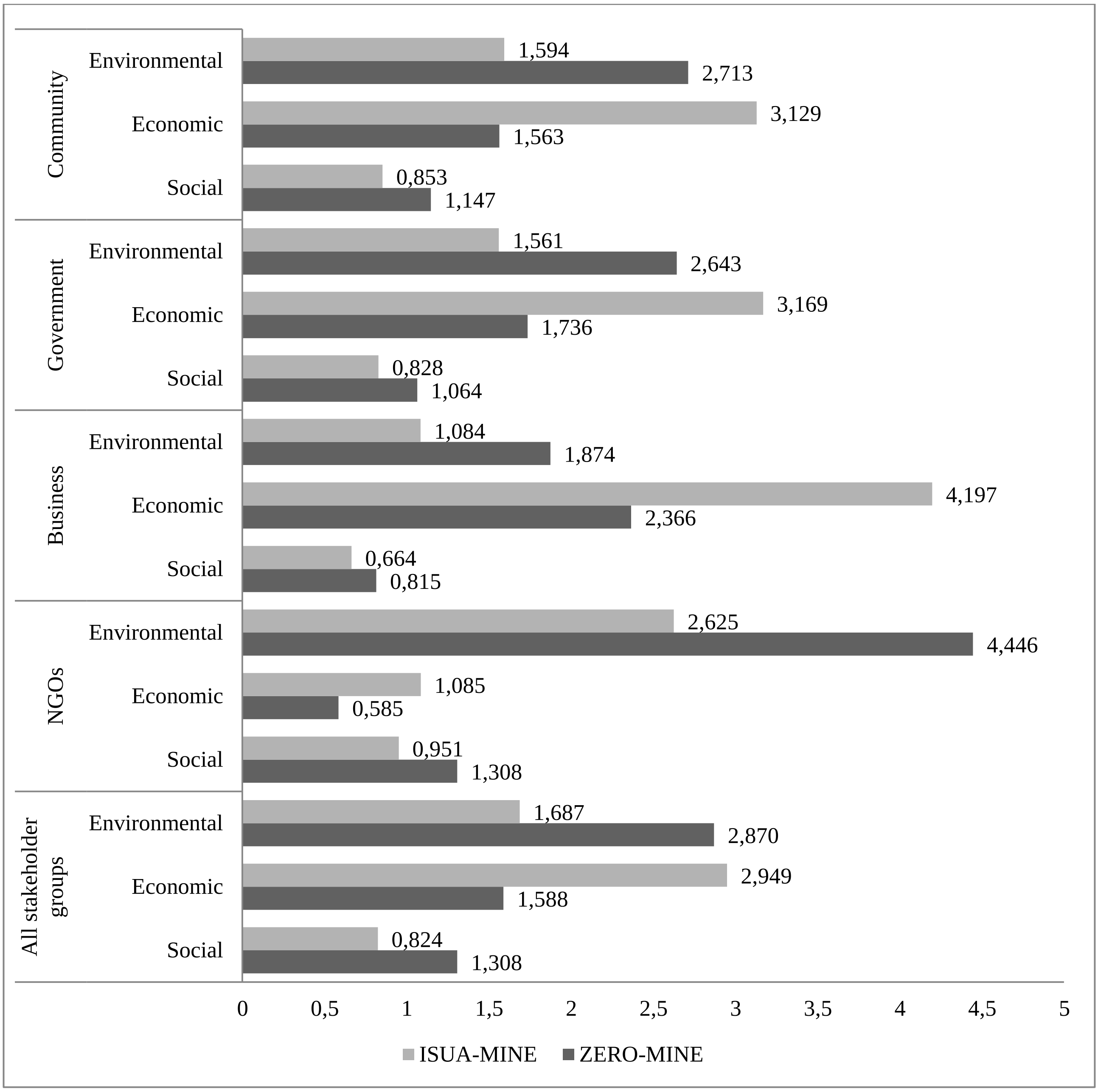

Figure 6 - Key stakeholder groups result

The community has an interest across all dimensions, since they are most likely to experience impacts in each (SIA of the Isua Iron Ore Project, 2013; EIA of the Isua Iron Ore Project, 2013). They are directly affected by the potential environmental damages and possible social consequences (Nuttall, 2012b). However, they also face opportunities for employment and economic prosperity resulting from a large-scale mine. The government too has a broad interest in all three dimensions. It will need to be concerned with potential environmental impacts since they have consequences for citizens' well-being, for which authorities are accountable. Similarly, the authorities will eventually have to deal with and provide solutions for any social problems that may be caused by the mine (Azapagic, 2004). Potential macroeconomic growth based on taxes and revenues from the mine due to employment opportunities at the mine is also a key interest of government, because it can lead to overall economic improvement and improved social services for the citizens (Government of Greenland, 2014). Therefore community and government have a similar score distribution between the two alternatives across all three dimensions. The business is mainly interested in new business opportunities for providing supply and services to the mine, contract packages, and employment (Aurora, 2012). They have some interest in the environmental and social dimensions, since they are local businesses. The business viewpoint represents the highest gap in the performance of the alternatives on the economic dimension, favoring the Isua-mine. This indicates that there might be potential to realize the key interest areas for this stakeholder group in terms of new business creation and industrial development. The main concern of the NGOs is the environment and to some extent the social issues (Azapagic, 2004; Bjørst, 2016), with economic aspects being of minimal interest. The NGOs' viewpoint represents the highest gap between the two alternatives on the environmental dimension among the stakeholder groups, favoring of the zero-mine alternative. This result is not surprising since mining and depletion of nonrenewable resources will inevitably cause some degree of disturbance and damage to the environment.

According to Figure 7 the total WSM result, which comprises the environmental, economic, and social dimensions across stakeholder perspectives, does not follow a similar pattern to the equal-weighted result in Figure 5. The result in Figure 7 shows that Isua-mine outperforms the zero-mine alternative from community, government, and business viewpoints, whereas according to the equal-weighted result the zero-mine outperforms the Isua-mine alternative. This clearly demonstrates that the evaluation of the two alternatives strongly depends on different stakeholders' perception of importance relative to each identified impact. While the performance gap between the alternatives from community and government perspectives is relatively similar, the gap is comparatively large from the business perspective. The combined stakeholder viewpoint indicates an outperformance by the zero-mine alternative opposed to the Isua-mine, which most likely can be explained by the relatively large gap in favor of the zero-mine alternative from the NGOs' perspective.

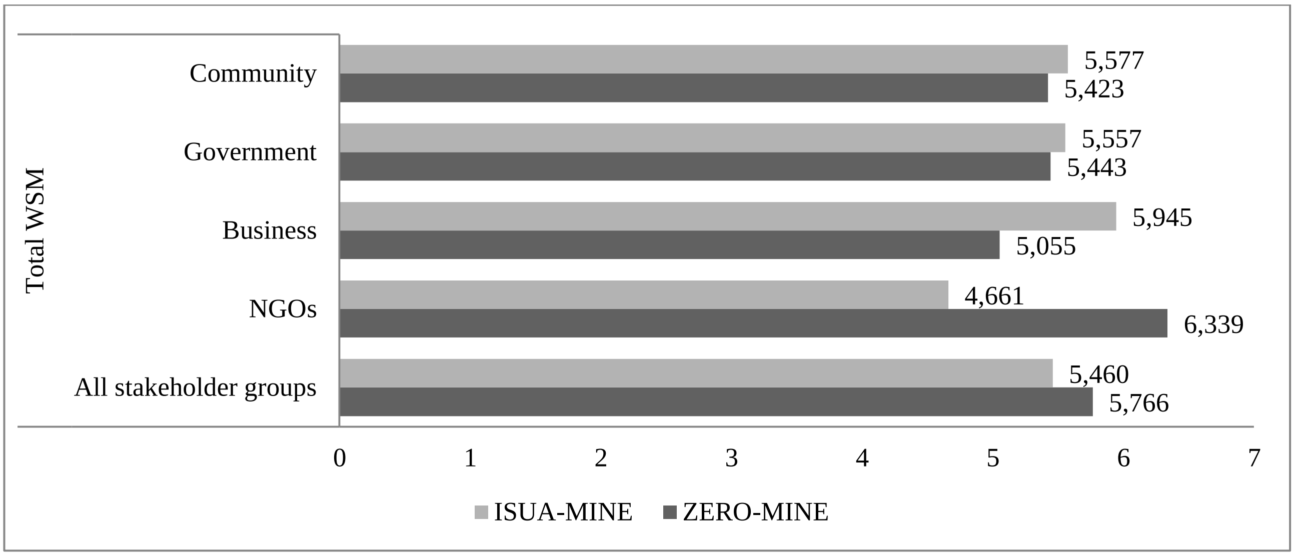

Figure 7 - Total WSM result

Even though the Isua-mine is only preferable to the zero-mine alternative on the economic dimension, the total sum of impacts favors the Isua-mine due to the perceived importance of the economic impacts combined with the potential positive economic impacts caused by the mine. While the Isua-mine may bring economic prosperity to the Greenlandic society, it does not necessarily follow that these potential impacts will become a certain reality. Ultimately, it depends on the extent to which society is capable of realizing these potential economic opportunities. Studies of other Arctic communities (Iceland and Faroe Islands) and the extractive industries emphasize that human capital development plays an important role in securing and maximizing local socioeconomic benefits (Smits et al., 2016). Others propose that an inclusive business approach can deliver socioeconomic development and improve sustainability (Virah-Sawmy, 2015). However, Greenland faces several uncertainties associated with appropriate competencies and experience required for the mining industry (The Committee for Greenlandic Mineral Resources to the Benefit of Society, 2014; Copenhagen Economics, 2012; Økonomisk Råd, 2012), a workforce of sufficient scale (Statistics Greenland, 2016a), and a business community dominated by small medium-sized enterprises (Statistics Greenland, 2016b). Hence, collaborative strategies are considered beneficial for the business community to increase business potential (The Committee for Greenlandic Mineral Resources to the Benefit of Society, 2014) and a focus on human capital development is essential (Smits et al., 2016) in order to overcome these uncertainties as an emerging resource economy. Economic growth, employment, and skills development derived from the development of the mining industry in Greenland are perceived as contributors to social sustainability (Tiainen, 2016). Lack of realization of potential benefits might offset the difference between the alternatives. This is evidence of the necessity of making trade-offs among the environmental, economic, and social dimensions when considering socioeconomic value creation and the sustainability of a large-scale mining project.

6.7 Discussion

The magnitude and type of development and associated change process is unprecedented in Greenland. The local society can face difficulties and challenges to absorb the changes, whether in the shape of pressure on public administrative authorities, health services, waste treatment, increased need for housing and transportation, or social and cultural conflicts with foreign workers (AMAP, 2010; Carrington, 1996; McMahon and Remy, 2001; SIA of the Isua Iron Ore Project, 2013). The environmental impacts from large-scale mining are inevitable, but monitoring and adequate mitigation actions can potentially reduce the negative impacts (EIA of the Isua Iron Ore Project, 2013). The local business community does not currently have the necessary capacity and competences to take full advantage of the potential new business opportunities created by large-scale mining (The Committee for Greenlandic Mineral Resources to the Benefit of Society, 2014; Copenhagen Economics, 2012; Økonomisk Råd, 2012). The mine can stimulate a broad area of business sectors by demanding goods and services to the mine site, including construction work, transportation and logistics, communication, housing, food and goods, materials, and fuel (SIA of the Isua Iron Ore Project, 2013). Ultimately, this can lead to a greater diversification of the local business community. However, the realization of potential new business ventures depends on the capability and availability of local businesses and local labor qualified for training (The Committee for Greenlandic Mineral Resources to the Benefit of Society, 2014), which is repeatedly stressed throughout the SIA report (SIA of the Isua Iron Ore Project, 2013).

Sustainable development cannot be achieved by just "doing better." Only when the positive impacts are sufficiently enhanced and the negative sufficiently mitigated can it be claimed that sustainable development is being achieved (Hacking and Guthrie, 2008). The key question is how to enhance the societal readiness for large-scale mining in a fashion that maximizes the socioeconomic value creation for the Greenlandic society. Trade-offs across the environmental, economic, and social dimensions may be necessary in order to consider large-scale mining as being sustainable for Greenland. Achieving solely positive impacts and completely avoiding negative impacts is unlikely to be realistic. Environmental impacts should be reduced to the greatest possible extent, but a certain level of footprint from mining will need to be tolerated. The social and economic dimensions provide greater possibility for adjustment to and improvement of negative impacts. Evidently, societal readiness, which includes a combination of mitigation and preparation for large-scale mining, may determine whether mining is sustainable for the local society.

Ensuring the necessary mechanisms to enable effective roles in decision making of local communities is among the greatest challenges in mining industry's contribution to local sustainable development (MMSD, 2002). Communities need to understand the full range of potential risk as they make critical decisions and plan for their future (Wilson and Stammler, 2016). While an increasing number of international companies within the extractive industries are showing interest in Greenland, there is a call for more public participation and consultation processes for large-scale projects (Nuttall, 2013). SIA should be regarded as a tool that enables decision makers to understand the consequences of their decisions before they act, allows effective management, and provides the opportunity for the affected people to participate in designing their future (Hansen and Mortensen, 2013). Impacts on the institutional capacity are not emphasized in the SIA guidelines (Hansen and Mortensen, 2013). Nevertheless, Greenland has limited administrative and technical capacity, which may result in poor governance (Hansen and Mortensen, 2013). Public participation, which implies public involvement in the decision-making process, is emphasized according to SIA guidelines (Hansen and Mortensen, 2013). However, there is a need for strengthening the regulation, guidance, and execution of public participation in Greenland (Olsen and Hansen, 2014; Wilson, 2016). These processes are still under development and improvement and those carried out so far, particularly for the Isua project, have been criticized for the lack of public involvement and the flow and quality of information (Hansen and Mortensen, 2013).

Mine developers and relevant government bodies should consider the interest of the public and include local knowledge and perspectives in decision-making at an early stage, as this can influence the social license to operate of projects and the legitimacy of the decisions (Hansen, Vanclay, Croal, and Skjervedal, 2016; Wilson and Stammler, 2016). A high level of involvement from local people and the local business community in the industrial activities generates clear local benefits, which creates a social license to operate (Smits et al., 2016). The quality of contact between a mining company and community stakeholders, rather than frequency of contact, alongside procedural fairness, where community members feel heard, is essential for enhancing trust in the mining company, which secures and maintains a social license to operate and acceptance of decisions and outcomes (Moffat and Zhang, 2014). *"The development of extractive industries as a basis for* *economic development is an issue that divides communities and, as more applications for exploration licences are submitted, it raises the prospect of further contested and controversial debate about how Greenland should not only prepare for a future society characterized by the presence and dominance of mining and oil companies, but how that future society will also manage and govern resource development*." (Nuttall, 2012b).

This should form the basis for discussions about Greenland's future and be a prerequisite for building relationships between companies within the extractive industries and local communities (Nuttall, 2012b, 2013). Continuous debate on Greenland as an emerging resource economy and how to maximize socioeconomic value creation and sustainable development is important, as the society holds positive expectations of a future with extractive industries, but faces anxieties and uncertainties related to share of benefits and social risks (Hansen et al., 2016).

This paper demonstrates and illustrates the application of MCDA for more holistic and inclusive assessments in a pre-mining context when EIA and SIA are prepared, which can be applied regardless of location. The assessment outcome serves as an illustrative example of how to apply the method, based on the selected case and the selected key stakeholder groups. Naturally, the outcome of such assessment will differ, when relevant stakeholder groups would provide real weights to each identified impact. The method can serve as a valuable tool for decision makers and increase local public participation throughout the feasibility and regulatory approval process to assess the sustainability of large-scale mining opposed to other alternatives, such as zero-mine or other industrial development activities.

6.8 Conclusion

This paper presents a method to conduct more holistic and inclusive assessments in a pre-mining context by translating the results of EIA and SIA of the proposed Isua Iron Ore Mine in Greenland into a MCDA result. The assessment framework comprises environmental, economic, and social dimensions, and it considers relevant stakeholders' perspectives (community, government, business, and NGOs). The application of the MCDA method demonstrates a quantitative approach for comparison of two alternatives, the Isua-mine and a zero-mine alternative, based on identified impacts in the EIA and SIA undertaken for the Isua-mine. The assessment outcome serves as an illustrative example of method application, which shows that the total sum of impacts, comprising the environmental, economic, and social dimensions, results in Isua-mine being favored by community, government, and business stakeholder groups. However, the Isua-mine only outperforms the zero-mine alternative on the economic dimension according to all stakeholder perspectives. Nevertheless, the combined stakeholder result favors the zero-mine alternative, which is mainly explained by the large performance gap between the alternatives in favor of the zero-mine from the NGOs' perspective. The evaluation of alternatives strongly depends on various stakeholders' perception of importance. While these results are only applicable to Isua-mine and the selected key stakeholder groups, the MCDA method can be applied to EIAs and SIAs regardless of location or magnitude for future mining projects within and outside Greenland. Ultimately, the holistic assessment framework can serve as valuable evaluation tool to support decision makers and increase local public participation throughout the planning processes and address socioeconomic value creation and the sustainability of a mining project.

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7 Chapter 7: Conclusion

In this concluding chapter, I integrate and discuss the main findings of the four research papers comprising the dissertation. First, I address findings relevant to micro-level socioeconomic effects of mining in the Arctic. I do this by presenting main findings derived from paper 1 and subsequently paper 2. Second, I present main findings of paper 3 that address the Greenlandic business community. Third, I present the main findings of paper 4. I synthesized the main findings derived from the four papers to concluding remarks about policy implications and contributions to Greenland. Finally, I discuss implications and issues for further research beyond the scope of this study.

7.1 Micro-level socioeconomic effects of mining in the Arctic

The initial research question, RQ1 (*What are the micro-level socioeconomic effects of mining in the Arctic?*), is addressed in paper 1 and paper 2, which constitute chapter 3 and chapter 4.

7.1.1 Life-cycle model of a mining project

In paper 1 (*"Socioeconomic value creation and the role of local participation in large-scale mining projects in the Arctic"*), I develop a life-cycle model for mining projects based on life-cycle theory that serves as a framework for analyzing socioeconomic effects of mining. The core life-cycle model of a mining project consists of five distinct phases: exploration, planning, construction, operation, and closure. The complementary level of the life-cycle model considers the integration of supporting industries, which includes transportation and logistics, construction, and service and supply industries. Direct job creation occurs at the core level, whereas indirect job creation and potential for derived business creation occurs at the complementary level. The life-cycle model represents a holistic approach to analyze socioeconomic effects of mining that equally consider both direct and indirect employment from the commencement to closure of a mining project. The timeline, duration of each phase, and socioeconomic outcomes vary based on the specific mining project. Specifically, there are great variations to the initial phase, exploration, and the operation phase due to the discovery and proof of a mineral deposit and when the mineral deposit will be exhausted and not feasible for further extraction. The shortest is the cost-intensive construction phase. Each phase comprising the life-cycle model is both distinct and interrelated, where actions and decisions in early phases can have effects on subsequent phases.

7.1.2 Socioeconomic effects of the Red Dog Mine and the Diavik Diamond Mine

The analysis of the micro-level socioeconomic effects of the Red Dog Mine in Northwest Arctic Borough in Alaska and the Diavik Diamond Mine in Northwest Territories in Canada showed that the most significant socioeconomic benefits are manifested throughout the construction and operation phases. Direct employment is a significant socioeconomic benefit in both cases, where approximately half of the total workforce is sourced locally. Both projects provided education and training to the local workforce cooperatively with the local community to enable regional residents to take up positions at the mines or contractors. This education and training was linked to employment opportunities and career advancements, and therefore is considered as a key socioeconomic benefit in both cases. Outsourcing of tasks created indirect business development opportunities derived from supporting industries. Both mining projects had substantial effects on the local business community: the service sector employment grew by 46 percent during the first four years of Red Dog operation, and 40 percent of total employees at Diavik were subcontractors. The derived business opportunities in supporting industries were similar in both cases and included transportation and logistics services, catering and camp services, construction support, and supply services such as fuel, explosives, and heavy equipment. The mining industry is not the biggest direct employer in the two regions. Nonetheless, both mining projects had an effect on growth and employment in supporting industries, which must be taken into consideration when assessing micro-level socioeconomic effects on local communities. Furthermore, both mining projects contributed to the general economy of the host regions, where taxes and royalties were utilized to improve services and care to local citizens, including those not involved in mining activities.

7.1.3 The role of participation

In paper 1, I explored the role of local participation in the decision-making and negotiation process throughout the planning phase of mine's life-cycle. Both cases displayed a high level of participation of local actors in the decision-making and negotiation processes concerning mine development during the planning phase, as well as trilateral dialogue and transparency. In the case of Diavik, partnership agreements were negotiated with each one of the five neighboring communities on employment, training, and business opportunities. Similarly, in the case of Red Dog, the local community had a significant influence in negotiating terms relevant to preferential employment, training, business partnering, and profit sharing. Furthermore, communities in both cases had secured continuous involvement in decision-making concerning project operation, where community representatives act as a liaison between the parties and are involved in monitoring and reviewing of operations and plans. Increased participation of local actors in decision-making and negotiation processes during the planning phase had a positive influence on socioeconomic outcomes throughout the following phases of the mining project life-cycle. This displays the interrelatedness of the phases comprising the life-cycle model.

7.1.4 Socioeconomic effects of mining in the Arctic regions of Sweden, Norway, and Finland

In paper 2 (*"Mining in Arctic and Non-Arctic regions: a socioeconomic assessment"*), I (co-authored with Anders Frederiksen) empirically establish the socioeconomic effects of mining on host municipalities in the Arctic regions of Sweden, Norway, and Finland that occur prior to the official mine opening and when the mine is in operation. The project focused on the period that spans three years prior to a mine opening to three years after the mine starts operation, to capture the effects during the construction and operation phases.

Our empirical results, based on municipality-level register data from Sweden, Norway, and Finland from 1986 to 2013, showed strong positive and significant employment effects and a clear shift in the industry structure in host municipalities. These effects appeared stronger in Arctic municipalities than in non-Arctic municipalities. The employment effects, measured by number of employed people in the host municipality, are evident in the years prior to mine opening and in the year the mine starts operation the effect accumulates to 364 persons. Hence, additional 364 new jobs are created in the host municipality compared to employment in municipality had there been no mine. This effect persists and moderately increases with an employment effect of 436 persons in year three of operation. Further, this effect is accompanied by a decrease in unemployment and a reduction in the number of people outside the labor force. The clear drop in unemployment is about half the magnitude of the employment effect, which points toward that people who were previously not considered part of the labor force now enter the labor market.

Mining does not alter the population size in host municipalities. This indicates that the positive employment effects remain local, since there is no significant change in population size. Mine development had a strong influence on the industry structure in host municipalities in the Arctic. For Arctic municipalities, the shift in employment share to the mining industry is significant: the employment share in the mining industry increases by 1.6 percentage points in the year the mine starts operation and the effect persists and increases to 3.1 percentage points in year three of operation. For the construction industry, the increase in employment share is evident up to three years before the mine starts operation, which is consistent with the construction phase of a mine's life-cycle. The year prior to operation and the year the mine starts operation, respectively, the employment shares allocated to the construction industry are 2.1 percentage points and 1.5 percentage points higher than usual. In the following years of operation, the construction industry reverts back to normal. The primary sector grows in the year prior to operation, where the employment share allocated to the primary sector increases by a significant 2.4 percentage points and the effect is persistent throughout the period of investigation. Further, there are significant effects for the wholesale and retail industry, which increases the year after the mine starts operation, but in year three of operation there is a significant drop in employment share in this industry. The empirical results showed no significant effects on the employment share allocated to other industries, including manufacturing, transportation, electricity, and gas and water supply.

The results showed a positive effect on the number of young people, 20–39 years old, in the host municipality. The number starts to increase three years prior to operation, and the effect remains positive during the period of investigating. We do not establish significant effects for gender composition (male and female proportions) or childbirth rate as a consequence of a mine opening. Neither do we establish a significant effect on the human capital distribution as a consequence of mine development when we include four education levels. However, we establish a positive effect on crime rate, where a significant drop in crime rate of 1.0 percentage point can be detected two years prior to operation and persists the following years.

7.1.5 Concluding summary of findings to RQ1

I assessed the micro-level socioeconomic effects of mining in the Arctic in paper 1 and paper 2 with different methodological approaches. Relevant to the geographical distribution of analyses, I included five Arctic countries with present mining activities: Alaska, Canada, Norway, Sweden, and Finland. In this section, I synthesize key findings.

I established that increased employment in host communities is a substantial socioeconomic outcome of mining. Direct employment is a significant and positive socioeconomic effect of mining projects. This variable is measured as direct employment numbers derived from official company reports in the case of Red Dog and Diavik, and in the Arctic Scandinavian analysis this variable is evident as employment share allocated to the mining industry. Hence, mining in the Arctic is beneficial for local societies as it contributes with local job creation in the mines. In addition to direct job creation, mining projects contribute with indirect job creation by providing derived business development opportunities in supporting industries in host regions. The local construction industry is a business area that benefits from mining projects in both cases of Red Dog and Diavik.

The Arctic Scandinavian analysis also shows an increase in employment share allocated to the construction industry during the period equivalent to the construction phase of the life-cycle model. Supply services and catering and camp services to Red Dog and Diavik is also a business area that is beneficial for the host regions. The Arctic Scandinavian analysis shows a significant positive effect in employment share allocated to the wholesale and retail industry in host municipalities, when the mine starts operation. Transportation and logistics services are identified as a contributing business area for local communities in Red Dog and Diavik cases. However, the Arctic Scandinavian analysis does not show evidence of any effect in employment share allocated to the transportation industry. This variance relates to contextual differences within the geographical distribution. In the cases of Red Dog and Diavik, training and education in the form of apprenticeship programs, job-shadowing programs, and hands-on training targeted toward working in the mine is provided to local residents.

However, we do not establish any effect for the four education levels – basic schooling, upper secondary schooling, tertiary education (short) and tertiary education (long) for the Arctic Scandinavian analysis. The difference is due to the measurement of this variable, the case study approach assesses the type of schooling, whereas the statistical analysis measures level of schooling for the reason that data for the type of schooling was not obtainable for the Arctic Scandinavian analysis. Finally, mining has a positive effect on young people aged 20–39, whereas mining does not have an effect on the remaining demographic variables assessed in the Arctic Scandinavian study, including population size, gender composition, and birthrates. However, mining reduces crime rates in the Arctic Scandinavian regions, which can be attributed the lack of alteration of population size.

7.2 Enhancing benefits for the Greenlandic business community

The second research question, RQ2 (*How can the Greenlandic business community overcome limitations of smallness and enhance local business development and application of Greenlandic businesses in mining projects?*), is addressed in paper 3, which constitutes chapter 5.

In paper 3 (*"Transitioning from an economic cluster to a collaborative community: mining projects in Greenland"*), I investigated the ability of cluster development and the collaborative approach to enhance capabilities of the local business community in Greenland. I applied the single-case study design based on qualitative data to analyze the Greenlandic business community and the recently established cluster relevant to extractive industries in Greenland, Arctic Cluster of Raw Materials

(ACRM). The cluster, ACRM, serves as a platform for businesses relevant to extractive industries and Greenland with the main purpose of strengthening competitiveness and increase opportunities for subcontractors to mining projects in Greenland. The analysis underlines that the Greenlandic business community is challenges by size limitations, inadequate resources and competencies, and lack of extensive experience with the mining industry. Further, the Greenlandic business community is met by a subcontractor barrier, where mining companies primarily assign known subcontractors within their own network who guarantee the delivery of large construction work, rather than using several smaller subcontractors to the same work.

A collaborative design is a strategy to overcome the prevailing limitations and challenges of the Greenlandic business community, as collaboration enables SMEs to gain economies of scale and mobilize a variety of resources, and thereby achieve competitive advantage and possibility to access new markets. Companies within a cluster are regarded as potential collaborators, and within this setting, potential collaborators are already interconnected through ACRM and share a common objective to accelerate in the mining industry. Therefore, the analysis presents the linkage between cluster and collaborative community development in order to overcome the prevailing limitations and increase business potential as subcontractors in the mining industry.

The analysis emphasizes that evolving and transitioning from a cluster to a collaborative community relevant to extractive industries in Greenland enables member firms to realize business development that a single member firm could not achieve with own efforts by being a part of a cluster. This transition should be pursued as a deliberate attempt by ACRM. To manage the transition process emphasizes the facilitating role of a shared service provider, as this role is needed in every collaborative community. The analysis underlines that ACRM has the ability to undertake the role of a shared service provider, as it carries no connotation of ownership, which fits with the facilitative management approach. ACRM already conducts strategic initiatives but needs to perform the remaining activities assigned to a shared service provider in order to support collaborative relationships among members. This includes developing and providing infrastructure, protocols, and knowledge commons, which are the core elements of the collaborative community design. The five proximity dimensions (cognitive, geographical, social, organizational, and institutional) are mechanisms that influence linkages between firms. It is important to consider these in the transition process and in the activities assigned to a shared service provider. In the analysis, I develop a conceptual model for the transition process from an economic cluster to a collaborative community, which is based on the core architectural elements of the collaborative community design. The conceptual model considers the five proximity dimensions both as enablers and barriers to the transition process and collaboration. The elements of the collaborative community have the possibility to mediate the proximity dimensions, as these elements can be tailored to fit the needs of the collaborative community.

Collaboration represents a new approach to business development and to organize small businesses in remote regions throughout the Arctic, including Greenland, with the purpose of enhancing local capabilities.

7.3 A holistic assessment framework

The final research question, RQ3 (*How can a holistic assessment framework be developed that considers environmental, economic, and social dimensions and include stakeholder values in order to evaluate mining projects prior to development?*), is addressed in paper 4, which constitutes chapter 6.

In paper 4 (*"Multi-criteria decision analysis approach to a holistic assessment of a proposed mining project in Greenland"*) I developed (co-authored with Igor Linkov) the holistic assessment framework to serve as a practical instrument that can be applied by various stakeholders relevant to mining projects in Greenland. The framework is prospective and represents a quantitative approach to evaluate mining projects prior to construction and includes environmental, economic, and social dimensions and stakeholder values. The framework integrates data assembled in environmental impacts assessments (EIA) and social impact assessments (SIA) and translates these into a multi-criteria decision analysis (MCDA). The framework applies the weighted sum method (WSM) among the various methods for MCDA to assess alternatives. MCDA includes stakeholders' weights to each criterion in the assessment, which represents each stakeholder's perception of importance for each criterion. The identified impacts throughout EIA and SIA reports comprise the criteria list.

I demonstrated the application of the framework by assessing the proposed mining project Isua iron ore mine in Greenland. The alternatives included and compared in the assessment are Isua-mine and a zero-mine. Impacts identified by EIA and SIA prepared by independent consultants for the Isua-mine comprise the criteria list, which includes 44 identified impacts. Each identified impact is originally scored by the independent consultants as negative or positive low, medium, and high. I converted these terms of performance measures into values from 1 to 10, where 1 is a very high negative impact and 10 is a very high positive impact. I selected four key stakeholder groups (community, government, business, and NGO), and provided stakeholder weights to each identified impact according to stakeholders' generic interests in order to illustrate the assessment framework. The outcome of the assessment serves as an illustrative example of method application and shows that the Isua-mine outperforms the zero-mine alternative only on the economic dimension according to all stakeholder perspectives. I found that the total sum of impacts, which comprises the environmental, economic, and social dimensions, results in Isua-mine being favored by three out of four stakeholder groups (community, government, and business). However, I found that the combined stakeholder result favors the zero-mine alternative, which is explained by the large performance gap between the alternative favoring the zero-mine from the NGO's perspective. Stakeholders' perception of importance of each impact has a strong influence on the evaluation of alternatives, which is a key contribution of applying MCDA.

This method of evaluation is applicable to future mining projects, regardless of context, when EIA and SIA are prepared. The holistic assessment framework is a valuable evaluation tool to increase local participation and support decision makers throughout the planning phase of mining projects and to address socioeconomic value creation and sustainability of mining projects.

7.4 Policy implications and contributions to Greenland

As an emerging resource economy, it is highly valuable for Greenland to build knowledge based on the experiences of other Artic communities that have encountered the mining industry. For this purpose, it is important to gain insight and inform about the socioeconomic effects of mining on host communities.

At the core level of a mining project's life-cycle, mining creates jobs in host regions through direct employment at the mines. At the complementary level of the life-cycle model, it is important to take stock of the business development opportunities in supporting industries accessible for the local business communities in host regions. Beside positive effects to the primary sector, supporting industries to mining projects – construction, wholesale and retail (comprising supply services, camp, and catering to mines), transportation, and logistics, are business areas that present opportunities for new business creation to the local business communities as subcontractors to mining projects. Further, mining projects contribute with education and training to the local workforce that is directed toward taking up jobs at the mine. Mining does not have a significant effect on demographic variables, including population size, gender composition, and birthrate. However, host regions can experience a drop in crime rates.

An important factor for communities dealing with the mining industry is participation and involvement in negotiation and decision-making processes throughout the planning phase. This way, local actors can engage and influence the terms of development and operation of mining projects relevant to employment, training, and further monitoring of operations. Hence, a holistic assessment framework based on multi-criteria decision analysis that integrates data derived in EIAs and SIAs and includes stakeholder values with the purpose of evaluating proposed mining projects prior to constructions is a valuable instrument to engage and increase local participation during the planning phase.

Evidently, mining provides socioeconomic benefits and business development opportunities in the derived industries to host regions. The realization of business opportunities provided by mining is determined by the capacity of the local business community. In this regard, the Greenlandic business community is faced with limitations of smallness, inadequate competencies and resources, lack of extensive experience with the mining industry, and subcontractor barriers. Collaboration is a strategy to overcome prevailing challenges, by gaining economies of scale and mobilizing a variety of resource, which can increase competitiveness and application of Greenlandic businesses in mining projects. Hence, managing the transition from Arctic Cluster of Raw Materials (ACRM) as a cluster relevant to extractive industries in Greenland into a collaborative community creates more value as it enables member firms to realize new business ventures that each single firm cannot achieve with own efforts by being a part of a cluster. The transition process emphasizes the facilitating role of shared service providers, where ACRM as a shared service provider should provide necessary infrastructure, protocols, and knowledge commons to support collaborative relationships among members. Ultimately, the transition from a cluster to a collaborative community should be pursued as a deliberate attempt by ACRM. The transition should set the direction for the Greenlandic business community to engage in meaningful collaborations and enhance local business development derived from the mining industry.

7.5 Implications for further research

I investigated the socioeconomic effects of operating mines derived mainly throughout the construction and operation phases. I established significant positive effects relevant to both direct and indirect employment of mining. In extension to this scope of study, it is interesting to investigate the socioeconomic effects of mining projects when they reach the end of life—the closure phase. What are the effects on employment structure in host regions and local businesses that have progressed based on the presence of a mining industry? In addition, it is interesting to investigate to what extent local residents can utilize their mining skills in other industries. This is particularly relevant to the Diavik Diamond Mine, as the mine is projected to reach closure between 2019 and 2025. Hence, it is highly valuable to investigate these urgent issues in the foreseeable future. In the Arctic Scandinavian study, I also came across events of mine closures, but it proved infeasible to study based on statistical analysis due to the low number of mine closures in the sample period. In this regard, the case study approach is preferred choice of method to study mine closures.

I developed the life-cycle model to serve as a framework for assessing socioeconomic effects of mining. However, the application of the life-cycle approach could be extended to serve as a generic model for studying other effects of mining, such as the environmental effects and consequences throughout each phase of a mining project.

Finally, the transition from a cluster to a collaborative community represents an approach for continuous evolvement and development of clusters both from a practical and theoretical perspective. Therefore, further research both into theory and practice on the transition process and into the role of a shared service provider in managing the transition process is important.

I emphasized in the closing remark in the introduction of my dissertation that the timing is impeccable to investigate and analyze the past, present, and future of the Arctic relevant to extractive industries. I analyzed the present and the past of operating mines throughout the Arctic and the related socioeconomic effects on host regions with the purpose of informing Greenland. I investigated the present circumstances of the Greenlandic business community and assessment methods of mining projects with the purpose of contributing to shape the future of Greenland as an emerging resource economy. Continuous research in the future relevant to extractive industries and Greenland is important, as it provides valuable knowledge for Greenland to manage their resources in a way that maximizes benefits for the Greenlandic society.

8 Appendix for paper 4 in chapter 6

This section presents the identified impacts of EIA and SIA and the impact level of each identified impact. Further, this section includes weights of each identified impact according to each of the four stakeholder groups. Finally, the calculations and results of the holistic assessment framework applied for Isua-mine and the zero-mine alternatives are presented.

8.1 Identified impacts

C: construction phase. O: operation phase.

	IMPACT	DESCRIPTION	IMPACT LEVEL	ISUA SCORE	ZERO SCORE
ENVIRONMENTAL	Landscape alterations	• Port area, pipeline, air strip, processing plant, adjacent facilities, mine pit, primary crusher, waste rock storage • Visible from the surrounding landscape and from the fjord • Impact during construction: Medium • Impact during operation: Low *Major alterations have already taken place during construction, therefore the overall impact is considered as negative medium.*	-M	3	8
	Hydrological changes	• Rivers, lakes and fjord due to construction activities	-L	4	7
	Erosion	• Excavation of local sand and gravel for construction purposes: roads, storage facilities, camps etc. • Excavation of the mine pit and waste rock deposit	-L	4	7
	Water supply and wastewater	• Water supply for the plant site • Wastewater treatment • Effluents	-VL	5	6
	Waste	• Domestic waste from employees, construction waste, tires from mobile equipment, and hazardous waste	-L	4	7
	Noise	• Drilling and blasting • Transport of supplies and machinery, ship transport and ships at wharf, helicopters	-L	4	7
	Light, heat and radiation	• "Ecological light pollution" due to activities day and night, year around	None		
	Dust and air emissions	• Dust from blasting, excavation and construction • Engine emissions from ships, truck transport, helicopter, mobile equipment, generators • combustion emissions for power generation and heating • Generate emissions of pollutants to air primarily consisting of PM, NOX and SO2.	-L	4	7
	Greenhouse gas	• Average fuel consumption during construction phase: 15 million litres/year	-H	2	9

	emissions	• Average fuel consumption during operation phase: 210 million litres/year • Increase import of fuel to Greenland by 84% and increase CO_2 emission by 89%. • Increase per capita CO_2 emission in Greenland from 11 T/per capita/year to 21T/per capita/year in operation phase • Currently limited industrial activity in Greenland, any new energy demanding industry is expected to increase CO_2 emission per capita significantly • *Due to an almost doubling of greenhouse gas emissions, the impact is considered as high.*			
	Waste rock stockpile and ice stockpile	• Rocks with no significant iron content, which removed to give access to the ore body • Removed ice to give access to the ore body and the development of the pit	-VL	5	6
	Tailings	• Tailings disposal will involve use of Lake 750 as an underwater tailings disposal facility	-L	4	7
	Water quality	• Majority of water and substances discharged from the mine processing plant will go to the tailings pond • Iron concentrate slurry is conveyed to the port dewatering plant through the product slurry pipeline • Key point for environmental monitoring, monitoring of effluent parameters throughout the lifetime	-L	4	7
	Hydro-geology	• Groundwater is flowing into the mine pit as well into the Tailings Pond • Any leaks into the groundwater aquifers are not likely	None		
	Caribou	• Disturbance and noise by the presence of vehicles, machines, buildings, personnel and other project infrastructure, which might cause displacement of caribou	-M	3	8
	Terrestrial mammals and birds	• Disturbance of other terrestrial mammals and birds • Arctic fox and Arctic hare, musk oxen, Greenland White-fronted Goose, The Harlequin Duck, White-tailed Eagle and Gyrfalcon	-L	4	7
	Barrier	• Barrier effect posed by infrastructure • 105 km pipeline-road will pose barrier to caribou movement unless crossing ramps are constructed • 45 locations are identified where gravel crossing ramps will be implemented	-L	4	7
	Accidental wildlife mortality	• Traffic can led to road kills • To reduce this risk a reasonable speed limit will be imposed	-L	4	7
	Marine environment	• Project-related shipping will generate visual disturbance above water and noise both above and	-L	4	7

	and shipping	below water			
	Terrestrial habitats	• The construction will lead to loss of terrestrial habitat including about 210 ha of vegetation • Temporary as re-growth will take place after closure and removal	-VL	5	6
	Freshwater habitats	• The loss of freshwater habitats • The diversity of aquatic life is very limited	-VL	5	6
	Marine habitats	• Local loss of shallow marine habitat	-VL	5	6
	Introduction of non-native species	• The ballast water can contain non-indigenous species and become a threat to indigenous species and the local ecosystem • Regulations of the International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM) will be enforced • Impact: Very Low, without mitigation the impact will be negative medium	-VL	5	6
	Hindrance of other land use (hunting and fishing)	Traditional livelihood • Important for caribou hunting during autumn and winter • The construction of the port and the traffic of vessels could potentially impact seal hunting • Arctic char fishing in rivers and lakes • To avoid shooting accidents, a 'no hunting' security zone will be requested	-L	4	7
	Increased demand on existing resources	• Shortage in nearby towns or put restrictions on other industrial activities	None		
	Disturbance of culturally significant sites	• The area has been used since ancient times in particular to caribou hunting activities • No ancient monuments of significant importance have been identified • No disturbance of archaeological features is expected	None		
	Other land use	Open up the area for other land use through changes in infrastructure • The area will not be opened up for other land uses	None		
	Cumulative impacts	• The Isua project will be the only human activity in the area, except from traditional hunting and fishing, occasional tourists, hikers and scientists	None		
ECONOMIC	Taxes and Revenues	• Increased public revenues through dividend and corporation taxes, income tax • Estimated Corporate and Dividend Taxes *: DKK 28.5 billion (US $4.8 billion) for 15 years of mine life. Income taxation of personnel (Construction + Operation): Estimated to be in the order of DKK 3.7 billion (US $641 million, during 15 years of	C: +L	7	4
			O: +H	9	2

		mine life). • indirect employment and indirect business activities • multiplier effect of 1.3			
	Direct and indirect employment during construction	• The construction will require in the range of 1000 to 3000 skilled and experienced foreigners. A workforce of such a size and with the necessary qualifications cannot be found in Greenland • Small construction packages and services packages will be offered to local Greenlandic businesses, which will account for 7% to 10 % of the total labor • Large construction work packages offered to large international specialized contractors • Estimated creation of 210 to 430 new indirect jobs • Multiplier effect: 1.3 *The impact of direct and indirect local employment during construction is estimated as positive medium. However, only 7-10% or the required workforce will be occupied by locals and uncertainties related to the relative low multiplier effect. Therefore the impact is assessed as positive low for both direct and indirect impacts.*	Direct +L	7	4
			Indirect +Low	7	4
	Direct and indirect employment during operation	• The share of local workers is expected to increase based on training and by the 5th year of operation it is an objective that 55% of the workforce is local • Experienced Chinese/Asian labor will fill out the position the first five years of operation, in addition to western and Greenlandic workers • Based on training the Chinese/Asian operators will progressively be replaced by local labor during the first 5 years • Local labor: 20-55% of total workforce of 680-810 • Expected indirect job: 180-240 • not require the employees to move close to the mine, and therefore the positive effects of local employment will be distributed along Greenland • The impact on indirect employment can be limited by how fast local businesses can accommodate the project's needs *The impact of indirect local employment during operation is estimated as positive high. However, there are uncertainties related to the relative low multiplier effect. Therefore the impact is assessed as positive medium.*	Direct +M	8	3
			Indirect +M	8	3
	Local business and economy during	• Local business life is expected to be most positively affected • Significant in volume, diverse and targeting	Direct +M	8	3

	Construction	different segments local business community • Contract packages during construction phase; transport services, food and goods, communication, logistics and support services • Housing and accommodation services • The realization of opportunities will depend on the capacity and readiness of the local business sectors	Indirect +L	7	4
	Local business and economy during Operation	• Transport services; air transport, helicopter, boat transport, and other supplies, material and fuel. • Food and Goods • Communication, logistical and support services • Housing and accommodations services • Business opportunities indirectly associated with the project; tourism and spare time services and • goods, entertainment, education and day care, health language teaching, counseling, and recycling	Direct +M	8	3
			Indirect +M	8	3
	Conflicts and Synergies with Other Economic Sectors	• Competition for human resources in the building and construction sector • Competition for qualified workers • Synergy within other oil and mining projects • Synergy with tourism and spare time services and goods • Potential shortage of available accommodation in Nuuk	C: -L	4	7
			O: -M	3	8
	Traditional livelihood	• *Main concerns are potential impact of the project on the caribou hunting* • *Expected to last from construction throughout the life of the project and will manifest immediately*	*-L*	*4*	*7*
	Training	Training skills development opportunities • Delivering of training programs in different languages, “on-job trainings”, apprenticeship, simulators, measuring performance • Coordination of the training with involvement of different Greenlandic agencies and resources • Technical training of a particular importance of local labor • upgrading of language, administrative and technical qualifications • Cultural Training to help foreign workers	C: +M	8	3
			O: +H	9	2
	Impacts on public services and development plans	• Pressure on administration of construction permits • Increase work load at customs and taxation office, immigration authorities, and the police of Greenland • Health services, waste treatment, maritime freight traffic, air traffic in Nuuk Airport, and housing *The impact during construction and operation is estimated as negative medium. The potential impact after mitigation, including coordination with local authorities, can be reduced to negative low. Even*	-M/-L	3,5	7,5

		with mitigation, the increased pressure is assumed inevitable due to the magnitude of the project and lack of local experience with such projects. Therefore the impact is assessed as -M/-L.			
SOCIAL	Demography and population changes during construction	• The vast majority of foreign workers (1000-3000) will be men • Workers will reside in the accommodation at the site and will have a limited but not prohibited access to Nuuk during some days off • It should not be excluded that some worker will stay in Greenland by involving in other jobs or business opportunities	-L	4	7
	Demography and population changes during operation	• The project is expected to reduce the out-migration of Greenlanders, as a result of increased job and business opportunities • Lack of housing in Nuuk is a significant negative impacts related to immigration, which can cause increase of pricing for accommodation	+M	8	3
	Social conflict during construction and operation	The assessment is based on experiences from other mining projects • The risk cultural conflicts between international workers and local workers, due to differing values, poor communication, and personal problems • Sale of drugs, prostitution, high number of unwanted/ unexpected pregnancies and abortions • Out-migration of women, following their new partners • Trafficking of wild life products • Take-over of local business *The impact during construction and operation is estimated as negative medium. The potential impact after mitigation; monitoring, awareness raising, adequate recreational facilities on-site, cooperate with Nuuk municipality, and session on intercultural understanding and Greenlandic culture, can be reduced to negative low. Even with mitigation, it is assumed inevitable to prevent people from making "bad" choices combined with lack of local experience and resources to prevent potential problems. Therefore, the impact is assessed as -M/-L.*	-M/-L	3,5	7,5
	Vulnerable groups	• Children in families with addiction problems, if the most well-functioning parent should take work at the mine and be absent due to rotation schemes • Unemployed, uneducated young males • Low-income workers	-L	4	7
	Resettlement impact	No resettlements involved	None		
	Assessment of potential	• Zero-tolerance of drugs and alcohol at mining site, firearms, including hunting guns and hunting	-L	4	7

	criminality at the mining site	knives			
	Occupational health and risk of accidents	• Mainly related to operation of heavy machinery, use of explosives and harsh weather conditions • Wind, ice conditions, and navigational challenges causing accidents involving vessels during the ore loading and transportation *The impact is estimated as negative medium. After mitigation the impact can be reduced to negative low.*	-L	4	7
	Health and quality of life	• Potential impacts and risks for the population of Nuuk, the employees of the project and their families when relevant • Concerns regarding the health profile of international workers • Transmission of STIs and tuberculosis, abortions and teen pregnancies, mainly via prostitution and sexual contact with the local population • Costs to the public health system is expected to be negligible, due to private health insurance requirement for international workers • Onsite medical facilities to aid workers with minor and less serious ailments • Risk of contact is mitigated due to the distance from the mine site to Nuuk • Positive impacts in diet and life style, as well as risk of incidence of alcohol and intoxicants abuse during operation due to long periods in camps at mine site *The impact is estimated as negative medium during construction. After mitigation the impact can be reduced to negative low.*	C: -L	4	7
			O: +L	6	5
	Sites or monument	*Sites or monument of cultural importance* • *Not significant*	*None*		
	Access to natural areas	*Access to natural areas perceived as important* • *Areas popular for caribou hunting and fishing*	*-L*	*4*	*7*

8.2 Key stakeholder group weights

Com: community, Gov: government, Bus business, NGOs: NGOs

	IMPACTS	KEY STAKEHOLDER GROUP WEIGHTING									
		Com weight	*Com norm.*	*Gov weight*	*Gov norm.*	*Bus weight*	*Bus norm.*	*NGOs weight*	*NGOs norm.*	*All weight*	*All norm.*
ENVIRONMENTAL	Landscape alterations	2	0,014	2	0,013	1	0,008	3	0,027	2,00	0,015
	Hydrological changes	3	0,021	3	0,019	2	0,017	3	0,027	2,75	0,021
	Erosion	2	0,014	2	0,013	1	0,008	2	0,018	1,75	0,013
	Water supply and wastewater	3	0,021	5	0,032	2	0,017	4	0,036	3,50	0,026
	Waste	3	0,021	5	0,032	2	0,017	3	0,027	3,25	0,024
	Noise	2	0,014	2	0,013	1	0,008	2	0,018	1,75	0,013
	Dust and air emissions	3	0,021	2	0,013	1	0,008	3	0,027	2,25	0,017
	Greenhouse gas emissions	1	0,007	2	0,013	1	0,008	3	0,027	1,75	0,013
	Waste rock stockpile and ice stockpile	2	0,014	2	0,013	1	0,008	2	0,018	1,75	0,013
	Tailings	2	0,014	3	0,019	1	0,008	3	0,027	2,25	0,017
	Water quality	3	0,021	4	0,025	2	0,017	4	0,036	3,25	0,024
	Caribou	5	0,035	4	0,025	3	0,025	5	0,045	4,25	0,032
	Terrestrial mammals and birds	5	0,035	5	0,032	3	0,025	5	0,045	4,50	0,034
	Barrier	3	0,021	3	0,019	2	0,017	5	0,045	3,25	0,024
	Accidental wildlife mortality	2	0,014	2	0,013	1	0,008	3	0,027	2,00	0,015
	Marine environment and shipping	2	0,014	2	0,013	1	0,008	3	0,027	2,00	0,015
	Terrestrial habitats	2	0,014	2	0,013	1	0,008	3	0,027	2,00	0,015
	Freshwater habitats	2	0,014	2	0,013	1	0,008	4	0,036	2,25	0,017
	Marine habitats	2	0,014	2	0,013	1	0,008	4	0,036	2,25	0,017
	Introduction of non-native species	2	0,014	2	0,013	1	0,008	3	0,027	2,00	0,015
	Hindrance of other land use (hunting and fishing)	5	0,035	4	0,025	3	0,025	5	0,045	4,25	0,032
ECONOMIC	Taxes and Revenues, construction	4	0,028	5	0,032	4	0,034	1	0,009	3,500	0,026
	Taxes and Revenues, operation	4	0,028	5	0,032	4	0,034	1	0,009	3,500	0,026
	Direct employment during construction	5	0,035	4	0,025	5	0,042	1	0,009	3,750	0,028
	Indirect employment during construction	5	0,035	4	0,025	5	0,042	1	0,009	3,750	0,028
	Direct employment during operation	5	0,035	5	0,032	5	0,042	1	0,009	4,000	0,030
	Indirect employment during operation	5	0,035	5	0,032	5	0,042	1	0,009	4,000	0,030
	Direct, Local business and economy during Construction	4	0,028	5	0,032	5	0,042	1	0,009	3,750	0,028
	Indirect, Local business and economy during Construction	4	0,028	5	0,032	5	0,042	1	0,009	3,750	0,028

	Direct, Local business and economy during Operation	4	0,028	5	0,032	5	0,042	1	0,009	3,750	0,028
	Indirect, Local business and economy during Operation	4	0,028	5	0,032	5	0,042	1	0,009	3,750	0,028
	Conflicts and Synergies with Other Economic Sectors, construction	2	0,014	3	0,019	5	0,042	1	0,009	2,750	0,021
	Conflicts and Synergies with Other Economic Sectors, operation	2	0,014	4	0,025	5	0,042	1	0,009	3,000	0,023
	Training, construction	5	0,035	5	0,032	5	0,042	2	0,018	4,250	0,032
	Training, operation	5	0,035	5	0,032	5	0,042	2	0,018	4,250	0,032
	Impacts on public services and development plans	3	0,021	5	0,032	3	0,025	1	0,009	3,000	0,023
SOCIAL	Demography and population changes during construction	3	0,021	3	0,019	2	0,017	2	0,018	2,500	0,019
	Demography and population changes during operation	3	0,021	4	0,025	3	0,025	2	0,018	3,000	0,023
	Social conflict During construction and operation	4	0,028	4	0,025	2	0,017	3	0,027	3,250	0,024
	Vulnerable groups	3	0,021	3	0,019	1	0,008	3	0,027	2,500	0,019
	Assessment of potential criminality at the mining site	2	0,014	2	0,013	1	0,008	2	0,018	1,750	0,013
	Occupational health and risk of accidents	4	0,028	4	0,025	3	0,025	4	0,036	3,750	0,028
	Health and quality of life, construction	3	0,021	3	0,019	2	0,017	3	0,027	2,750	0,021
	Health and quality of life, operation	4	0,028	4	0,025	2	0,017	4	0,036	3,500	0,026
	Total	143	1,000	157	1,000	119	1,000	112	1,000	132,750	1,000

8.3 The holistic assessment framework applied for Isua-mine and zero-mine

Com: community, Gov: government, Bus business, NGOs: NGOs

		ISUA-MINE						ZERO-MINE					
			Com	*Gov*	*Bus*	*NGOs*	*All*		*Com*	*Gov*	*Bus*	*NGOs*	*All*
	IMPACTS	***Impact***	***score***	***score***	***score***	***score***	***score***	***Impact***	***score***	***score***	***score***	***score***	***score***
ENVIRONMENTAL	Landscape alterations	3	0,042	0,038	0,025	0,080	0,045	8	0,112	0,102	0,067	0,214	0,121
	Hydrological changes	4	0,084	0,076	0,067	0,107	0,083	7	0,147	0,134	0,118	0,188	0,145
	Erosion	4	0,056	0,051	0,034	0,071	0,053	7	0,098	0,089	0,059	0,125	0,092
	Water supply and wastewater	5	0,105	0,159	0,084	0,179	0,132	6	0,126	0,191	0,101	0,214	0,158
	Waste	4	0,084	0,127	0,067	0,107	0,098	7	0,147	0,223	0,118	0,188	0,171
	Noise	4	0,056	0,051	0,034	0,071	0,053	7	0,098	0,089	0,059	0,125	0,092
	Dust and air emissions	4	0,084	0,051	0,034	0,107	0,068	7	0,147	0,089	0,059	0,188	0,119
	Greenhouse gas emissions	2	0,014	0,025	0,017	0,054	0,026	9	0,063	0,115	0,076	0,241	0,119
	Waste rock stockpile and ice stockpile	5	0,070	0,064	0,042	0,089	0,066	6	0,084	0,076	0,050	0,107	0,079
	Tailings	4	0,056	0,076	0,034	0,107	0,068	7	0,098	0,134	0,059	0,188	0,119
	Water quality	4	0,084	0,102	0,067	0,143	0,098	7	0,147	0,178	0,118	0,250	0,171
	Caribou	3	0,105	0,076	0,076	0,134	0,096	8	0,280	0,204	0,202	0,357	0,256
	Terrestrial mammals and birds	4	0,140	0,127	0,101	0,179	0,136	7	0,245	0,223	0,176	0,313	0,237
	Barrier	4	0,084	0,076	0,067	0,179	0,098	7	0,147	0,134	0,118	0,313	0,171
	Accidental wildlife mortality	4	0,056	0,051	0,034	0,107	0,060	7	0,098	0,089	0,059	0,188	0,105
	Marine environment and shipping	4	0,056	0,051	0,034	0,107	0,060	7	0,098	0,089	0,059	0,188	0,105
	Terrestrial habitats	5	0,070	0,064	0,042	0,134	0,075	6	0,084	0,076	0,050	0,161	0,090
	Freshwater habitats	5	0,070	0,064	0,042	0,179	0,085	6	0,084	0,076	0,050	0,214	0,102
	Marine habitats	5	0,070	0,064	0,042	0,179	0,085	6	0,084	0,076	0,050	0,214	0,102
	Introduction of non-native species	5	0,070	0,064	0,042	0,134	0,075	6	0,084	0,076	0,050	0,161	0,090
	Hindrance of other land use (hunting and fishing)	4	0,140	0,102	0,101	0,179	0,128	7	0,245	0,178	0,176	0,313	0,224
	Sum	*86*	*1,594*	*1,561*	*1,084*	*2,625*	*1,687*	*145*	*2,713*	*2,643*	*1,874*	*4,446*	*2,870*
ECONOMIC	Taxes and revenues, construction	7	0,196	0,223	0,235	0,063	0,185	4	0,112	0,127	0,134	0,036	0,105
	Taxes and revenues, operation	9	0,252	0,287	0,303	0,080	0,237	2	0,056	0,064	0,067	0,018	0,053
	Direct employment during construction	7	0,245	0,178	0,294	0,063	0,198	4	0,140	0,102	0,168	0,036	0,113
	Indirect employment during construction	7	0,245	0,178	0,294	0,063	0,198	4	0,140	0,102	0,168	0,036	0,113
	Direct employment	8	0,280	0,255	0,336	0,071	0,241	3	0,105	0,096	0,126	0,027	0,090

	during operation											
	Indirect employment during operation	8	0,280	0,255	0,336	0,071	0,241	3	0,105	0,096	0,126	0,027	0,090
	Direct, local business and economy during Construction	8	0,224	0,255	0,336	0,071	0,226	3	0,084	0,096	0,126	0,027	0,085
	Indirect, local business and economy during Construction	7	0,196	0,223	0,294	0,063	0,198	4	0,112	0,127	0,168	0,036	0,113
	Direct, local business and economy during Operation	8	0,224	0,255	0,336	0,071	0,226	3	0,084	0,096	0,126	0,027	0,085
	Indirect, local business and economy during Operation	8	0,224	0,255	0,336	0,071	0,226	3	0,084	0,096	0,126	0,027	0,085
	Conflicts and synergies with other economic sectors, construction	4	0,056	0,076	0,168	0,036	0,083	7	0,098	0,134	0,294	0,063	0,145
	Conflicts and synergies with other economic sectors, operation	3	0,042	0,076	0,126	0,027	0,068	8	0,112	0,204	0,336	0,071	0,181
	Training, construction	8	0,280	0,255	0,336	0,143	0,256	3	0,105	0,096	0,126	0,054	0,096
	Training, operation	9	0,315	0,287	0,378	0,161	0,288	2	0,070	0,064	0,084	0,036	0,064
	Impacts on public services and development plans	3,5	0,073	0,111	0,088	0,031	0,079	7,5	0,157	0,239	0,189	0,067	0,169
	Sum	*104,5*	*3,129*	*3,169*	*4,197*	*1,085*	*2,949*	*60,5*	*1,563*	*1,736*	*2,366*	*0,585*	*1,588*
SOCIAL	Demography and population changes during construction	4	0,084	0,076	0,067	0,071	0,075	7	0,147	0,134	0,118	0,125	0,125
	Demography and population changes during operation	8	0,168	0,204	0,202	0,143	0,181	3	0,063	0,076	0,076	0,054	0,054
	Social conflict during construction and operation	3,5	0,098	0,089	0,059	0,094	0,086	7,5	0,210	0,191	0,126	0,201	0,201
	Vulnerable groups	4	0,084	0,076	0,034	0,107	0,075	7	0,147	0,134	0,059	0,188	0,188
	Assessment of potential criminality at the mining site	4	0,056	0,051	0,034	0,071	0,053	7	0,098	0,089	0,059	0,125	0,125
	Occupational health and risk of accidents	4	0,112	0,102	0,101	0,143	0,113	7	0,196	0,178	0,176	0,250	0,250
	Health and quality of life, construction	4	0,084	0,076	0,067	0,107	0,083	7	0,147	0,134	0,118	0,188	0,188

	Health and quality of life, operation	6	0,168	0,153	0,101	0,214	0,158	5	0,140	0,127	0,084	0,179	0,179
	Sum	*37,5*	*0,853*	*0,828*	*0,664*	*0,951*	*0,824*	*50,5*	*1,147*	*1,064*	*0,815*	*1,308*	*1,308*
	TOTAL WSM	**228**	**5,577**	**5,557**	**5,945**	**4,661**	**5,460**	**256**	**5,423**	**5,443**	**5,055**	**6,339**	**5,766**

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Title:	Mining in Arctic and Non-Arctic Regions: A Socioeconomic Assessment
Authors:	Anders Frederiksen and Maja Due Kadenic

The article/manuscript is: Published ☐ Accepted ☐ Submitted ☐ In preparation ☑

If published, state full reference:

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Has the article/manuscript previously been used in other PhD or doctoral dissertations?

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- B. Major contribution
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Element	Extent (A-E)
1. Formulation/identification of the scientific problem	C
2. Planning of the experiments/methodology design and development	C
3. Involvement in the experimental work/clinical studies/data collection	C
4. Interpretation of the results	C
5. Writing of the first draft of the manuscript	C
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Element	Extent (A-E)
1. Formulation/identification of the scientific problem	B
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