Requirement Analysis of an open access decision model for strategic planning of the Arctic Region

Hera Grímsdóttir

Thesis of 30 ECTS credits
Master of Science in Construction management

January 2014

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Supervisor:

Þórður Víkingur Friðgeirsson
Docent, Reykjavík University, Iceland

Examiner:

Guðni A Jóhannesson
Prof. PhD, Director General of Orkustofnun

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Abstract

Purpose - This study attempts to do a requirement analysis for a decision model to benefit the business community and the government in making decisions. This research is the first part in a research program named DMA (Decision Model for the Arctic) arranged by CORDA (Centre of Risk and Decision Analysis) which is a part of School of Science and Engineering at RU. Their program aims at providing answers on how the rapidly growing human activities in the North Atlantic will affect the economy by developing a decision model. To be able to answer these questions and project possible scenarios of the future it has to be clearly defined from the beginning what the decision is about and how to prioritize. The problems and opportunities must be identified and the possible options identified. This is the objective of this study. The aim is to define the parameters for the decision model to be built and to establish statistical attributes and interconnection. The goal was to structure a conceptual model to gain a better perspective of the decision problem regarding the Arctic activities. The purpose was to link together different disciplines and to present a guide of working practice for future work of the DMA project.

Design/Methodology - To identify and to scope the decision problem this research followed the steps of the early requirement analysis and iterated between the steps as the research proceeded. This study is pragmatic and the three approaches that were applied in this study included:

- Step 1-Expert Interviews: To define the economic parameters impacting the Arctic Region (i.e. Iceland) due to future activities in the area with qualitative data. Information was collected with techniques including interviews and document analysis. The results of the interviews were investigated with the aim of defining the most critical parameters to be included in the model.
- Step 2-Internet based surveys: To validate the findings from previous step and to highlight the most critical economic parameters with quantitative data. Information was collected using a questionnaire available via the internet based survey.
- Step 3-Conceptual model: To visually study the economic parameters, their relationship, impact and interactivity. Findings from step 1 and 2 were used as input to the formulation of the concept model.

Findings - It can be concluded that the findings of this study (step 2) supported the definition of the economic parameters in (step 1) of this research since all of the economic parameters were assumed to have average to high impact on the Icelandic economy the next 20 years. Therefore the defined economic parameters in this study can be used as input to the DMA project carried out by CORDA. On the other hand, the sample size in step 2 is estimated to have been too small which lead to the expected value of the impact factor not to reflect the real impact of the economic parameters on the Icelandic economy with statistical significance. The data analysis supports this and indicates that there are uncertainties among stakeholders regarding the impact. Nevertheless, limited numbers of respondents was regarded as sufficient for the purpose of this thesis, since the main goal was to identify and define the economic parameters due to business activity in the Arctic. The conceptual model in this study visualizes the application that will be constructed for the strategic business planning of the Arctic Region. It clearly demonstrates the complications of the interrelation of the economic parameters and that they cannot be dealt with as isolated entities. The iterative work procedure presented in this study is highly robust and will benefit the future work of the CORDA program. The procedure can also be beneficial in structuring and assessing possible impacts of different alternatives for other decision problems.

Keywords – Decision Analysis, Requirement Analysis, Conceptual Model, Arctic, Cross-Impact Analysis, Business Activities.

Útdráttur

Tilgangur og Markmið - Í ritgerð þessari verður leitast við að útbúa þarfagreiningu fyrir ákvörðunarlíkan sem hefur það að markmiði að aðstoða atvinnulífið sem og stjórnvöld við ákvörðunartöku. Rannsóknin er fyrsti hlutinn af stærri rannsókn á vegum CORDA (Centre of Risk and Decision Analysis) sem er hluti af tækni- og verkfræðideild HR. Rannsókn þeirra: „An open access decision model for strategic planning of the Arctic Region“ (DMA) leitast við að skoða hvernig ört vaxandi umsvif á Norðurhveli jarðar mun hafa áhrif á efnahagslífið í náinni framtíð með þróun ákvörðunarlíkans. Áður en slíkt ákvörðunarlíkan er þróað, og til þess að unnt sé á marktækan hátt að spá fyrir um hugsanlega atburðarás í framtíðinni, þarf að vera skýrt skilgreint frá upphafi á hverju ákvörðunartakan byggir, hvaða vandamál og tækifæri á að bera kennsl á sem og hvaða valmöguleika þurfi hugsanlega að vega og meta. Þetta er tilgangur þessa rannsóknar. Markmiðið var að skilgreina þær efnahagslegu breytur sem ákvörðunarlíkanið kemur til með að byggja á, að meta áhrif þeirra og innbyrðis tengsl. Til að öðlast betri yfirsýn ákveðinna vandamála í tengslum við starfsemi á norðurslóðum var sett fram hugmyndafræðilegt líkan byggt á umræddum efnahagslegum breytum. Tilgangurinn var að tengja saman mismunandi fagsvið og að setja fram leiðbeinandi vinnuaðferðir sem gætu gagnast áframhaldandi vinnu í DMA verkefninu.

Hönnun og Aðferðafræði – Við skilgreiningu og afmörkun vandamála fyrir ákvörðunartöku studdist rannsóknin við aðferðarfræði þarfagreiningar. Eftirfarandi aðferðir voru notaðar í þessai rannsókn:

- Skref 1 – Viðtöl við sérfræðinga: Tilgangurinn var að skilgreina með eigindlegum gögnum hvaða efnahagslegar breytur hefðu áhrif á norðurskautssvæðið, þ.e. á Ísland, vegna komandi starfsemi á norðurslóðum. Upplýsinga var aflað með því að taka viðtöl við sérfræðinga og skoða fræðirit þessu tengdu. Niðurstöðurnar voru yfirfarnar með það að markmiði að skilgreina mikilvægustu breytur sem ættu heima í ákvörðunarlíkani DMA.
- Skref 2 - Netkönnun: Tilgangurinn var að sannreyna niðurstöður úr fyrra þrepi og að varpa ljósi á helstu krítísku efnahagslegu breyturnar með megindlegum gögnum. Upplýsinga var aflað með því að senda spurningalista á aðila í gegnum veraldavefinn.
- Skref 3 - Hugmyndafræðilegt líkan: Tilgangurinn var að geta skoðað myndrænt efnahagslegu breyturnar, tengsl þeirra, áhrif og gagnvirkni. Niðurstöður úr skrefi 1 og 2 voru notaðar við uppbyggingu líkansins.

Niðurstöður - Draga má þá ályktun að niðurstöður þessarar rannsóknar (skref 2) styðji við skilgreiningu á efnahagslegum breytum (skref 1) þar sem allar breyturnar voru taldar hafa miðlungs til mikil áhrif á íslenskt hagkerfi á næstu 20 árum. Þessar skilgreindu efnahagslegu breytur má því nota sem innlegg í DMA verkefnið á vegum CORDA. Hinsvegar ber að geta þess að ætla má að úrtakið hafi ekki verið nægilega stórt sem leiðir til þess að væntigildi áhrifaþátta (impact factor) endurspeglar líklega ekki raunveruleg áhrif efnahagslegu breytanna á íslenskt efnahagslíf. Úrvinnsla gagnanna styður þetta og gefur til kynna að það er töluverð óvissa meðal hagsmunaaðila um möguleg áhrif. Engu að síður var þessi fjöldi svarenda talinn fullnægjandi við úrvinnslu þessara rannsókna, þar sem helsta markmiðið var að skilgreina efnahagsleg breytur vegna atvinnustarfsemi á norðurslóðum. Huglæga líkanið sýnir myndræna útgáfu af ákvörðunarlíkaninu sem nýtist við áætlanagerð á norðurslóðum. Það sýnir greinilega flókin innbyrðis tengsl breytanna og leiðir í ljós að ógerlegt er að meta eina breytu óháð annarri. Vinnuferlið sem unnið var eftir í rannsókninni reyndist afar gagnlegt og mun nýtast við áframhaldandi vinnu DMA verkefnisins. Að auki gæti sú aðferð sem þróuð var gagnast atvinnulífinu sem og stjórnvöldum þegar skilgreina og afmarka þarf vandamál sem upp koma og taka þarf tillit til þegar lausnar er leitað og áður en endanleg ákvörðun er tekin.

Lykilorð - Ákvörðunarfræði, þarfagreining, huglæg líkön, Norðurslóðir, þverfagleg áhrif, atvinnustarfsemi.

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Hera Grímsdóttir 10. January 2014

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List of abbreviations

DMA = CORDA project named: An “open access” decision model for strategic planning for the Arctic region

DP = Discriminative Power

SD = Standard Deviation

CIA = Cross Impact Analysis

1 Introduction

In this chapter the guidelines for the thesis will be presented. The background to the subject of the research will be described followed by a statement of the problem. The research questions, the main aim and objective of the thesis will be described. Finally the limitation of the research and they outline of the main chapters will be given.

1.1 Background

This study attempts to do a requirement analysis for a decision model to benefit the business community and the government in making decisions. The research seeks to establish an abstract of the model and guidelines of proper working methods of how to define the requirements.

This research is the first part in research program arranged by CORDA (Centre of Risk and Decision Analysis) which is a part of School of Science and Engineering at RU. The CORDA project is named; An "open access" decision model for strategic planning for the Arctic Region (DMA) and aims at providing answers on how the rapidly growing human activities in the Arctic will affect the economy by developing a decision model.

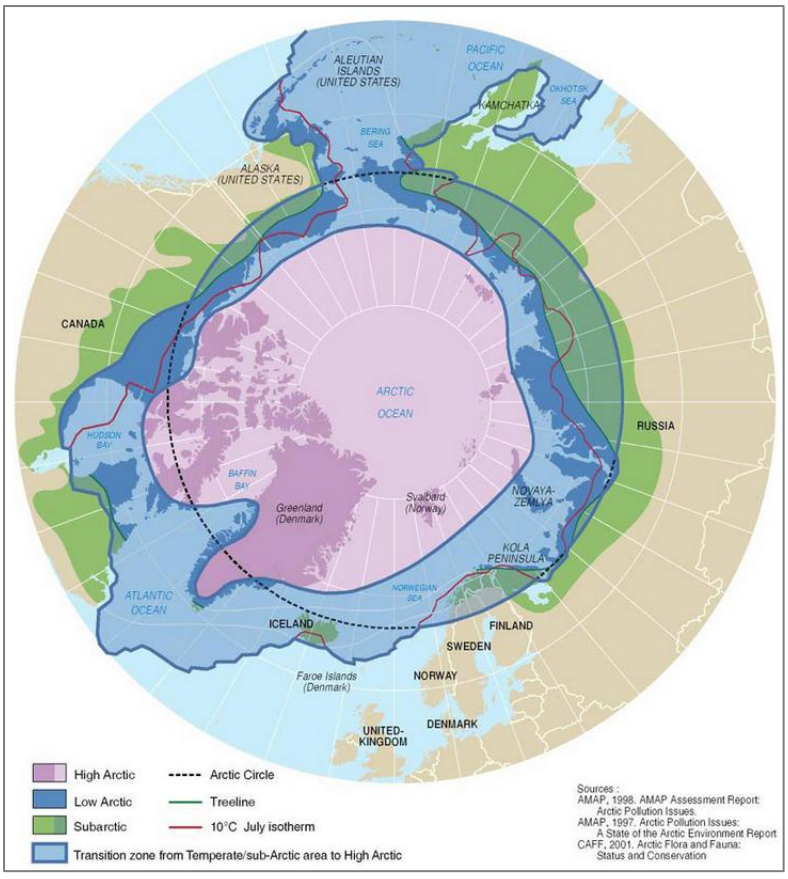


Figure 1 – The Arctic Region[3].

The Arctic is a polar region located at the northernmost part of the Earth. There are several definitions to be found of the Arctic but this thesis is based on the definition that states that the Arctic is the region above the Arctic Circle, an imaginary line that circles the globe at 66° '32N and the approximate limit of the midnight sun and the polar night as shown as dotted line on the picture to the right[1].

The Arctic States are eight in total; Norway, Sweden, Finland, Russia, the United States (Alaska), Denmark (Greenland), Canada and Iceland. Within the Arctic area of these 8 states, there live around 4 million people or 2% of the total population of the Arctic countries (including only Alaska of the US)[2].

1 http://nsidc.org/cryosphere/arctic-meteorology/arctic.html

2 http://arcticportal.org/

3 http://www.eoearth.org/view/article/150179/

The perennial ice area or the multiyear ice has been reducing drastically over the recent years (Comiso, 2012). Because of the clear visibility of the recent climate change in the region people's eyes have moved north in recent years. These changes can be of grave concern for the environment and local people but might also create unprecedented business opportunities for the Arctic states. Due to this the Arctic Region could be industrially utilized, and commercial sailing through the Arctic Ocean might become an actual option in the near future. By sailing through the Arctic Ocean, the shipping route from Europe to Asia is significantly shorter and therefore very attractive for shipping companies. In addition, enormous amounts of resources lie in the area, including oil and gas reserves that are extremely valuable. Other opportunities for the Arctic states could be in relation to increased tourism or miscellaneous services. However, the uncertainties are many with respect to economic, environmental, social, legal and political issues.

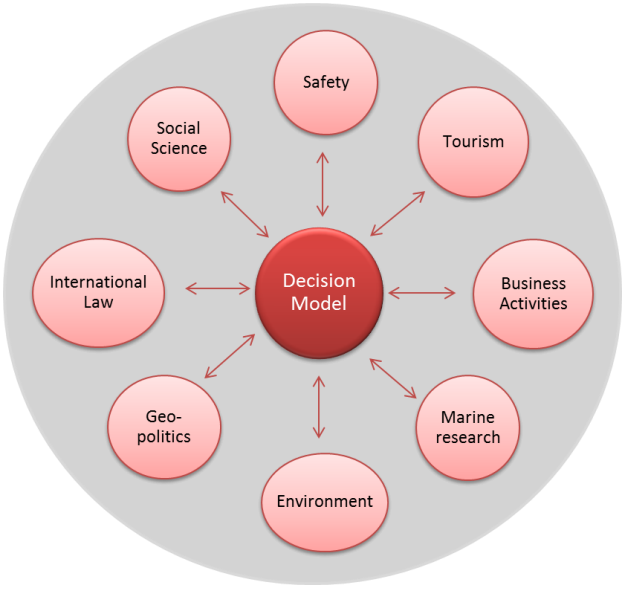


Figure 2 – Example of input to a decision problem for the Arctic Region

To complicate matters further these topics are interrelated and cannot be dealt with as isolated entities. Figure 2 shows an example of different topics that can influence the decision problem in regards to the Arctic Region.

In the light of these climate developments decision makers; being scientists, business people, government and other stakeholders; face a complex situation when it comes to a decision making regarding the economic/businesswise future activities in the Arctic. These decisions can include major uncertainties and opportunities that are difficult to put in context without a holistic overview of the decision problem and many possible outcomes and scenarios are possible for the Northern hemisphere. Today this holistic picture as well as tools to identify the important aspects from the irrelevant ones is missing.

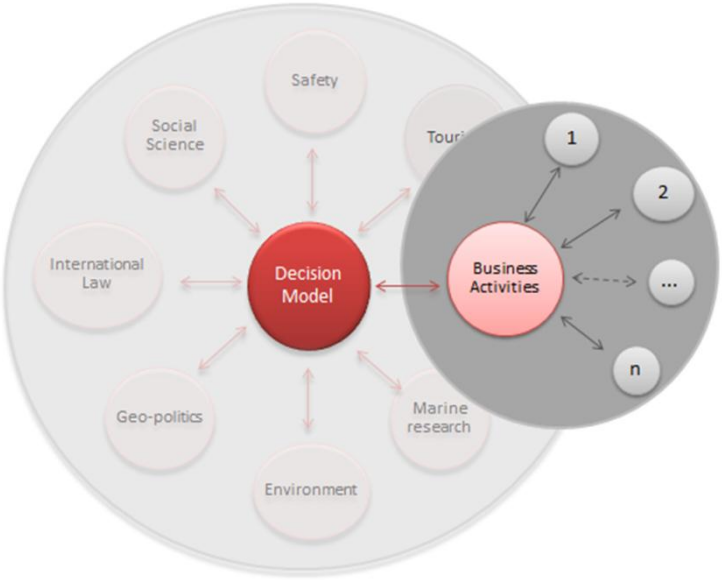
The discussion forum and work carried out today in Iceland by various stakeholders associated with the Arctic Region is diverse and variously advanced. Often, experience-based techniques or solutions that are thought to be the most appropriate for a particular decision are used for modern problem-solving. In the case of the Arctic Region, the environment needs to be explored fully and has multiple uncertainties. Therefore, unaided decisions for strategic business planning in the Region should be avoided. A way to improve judgment is to replace the human judge with an actual model.

Decision problems in general involve multiple objectives where possibly no course of action can achieve all of the desired options for the decision maker, who would have to consider tradeoffs between benefits. The objective of the DMA project, which this study is part of, is to develop a decision model for strategic planning of the Arctic Region based on open access ideology to answer "What-if" questions. These questions are based upon the exploiting what will happen in the system if some parameter evolves in a certain direction, and how or if that will impact on other parameters in the system. By using this model scientists, business people, government and other stakeholders can enter and retrieve data

pertaining to the decision problem. The decision model will be predicated on the assumption that decision makers want to make optimal decisions, but are unable to because of the lack of knowledge or cognitive overload in the face of a complex, risky situation. The use of the model can also serve demonstrate where the risk lies or as a hedging against possible risk. The model will be developed incremental as information becomes available through research in economics, social studies and science.

The design of the model can play an important part in understanding and clarifying the decision problem facing the Arctic states. It is of highly importance in the initial steps of any decision problem to start by clearly defining what the decision is about, and to identify the problems and opportunities, to be able to forecast possible scenarios of the future. Equally important is to define the architecture of the work to be performed, how the required information will be accessed and elicited. This is the aim of this study by defining the requirements needed for model to be constructed in the DMA project.

In the case of Arctic affairs the alternatives are multiple and to narrow the scope this research focuses merely on the economic parameters affecting Iceland the next 20 years.



Economic parameter is defined in this research as:

A variable that can influence cost and/or income directly or indirectly, for business life and government in the coming decades.

The reason for the fixed timeframe of 20 years was to set boundaries to the decision analysis; and 20 years was the minimum effective time for all of the economic parameters (under consideration) to have some significant impact.

Figure 3 – Parameters to be focused on in this research

Therefore this study attempts to define the parameters influencing cost and/or income for business life and government the next decades though other parameters clearly affect the decision making in the Arctic as well. The goal is to establish an abstract of the DMA decision model to visually study the economic parameters, their relationship, impact and interactivity. This research also seeks to establish the proper working methods to be used as guidelines in the future work of the DMA project, both to include a larger sample and to define new parameters in different fields.

1.1.1 DMA Project – Brief Introduction

The DMA project is organized in four chronological phases including the definition, design and building followed by the operation of the model. The following are the objectives of each phase:

Phase 1 - Model abstraction:

- To define the most important parameters of uncertainty to be included in the model.

Phase 2 – Definition, data procurement and statistical attributes.

- To bring together stakeholders and parties of interest for work.
- To define, assemble and sort out the data governing the model parameters.
- To define procedures of use and application.
- To define the mathematical relationship between the model parameters.

Phase 3 – Programming and testing.

- Design of user friendly interface
- Programming
- Testing
- Launching

Phase 4 – Implementation and application

Figure 4 refers to the project timeline where the coloured box represents the work performed in this study:

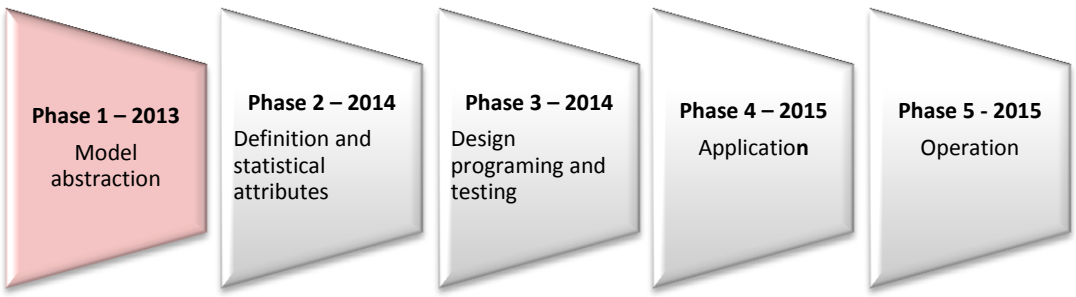


Figure 4 - The DMA projected timeline

The project WBS in chronological order is visualized in Figure 5:

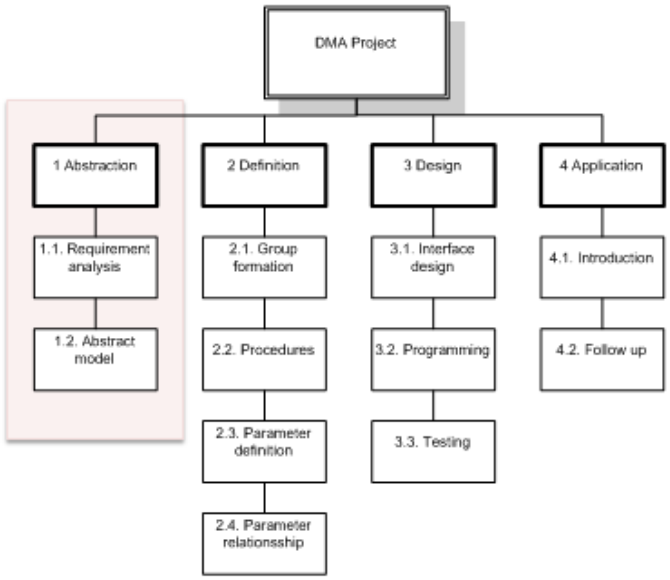


Figure 5 - The DMA Work Breakdown structure.

This study refers to deliverables number 1 in figure 5 above. The conceptual model or the abstract in this study is the first step in further development of the operational model and is part of activities within the CORDA program at Reykjavik University. The objective is to get a holistic overview and to gain further understanding of the economic parameters impacting Iceland in the next 20 years.

1.2 Arctic Region - Statement of problem

The Arctic will almost for certain reach a new climatic state in the next decades (Comiso, 2012). This is of grave concern for the environment but might also create business opportunities for the Arctic states; which were evident by the tremendous interest that Arctic conference in October 2013 received with more the 1200 people attending from 40 nations[4].

The Arctic region is relatively unexplored area with considerable uncertainty with respect to economic, environmental, social, legal and political issues. There is no doubt that from economic perspective the Northern hemisphere could be one of the most exiting places of the world. Resource utilization, tourism, service industry, maritime activities, transport service, fisheries, safety/rescue industry, etc. are all examples of business activities likely to escalate over the next decades. However, we do not know how much and we do not know the impact.

It can therefore be stated; that the future of the Northern is exiting but is it subject to uncertainty and many outcomes and scenarios are possible so the need for a holistic picture is great.

1.3 Research Questions

Research questions are claimed to be able to define the success of the research projects, the characteristics of a good research question according Robson (2011) and Silverman (2010) should be:

4 http://arcticcircle.org/

- Clear and unambiguous and show a clear purpose of the project
- Answerable and point to the methods and the type of data needed to provide answers
- Show the project boundaries
- Keep the researcher focused
- Provide a framework when writing up the research
- Form a coherent interconnected set

(Robson, 2011; Silverman, 2010)

The following research questions were developed:

1. *What is the scope of an open access decision model for strategic business planning of the Arctic Region (i.e. Iceland)?*
2. *What are the parameters with the highest impact on business evolution in a specific area within the Arctic Region (i.e. Iceland)?*
3. *Is it possible to define the interconnection between these parameters and cross-functional influence?*

As the research progressed, the focus in questions 2 changed from the business evolution in the Arctic in general to Iceland as a more convenient means from which, potentially, some generalization might be drawn for the Region as a whole.

The defined research questions were the drivers in this study and they all fitted well with its exploratory purpose. They organized the project and gave the study the direction and coherence needed to keep the researcher focused. In shorts this study seeks to identify the requirements that are needed to formulate an open access decision model for strategic business planning of the Arctic Region.

1.4 Aim and objectives of the research

The aim was to define the parameters for the DMA project and to establish their internal priorities, with the goal of structuring a conceptual framework within the predefined research group.

The objectives were to:

- Involve stakeholders from academia, industry and government to identify the parameters contributing to the economic development in the Iceland in context of altered condition in the Arctic.
- To define what parameters in the Arctic development will influence the Icelandic economy within the scope of this research.
- To estimate the relative impact and statistical attributes (distributions) of the parameters.
- Propose a conceptual model and definition of the connection between the parameters with the highest impact.
- Present a guide of working practices for phase 1 for the DMA project

The purpose was to link together different disciplines and gain a better perspective of the decision problem regarding the Arctic activities.

1.5 Limitation

This research was limited to Iceland but can be scaled to include other countries by iteration.

The scope was narrowed down to focused merely on the impact of the economic activities in the Arctic. There are clearly other parameters or activities influencing the decision making in the Arctic Region, for example environmental and political. Environmental issues are becoming more and more important in the world. Sailing on the Arctic routes with giant oil-powered ships could presumably coat the ice with black layer of oil residues. Nuclear driven ships might impose great risk to the Arctic environment if accidents occur and many dangerous scenarios can be outlined. This might result in negative public opinion which is not addressed in this thesis. There are also some legal and international uncertainties this thesis did not deal with.

Another limitation is that the sample in the data collection might not be representative of the population or the future stakeholders of an open access decision model for strategic business planning of the Arctic Region.

Finally there is the limitation of time and access to data available to the researcher.

1.6 Thesis outline

This thesis begins with an introduction that discusses the background and subject of the research. Then the frame of reference is given to define the theoretical background in decision analysis, requirement analysis and conceptual model. The third chapter is about the procedure of the research work and the research methodology is described. In the following chapters the information is compiled and arranged. The thesis concludes by analyzing the findings and giving a prognosis for future practice. The broad layout of the thesis is given in figure 6 below.

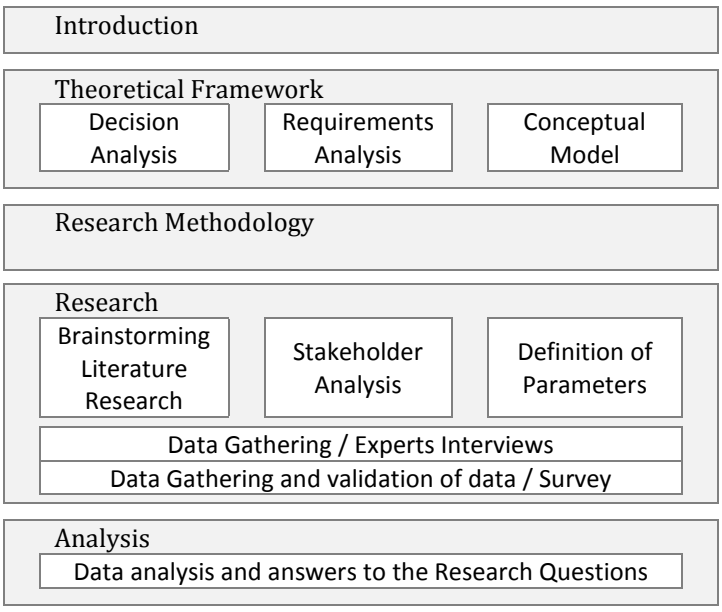


Figure.6 - Thesis Layout

2 Theoretical framework

In this chapter, the theoretical framework which underlies this research will be described. It reviews how the methodology of decision analysis and requirement analysis can be utilized in this study. Additionally, the theoretical framework of a conceptual model will be described.

2.1 Introduction

The research objective at this stage is to identify the theoretical background of the study. The literature described on the following pages seeks to establish the foundation for the research to come in this thesis, e.g. requirement analysis of the parameters needed to formulate an abstract of the decision model.

2.2 Decision Analysis

Decision analysis is a discipline that involves the practice necessary to address important decisions in a formal manner. Decision analysis includes multiple procedures and tools for identifying, clearly representing, and formally assessing important aspects of a decision for prescribing a recommended course of action. Decision problems can be divided to those not including uncertainties or those including uncertainties. Decision concerning selecting the lowest priced product from a set of catalogues does not include uncertainties. A decision based on forecast of future prices does. Decision problems regarding the economic impact on the Icelandic economy due to future activities in the Arctic do as well.

This chapter seeks to give an overview of the decision modelling process. Having the scope of this research in mind the focus will be on the initial step of the decision process were the problems and opportunities are identified but not on the evaluation of the decision model itself. The framework for procedures and explanations presented in this chapter are largely based on research Professor Ralph L. Keeney's work, which has been awarded the Ramsey Medal for Distinguished Contributions in Decision Analysis by the Decision Analysis Society and is a member of the National Academy of Engineering. Secondly, it is based on the work of Sven-Ove Hansson, Professor in Philosophy.

2.2.1 Decision Theory

This study will not go into details of the decision theory and the objective of this section is to give a brief overview of the literature. The *normative decision theory* and the *descriptive cognitive theory* are the two distinct types of decision-making theories (Bell et al., 1988; Han and Diekmann, 2001; Hansson, 1994). Descriptive models attempt to describe how decisions are actually made. They are concerned with how and why people think and act the way they do and are evaluated by the extent to which they correspond to observed choices. On the other hand, normative decision theory attempts to analyze decision tasks to prescribe the optimal way to behave and the models are evaluated by the degree to which they provide acceptable idealization or rational choice (Bell et al., 1988; Hansson, 1994). The third type of decision making theory is "prescriptive". Prescriptive models are evaluated by their pragmatic value that is by their ability to help people make better decision. Some use the term "normative" and "prescriptive" interchangeably (Bell et al., 1988: 10–17).

There are some basic concepts of decision theory, such as alternative, outcome and state of nature that have a bearing in this study.

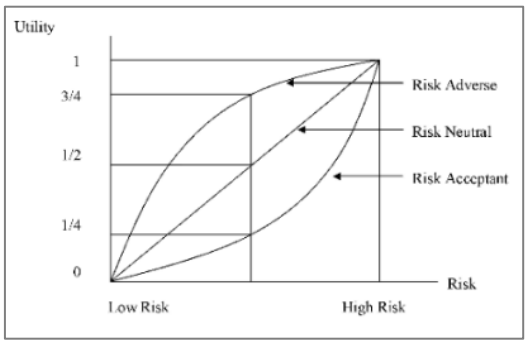
First, *alternatives (options*) are typically courses of action that are open to the decision maker at the time of the decision. The set of alternatives in some decision problems can be classified as open in the sense that new alternatives can be invented or discovered by the decision-maker. In other decision problems, the set of alternatives is closed, i.e. no new alternatives can be added (Hansson, 1994:23-24). In the beginning of the decision process the alternatives might be open but after gathering data and consideration the alternative might be a close set, as is the case in structuring the conceptual model in this research.

The outcome or the decision does not only depend on the choices of alternatives, but also depends on factors outside of the decision maker's control. Some of these factors might be known but others unknown and depend on features of nature that are unknown to the decision maker defined by Hanson as "*states of nature"*. This wording is misleading since it also includes possible decision by other persons but not only on features of the nature. State of nature is often referred to as uncertainty and will be discussed in more details in a later section of this chapter. Hence the possible *outcome* of a decision is defined as the combined effect of a selected alternative and the state of nature obtained (Hansson, 1994:25).

2.2.1.1 Decision under risk

Expected value theory states that when faced with a choice between risky prospects each potential outcome should be weighted by the probability of its occurrence. The expected value of any given alternative is the sum of its weighted outcomes and the alternative with the highest expected value should be chosen (Hardman, 2009). Expected value can be regarded as an average outcome if a process is repeated a large number of time (Goodwin and Wright, 2009).

The attitude towards risk of the decision maker can be taken into account by eliciting a utility function. Utility refers to the preferences of the decision maker with regard to choices that have uncertain outcomes. Utility cannot be measured or observed directly nonetheless, techniques exist for eliciting people utility functions as described by Goodwin and Wright (2009) and Hardman (2009)



The concave shape on figure 7 represents a risk adverse decision maker or a person that would need a higher probability of success then risk neutral person. Utility function of a risk-seeking person is represented with a convex shape on the figure. The extent to which a utility function departs from the diagonal line reflects the extent of a decision maker's risk attitude

Figure 7 - Shape of utility function (Goodwin and Wright, 2009)

When the decision maker does not have a neutral attitude towards risk the concept of expected utility allows the decision maker attitude to risk to be incorporated in the decision model. The concept of utility has the advantage of being applicable to things other than money. The expected utility theory states that rational decision makers should weight the utilities, instead of values, of outcomes by their probability of occurrence (Goodwin and Wright, 2009; Hardman, 2009).

2.2.2 Level of Complexity

Many decision problems today and in the future are complicated and include considerable range of issues, such as those related to the environment. Decision problems in general involve multiple objectives where possibly no course of action can achieve all of the desired options for the decision maker, who would have to consider tradeoff between benefits. To compound matters, many decisions cannot be predicted with certainty the consequences of the alternative course of action, and then the attitude of the decision maker can also highly affect the solution selected. This complex structure makes decision problems often difficult to understand and that some of the decision might be sequential makes it even harder to comprise (Goodwin and Wright, 2009).

In this section the objective is to highlight some of these complications in the initial steps of the decision analysis process.

2.2.1.2 Multiple objectives

Generally decision involves multiple objectives and it is desirable to achieve even several objectives at once. In future strategic planning of the Arctic Region, the business drivers' aim would be to maximize economic benefits. At the same time they would not attain global support unless they would consider minimizing environmental impact, minimizing health and safety hazards, maximizing positive social impact, and pleasing all groups of interested citizens. It might be impossible to achieve all this with a single alternative, so it is important to assess how well each objective is achieved through competitive selection (Goodwin and Wright, 2009; Keeney, 1982).

Long-time horizons

The consequences of many decisions cannot all be felt immediately, they often happen over a long time period. Sea ice is the dominant physical feature in the Arctic Region and is presently impassable in some aspect. This might change within the near future due to warming in the atmosphere and drastic decline in the multiyear ice. Due to reduction of the perennial ice, the Arctic Region could be industrially utilized and commercial shipping through the Arctic Ocean may soon become an actual option. Future implications of alternatives now being considered should be accounted for in the decision making process.

Many impacted groups

Major decisions often affect groups of people whose attitudes and values differ greatly in many ways. The Arctic consists of the Arctic Ocean and Iceland, Denmark (Greenland), Norway, Sweden, Finland, Russia, the United States (Alaska) and parts of Canada. The area can be defined as north of the Arctic Circle (66° 33'N), the approximate limit of the midnight sun and the polar night. The Region is a unique area among Earth's ecosystems and the cultures and the Arctic indigenous peoples have adapted to its cold and extreme conditions. Socially and politically, the Arctic Region includes the northern territories of the eight Arctic states (Arctic, 2013). Because of these differences, concern for equity contributes to the complexity of a problem (Keeney, 1982).

Risk and uncertainty

With essentially all problems, it is not possible to predict precisely the consequences of each alternative (Goodwin and Wright, 2009; Keeney, 1982). The decision making in the Arctic is not excluded and each economic parameter involves, to some degree, risks and uncertainties. The major reasons for the existence and persistence of these uncertainties in the Arctic Region include for example (Keeney, 1982):

- Difficulties of gathering data for some events
- Data can be very expensive or time-consuming to obtain
- Natural phenomena and unknown environment
- Population shifts could affect future impact
- Priorities change over time
- Actions of other influential parties, such as government or competitors

Value tradeoffs

Important decisions involve critical value tradeoffs to indicate the relative desirability between, for example, environmental impact and economic costs today, negative impact to a small group versus smaller positive impact to a larger group, immediate social costs versus future social benefits, and sometimes the value of a human life versus the benefits generated by a hazardous technology (Keeney, 1982).

Risk attitude

The Nordic nations will presumably all be affected by this eminent development. The biggest impact will arguably be in Greenland, Iceland, Faro Islands and Norway and even if the likely various consequences are unknown, crucial value judgments about an attitude toward risk are essential to appraise the appropriateness of accepting risks accompanying each alternative (Keeney, 1982). A risk attitude was described in more details in section 2.2.1.1 of this thesis.

Sequential nature of decisions

Rarely is one decision completely uncoupled from other decisions. If oil is discovered in commercial quantities on the East Greenland coast shelf how will the discovery impact fisheries to name a simple example? Choices made today can both affect the alternatives available in the future and the desirability of those alternatives. As Keeney states: *"many of our present choices are important because of the options they open or close or the information they provide rather than because of their direct consequences"* (Keeney, 1982).

Interdisciplinary substance

Globalization is allowing more local firms to compete internationally and the Arctic will not be any exception. However, entry decisions for international firms are difficult due to the uncertainties associated with the international domain. International projects involve for example the uncertainties that arise on domestic construction projects and the failure to understand the political, economic, cultural, and legal project condition (Han and Diekmann, 2001). Another important factor is the economic risk associated with international projects. For example, currency devaluation, currency exchange restrictions, cultural differences, or changes in law or regulations (Han and Diekmann, 2001;

Keeney, 1982). Qualified professionals should supply the relevant inputs on these key factors in a major decision.

Collectively, these complication features mentioned above describe many complex decision problems and are all relevant to the decision problem of the strategic business planning of the Arctic Region. Although the features may differ in specific problems, the bottom line is that many of today's decision problems have the following characteristics:

- *High stakes.* The difference in perceived desirability between alternatives is enormous. It may involve millions of dollars or severe environmental damage, for instance.
- *Complicated structure*. Numerous features (discussed above) make it extremely difficult to appraise alternatives informally in a responsible manner.
- *No overall experts*. The various concerns involved in most important decision problems mean that there are no overall experts. Different individuals, however, have expertise in disciplines such as economics, engineering, and other professions which should be incorporated into the decision process.
- *Need to justify decisions.* Decisions may need to be justified to regulatory authorities, shareholders, the public, or oneself.

2.2.3 Decision Process - Methodology

As discussed above decision making can be complex, is not momentary and the analysis often takes time. In the process the decision problem is generally broken down into manageable and smaller problems. Each smaller problem is dealt with separately and the results integrated so that a course of action can be provisionally selected. This method is referred to as the 'divide-and-conquer orientation' of decision analysis (Goodwin and Wright, 2009; Hansson, 1994; Keeney, 1982).

The objective of this section is to review the theoretical process of decision analysis.

The Phases of Decision Making

The process of decision models can both be 'sequential' or 'non-sequential'. The former procedure is sequential in the sense that it divides the decision processes into parts that always comes in the same order. A more realistic model allows the various parts of the decision process to come in different order in different decision or to be performed parallel. This is referred to as non-sequential (Hansson, 1994). A number of frameworks have been put forward to describe the phases of decision making and perhaps the most well known in Simon's *intelligence-design-choice* trichotomy which follows the sequential process (Hansson, 1994; Mintzberg et al., 1976). According to more recent authors the decision process consists of the same major phases as Simon defined but the phases do not have a simple sequential relationship (Hansson, 1994; Keeney, 1982; Mintzberg et al., 1976).

Mintzberg et al and Hansson (1976) define the phases as *identification*, *development* and *selection.* The relationship between the phases and the routines of decision process is shown on the diagram below.

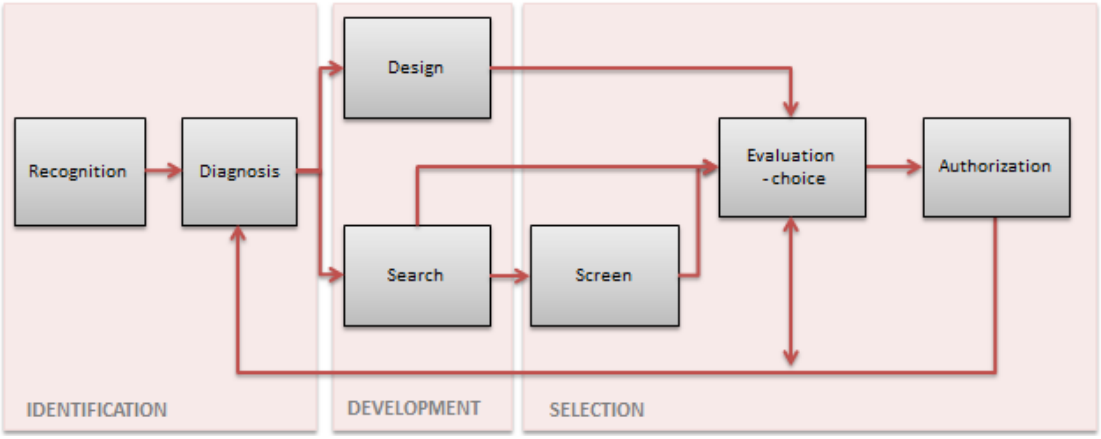


Figure 8 - The relationship between the phases and routines of a decision process (Mintzberg et al., 1976).

The scope of this research applies to the identification phase only and consists of two routines according to Mintzberg et al. (1976). The first is the 'decision recognition' in which problems and opportunities are identified and the second routine in this phase is ´diagnosis'. The other phases of the design process described above will be described in more details in the remaining phases of the DMA project.

Keeney (1982) decomposes the methodology of decision analysis into four steps.

1. Structure the decision problem,
2. Assess possible impacts of each alternative
3. Determine preferences (values) of decision makers, and
4. Evaluate and compare alternatives.

Figure 9 illustrates the interdependencies of each of the steps and compares the overall process to the three major phases defined above.

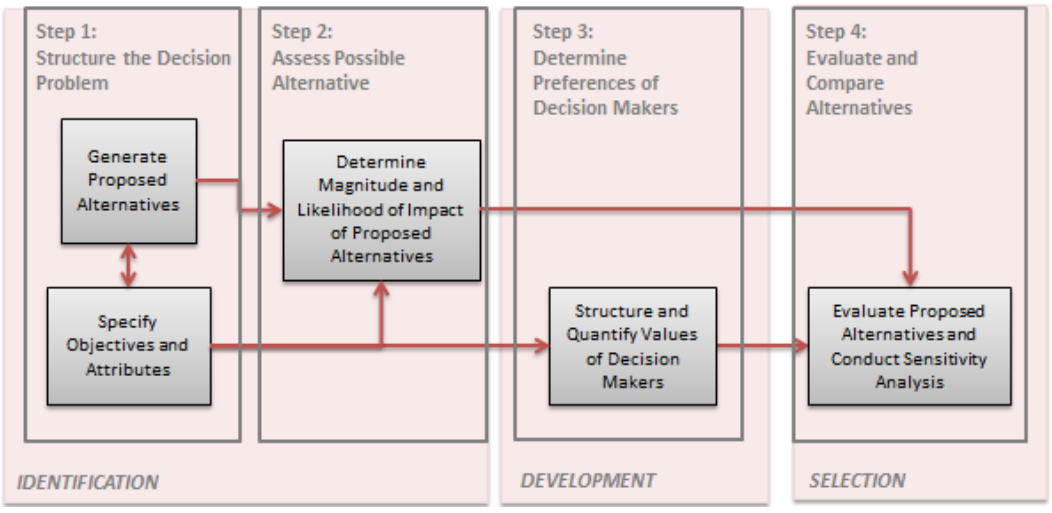


Figure 9 - Diagram showing the relationship between the phases and routines of a decision process (Keeney, 1982) compared to the three major phases defined above.

Step 1 - Structure the Decision Problem

This procedure seeks to generate the alternatives and the specification of objectives (Keeney, 1982). It is important that there is an exact description of the specific subject, i.e. what is it that

should be sought and even what is not being sought. The decision maker must look for causative factors for the subject, i.e. affecting variables. Often this step does not receive the attention it deserves and the mistake is made to decide what the problem is in advance (Friðgeirsson, 2013).

Step 2-Assess the Possible Impacts of Different Alternatives

In this step of decision analysis the impact of each alternative is determined. In figure 9 this step is included in phase 1 – identification though further analysis and development will take place in the remaining phases of the CORDA project. (Friðgeirsson, 2013; Keeney, 1982).

To interpret the implications of these steps mentioned above it is important to keep two facts in mind. First, one iterates among the various steps. Not only what should be done in one step but how it should be done can be affected by preliminary results from another step. Second, decision analyses concentrating on some steps almost to the exclusion of others may be appropriate and useful (Hansson, 1994; Keeney, 1982).

Step 3 - Determine Preferences of Decision Makers

This step involves the creation of a model of values to evaluate the alternatives and is not within the scope of this research. Section 2.2.1.1 gives and overview of the theoretical framework and table 1 in section 2.2.5 compares different tools or models for overview.

Value tradeoffs and risk attitudes highly affect this step since it is highly unlikely to achieve the best level with respect to each objective in a decision problem. An objective function or a utility function, symbolically written u, which aggregates all the individual objectives and an attitude toward risk, is formed in this step. Then $u(x)$, the utility of the consequence x, indicates the desirability of x relative to all other consequences. Alternatives with higher expected utilities should be preferred to those with lower expected utilities. This is done by quantifying value judgments about possible consequences in the problem in structured manner. Additionally a sensitivity analysis of the value judgments can be conducted to appraise their importance for the overall decision (Goodwin and Wright, 2009; Keeney, 1982).

Step 4 – Evaluate and Compare Alternatives

In the final step; after the magnitude and the associated likelihoods of consequences has been determined, and the preference structure established; the information must be synthesized in a logical manner to evaluate the alternatives (Keeney, 1982). As step 3 this was not performed in this study.

This research incorporates the identification phase defined above and uses the first two steps in the decision analysis process defined by Keeney, to structure the decision problem and to assess possible alternatives for the economic parameters impacting Iceland due to the activities in the Arctic. Information from both step 1 and 2 will be based on the analysis of existing data, data collected specifically for the decision problem and/or professional judgment.

The formation of the utility function and the creation of a functional decision model are not within the scope of this research and will be conducted in the next phase of the DMA project.

2.2.4 Demarcation of Decision

Any analysis of a decision must start by clearly defining what the decision is about and what the options are those should be evaluated and selected. This is not often the case and demarcation, or the frame, is often far from settled. In this section the objective is to distinguish between four degrees of uncertainty of demarcation. The first three are related to problems associated with generating alternatives in the initial steps of the decision analysis (Hansson, 1994; Keeney, 1982). In the fourth classification of demarcation, it is not even clear what the decision is all about. The scope of the decision is not well-determined or what problem it is supposed to solve (Hansson, 1994). The objective of this section is to review these demarcations of decision in relation to the Arctic decision problem.

The first problem, associated with generating alternatives in the initial steps of the decision process, might be a large number of potential alternatives and many of which are not especially valuable or good. It may be difficult to differentiate between the good alternatives and those which are eventually found to be inferior early in the investigation of the decision problem (Keeney, 1982). This study seeks to minimize the pool of alternatives by narrowing the focus of the requirement analysis to the economic parameters influencing Iceland due to future activities in the Arctic Region.

The second major problem in the investigation phase could be a complete lack of reasonable alternatives. In this case, it is often worthwhile to utilize the objectives of the problem to stimulate creativity. The objectives of this research are specified in chapter 1.4 and broken down into manageable parts with the research question stated in chapter 1.3 or more detailed objectives. If the objectives are clearly specified, one can describe possible consequences of the problem which are particularly desirable (Keeney, 1982).

The third occurs when the general purpose of the decision is well determined but it is not certain if all of the available options have been identified. This has been referred to as decision-making with an *unfinished list of alternatives* (Hansson, 1994). There are at least three distinct methods to minimize the uncertainty related to an unfinished list of options. The first is to choose from available list of options in spite of the fact that better methods may become available later on. This is called *closure of the decision problem.* A second method is to search for better options and postpone the decision. This is called *active postponement* (in contrast to "passive postponement", in which no search for more options takes place). A third way is to select and carry out one of the available options, but search for a new and better option and plan for later reconsideration of the issue. For this to be meaningful, the preliminary decision has to be reversible. This is *called semi-closure of the decision* (Hansson, 1994).

The choice between these strategy-types is an integrated part of the overall decision, and generally cannot be made prior to the actual decision. The division of options into the three strategy-types is an aspect of the individual decision. In this study the available alternatives will be selected for further analysis and to form the conceptual model; however new and better options will be search for through the lifetime of the DMA project. It is not to be defined in this project which type of strategy applies and if new options will be search for after the DMA project ends.

The fourth uncertainty of demarcation is when the scope is ill-defined and can be called *decision-making with an indeterminate decision horizon*. It is necessary to draw the line somewhere when formulating a decision problem, and to determine a "horizon" for the decision. A decision horizon includes a time perspective since we cannot plan indefinitely into the future. Therefore, some sort of an informal time limit is needed which in some cases can have a major influence on the decision. Two major strategy-types can be used to minimize the effect form this type of uncertainty. One is subdivision of the decision.

The other strategy-type is fusion of all the proposed horizons, in other words the choice of the narrowest horizon that comprises all the original ones. The rationale for this latter approach is that if we have to settle for only one decision horizon, then we should choose one that includes all the considerations. In a rational discourse, arguments should not be dismissed merely because they require a widened decision horizon. There is not in general a single horizon that is "right". In controversial issues, it is common for different interest groups to draw the line differently (Hansson, 1994).

In the matters of the Arctic Region the uncertainty due to the melting of the icecap makes it difficult to grasp the future results or impact of these changes. This research adopts the second approach to determine the horizon for the decision by limiting the impact of the economic parameters due to the future activities in the Arctic to 20 years.

Finally, effects due to the sensitive nature of decision information, inherent conflicts, and unconscious biases can be reduced by using four devices (Keeney, 1982)

- *Iteration with consistency checks.* Inconsistencies should be investigated until consistency is achieved. Then, there is some comfort that the major discrepancies are eliminated.
- *Assessments with different individuals*. Use of judgments about the same factor obtained from different qualified individuals has obvious virtues
- *Decomposition*. Involves dividing the assessment into component parts and obtaining judgments on the components. Different individuals should provide these inputs which would then be utilized to provide estimates of profit
- *Sensitivity analysis*. Used to identify problem elements which are crucial for the evaluation of the alternatives.

2.2.5 Decision Model

The development and selection phase of the decision analysis or the making of a decision model for strategic planning in the Arctic was not the scope of this research but will occur in the latter stages of the DMA project as mentioned. Therefore this chapter will not dwell on the details of decision modeling but give a broad overview and insight into decision modeling.

According to Krogerus (2011:6-7), “models do not define what or how we should think; they are the result of an active thought process. Each model is only as good as the person who uses it.” The complexity cannot be avoided in making decisions and it is integral part of the problem, not only part of the solution process. Formal models can be used to capture as much of the complexity as possible (Keeney, 1982).

The standard format for decision models or the evaluation-choice routine is that of a decision matrix or spreadsheets (Friðgeirsson, 2013; Hansson, 1994). Each is composed of variables and data that can be classified in the following definitions.

- Numerical data: Such as cost, capacity machines, etc.
- Uncontrollable Variables: Parameters that are numerical data and which can vary, although the decision maker does not have direct control over them. An example of this is the customer's demand, inflation, exchange rates and the yield on investment in the future

- Decision Variables: Parameters that are controllable. These are the variables that the decision maker can arrange and can adjust the size of, such as production volume, number of employees, capital cost etc.
  (Friðgeirsson, 2013).

In many decision problems the evaluation of alternatives is complicated due to at least some attributes not being known with certainty. Intuitively, this uncertainty is recognizable as a lack of complete knowledge or certainty but can derive from many sources and thus assume multiple forms. The term "uncertainty" is primarily for uncertainty arising when the consequences of an action are unknown because they depend on future events. Sometimes this is termed an external uncertainty because it relates to uncertainty about environmental conditions lying beyond the control of the decision maker (Durbach and Stewart, 2012). This is what Hansson (1994) referred to as state of nature.

In limited cases the decision makers may know which state of nature will be obtained: there are no uncertainties. If the outcome on the other hand for each alternative is unknown then the decision maker is said to act under non-certainty and the standard representation would include a probability assignment to each of the state of nature. It is common to divide the decision into the following categories, depending on the knowledge situation in the decision problem:

- Decision under Certainty: Deterministic knowledge
- Decision under Risk: Complete probabilistic knowledge
- Decision under Uncertainty: Partial probabilistic knowledge
- Decision under ignorance: No probabilistic knowledge
  (Hansson, 1994:28)

The decision model describes how these variables link to each other and includes a probability assignment to each of the state of nature when relevant. Decision model structures where stakeholders can access information and study their relationship, impact and interactivity can form an important forum to gain further understanding of the overall and holistic picture of both threats and opportunities.

Important aspect of model development is selecting the appropriate technique for evaluating the uncertainty associated with a specific decision. The decision model in its simplest form can be seen in the flowchart below. (Figure 10)

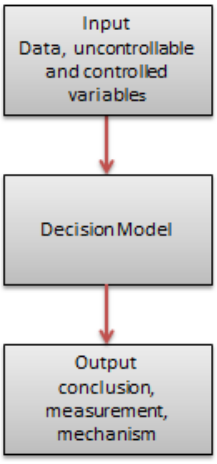


Figure 10 Basic Decision Model (Friðgeirsson, 2013).

It is not possible to precisely forecast the impact and to associate one consequence with each alternative. If that would be the case then the evaluation of alternatives would boil down to a choice of the best consequence. Facilitating decisions under conditions of uncertainty requires a choice about how this uncertainty is to be modeled. Because of uncertainties about the eventual consequences as mentioned in the previous section the problem is not so easy to solve. For each possible alternative it is therefore desirable to determine the set of possible consequences and the probabilities of each occurring. This involves choosing an uncertainty format – a way of representing the possible outcomes that may occur – and a related choice of a decision model with which to represent preferences. Several formats exist for representing uncertainty, and for each of these formats many decision models have been developed (Durbach and Stewart, 2012; Keeney, 1982).

It is not by default that all decisions can be given a definite relationship between dependent and independent variables. The models have various forms and can be classified as normative, descriptive or prescriptive as defined in chapter 2.2.1 Decision Theory (Bell et al., 1988; Han and Diekmann, 2001; Hansson, 1994). The most widely used uncertainty reasoning tool is the mathematical theory of probability. In addition to probability theory, there are other numerical calculi for the explicit representation of uncertainty or techniques to manage uncertainty using logic or other symbolic formalism (Durbach and Stewart, 2012; Han and Diekmann, 2001; Hansson, 1994; Stewart et al., 2013). Most of the uncertainties reasoning techniques are data intensive; they require significant data collection, formulation of mathematical representations and assessment of conditional probabilities or definition of probability density functions. Table 1 below compares the advantages and disadvantages of several common uncertainty reasoning tools as a guideline by many authors (Han and Diekmann, 2001:303; Krogerus, 2011).

Table 1 - Comparisons of Uncertainty Reasoning Tool. (Han and Diekmann, 2001:303).

Tools	Advantages	Disadvantages
Intuition-based analysis	Applies to simple and general situations	Easily influenced by information uncertainty and biases; ineffective in solving complex problems
Statistical approach	Used for incorporating history data in risk analysis	Requires tremendous effort in data collection
Decision tree	Used to calculate correlated decision and risk variable sequences	Too much complexity in the form of correlated variables
Simulation	Assesses risk variable through repeated iterations; very good at handling complexity	Needs a mathematical model (i.e., cost or schedule formula); needs to define probability density function for each variable
Analytical methods	Attractive under simple conditions because it can develop quantitative evaluation tools; output can be readily interpreted	Not applicable to complex problems; need multiple factors to reflect a realistic situation
Influence diagram	Good at modeling conditional probability relationship among variables; useful when handling model complexity	Requires detailed representation of the relationships
Neural network	Superior convergence capability in the case of a large amount of historical data sets	Highly sensitive to data set; requires a large amount of historical data

The goal of a decision model should be to *simplify*; they do not aim to embrace every aspect of reality but only include those aspects that seem relevant. They should be *pragmatic* and focus on what is useful. They should be executive *summaries* of complex interrelation. Through images and diagrams they should convey *visually* concepts that are difficult or explain in words. They *organise* by providing structure and create filing system. They do not provide answers but are *methods* and ask questions. Answers emerge once the model has been used (Krogerus, 2011:6–7). Models do not reflect reality but help us to reduce the complexity of a situation by enabling us to suppress most of it and concentrate on what is important. Models are intended to compile the main assumptions behind the decision and display them in a way that helps the decision maker to have a better overview of the possible course of

action or answer. Generation of a model is also important to understand the problem and challenge in question.

By using a decision model for strategic planning for the Arctic Region, variables from different categories are studied, as well as the logical interrelationship between them. As statistical information becomes available, accumulated data creates opportunities to develop "What-if" analysis, such as scenarios, sensitivity of different variables, risk assessment, statistical diagnosis, cost-benefit analysis, etc. The model is developed incremental as information becomes available through research in economics, social studies and science. By using the model scientists and other stakeholders can enter and retrieve data pertaining to the project. The first version of the model will only include few interconnected parameters but the structure will be designed so the model can grow.

The results of this study will not generate an operational model but an abstract of a decision model that demonstrates the variables and how they are interconnected. The probability distribution function p(x) over the set of attributes for each alternative will be determined by input from experts and stakeholders. If the uncertainty associated with an alternative may be small then, an appropriate simplification is to omit the uncertainty for that alternative.

2.2.6 Judgment and decision making

Judgments are essential evaluations or estimates whereas decisions indicate an intention to pursue a particular course of action. The decision taken is informed by the judgment of the decision maker (Hardman, 2009:3).

Often experience-based techniques or solutions that are thought to be the most appropriate for a particular decision are used for problem solving. These methods referred to as heuristics, seek to identify satisfactory course of action but are not guaranteed to be the optimum. Gigerenzer et al emphasized that people's heuristics are often well adapted to the structure of their knowledge about the environment (Gigerenzer et al., 1999). The work of Kahneman and Tversky (2003) indicates that the human mind uses in fact rule of thumb rather than computations and statistical evidence when making judgement under uncertainty. The influence of intuitive impressions on the mind and how it is connected to our behaviour challenges people judgement and strategies. Kahneman and Tversky (2003) described three general-purpose heuristics – *availability*, *representativeness*, and *anchoring and adjustment.*

- *Availability*
  What is and how easily is the event brought to mind of the decision maker?
  This can affect the judgment of the probability of the occurrence. The easier it is to bring an example to mind, the greater the estimated frequency of the respective event.
- *Representativeness*
  What is normal or typical to the decision maker?
  The decision maker ignores that many events are statistically independent and occur randomly and that sample sizes are important. They substitute the judgment of probability with a judgment of similarity.
- Anchoring and adjustment
  How does the mind of the decision maker process the quantitative data?
  Independent events are considered dependent and vice versa. This might be an arbitrary value or an initial assessment that comes to mind during the course of evaluation.

(Goodwin and Wright, 2009; Hardman, 2009; Lovallo and Kahneman, 2003).

These heuristics can lead to systematically biased judgments though in some cases they can provide good estimates and reduce the effort required by the decision maker. Also the way people respond to evidence depends often of their existing beliefs and the strength of their opinion. Where people hold strong opinion they tend to maintain their beliefs though contradictory evidence is available. Beliefs can also affect the way that people perceive things. (Hardman, 2009)

In the case of the Arctic Region the environment remains to be fully explored and has multiple uncertainties. Therefore unaided decision for strategic business planning in the Region should be avoided. The decision model for strategic planning of the Arctic Region will be predicated on the assumption that decision maker wants to make optimal decisions, but is unable to because of the lack of knowledge or cognitive overload in the face of a complex, risky situation. The risk or the uncertainty in the decision making does not have to be regarded as immutable. A decision model can be used, provided a structured approach, to reduce the risk and even identifying opportunities which can lead to much greater returns (Chelst et al., 2000).

2.2.7 Discussion

Any analysis of a decision must start by clearly defining what the decision is about, to identify the problems and opportunities. This is the aim of this study and therefore the initial steps of the decision analysis are of interest to this study.

This section has given an overview of theoretical framework in the decision process and highlighted the identification phase as it is defined above. This research will incorporate the identification phase defined in chapter 2.2.3 and use the first two steps in the decision analysis process defined by Keeney as a framework to structure the decision problem and to assess possible alternatives for the economic parameters impacting Iceland due to the activities in the Arctic. The study will results in an abstract of a decision model that demonstrates the economic parameters and how they are interconnected. The expected value of their impact will determine and as well as the probability distribution function p(x) over the set of attributes for each alternative.

By specifying probability distributions of the economic parameters the risk and uncertainty aspects of the decision problem is addressed. In describing the possible impact, the time in which consequences might occur should be indicated, thus, the feature of long-time horizons is addressed in this step with fixing the impact time to 20 years in this study (Keeney, 1982).

By focusing on the problem complexities, there are many useful by-products of decision analysis. By including different individuals in the process and to the issues, a clear understanding of the substantive issues of a problem is often developed in the process or at least a common set of terms to discuss the problem (Keeney, 1982).

The interdisciplinary substance is also included in this study by utilizing the skills of the various stakeholders from the industry, academy and government to develop and structure the possible alternatives, to provide information and give professional judgments relevant to the discipline (Keeney, 1982).

The definition or the classification of the decision model to be constructed in the DMA project will be defined in the second phase of the DMA project and therefore this chapter has only given a brief overview of the theoretical framework of the development and selection phase of the decision analysis process.

Though heuristic judgment can lead to good estimate and reduce the effort required by the decision maker unaided decision for strategic business planning in the Arctic Region should be avoided The area remains to be fully explored and involves multiple uncertainties to take under consideration. A way to improve judgment is to replace the human judge with an actual model, as is the objective of the DMA project.

As Keeney (1982) points out: "*decision analysis will not solve a decision problem, nor is it intended to. Its purpose is to produce insight and promote creativity to help decision makers make better decisions"*.

2.3 Requirement Analysis

The requirement analysis literature concerns mostly systems engineering and software engineering. The theoretical framework in this study will be based on that foundation, though some items are not directly applicable. This section's objective is to give insight into the requirement analysis process that is beneficial for the initial steps of decision making process.

2.3.1 Introduction of Requirements analysis

In product development and process optimization, a requirement is a statement that identifies a necessary attribute, capability, characteristic, or quality of a system for it to have value and utility to a customer, organization, internal user, or other stakeholder ("Requirement," 2013).

In the general engineering approach, requirements are used as inputs into the design stages of product development. They are also an important input into the verification process, since tests should trace back to specific requirements. In system and software engineering, requirement analysis is focused on what are called early requirements (Giorgini et al., 2008; Samavi et al., 2009; Yu et al., 2011). This type of analysis is concerned with the high-level objectives of the stakeholders and decision makers rather than the specific functionalities of the system-to-be and the organizational setting where it will operate. This procedure enables the analyst to understand and explore the real motivations behind the users' requests before getting down exploring the possible solutions for their implementation (Giorgini et al., 2008). Early requirements will substantially reduce the possibility of misunderstanding the users' requests and, consequently, reduce the risk of failure for the project (Giorgini et al., 2008; Yu et al., 2011).

Types of Requirements

Requirements are typically classified into types produced at different stages in a development progression. The following classification scheme was devised by the International Institute of Business Analysis in their Business Analysis Body of Knowledge (IIBA, 2009):

- *Business requirements*
  These requirements are high-level statements of the goals, objectives, or needs of an organization.

- *User (stakeholder) requirements*
  Include mid-level statements of the needs of a particular stakeholder or group of stakeholders. They usually describe how someone wants to interact with the intended solution.

- *Functional (solution) requirements*
  These types of requirements are usually detailed statements of the behavior and information that the solution will need.

- *Quality-of-service (non-functional) requirements*
  Normally detailed statements of the conditions under which the solution must remain effective, describing the qualities that the solution must have, or constraints within which it must operate

- *Implementation (transition) requirements*
  These requirements are usually detailed statements of capabilities or behavior required only enabling transition from the current state of the enterprise to the desired future state, but that will thereafter no longer be required.

In the methodology of systems engineering and software engineering the requirements are categorized in several ways (Bray, 2002; Chung and Leite, 2009; Giorgini et al., 2008; Laplante, 2009).

The following are the two common categorizations of requirements:

- *Functional Requirements*
  Functional requirements explain what has to be done by identifying the necessary task, action or activity that must be accomplished (Laplante, 2009). These requirements can be referred to as ordinary or behavioral requirements. This is presumably because they can be met by appropriate behavior or functionality on the part of the solution system (Bray, 2002:15).

- *Non-functional Requirements*
  These requirements specify criteria that can be used to judge the operation of a system, rather than specific behaviors (Laplante, 2009:6). According to Bray (2002) the non-functional requirements can be classified as the design constraints. They affect how the system is built but not what it does directly and can include the underlying architecture can be classified as non-functional requirements.

Other types of requirement can include:

- Customer Requirements
- Performance Requirements
- Derived Requirements
- Allocated Requirements

(Laplante, 2009).

The awareness of the difference categories of requirements can assist in structuring the process and the resultant documents. Table 2 summarizes the classification of Bray (2002).

Table 2 - Classification of requirements (Bray, 2002)

Problem domain description (how the world is)	Requirment (what the clients wants)						
	Commercial constraint (time and money)	Design Constraint (how to build it)	Functional (what it does)				
			'Ordinary'	Performance			
				Speed	Capacity	Reliabil	Usabilit

The requirements gathered in this study are classified as non-functional or design constraint. The other types of requirement shown in table 2 above will be or have been classified in the DMA project.

2.3.2 Requirement Analysis Process

In general requirement analysis includes three types of activity

- *Eliciting requirements*
- *Analyzing requirements*
- *Recording requirements*

The requirements should be actionable, measurable, testable, related to identified business needs or opportunities, and defined to a level of detail sufficient for system design (Laplante, 2009).

2.3.2.1 Eliciting Requirements

Eliciting requirements includes the task of communicating with customers and users to determine what their requirements are (Laplante, 2009). Elicitation concerns the gathering of information and includes three main considerations according to Bray (2002):

- What information is required and should be gathered?
- From what sources it can be gleaned?
- By what mechanisms or techniques might it be gathered?

The output of the elicitation can be referred as elicitation notes and is often in the form of notes taken during interviews, questionnaires, audio or video recording and so on. This output is quite distinct from analysis output because it is largely unprocessed, unstructured and may contain many irrelevancies (Bray, 2002).

Stakeholder identification

Before the data gathering can be initiated the sources of information needs to be identified (Bray, 2002; Laplante, 2009). There is neither pre-existing system nor documentation relating to decision making of strategic business planning of the Arctic Region. Therefore it is important for this study to identify all the stakeholders, take all their needs into account and ensure they understand the implications of the new systems. Stakeholders in this research are defined as persons or organizations which have a valid interest in the system and may be affected by it, either directly or indirectly.

Elicitation techniques

Analysts can employ several techniques to elicit the requirements from the customer. The objective is to establish the exact requirements of the stakeholders, so that a system that meets the business needs is produced. This can include such things as holding interviews, holding focus groups, creating requirements lists, prototyping, and use cases. Selection should depend upon the circumstances for the development and where necessary, the analyst will employ a combination of these (Bray, 2002; Laplante, 2009). The predominant elicitation technique used in requirement analysis are stakeholder interviews (Bray, 2002:224). Interviews may reveal requirements that are not previously anticipated as being within the scope of the project, and requirements may be misleading. However, each stakeholder will have an idea of their expectation or will have visualized their requirements (Laplante, 2009).

The main strength of this technique is:

- Extensive communication
- Inherent flexibility
- The scope to address all types of required information

During the early stages, when little is known of the problem and outline requirements are the target, it is ineffective if not impossible to plan questions in great detail. Whereas, in the later stages, an interview could well target specific aspects very precisely (Bray, 2002).

2.3.2.2 Analyzing requirements:

The objective of analyzing the requirements is to determine whether the stated requirements are unclear, incomplete, ambiguous, or contradictory, and then resolving these issues. As mentioned above the need to be actionable, measurable, testable, related to identified business needs or opportunities, and defined to a level of detail sufficient for system design (Laplante, 2009).

Analysis is closely linked with the elicitation process and the unprocessed information, or the elicitation notes, are used as input. However, it is an iterative process and the analysis informs the elicitation process and provides many of the necessary prompts and questions. Therefore these two tasks can proceed in parallel and be performed by the same staff. The output from the analysis is the analysis documentation, often referred to as the requirements document and should include all the client's requirements (Bray, 2002).

Measurable goals

A procedure to discover the actual business purpose is to take the composed list of requirements merely as clues and repeatedly ask "why?". In this research the question "how much?" will be repeated to estimate the real impact of the economic parameters or the requirements to be included in the DMA project. Stakeholders and developers can then devise tests to measure what level of each goal has been achieved thus far. Once a small set of critical, measured goals has been established, rapid prototyping and short iterative development phases may proceed to deliver actual value long before the DMA project is half over (Laplante, 2009).

Testable

Requirement validation seeks to discover and correct any errors that occur during the requirements phase. Techniques to validate the performance of the requirements according to Bray (2002) include:

- Simple checks
- Review of documents
- Logical analysis
- Use of prototypes
- Functional test planning
- Development of user interface

This study will validate the requirement found by interviewing stakeholders with a survey sent to broader range of stakeholders.

2.3.2.3 Recording requirements:

Requirements are usually written as a means for communication between the different stakeholders and might be documented in various forms, such as mockups, natural-language documents, use cases, user stories, or process specifications. Prototypes are mockups of an application and allow the users to visualize an application that has not yet been constructed. It is of importance that the requirements are easily understood both for normal users and for developers (Bray, 2002; Giorgini et al., 2008; Laplante, 2009).

The attained requirements in this study were documented on an *n* x *m* matrix where *n* represents the economic parameter and *m* represents the sub-economic parameter. For example *n* could represent natural resources and *m* the processing of oil and gas. An abstract or conceptual model showing the expected impact and interconnection of the parameters will also be constructed.

2.3.3 Discussion

"Detailed design and testing do not make much sense without their preceding phases of understanding what the real-world problem is to which a software system might be proposed as a solution" (Bray, 2002).

The aim of the DMA project, which this study is part of, is to provide answers on how the rapidly growing human activities in the North Atlantic will affect the economy in the area. To be able to answer these questions and forecast possible scenarios of the future it has to be clearly defined what the decision is about and what are the possible option that should be evaluated and selected. This was the objective of this research and the requirement analysis literature, with focus on the early requirements in system and software engineering, fitted therefore well to this scope of this study. By following the steps of the early requirement analysis the frame or the demarcation of the study was also confirmed. This study adopted the requirement analysis activities and iterated between the steps as the research proceeded. The requirements gathered in this research are classified as non-functional or design constraint as most real world problems (Bray, 2002). The defined requirements will be validated with surveys sent to a broad range of stakeholders. The other types of requirement shown in table 2 above will be or have been classified in the DMA project.

The strategic reasoning about business models is an integral part of service design. Businesses must be able to recognize and respond strategically to disruptive change in continuously changing and fast moving markets. Questions such as: *what are the threats and opportunities in emerging technologies and innovations?* must be answered (Samavi et al., 2009).

2.4 Conceptual Model

The purpose of generating a conceptual model in this study was to express visually the economic parameters and any possible business opportunities. Additionally the interconnection will be shown to some degree. The development of conceptual model of the a strategic business model will establish a common understanding of the concepts that are needed in order to facilitate communication between stakeholders (Samavi et al., 2009). This is one way of representing the requirements discussed in previous chapter.

2.4.1 Cross – Impact Analysis

The design of the model can play an important part in understanding and clarifying the decision problem facing the nations in the North Atlantic region. However, uncertainties are difficult to assess using traditional tools as described in chapter 2.2.5 – Decision Model, such as probability theory and influence diagrams. The reason is that the data required for these models are judgmentally intensive and scarce, unavailable, or very expensive to collect. For these reasons this research adopts the foundation of the cross-impact analysis (CIA) method for the formulation of the conceptual model (Han and Diekmann, 2001).

According to (Han and Diekmann, 2001) the CIA method is most effective in the following circumstances:

1. When the model involves very complex and unclear relationships among variables.
2. When the data required for the model are scarce, unavailable, or very expensive to collect.
3. When the model involves various possible decision alternatives.

2.4.2 Cross-Impact Process

The CIA method is specially designed to predict future events by capturing the interactions among variables. It attempts to describe an initial probability of each variable and to determine the connection between variables with cross-impact relationships. These relationships can then be categorized as either positive or negative to each other and used to determine which scenarios are most probable or likely to occur within a given time frame. The main goal of CIA is to forecast events based on the principle that the occurrence of events is not independent (Bañuls and Turoff, 2011; Han and Diekmann, 2001). In the original mechanism the impact of A on a posterior probability of B ignored the strength of the relationships among the variables (“Conceptual model,” 2013); this approach will be adopted in this study. Subsequently, researchers have proposed more rigorous mechanisms to calculate the posterior probabilities and the general steps of the procedure according to Han and Diekmann (2001) include:

1. Define variables to be included in the analysis. This will be the eliciting requirement notes defined in previous chapter and included in step 1 of this research.
2. Determine the initial probability of each variable. Included in step 2 of this research.
3. Judge the CIA relations for each variable pair. Included in step 3 of this research.
4. Perform the cross-impact calculations by Monte Carlo simulations. Not within the scope of this research.
5. Evaluate the posterior probability to forecast future events. Not within the scope of this research.

2.4.3 Cross-Impact Matrix

The main output of the process is a cross-impact matrix and a cross-impact diagram which are a visualization of the CIA. The rows and the columns of the matrix represented in this study show the variables *n* and *m,* and the cells include the influence or interrelation between these variables. The matrix allows for modification and analyst to find both the most influential variables and those variables that are impacted by the most other variables (Bañuls and Turoff, 2011; Heuer and Pherson, 2011). The matrix and the diagram are demonstrade on figure 11 were A, B, C and D represents the variables, the second coloum in the matrix their impact factor and the cells show the influence factor or their interrelation. The influence factor or the strenght of the interrelation will not be established in this study and only indicated with simple yes or no in the matrix as mentioned above.

Variable	Impact Factor	A	B	C	D
A	3	No	MOD+	No	No
B	2	MOD+	No	No	No
C	3	No	No	No	No
D	4	SIG+	SIG+	SIG*	No

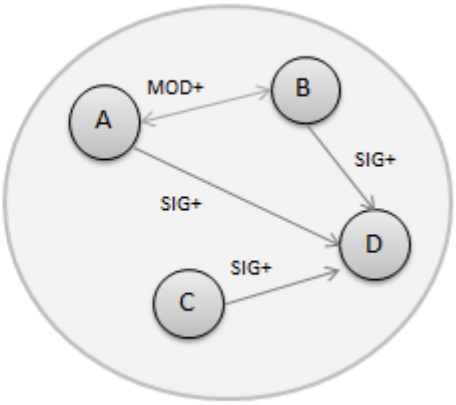


Figure 11 – CIA Strength Relationships (Han and Diekmann, 2001).

2.4.4 Discussion

The CIA method is a powerful technique to deal with ill-defined uncertainty and circumstances that are judgmentally intensive but data poor as is the case with in the Northern hemisphere (Han and Diekmann, 2001). The CIA method will be utilized partly in this study by generating a cross impact matrix and diagram of the economic parameters as described above. By eliciting requirement, as defined in the previous chapter, the variables were defined. These definitions were validated and the initial probability or the impact factor of each variable determined by a survey. Finally the possible CIA relations or the interconnection for each variable pair was judged thought the strength was not estimated.

Steps 4 to 5 of the general CIA procedure are not within the scope of this research.

2.5 Conclusion

The objective of this chapter was to outline the theoretical framework for this study.

Most of the literature research regarding decision analysis focused on the development and the selection phase of a decision problem, or the last two steps of the analysis which is not within the scope of this research. This is in accordance with the findings of Hanson (1994) and Mintzberg et al. (1976).

The drivers of this research are to define the economic parameters for the DMA project, which can be classified as the initial step of the decision analysis or the identification phase. This research therefore

adopted the first two step of the identification phase of the decision analysis process, defined by Keeney, as a framework to structure the decision problem and to assess possible alternatives for the economic parameters impacting Iceland due to the activities in the Arctic.

The literature review of the requirement analysis and the conceptual model focused largely on literature regarding software and system engineering. The theoretical framework of this study will be partly based on that. This chapter has explained how the requirement analysis can be utilized in pursuing the input for the decision analysis purpose, and described the conceptual models to be used as an abstract of the decision model for the Arctic Region.

3 Research methodology

This chapter describes the research methods underlying this thesis. It starts with classifying the research methodologies on which the research project is based, the conceptual framework follows to describe the general research plan and concludes with a description of how the practical research work was executed and which methods are used in the field.

3.1 Introduction

Good research clearly states how it was executed to help the reader understand what methodologies were used to produce the findings. Appropriately chosen research methods are important to guarantee knowledge creation and effective research. It is also vital to use research methods that are defendable and produce reliable and valid results.

3.2 Classification of the research project

The researcher wants to explore and to do a requirement analysis that will lead to the formation of the economic parameters needed to construct an open access decision model for the Arctic Region, to gain insight in to the value and need of such a model. This kind of research is classified as real world research and refers to applied research projects which tend to be related to change often seeking to evaluate some initiative, service or whatever (Robson, 2011).

Much real world research focuses on problems and issues, in this case with uncertainty regarding decision making in the Arctic Region; to help find ways of dealing with the lack of holistic view and to gain a better understanding of the issue which are practical. This study will present a conceptual model of the economic parameters. This model will be the first step in building a decision model.

Robsons (2011) claims that design is concerned with turning research questions into projects and puts forward a framework for research work that is shown below (Robson, 2011). This study follows this approach but the researcher adjusted the model to fit the design of this research by showing two-way arrows between each of the components in the figure instead of one-way. The two-way arrows indicate that all of the aspects below (purpose, conceptual framework, research questions, methods and sampling strategy) were revisited throughout the lifetime of the study with the final form of the framework of the design emerging from that.

Figure 12 - Framework for research design (Robson, 2011).

This approach is in accordance with Maxwell (2005) who adds the fifth component, validity, which is demonstrated by the interactive relationship between the components stressed by linking those using two-way arrows.

This study was pragmatic, driven and guided by the research questions, with input from various stakeholders based on their practical experience. This approach therefore indicates a concern for practical matters, being guided by practical experience rather than theory and that the truth is simply defined as 'what works'. In relation to research, a pragmatist would advocate using whatever methodological approach works best for the particular research problem at issue. Using this approach provides one way of justifying bringing together qualitative and quantitative approaches (Robson, 2011).

The initial phase of this research is classified as a flexible design using qualitative data collection and so all three research questions can be answered in some way using this method. The collected data are non-numerical in the form of words collected through experts' interviews. In addition, it is a flexible style in the sense that, while there may be a considerable amount of preliminary planning, details of procedure are not fixed in advance and the focus is liable to change as the research proceeds. Here the detailed design evolves iteratively as a result of what is found out in the early stage (Robson, 2011).

The analysis is followed by a quantitative data collection in the second phase of the research. In this second phase the purpose is to validate the results from phase one as well as to receive a numerical value of the impact of the economic parameters due to the activities in the Arctic Region on the Icelandic economy and to find the distribution of these parameters. These findings are directly connected to all of the research questions specially focusing on the last two. The design of the second phase is therefore classified as fixed and the research strategies are fully pre-specified before the main data collection in this phase begins (Robson, 2011).

Therefore this study can be classified as a multi-strategy design combining substantial elements of both fixed and flexible design. According to (Robson, 2011), based upon the sequence of the design elements and the priority that they are given, the design of this research can be categorized as a sequential exploratory design where the initial phase is a qualitative data collection and analysis followed by a phase of quantitative data collection and analysis. Priority is given to the qualitative aspect of the study and the primary focus of this design is to explore phenomena (Robson, 2011).

3.3 Conceptual framework or general research plan

A conceptual framework explains the main things to be studied and the presumed relationships among them, either graphically or in narrative form (Robson, 2011:67). A conceptual framework is used in this research to present a preferred approach to an idea or thought. This research starts with a real problem regarding defining the needs to build a conceptual model of the economic parameters as an input to a decision model for the Arctic Region. The process used for seeking the definition of the scope of the conceptual model or the general plan of the thesis is shown in Figure 13 below.

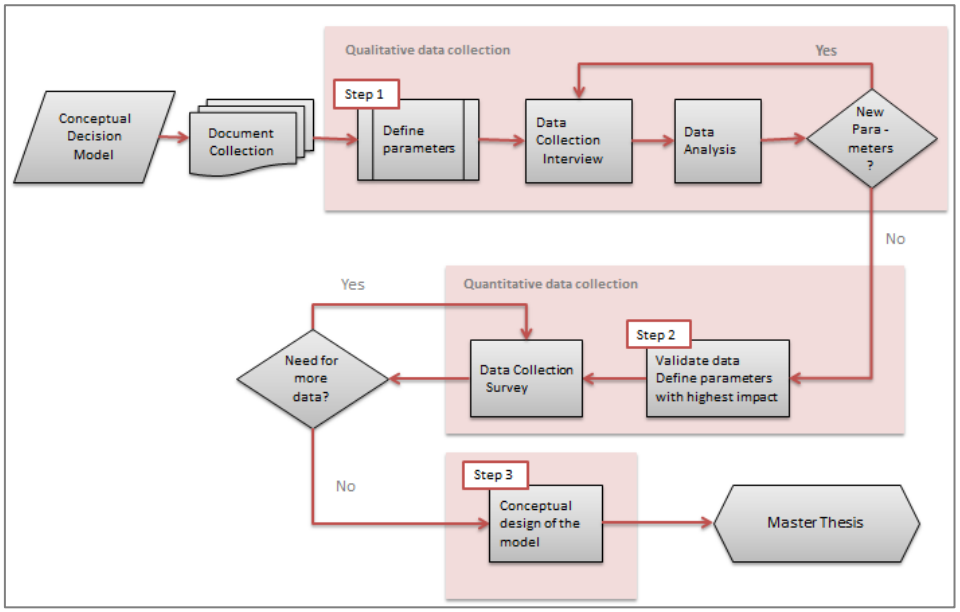


Figure 13 - General research plan

Each step of the study is designed so that a clear focus on the research questions is kept throughout the lifetime of the research. The workflow of the study where the objective is to seek answers to these questions is shown in figure 14. The step 1 to 3 mentioned in the figure will be clarified on the following pages.

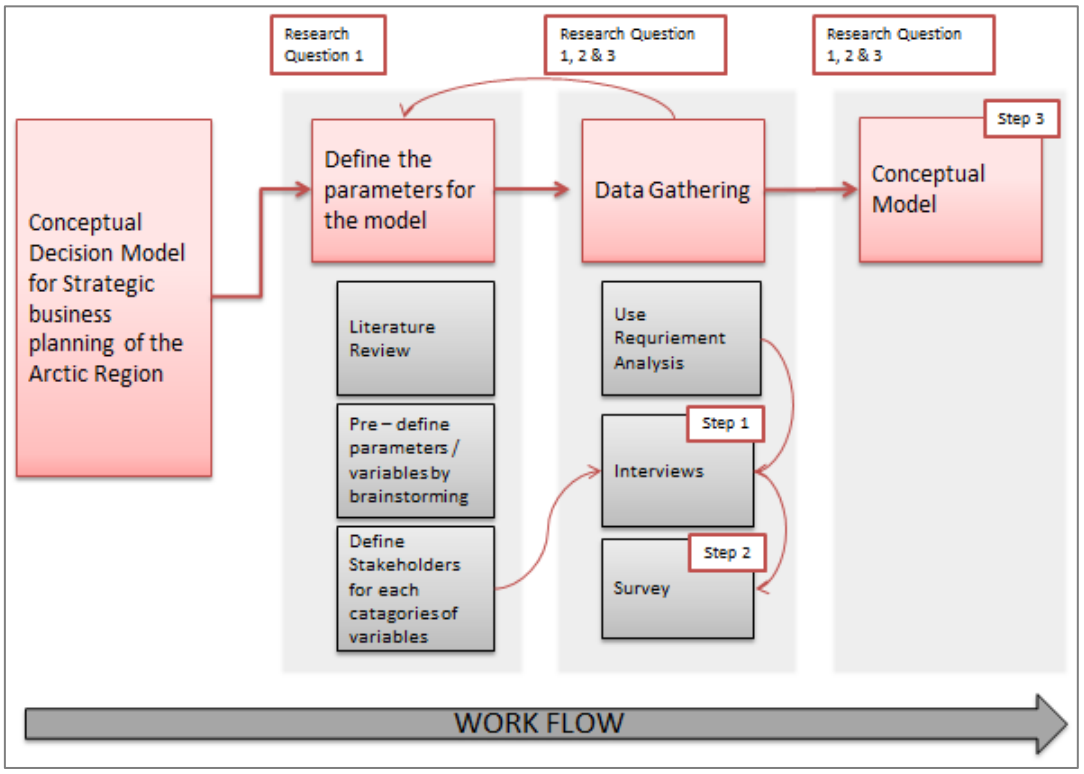


Figure 14 - Work flow

3.4 Practical research methods

After having defined the type of study, the research techniques that are best suited to perform the work need to be determined.

The initial steps, or the identification phase, of decision analysis methodology and requirement analysis technique will be used to define the scope for a conceptual model where the economic parameters impacting the Arctic Region (e.g. Iceland) will be defined.

This study consists overall of five steps, which are described in the following chapters. The economic parameters and their interconnection will be defined in the first step which is divided into three phases: planning, data collection and analysis. The second step of the research involves validating these results and evaluating the value of the impact from these parameters. This step has the same work process as the previous step (planning, data collection and analysis). In step three, the resulting economic parameters will be used to form a conceptual model, to visual the requirements that are needed for the decision problem. In step four, the findings are interpreted and step five is the collection of input or information regarding the uncertainty of the decision model. Step 5 is not part of this study. Figure 15 shows an overview of the first three steps in the research process.

The objective of this section is to describe the research tools that are used to collect all necessary data to obtain the desired goal.

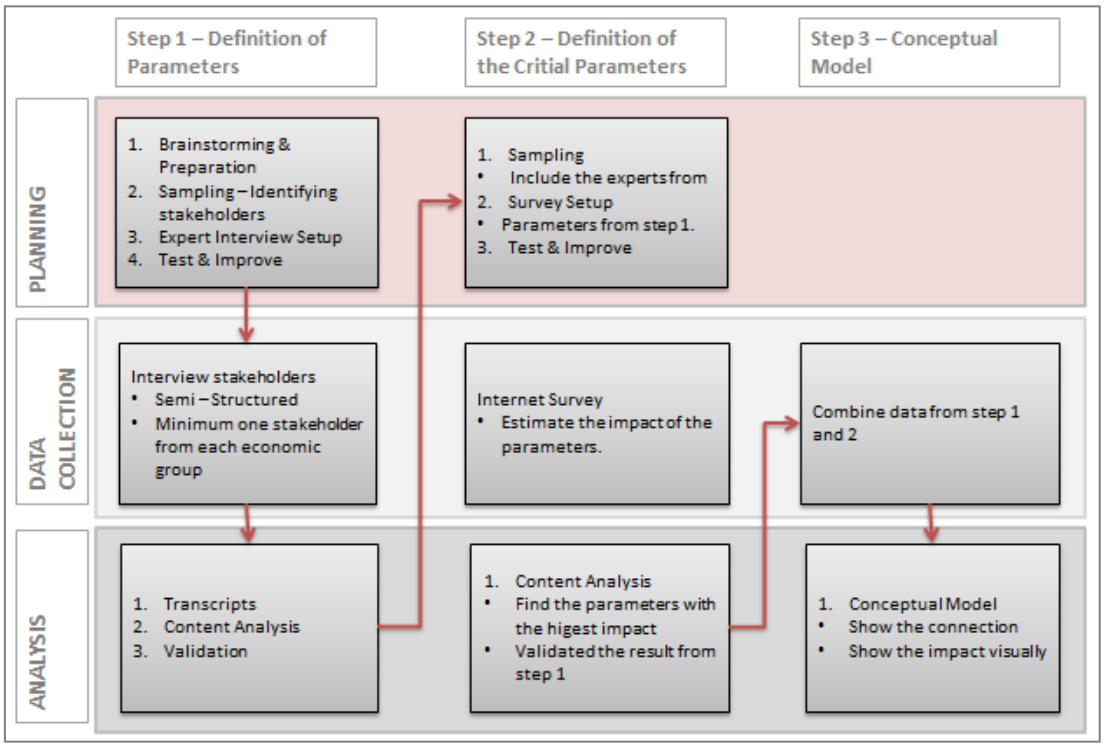


Figure 15 - Research Plan

3.4.1 Step 1 – Definition of the Parameters

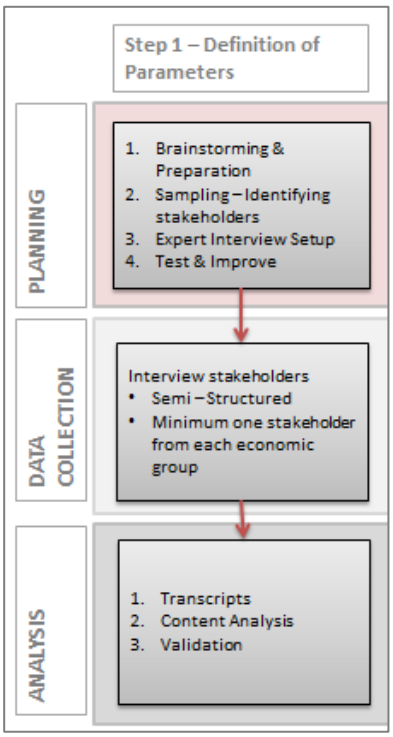


Figure 16 - Research plan – step 1

The research objective at this first step of the enquiry was to from the foundation for the conceptual model for strategic planning of the Arctic Region.

This enquiry was classified as a flexible design using qualitative data collection and the aim was to gain insight in to the answers of all of the three research questions. The collected data are non-numerical in the form of words collected through experts' interviews

This phase was the first step in the requirement analysis or eliciting requirement. Analysis of the requirement attained in this step resulted in the definition of the requirements or the economic parameters.

Step 1 was divided into three phases: planning, data collection and analysis (Figure 16).

3.4.1.1 Planning

Brainstorming and Preparation

To be able to define the scope of the abstract of the decision model the first part of the study involved brainstorming and preparation to identify different possibilities of economic parameters. This resulted in a preliminary definition of the classification of the main economic parameters from 1 to *n*, see figure 17. This was supported by informal (literature) research; by reading various books, attending the Arctic Circle conference, talking informally to various people and by screening the internet. The aim was to identify wider range of economic parameters and to get more familiar with the research topic. Classification of the parameters into main groups (1,..,*n*) was essential to form the foundation on which the data collection in the research would be based.

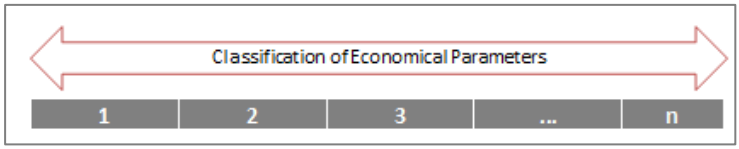


Figure 17 - Classification of Economic Parameters

These categories were also used in the sampling strategy and as a base to form the questions for the interviews. In the following steps of the study these parameters were fine-tuned and additional ones added after interviewing the stakeholders.

Sampling

The sample was a selection from those interested or benefitting from using the open access decision model for strategic planning of the Arctic Region. The sample reflected the business driver in the Icelandic environment. Without doing a detail stakeholder analysis for the usability of the decision model itself the possible users were classified in to government, industry, academic and others enthusiasts of the Arctic Region (Figure 18).

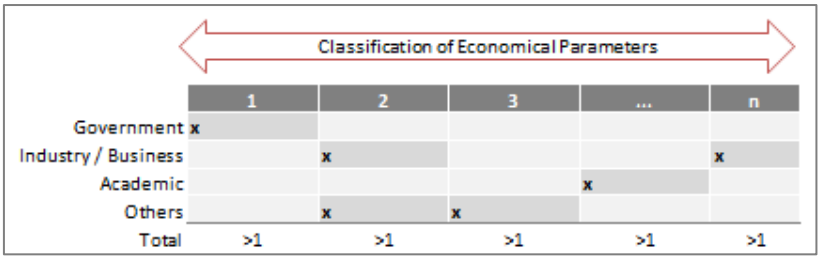


Figure 18 - Stakeholder Analysis

The sampling needed to take the preliminary definition of the economic parameters into account was set to represent at least one from each group being either the government, industry, academic or other enthusiast of the Arctic Region stakeholder group (see Figure 18).

In the beginning of this research the plan was to collect data from the international members of the Arctic Center conference scheduled in October 2013 through a workshop. The researcher estimated

some risk involved in that approach, mainly in connection with participants to be involved in the workshop and the schedule of the conference itself. It was not possible to control who would attend the workshop which led to two high risk factors for the course of the study. The main risk was if the participants would be too few and/or if all of the participant would represent the same pre-defined main categories of parameters. This could lead to uniform results. Another risk was the schedule of the conference which was unknown at the time.

To minimize this risk, interviews with individuals from all groups of stakeholders defined above where scheduled, due to location and simplicity these stakeholders where all Icelandic. This affected the study in a way that the focus was shifted from the economic impact on the Northern hemisphere and narrowed down to the economic influence merely in Iceland. The purpose of these interviews was to define the economic parameters in the foreseeable future and the work was produced by exclusively using primary source.

As it turned out the workshop was scheduled at the very end of a three-day conference which led to very few participants and, ultimately, cancellation of the workshop.

Interview Setup

This describes how the interviews were setup to obtain the requested knowledge. The method that was chosen, to attain the requirements to build a conceptual decision model, was to interview stakeholders with various backgrounds defined in the previous step. The setup of the interviews was semi-structured with open ended questions which served as a primary method of data collection. The advice of Bray (2002:224), “better to have a plan and depart from it than have no plan at all” was followed.

The questions asked in the interview are designed to help achieve the goals of the research and in particular to answer all three research questions. Therefore the breakdown of the research questions was used to formulate the guidance for the interview. See appendix A for the breakdown of each research question. This study followed the data collection process described by Robson (2011) based on Czaja and Blair (2005). This process shows how the survey questions fit into the overall survey process and how it emphasizes the researcher’s task of linking research questions to survey questions. It also demonstrates the respondent’s involvement and how accurate information is elicited which is shown on Figure 19.

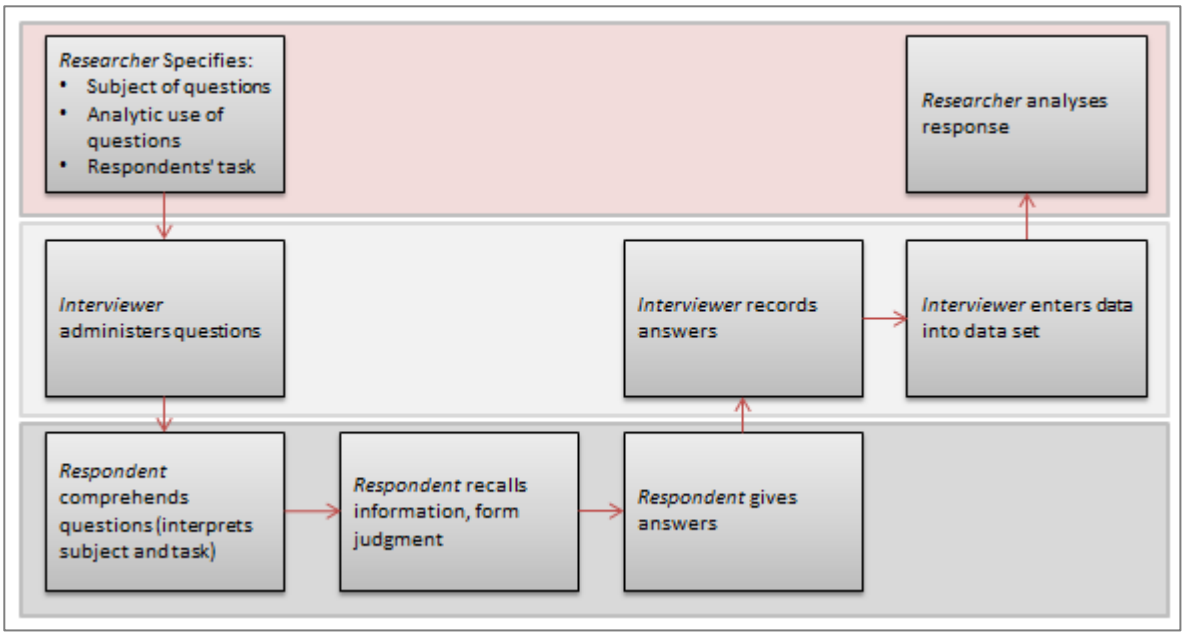


Figure 19 - Model of the survey data collection process (Robson, 2011).

The questionnaire can be referred to as the interview schedule (Robson, 2011:261). The sequential arrangement of the questions takes the logical course of inquiry into account. Therefore, the questions were designed to identify: (1) the usability of a Decision Model for strategic business planning of the Arctic Region by asking how the interviewee was connected to the Arctic; (2) the functionality of the model by asking focused questions regarding the economic parameters due to the foreseen activities in the Arctic; and (3) the uncertainty or the risk associated with each parameter mentioned.

This interview schedule covered:

- What the interviewer says by way of introduction
- Introduction to the purpose of these questions to the research and the group of questions.
- Usability or the relevance of the participant to the Arctic Region
- Functionality of the model by defining the input parameters
- Discussion regarding the uncertainty in relation to each parameter
- Summary of what was covered in the interview
- Closing comment and reminder to the interviewer.

All participants were asked to answer focus questions on the business drivers and weigh/prioritize according to importance, complexities, etc. When no new economic parameters were added to the data collection, step 1 was regarded as finished.

The summary of the interview instrument and the breakdown of the research questions are available in Appendix A and B respectively.

Test & Improvements

To test the interview instrument, two pilot interviews were carried out. The aim was to confirm that the questions were clear, simple and unambiguous. Some questions were clarified and the structure of the interview instrument was improved before interviewing proceeded.

3.4.1.2 Data Collection – Interviews

All interviews were attended by the interviewee and the interviewer who took notes during the interview as well as recorded them. The objective was to define the most critical economic parameters in the Arctic Region impacting Iceland and the data collected after each interview was analyzed immediately.

3.4.1.3 Analysis

The content analysis of the responses to the open-ended questions involved combining the detailed information into a limited number of both pre-defined categories from literature research and categories emerging from the data analysis. The main purpose was to simplify many individual responses by classifying them into smaller number of groups, each including responses that were similar in content and that enabled simple description of the data (Robson, 2011).

The responses were transcribed and analyzed in two distinctive ways: (1) by copying all the responses to a particular question on a sheet of paper, headed by the text of the questions; and (2) by forming an [*nxm*] matrix where (1,..,*n*) represent the main categories of economic parameters in the Arctic Region and (1,…,*m*) represent sub-categories. An example could be the main category of Shipping with the sub-categories of fishing vessels, cargo ships, cruise ships, oil ships, etc. (Table 3).

*Table 3 - Example of [*nxm*] matrix representing the main and sub categories of economic parameters.*

	1	2	3	…	n
1	A	E	C		A
2	B	F	G		C
3	C		H		I
…	D				J
m-1	G				
m					K

The matrix enabled the research to form connection between the most important parameters, estimate cross-functional influence and connections.

Another way of looking at this matrix is to visual how these parameters would be included in the conceptual decision model (see Figure 20). Here, the inner circle represents the main group of economic parameters (1,…,*n*) each of which has a sub-group of economic parameters (1,…,*m*) represented by the outer circles.

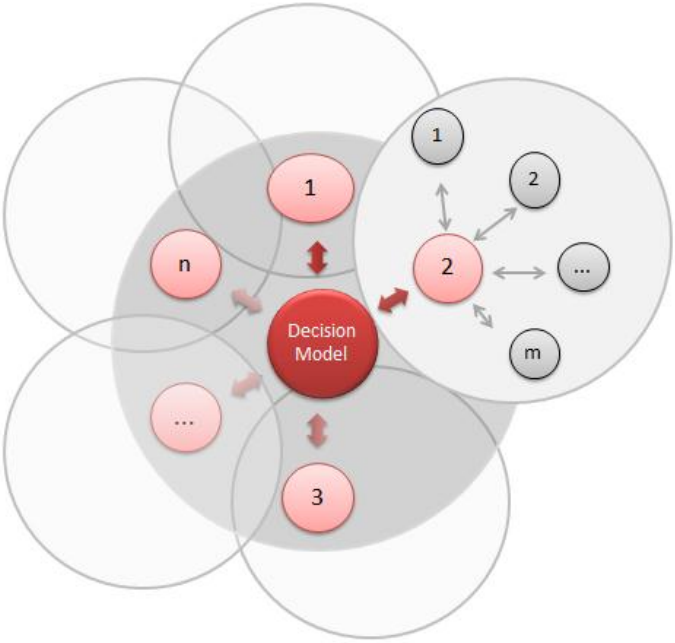


Figure 20 - Visual connection of the nxm *parameters*

Validation

The reliability and validity of survey data depends to a considerable extent on the technical proficiency of the interviewer. The possible problem of not obtaining valid information about the respondents and what their true opinion is referred as internal validity (Robson, 2011). To avoid this pitfall and to ensure that the questions are not incomprehensible or ambiguous they were tested and refined in pilot interviews. The interviewer was aware of securing a high degree of involvement face-to-face collection of the data.

If the sampling is faulty this produces an external validity problem (Robson, 2011). Due to the limited time available for this research a constraint was to stop collecting data at this stage when no new parameters would emerge.

Another type of external validity problem occurs if we seek to generalize from what people say in a survey to what they actually do (Robson, 2011:239). The setup of the data analysis avoids this by only seeking to build an [*nxm*] matrix as described above highlighting the economic parameters and their priorities instead of interviewee thoughts and feelings. At the end of the interviews these parameters were summarized and the participant was asked to confirm them or add a parameter if there was anything missing. The respondents were assured that their answers were anonymous to ensure their cooperation.

3.4.2 Step 2 – Definition of the Critical Parameters

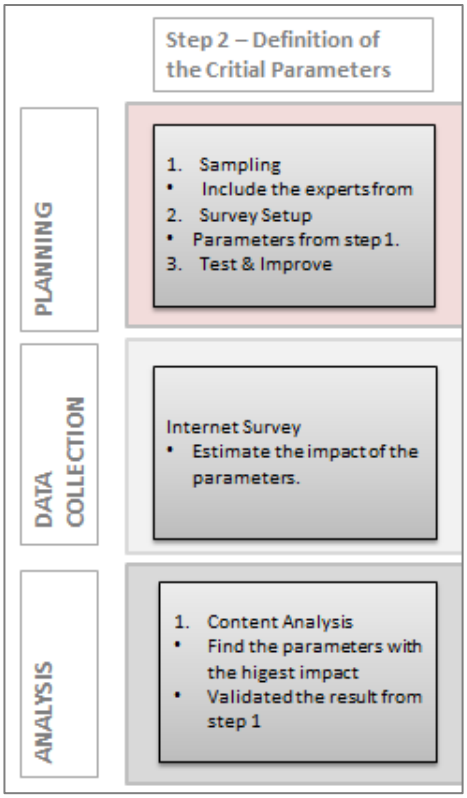


Figure 21 - Step 2 – Define the critical parameters.

To quantify the impact of the individual parameters a follow up was arranged by an internet based survey where stakeholders from industry, government and academia were asked to rate the impact of each parameter on a 5 point scale.

The goal of the second step of the research data collection was to identify the pre-defined economic parameters, defined in the previous step, with the highest impact on the Icelandic economy in the next 20 years. The aim of this step was also to analyze the requirements and to validate the outcome from step 1.

These data will be combined with the data collected from the interviews for further analysis.

Step 2 was divided into three phases as in the previous step: planning, data collection and analysis. The objective was to answer the first two research questions and to give the economic parameters numerical values.

The design in this step followed the basic scene of a fixed design quantitative data collection where the typical features are (Robson, 2011; Silverman, 2010)

- Selection of samples of individuals from known populations
- Allocation of samples to different experimental conditions
- Measurement on relatively small number of variables

3.4.2.1 Planning

Sampling

This study uses the approach of purposive sampling where the principle of selection was the researcher's judgment and the sample was built up which enables the researcher to satisfy her specific needs in the project; in this case to validate the outcome of data collection in step 1 and to estimate the impact of the economic parameters. This approach is commonly used within other flexible designs (Robson, 2011).

The aim was to send a questionnaire to a broader range of stakeholders or parties interested in the Arctic Region than in previous the step. The sample was a selection from those interested in one way or another in the Arctic Region and who attended the Arctic Center Conference 2013[5]. Due to the outcome of the data analysis of the experts' interviews in step 1, the economic parameters focused merely on the Icelandic economy. Therefore the focus of the sampling in this second step of the research only included Icelandic participants. The sampling frame consisted of an email list sent to the researcher of Icelandic

5 http://www.arcticcircle.org/

participant in the Arctic Center Conference 2013 and was therefore regarded as representative of the population. This can lead to 'ineligibles' or a person on the population list who is not part of the research target list but for some other reason attended the conference for another reason than pure interest in Arctic affairs. Since the conference was sold out it was assumed that no-one attended the conference that was not interested in the Arctic affairs. Also, an 'eligible' person might not get on to the list if an Arctic enthusiast for some reason did not attend the conference which is more likely in this study. This could cause problems with representativeness and lower the sample size. (Robson, 2011)

Setup of Survey

The objective was to highlight the parameters that became apparent in the interviews and to collect additional information using a questionnaire in a standardized form through internet survey. The design of the questions for the questionnaire followed the same process as described in Figure 19 above. The findings from the data collection in step 1, or the economic parameters, were used to form the questions. The questions had to reflect the line of inquiry underlying this phase of the research. Therefore the questionnaire was design to help achieve the goals of the research and in particular to answer research question 2: *What are the parameters with the highest impact on business evolution in a specific area within the Arctic Region (i.e. Iceland)?*

The design of the questionnaire was done in three steps.

- Firstly it was determined which questions to ask in relevance to each main economic parameter (*n*) or sub economic parameter (*m*). All questions focused on estimating the impact factor of the relevant parameter.
- Secondly, the wording was reviewed and
- Finally, the question sequence and overall questionnaire layout was finalized.

The questions were all defined as closed-end questions and worded to receive straightforward and clear answers. The questionnaire can be found in Appendix C.

All of these questions used the Likert scale for assessment. When responding to a Likert questionnaire item, respondents specify their level of agreement or disagreement on a symmetric *agree-disagree* scale with a set of statements. They were offered six fixed alternative choices labeled 'no opinion', 'very low', 'low', 'average', 'high', 'very high' and these were assigned the values of 0, 1, 2, 3, 4 and 5 respectively. All questions in the questionnaire were positive statements concerning how much a parameter *n* or *m* could possibly impact the Icelandic economy in the near future. The Likert scaling assumes that distances on each item are equal. By using the scale the participants answered how effective or favorable each item was on the time horizon of 20 years (Robson, 2011).

To prevent the use of biased or leading questions and to insure the questions would be understood by the interviewees the questionnaire was piloted before used in practice. The full questionnaire used in this research can be found in Appendix C.

3.4.2.2 Data Collection

The survey was based on the use of Survey Monkey[6]. Each participant was sent an introduction letter by email and could easily reply or send the researcher queries regarding the questions or study.

3.4.2.3 Analysis

After the questionnaire was completed each item or statement was analyzed separately and grouped in relation to each main economic parameter (*Greenland, Transportation – Shipping/Air, natural Resources, Fisheries, Tourism, Transshipment Port, Rescue and Security, and Service*) for further analysis. The objective was to compare and determine the parameters with the highest impact.

The second objective was to validate the results from step 1 and possibly omit the parameters not estimated to have a great impact on the Icelandic economy. The distribution of the evaluated impact for each statement was analyzed for this purpose.

The discriminative power (DP) was calculated to differentiate between the responses of the upper quartile of respondents and the responses of the lower quartile. The upper quartile representing the 25 percent with the highest total scores; the lower quartile the 25 percent with the lowest total score (Robson, 2011:304-305).

Validation

To avoid internal validity, it is important that the questions are comprehensible and unambiguous. (Robson, 2011:239). Securing high involvement by the respondents can be complex or insoluble when a survey is carried out via the internet compared to when the survey is conducted face-to-face. Securing involvement is partly also a technical matter and a poor design and lengthy questionnaire are unlikely to get good response. On the other hand, reliability can be more straightforward when collecting data with an internet-based survey since all the respondents are presented with the same standardized questions (Robson, 2011; Silverman, 2010). To ensure high validity the design of the questionnaires followed the approach of the steps described by Robson (2011) and Silverman (2010). The pilot survey was also sent to two participants, one familiar to the Arctic activities and the second not familiar.

As in step 1 the number of respondents was limited to what is commonly practiced and internet-based surveys typically have low response rate as well. Therefore it can be difficult to know if the sample is in fact representative which can lead to what is called an external validity (Robson, 2011:239).

The main goal of step 2 was to validate the critical parameters found in step 1 and to analyze their impact on Iceland. The data collected with both methods will be combined to form the foundation of the conceptual decision model. Therefore the number of participants in this data collection is not viewed as crucial in this research. A low response is not classified as a show-stopper for this study since the economic parameters used in the conceptual decision model where defined in step 1 and can easily be modified when the decision model itself is built.

The exercise of writing the questions for the internet-based survey led to the research questions and the focus of the study being revisited as noted earlier.

6 https://www.surveymonkey.com

3.5 Reliability and validity of data collected

The validity of the data collection has been discussed in previous sections for each step of the research data collection method. Validity is concerned with whether or not the findings are really about what they appear to be about and considers generalizability and reliability. Generalizability refers to the extent to which the findings of the total enquiry (steps 1 and step 2) are more widely applicable outside the specifics of the situation studied. While reliability refers to the consistency or stability of a measure, for example, if it were to be repeated would the same result be obtained (Robson, 2011).

In this study methodological triangulation was used to enhance the rigour of the research. It refers to the application and combination of several research methodologies in the study of the same phenomenon, in this research the qualitative (inquiry) and quantitative (validation) studies. Corroboration or support for the statements found by qualitative data collection methods in step 1 is found from the use of quantitative data in step 2. This enhances the validity of findings (Robson, 2011).

3.6 Conclusion

This study is pragmatic and can be classified as mixed or multi-strategy design combining both fix and flexible design elements.

The priority of the study was the qualitative data collection in step 1 that was followed by a quantitative data collection in step 2. These two approaches that were applied in this study included:

- Step 1-Expert Interviews: To define the economic parameters impacting the Arctic Region (i.e. Iceland) due to future activities in the area with qualitative data. Information was collected with techniques including interviews and document analysis. The results of the interviews were investigated with the aim of defining the most critical parameters to be included in the model. This part of the research was flexible design and was classified as exploratory. The objective was to answer all three research questions but focusing on the first.

- Step 2-Internet based surveys: To validate the findings from previous step and to highlight the most critical economic parameters with quantitative data. Information was collected using a questionnaire available via the internet. This part of the research is fixed and classified as exploratory. The objective is to answer all three research questions, but focusing on the second.

One of the benefits of using a mixed strategy approaches was the opportunity to validate the results from the qualitative data collection with a quantitative approach. The data collected with both methods will be combined and used to form the foundation of the conceptual decision model in step 3 which focuses on answering research question number 3.

4 Step 1: Definition of Parameters

The objective of this chapter is to identify and define the parameters. The results are summarized under the heading of each question to be analyzed and discussed. Finally the economic parameters are defined based on the findings of the expert's interviews and document analysis. The data collection in this chapter is guided by the explanatory models established in Chapter 3.

4.1 Introduction

The objective of this chapter is to define the economic parameters that will be used as input to the model for the DMA project. The findings are aimed to answering all three research questions driving this research and for use as input to the model.

Economic parameter was defined in this research as:

> *A variable that can influence cost and/or income directly or indirectly, for business life and government in the coming decades.*

Seven various experts on Arctic affairs were interviewed for this purpose. To respect the openness of the interviewees they will be anonymous and represent by the letters A,B,…,G in this thesis.

The procedure followed the working method defined in chapter 3.4.1 – Step 1 – Definition of the Parameters.

4.2 Target group

Interviewees were classified as having a background in government, industry, academia or as an enthusiast for the Arctic Region. The constraint was set to interview at least one stakeholder with expertise for each economic parameter, *n*. The table below shows the connection of the seven interviewees to the pre-defined economic parameters. Note that one stakeholder can have expertise in more than one field.

Table 4 – The connection of the interviewee to the economic parameters.

		CATEGORIES OF (pre-defined) ECONOMICAL PARAMETERS n,					
		Transportation - Sailing / Air	**Natural Resources**	**Tourism**	**Transshipment Ports**	**Rescue and Security**	**Service (added value)**
STAKEHOLDER:	Government	1	1	1	1	1	1
	Industry		3	1	1		1
	Academic	2				2	
	Others	1	1	1			1
	TOTAL:	**4**	**5**	**3**	**2**	**3**	**3**

4.3 Interview write up

Characterization

1.1 - Could you tell me shortly what is your connection or interest in the Arctic Region?

The purpose of this question was to confirm that the participant belong to the relevant stakeholder group. The respondent interest or background in regards to Arctic affairs can be shown in the table 5 below.

Table 5– Usability or Stakeholders

Coast Guard	1
University	2
Consulting Engineer firm	2
Arctic Cooperation Network	1
Industry	4
Ministry of Foreign Affairs	1

Functionality

2.1 - What do you think is the most influential economic parameters due in regard to the general development in the Arctic?

The main goal of this question was to establish the definition of the economic parameters, both the categories of economic activities and their sub-categories. The parameters that were observed in the interviews are listed in the table below. The columns represent the participants and the rows the findings or the parameters. The orders of the rows demonstrate the hierarchy of the parameters where the last column shows how often the relevant parameter emerged. This resolves to a strong emphasis on business activities in Greenland.

Table 6 – Definition of the Economic Parameters.

	A	B	C	D	E	F	G	H	Total
Service (infrastructure) to Greenland	1		1	1		1	1	1	**6**
Greenlands opportunities (energy, tourism and infrastructure) and increase sailing	1		1		1	1	1	1	**6**
Rescue and Security (Joint Coordination Center	1	1	1	1			1		**5**
Natural Resource - Arctic	1			1	1		1	1	**5**
Transportation - shipping / New Sailing routes	1			1	1		1	1	**5**
Tourism	1				1		1	1	**4**
Oil - Drekasvæði				1		1	1	1	**4**
(+/-) Fishing	1			1			1	1	**4**
New sailing routes	1		1		1				**3**
Transportation hub	1		1						**2**
Finnafjörður harbor and infrastructure			1	1					**2**
Transportation - Air							1	1	**2**
Hydroelectric power plants (energy to Greeland)						1			**1**

Table 7 – Overview of all Economic parameters n and m.

Sailing / Shipping	Transportation / Air	Natural Resource	Greenland	Oil & Gas	Mining	Energy	Tourism	Ports	Safety	Social / Infrastructure	Service	Fishing
Cruise ships	Due to increase in resource and people moving	Greenland	Current and unknown	Service and Knowhow	Service and Knowhow	Service and Knowhow	Cruise ships	Finnafjörður - service - safety - tank hotel - oil - Transportational	Monitoring marine	Town, airport, hospital, ... In east of Iceland	Insurance	Changes of fish species
Transport	Air transport, airport	Russia	Energy to Greenland	Industry: Hub, transport, maintenance, drilling, ...	Industry: Hub, transport, maintenance, drilling, ...	Energy to Greenland	Due to increase resources in Greenland	Air transport, airport	Coordinate CENTER response + rescue	Support Greenland by Icelandic infrastructure	to Greenland	Icelandic Knowhow
Oil & Gas		Drekasvæði	oil & gas	Work Force: Educated, Software, Engineers, Project managers, Constructors	Work Force: Educated, Software, Engineers, Project managers, Constructors	hydroelectric power plants	Due to transport of habitat (migration of people)	Sundahöfn - transport to and from Greenland	strategically located vessels & Aircrafts	Work Force: Educated, Software, Engineers, Project managers, Constructors	to oil and ship from Russia	
Fishing Vessels		Jan Mayen	Mining - list them up!	Jan Mayen	Procurement and processing	Work Force: Educated, Software, Engineers, Project managers, Constructors	in north east Iceland and all Iceland		Icelandic Knowhow	Location of Iceland	Service due to the sailing route Russia and US	
Ice breakers		Norway	Service	Drekasvæði		Geothermal	in the Arctic Region		LV of the North (something attractive for workers and tourism)		Hospital	
Cargo		Alaska	shipping to and from Greenland	Procurement and processing			Town, airport, hotels				Maintenance	
			Support Greenland by Icelandic infrastructure				Cruise ships				Polar Code	
							Focus on the structure and socially responsible companies				due to oil and gas exploration	

2.2 - What are the sub categories of the business activities you described previously?

The findings are represented in table 7. This output will be used as an input for the cross-impact matrix (*n*x*m*) where *n* equals the economic parameters and *m* equals their sub-categories.

2.3 - What parameter do you think has the greatest benefits for Icelandic economy?

The aim was to narrow the ongoing discussion to the impact on the Icelandic economy. Since all of participants focused on the benefits exclusively for Iceland from the beginning this question was dismissed. These findings led to a focus change of the research from the overall economic impact on the Arctic Region to narrowing it down to the Icelandic economy.

2.4 - Now you have mentioned XXX, XXX and XXX as the economic parameter, could you give each one of them a score from 1-5 where 5 is a parameter with a very high impact on the Arctic?

The purpose of this question was to evaluate the impact of the economic parameters. A majority of participants prioritized their parameters in relation to time. The table below shows how each participant prioritized this/her parameters.

Priority with respect to time

A	B	C	D	E	F	G
1. Rescue and Security	1. Coordination Center for joint response and rescue	1. Greenland's opportunities	1. Projects in Greenland	1. Service to Greenland and Drekasvæði	1. Fish & tourism	1. Tourism
2. Service / infrastructure to Greenland	2. Infrastructure of the area	2. Finnafjörður harbor and infrastructure	2. Drekasvæði	2. Fishing	2. Shipping /sailing and oil	2. Oil
3. (+/-) Fishing				3. Shipping	2. infrastructure in East of Iceland	3. Mining
4. New sailing routes						4. Transport
5. Tourism						
6. Transformational hub						

Figure 22 - Prioritization of the economic parameters.

This reveals that it is assumed that there will be severe impact on the Icelandic economy in the next decades due to the foreseen miscellaneous business activities in Greenland. Coordination Center for join response and security is assumed of high importance and tourism is expected to have high impact as well.

Uncertainty

3.1 - What do you think are the most influential environmental parameters on these economic parameters?

The objective here was to get an idea of the foreseen uncertainty in relation to each of the business activities discussed so far. These findings will not be further analyzed in this phase of the DMA project.

Overall uncertainty can be summarized (not in hierarchical order) as:

- Environment will have the highest uncertainty
- Politics
- Social problems
- Technical uncertainty in the nearest future
- Legal uncertainty
- Great disaster can happen from small things

Uncertainty related to specific parameters (not in hierarchical order) as:

Shipping (new routes)

- That the traffic will not come to Iceland
- Lack of credibility
- Lack of equipment
- Politics
- That the Arctic freezes again
- Global logistic companies

Fisheries:

- Climate changes
- Shifting of fish stock
- Dominance
- Oil accidents
- Politics
- Lack of maps
- Lack of joint rescue response plan

Transformational Port

- Both industry and government need to show stability and focus.
- Iceland has to show initiative act
- How Iceland prepares, plans and communicates
- Global logistic companies
- The image of Iceland

Shipping:

- Climate changes
- Lack of maps
- Lack of infrastructure
- Lack of cooperation
- Lack of joint centre of risk
- Extreme condition and environment
- The image of Iceland
- Global logistic companies

Greenland

Mining in Greenland:
- Lack of Infrastructure
- Lack of workforce
- Lack of education
- Communication
- Very expensive to mine in Greenland
- World price of minerals

Geographical closeness to Greenland:
- Communication
- Industry
- Preparation
- Environmental impact Assessment
- That the service for Greenland will be in Greenland

Tourism
- The image of Iceland
- Lack of Infrastructure
- Extreme condition
- Joint rescue response plan

China
- High uncertainty is also that Iceland doesn't know what Chinas goal or plan is
- Communication

Oil
- Quantity is the uncertainty
- Lack of maps and extreme unknown environment
- Image of Iceland
- Accident and communication
- Oil spillages

3.2 - Which uncertainty do you think is the most critical one and has the highest impact on all of these economic parameters?

The aim was to summarize the highest uncertainty discussed in the previous question. The highest uncertainty or risks to all economic variables are as follows:

- How Icelandic politicians and industry will response to all of these changes; that is in communication and preparation or planning due to the foreseen changes.
- Lack of infrastructure and credibility in equipment
- Uncertainty in politics
- Climate / extreme weather

Summary

4 - If I try to summarize what we have discussed so far, what are the highest impact economic parameters in your opinion?

In this phase of the interview the discussion was summed up and the participants had an option to add a parameter or omit ones they had already defined.

The economic parameters that stood out from the interview with various stakeholders were 'Service' and 'Local knowledge'. The findings of this question are in accordance with the findings of question 3.5 since 'service' and 'local knowledge' can be regarded as sub-categories of the economic parameter 'Greenland'.

4.4 Definition of the Economic Parameters

The analysis of the data obtained in the interviews, from the literature (Conley, 2012; Guðjónsson, 2013; Jónsdóttir et al., 2013) and the Arctic Circle conference[7] lead to the following definition of the main economic parameters.

4.4.1 Greenland

Possible future oil and gas exploration, mineral extraction, constructions, shipping and tourism in Greenland will not only impact the economy in Greenland but possibly the whole Northern hemisphere. These activities call for increased shipping to and from Greenland. The infrastructure will grow as a result and this could also lead to increases in population if not only due to foreseen increased demand for the workforce.

4.4.2 Transportation – Shipping and air

The changes in the climate and melting of the ice in the Arctic Region could influence the transportation net as it is today for delivering goods between Asia and Europe/USA with the opening of new shipping routes. Mining, power plants, constructions and seeking for oil in the Arctic Region will also have impact on transportation of equipment, material, products and labor both by sea and air.

4.4.3 Natural Resources – Oil, gas, minerals, energy

New commercial opportunities in the Arctic arise as the sea ice retreats. Natural resources that were once unreachable are becoming available for extraction. In addition to hydrocarbon deposits the Arctic is also believed to be rich in nickel, iron ore, and rare earth minerals. Although the full extent of these resources is not yet known, each of the different Arctic states has made efforts to exploit these resources (Conley, 2012; Guðjónsson, 2013). Simultaneously, there is a need to develop new technologies and approaches for tackling the harsh and unpredictable environment for offshore drilling and transportation in the Arctic (Conley, 2012).

4.4.4 Fisheries

The Arctic Ocean is connected to several significant breeding areas of fish stocks, which are anticipated to move farther north as an apparent result of changes in Arctic water temperatures. As a shift in fish stocks takes place, increased fishing opportunities are likely to result in disputes over quotas and fishing areas.

4.4.5 Tourism

The tourist trades with wide variety of companies in different industries. Tourism industries include, for example, accommodation, food and beverages, passenger transport and travel agencies. The core business of tourism is defined as transportation, activity and accommodation (Jónsdóttir et al., 2013).

7 http://www.arcticcircle.org/

4.4.6 *Transshipment Port*

Transportation between Asia and Europe/USA is vastly important and shipping efficiency compared to land transport is unambiguous. Without transportation, areas and countries would need to be self-sufficient in all manners (Guðjónsson, 2013).

4.4.7 *Rescue and Security*

With the rise of Arctic economics, and an increasingly ice-free and hostile climatic environment the security challenges are major. This includes search and rescue, environmental remediation, piracy, terrorism, natural and man-made disaster response, around fishing vessels, surveillance of ice thickness and border protection. The Arctic Region faces a new security challenge with increased oil and gas exploration, mineral extraction, intra-Arctic shipping, tourism, commercial fishing and additional borders to protect. Oil-spill prevention, preparedness and response and enhanced search and rescue capabilities will require training, equipment and cooperation with civilian agencies (Conley, 2012).

4.4.8 *Service*

Various services due to increased economy, growing infrastructure and population in the Arctic are foreseen in the future. Types of service might include various engineering, management, maintenance of tools and equipment, hospital, construction of infrastructure and software/internet services.

4.5 **Discussion of the results**

The limited number of interviewees could be criticized. Nevertheless, a limited number of respondents are regarded as sufficient for the purpose of this thesis since the main goal at this stage is to define the economic parameters due to the activity in the Arctic. The decision to stop collecting data when no new parameters have merged was respected. Limited time affected this decision.

This technique of eliciting requirements to define the economic parameters was quite beneficial and added value to this study. By including different individuals in the process and in discussing the issues, a clear understanding of the substantive issues of a problem were developed. It is believed that the opinions of participants were reliable.

The work method designed in this step of the study had the aim to identify problems and opportunities as well as to structure the decision problem. The designed procedure served this purpose well and it is believed it will be beneficial for the remaining work of the DMA project, both on a larger sample and to define new parameters in different fields.

4.6 Conclusion

It can be concluded from the analysis of the data that there is an interdisciplinary agreement of which economic parameters will have the most impact on the Icelandic economy as a result of business activities in the Arctic Region in the next 20 years. When responses from the interviews with experts were analyzed and the findings summarized the following order of impact on the Icelandic economy (1 being the highest impact) can be observed:

1. Greenland
2. Tourism and Rescue & Security
3. Fishery and Natural Resources

Transportation – new shipping and air routes, and Transshipment Ports are not thought to be of high importance to the Icelandic economy.

The respondents all concluded that business activities in relation to miscellaneous services and local knowledge would play an important role in the coming decades.

The highest uncertainty or risks to all economic variables are as follows:

- How Icelandic politicians and industry will response to these changes; that is in communication and preparation or planning due to foreseen changes.
- Lack of infrastructure and credibility of equipment's
- Uncertainty in politics
- Climate/extreme weather

The objectives to create and to define the economic parameters that will be used as input in the model for the DMA project were fulfilled in this step of the research.

The findings revealed useful insights that helped in answering all three research questions.

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5 Findings - Step 2: Surveys

The objective of this chapter was to identifying the parameters with the highest impact on the Icelandic economy in the next 20 years. First the stakeholders are identified following an analysis of the economic parameters. Finally, each statement or sub-category of the economic parameters is analyzed. The data collection method in this step is quantitative and guided by the models established in chapter 3.

5.1 Introduction

The objective of this chapter was to identify the parameters with the highest impact on the Icelandic economy in the next 20 years.

An internet based survey was used to validate the findings from the interviews and to put numerical values to the impact of the defined parameters. The validation of the parameters was investigated and continued to analyze the requirements.

In this phase of the analysis each statement or sub-category of the economic parameter was analyzed. The data collection in this step is quantitative and the procedure followed the working method defined in chapter 3.4.2 – Step 2 – Definition of the Critical Parameters.

The findings were aimed at answer the first two research questions driving this research and are to be used as input to the conceptual model.

5.2 Stakeholders Identification

All participants in the research were asked to categorize their connection with the Arctic Region as Academic, Industry, Government or Other. Five of them classified themselves as other.

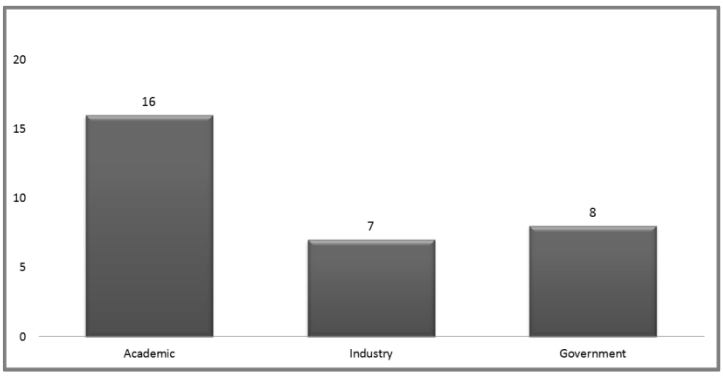

Figure 23 - Stakeholders Identification

The response rate of the survey via the internet was 50%, where 28 out of 56 participants answered. Two of the participants classified in the Academic stakeholder group and one classified as industry answered all of the questions in the survey as 'No Opinion'. That respondent was omitted from the data analysis.

5.3 Analysis per Group of Economic Parameters

The mean and the standard deviation of each statement in the questionnaire were calculated by using formula 1 and 2 below. The large number of parameters rated as important means a relatively strong consensus among the majority of the stakeholders regarding those parameters. The standard deviation indicates how far from the mean the data points falls. A small standard deviation indicates that the data points are clustered closely around the mean. A high standard deviation indicates that they are far from the mean and indicates diverse opinion among the stakeholders on the importance of the parameters.

Mean: $$\bar{X} = \frac{\sum_{n}^{1}(X_n)}{n} \quad 1)$$

Standard Deviation: $$\sqrt{\frac{\sum(X-\bar{X})^2}{(n-1)}} \quad 2)$$

Where $\bar{X}$ equals the mean, X value of the impact factor and n number of respondents.

(Field et al., 2012)

These statement and their values were grouped under the relevant category of economic parameter defined in the previous step. The average impact value and standard deviation of those parameters were calculated using the same formulas and can be shown on figure 21.

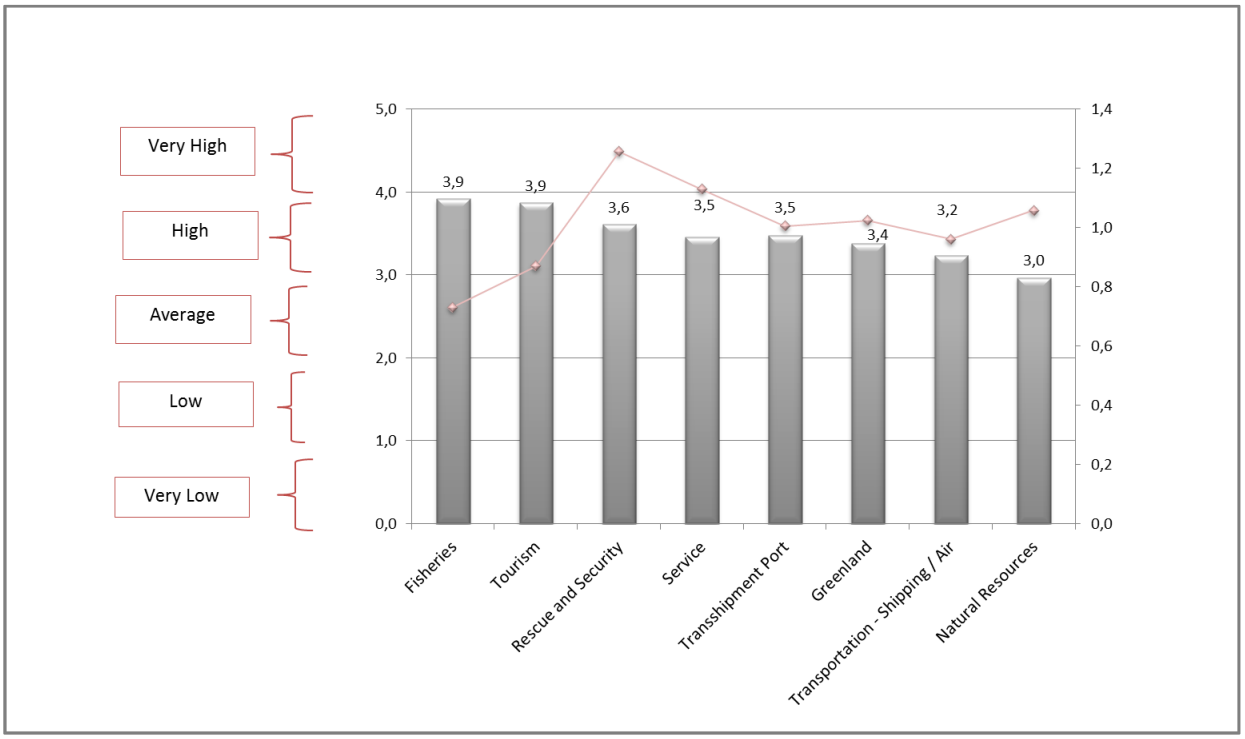

Figure 24 – Impact factor of the categories of economic parameters.

The analysis indicates that all of the predefined categories of economic parameters defined in step 1 receive an impact factor higher than average as shown on the left vertical axis in Figure 24. Further it reveals that business activities in connection with fisheries and tourism will have the highest impact on the Icelandic economy in the next 20 years. The standard deviation for each category of the economic

parameter indicates that the data points are distributed and do not cluster closely around their mean. The economic parameters with the highest expected impact are Fisheries with impact factor of 3,9 and SD 0,7 and Tourism with the same estimated impact factor but 0,9 as SD. The economic parameters estimated to have the lowest impact on the Icelandic economy are Natural Resources with impact factor 3,0 and SD of 3, and Transportation – Shipping/Air with impact factor of 3,2 and SD 1.

5.3.1 Likert Scale

The discriminative power (DP) was calculated to differentiate between the responses of the upper quartile of respondents and the responses of the lower quartile. High DP suggests large diversity in the responses, since the difference between the upper and lower quartile is significant. The variability of the response would then suggest no unified opinion regarding the impact of the relevant economic parameter. Figure 25 shows calculated DP for each economic parameter.

	Fisheries	Greenland	Natural Resources	Rescue and Security	Service	Tourism	Transportation - Sailing / Air	Transshipment Port
Mean for each Likert item - Upper quartile	3,9	4,4	3,9	4,4	4,5	4,2	4,0	4,5
Mean for each Likert item - Lower quartile	3,7	2,6	2,1	2,5	2,6	3,8	2,7	3,0
Discriminative power (DP=Upper-Lower)	0,3	1,8	1,8	2,0	1,9	0,3	1,3	1,5

Figure 25 – Discriminative power for the economic parameters.

Two of the calculated DP for the economic parameter had a very low value suggesting little diversity in the responses. It can therefore be assumed that the participants where in overall agreement regarding the impact of these two economic parameters; Fisheries and Tourism, on the Icelandic economy in the next 20 years.

The economic parameters; Transportation – Shipping/Air and Transshipment Port, received a DP between 1 and 1,5 suggesting some diversity in the responses regarding their impact factor.

The other four economic parameters; Greenland, Natural Resource, Rescue and Security and Service, received calculated DP between 1,5 and 2 suggesting some disagreement regarding the foreseen impact of the parameters in the next 20 years.

5.3.2 Preference per stakeholder

To evaluate how different group of stakeholders estimate the foreseen impact due to the business activities the findings were grouped to visualize these differences, as shown on Figure 26.

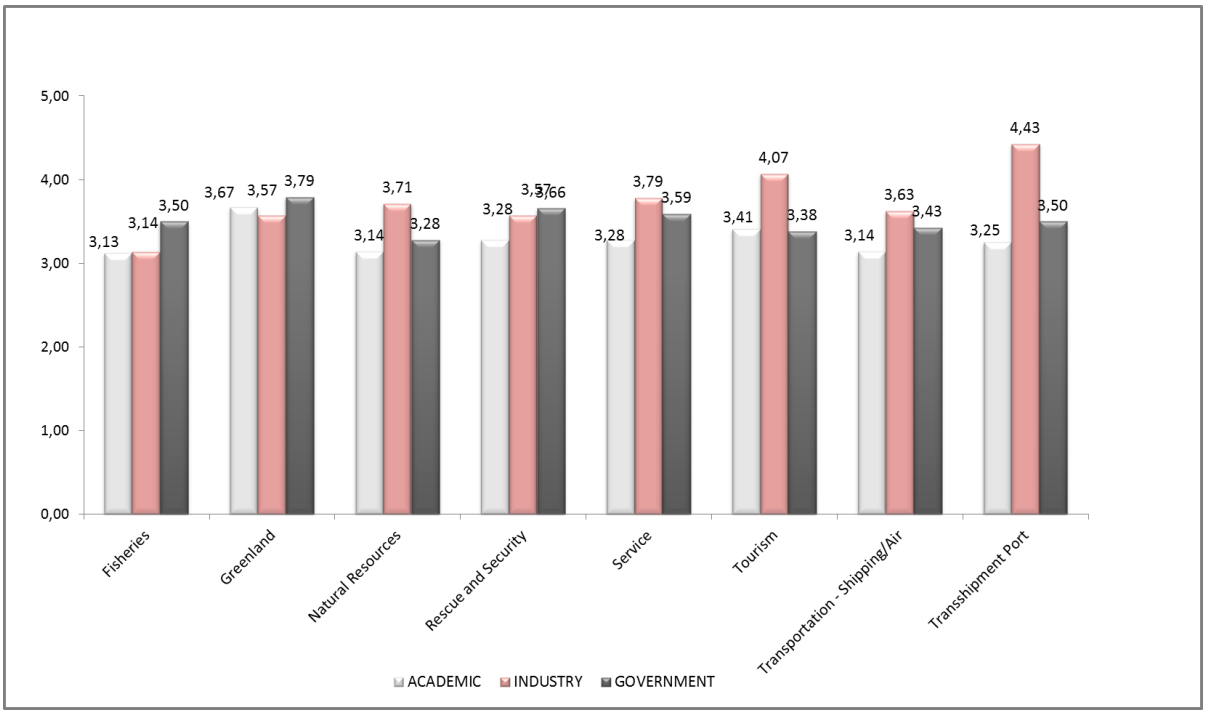

Figure 26 – Impact factor of economic parameters per stakeholder group

5.4 Analysis of Sub-Categories of Economic Parameter

In this phase of the analysis each statement or sub-category of the economic parameter was analyzed. The mean and the standard deviation were calculated using formula 1) and 2) above. Summary of the data collected can be seen in table 8 but a better overview might be figure 27 on next page.

Table 8 –Summary of the data collection in phase 2 of the study sorted by the impact factor.

#	Economic Parameter	Question	Average	SD
4	Tourism	Impact factor of tourism in the Arctic region	4,12	0,73
15	Service	Impact factor of local knowhow and experience in relation to miscellaneous service in the Arctic	4,04	0,89
9	Fisheries	Impact factor of fisheries in the Arctic Region	3,92	0,70
13	Fisheries	Impact factor of re-shifting of the fish stocks in the Arctic Region	3,92	0,76
21	Rescue and Security	Impact factor of the need of Coordination, collaboration, and interoperability among and between the Arctic nations	3,92	1,22
24	Rescue and Security	Impact factor of the need of monitoring marine traffic (fishing vessels, ice breakers, cruise ships etc.)	3,80	1,29
7	Greenland	Impact factor of local knowhow and experience in relation to miscellaneous service in Greenland	3,76	0,88
23	Greenland	Impact factor of the geographical closeness to Greenland	3,76	1,23
14	Fisheries	Impact factor of maritime activities across the Arctic	3,68	0,85
8	Transportation - Sailing / Air	Impact factor of cruise ships in the Arctic region	3,63	1,01
6	Transportation - Sailing / Air	Impact factor of passenger's aircrafts in the Arctic Region	3,52	1,08
28	Rescue and Security	Impact factor of interaction and information sharing with the private sector	3,52	1,48
20	Greenland	Impact factor of the need of educated workforce in Greenland	3,48	1,12
22	Transshipment Port	Impact factor of transportation port in Iceland	3,48	1,00
25	Service	Impact factor of the need of educated workforce in the Arctic region	3,42	1,38
3	Transportation - Sailing / Air	Impact factor of maritime activities in the North East passage	3,32	0,90
19	Service	Impact factor of the need of supporting infrastructure in the Arctic (public transport and accommodation)	3,32	1,22
1	Natural Resource	Impact factor of oil and gas exploration	3,24	1,05
12	Rescue and Security	Impact factor of Joint Coordination Center for search-and-rescue operations	3,20	1,04
18	Greenland	Impact factor of cargo shipments to and from Greenland	3,16	0,94
26	Greenland	Impact factor of processing oil and gas in Greenland	3,13	1,03
5	Service	Impact factor of migration of people to the Arctic Region	3,08	1,04
11	Natural Resources	Impact factor of energy consumptions in the Arctic	3,08	1,15
16	Transportation - Sailing / Air	Impact factor of cargo aircrafts in the Arctic Region	3,08	0,91
2	Greenland	Impact factor of mining activities in Greenland	3,04	0,93
10	Natural Resources	Impact factor of processing of oil and gas	2,88	1,13
17	Natural Resource	Impact factor of processing minerals in the Arctic	2,68	0,90
27	Transportation - Sailing / Air	Impact factor from maritime activities in the North West passage	2,58	1,06

The higher important factor means a relatively strong consensus among the majority of the stakeholders regarding the impact of those parameters on the Icelandic economy. A high standard deviation indicates diverse opinion among the stakeholders on the importance of the parameters.

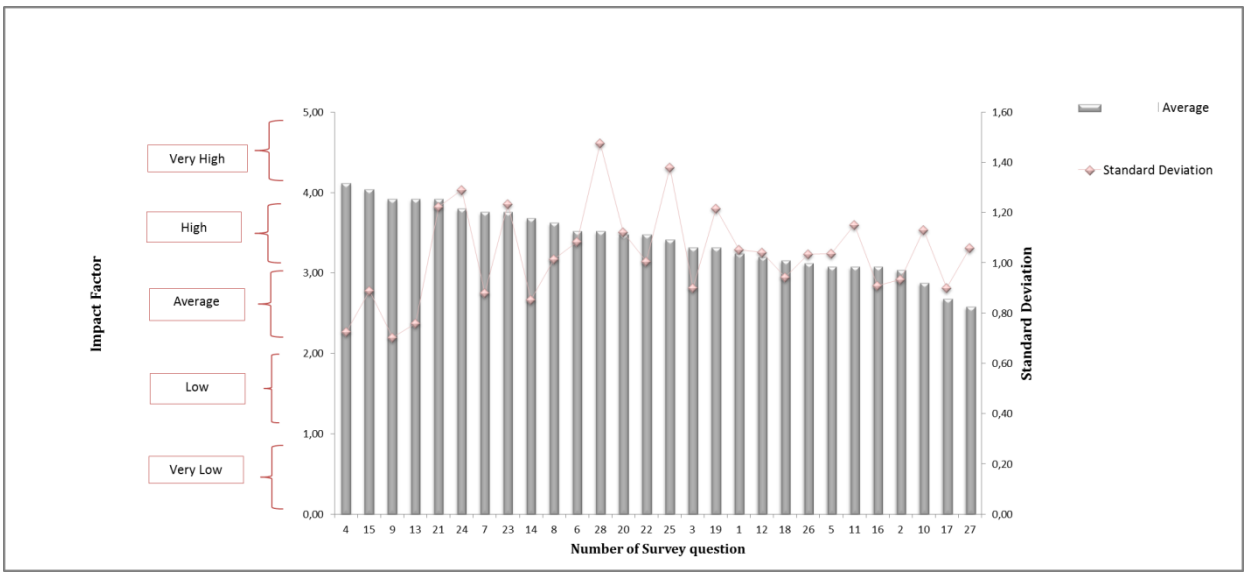

Figure 27 – Impact factor of sub-categories of the economic parameters or statements. Note that the numbers on the x axis refer to the questions in table 8 above.

None of statements received the impact value low or very low.

All but five of the predefined economic parameters had a weighted average between 3 and 4 which implies that they are expected to have high impact on the Icelandic economy in the next 20 years. Two parameters are assumed to have very high impact on the Icelandic economy: 'tourism in the Arctic region' and 'the local knowhow and experience in relation to miscellaneous service needed in the Arctic'.

Three of the parameters are estimated to have average impact and received an impact factor below 3: 'Processing of oil and gas', 'Processing minerals in the Arctic' and 'Maritime activities in the North West passage'.

Majority of the parameters receive standard deviation above the value 1 indicating a diverse opinion among the stakeholders on the importance of the parameters. The economic parameters that can be grouped under the category 'Service' and 'Rescue and Security' (questions number: 21, 24, 28, 25 and 19) all receives high number of importance points and large standard deviation. This means that although many strongly believe in the importance other are sceptic and the data points are not clustered around the mean.

The data analysis shows that all of the economic parameters defined in previous step 1 of this research are relevant and should be included in step 3, or the formulation of the conceptual model.

Further details of the data analysis of each statement or sub-category of the economic parameter can be found in Appendix D.

5.4.1 Likert Items

As in the analysis for the economic parameters the discriminative power (DP) was calculated to differentiate between the responses of the upper quartile of respondents and the responses of the lower quartile for each item or statement in the survey. Table 9 shows the DP for each statement in hierarchy order where the far left column represents the number of the statement in the questionnaire, second column shows what economic group the statement belongs to and the third column describes the relevant statement.

Seven items received DP higher than or equal to the value 2. This suggests diversity in the responses and that the respondents were not in agreement regarding the impact of these economic parameters, which can be seen in table 9 on next page.

Fifteen of the parameters received a DP between 1 and 2 which suggests some diversity in the responses.

Six of the economic parameters have a DP below 1 suggesting that the respondents were in overall agreement regarding the impact of these economic parameters on the Icelandic economy in the next 20 years.

Table 9 – Discriminative power for sub–categories of the economic

			Mean for each Likert item - Upper quartile	Mean for each Likert item - Lower quartile	Discriminative power (DP=Upper-Lower)
25	Service	Impact factor of the need of educated workforce in the Arctic region	5,0	2,2	2,8
24	Rescue and Security	Impact factor of the need of monitoring marine traffic (fishing vessels, ice breakers, cruise ships etc.)	4,7	2,3	2,3
20	Greenland	Impact factor of the need of educated workforce in Greenland	4,7	2,5	2,2
23	Greenland	Impact factor of the geographical closeness to Greenland	4,8	2,7	2,2
11	Natural Resources	Impact factor of energy consumptions in the Arctic	4,2	2,2	2,0
28	Rescue and Security	Impact factor of interaction and information sharing with the private sector	4,5	2,5	2,0
21	Rescue and Security	Impact factor of the need of Coordination, collaboration, and interoperability among and between the Arctic nations	4,8	2,8	2,0
17	Natural Resource	Impact factor of processing minerals in the Arctic	3,8	2,0	1,8
10	Natural Resources	Impact factor of processing of oil and gas	3,7	1,8	1,8
7	Greenland	Impact factor of local knowhow and experience in relation to miscellaneous service in Greenland	4,8	3,0	1,8
18	Greenland	Impact factor of cargo shipments to and from Greenland	4,2	2,5	1,7
5	Service	Impact factor of migration of people to the Arctic Region	4,2	2,5	1,7
19	Service	Impact factor of the need of supporting infrastructure in the Arctic (public transport and accommodation)	4,3	2,7	1,7
6	Transportation - Sailing / Air	Impact factor of passenger's aircrafts in the Arctic Region	4,5	2,8	1,7
1	Natural Resource	Impact factor of oil and gas exploration	4,0	2,3	1,7
15	Service	Impact factor of local knowhow and experience in relation to miscellaneous service in the Arctic	4,7	3,2	1,5
22	Transshipment Port	Impact factor of transportation port in Iceland	4,5	3,0	1,5
12	Rescue and Security	Impact factor of Joint Coordination Center for search-and-rescue operations	3,7	2,2	1,5
16	Transportation - Sailing / Air	Impact factor of cargo aircrafts in the Arctic Region	3,8	2,5	1,3
2	Greenland	Impact factor of mining activities in Greenland	4,0	2,7	1,3
14	Transportation - Sailing / Air	Impact factor of maritime activities across the Arctic	4,2	3,0	1,2
3	Transportation - Sailing / Air	Impact factor of maritime activities in the North East passage	4,0	3,0	1,0
26	Greenland	Impact factor of processing oil and gas in Greenland	3,3	2,5	0,8
27	Transportation - Sailing / Air	Impact factor from maritime activities in the North West passage	3,2	2,3	0,8
8	Tourism	Impact factor of cruise ships in the Arctic region	3,8	3,4	0,4
13	Fisheries	Impact factor of re-shifting of the fish stocks in the Arctic Region	3,8	3,5	0,3
4	Tourism	Impact factor of tourism in the Arctic region	4,5	4,2	0,3
9	Fisheries	Impact factor of fisheries in the Arctic Region	4,0	3,8	0,2

5.4.2 Analysis per economic parameter

Detail analysis of the distribution of the impact of each statement, e.g. sub-categories of the economic parameter, on the Icelandic economy in the next 20 years can be found in Appendix E.

The analysis reveals that each economic parameter is expected to have average to very high impact on the Icelandic economy which indicates a consensus among the majority of the stakeholders regarding those parameters. On the other hand the distributions of the data points are considerable and in most cases the extreme values, or the minimum and the maximum points, on the distribution graphs suggest that there is some uncertainty involved. Majority or more than 90% of the calculated standard deviation for the parameters are higher than 0.9 as shown in table 8. This suggest that the data points are quite spread and not clustered around the mean value and indicates that there are some skeptics regarding this high impact of these parameters on the Icelandic economy.

5.4.3 Preference per Stakeholder

The extent to which different groups of stakeholders estimate foreseen impact, as a result of the business activities described in each statement of the survey, is shown in Figure 28. The numbers on the x axis correspond to the numbers and statements in table 10 below the figure.

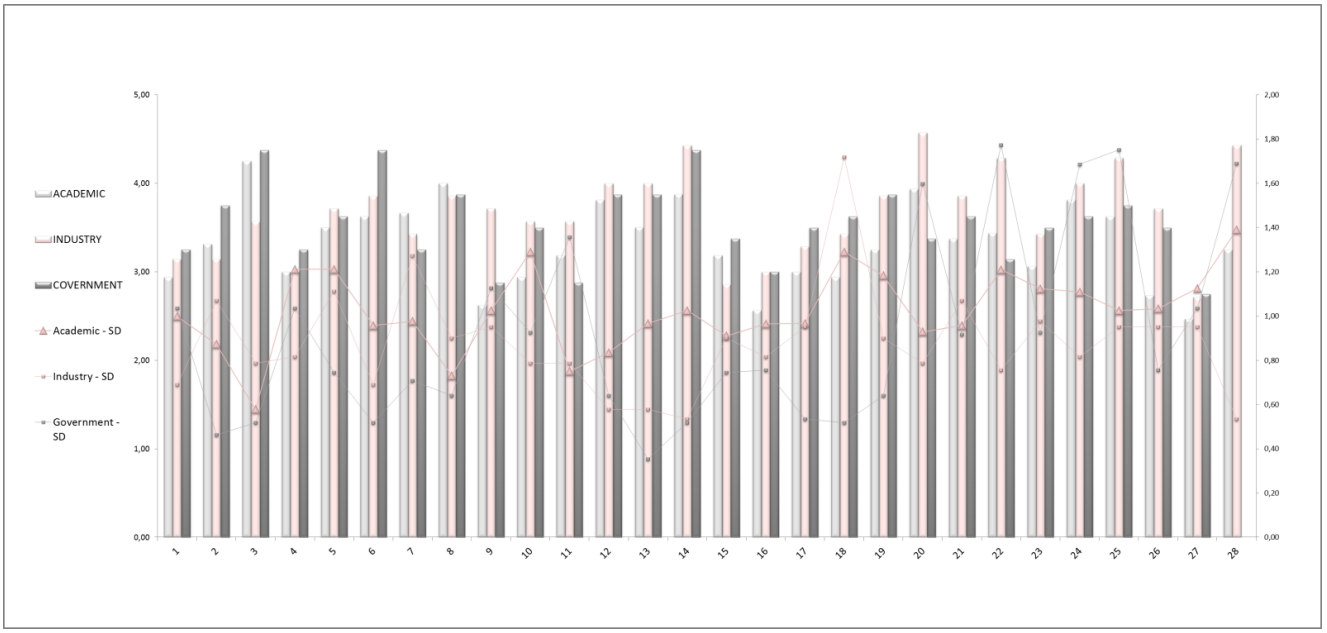

Figure 28 – Impact factor per stakeholder group

Table 10– Sub – categories of economic parameters grouped under the each main economic parameter.

Economic Parameter	Sub - Category of Parameter	#
Fisheries	Impact factor of fisheries in the Arctic Region	1
	Impact factor of shifting of the fish stocks in the Arctic Region	2
Greenland	Impact factor of mining activities in Greenland	3
	Impact factor of local knowhow and experience in relation to miscellaneous service in Greenland	4
	Impact factor of cargo shipments to and from Greenland	5
	Impact factor of the need of educated workforce in Greenland	6
	Impact factor of the geographical closeness to Greenland	7
	Impact factor of processing oil and gas in Greenland	8
Natural Resource	Impact factor of oil and gas exploration	9
	Impact factor of processing minerals in the Arctic	10
	Impact factor of processing of oil and gas	11
	Impact factor of energy consumptions in the Arctic	12
Rescue and Security	Impact factor of Joint Coordination Center for search-and-rescue operations	13
	Impact factor of the need of Coordination, collaboration, and interoperability among and between the Arctic nations	14
	Impact factor of the need of monitoring marine traffic (fishing vessels, ice breakers, cruise ships etc.)	15
	Impact factor of interaction and information sharing with the private sector	16
Service	Impact factor of migration of people to the Arctic Region	17
	Impact factor of local knowhow and experience in relation to miscellaneous service in the Arctic	18
	Impact factor of the need of supporting infrastructure in the Arctic (public transport and accommodation)	19
	Impact factor of the need of educated workforce in the Arctic region	20
Tourism	Impact factor of cruise ships in the Arctic region	21
	Impact factor of tourism in the Arctic region	22
Transportation - Sailing / Air	Impact factor of maritime activities across the Arctic	23
	Impact factor of maritime activities in the North East passage	24
	Impact factor of passenger's aircrafts in the Arctic Region	25
	Impact factor of cargo aircrafts in the Arctic Region	26
	Impact factor from maritime activities in the North West passage	27
Transshipment Port	Impact factor of transportation port in Iceland	28

5.5 Discussion of the results

The response rate for the survey of 50% is sufficient to validate the findings from step 1 and to evaluate the impact factor for each statement for the purpose of this thesis. Even so, the number of participants in this research is limited. The analysis of each economic parameter, e.g. sub-categories revealed there are some skeptics regarding the impact of these parameters on the Icelandic economy indicating the necessity of increasing the sample size.

The work method designed in this step of the study is believed to be beneficial for the remaining work of the DMA project, both on a larger sample and to define new parameters in different fields. Also, the data collection in this step of the research can continue with the aim of supporting the DMA project with more robust impact factors for each category and sub-category of the economic parameters. The methodology used in this step has proved to be of value to the work in validating these impact factors.

5.6 Conclusion

The analysis indicates that all of the predefined categories of economic parameters defined in step 1 receive an impact factor of higher than average suggesting a relatively strong consensus among the majority of the stakeholders regarding the impact of those parameters. The economic parameters estimated to have the highest impact on the Icelandic economy next 20 years based on the analysis of the findings of step 2 of the research are (in hierarchy order):

1. Fisheries
2. Tourism
3. Rescue and Security
4. Service
5. Transshipment Port
6. Greenland
7. Transportation – shipping and air
8. Natural resources

On the other hand the standard deviation for each category of the economic parameter indicates some diverse opinion among the stakeholders on the importance of the parameters since the data points do not all fall close to the mean value. The use of discriminative power also suggested some disagreement amongst the respondents, but not high.

It can be concluded that these findings did support the definition of the economic parameters in step 1 of this research since they are all assumed to have average to high impact. On the other hand, the economic parameters with the highest impact are not in line with the findings from the interviews with experts in step 1.

Analysis of each statement, or sub-category of the economic parameters, showed that they are all assumed to have average to very high impact on the Icelandic economy in the next 20 years. Some diversity in the responses was discovered by calculating the discriminative power for each statement which suggests that the respondents were not in agreement regarding the impact of the economic parameters. The majority or more than 90% of the calculated standard deviation for the parameters are higher than 0.9 which means that the data points are quite spread and not clustered around the mean value. This indicates that there are some skeptics regarding this high impact of these parameters on the Icelandic economy. The extreme values (minimum and maximum values) support this.

The objective of this chapter was to identify the parameters with the highest impact on the Icelandic economy in the next 20 years, to continue analyzing the requirements and to validate the findings of the previous step. These objectives have all been met with the analysis of the data collected from the surveys.

The findings answer the first two research questions driving this research and can be used as input of the conceptual model

6 Step 3 – Conceptual Model

In this step of the research the findings from document analysis, step 1 – interviews with various experts and step 2 –surveys will be combined and used as an input to formulate the conceptual model.

6.1 Introduction

The possible cross-impact relations or the interconnection for each economic parameter defined in this research was judged thought the strength was not estimated.

Two cross-impact matrixes were generated guided by the theoretical framework presented in chapter 2.4.3. The first matrix represents the connection of each sub-category of economic parameter to the eight groups of economic activities. The second matrix evaluates how these parameters of the sub-group are interconnected.

Conceptual model was also constructed where the size of the circle, or the economic parameter, indicates the impact on the Icelandic economy in the next 20 years.

The probability of each parameter and the strength of the interconnection are not within the scope of this research.

6.2 Cross Impact Matrix [nxm]

The cross impact matrix on the next page has the rows and columns representing the economic parameters *n* and sub-categories *m* respectively defined by document analysis and in step 1 of this research. The impact factor for each economic parameter estimated in step 2 of this research is shown in the top row of the matrix. The cells suggest the connection of the sub-parameter to the relevant economic parameter with simple yes or no. The connections are merely suggestions at this phase of the DMA project and have not been verified. Note that the suggested connection might be positive and/or negative.

Table 11 – Cross Impact Matrix indicating the interconnection of parameters.

Impact Factor:	3,4	3	3,9	3,5	3,2	3,6	3,5	3,9
ɔnomic Parameter:	Greenland	Natural Resources	Tourism	Trans-shipment Port	Transport - Shipping/Air	Rescue and Security (Safety)	Service (Added value)	Fisheries
Oil & Gas in Russia	NO	YES	NO	YES	YES	YES	YES	YES
Oil & Gas in Greenland	YES	YES	NO	YES	YES	YES	YES	YES
Mines in Greenland	YES	YES	NO	YES	YES	YES	YES	NO
Energy to Greenland / Arctic	YES	YES	NO	YES	YES	YES	YES	NO
Oil in Iceland (Drekasvæði)	NO	YES	YES	YES	YES	YES	YES	NO
Tank Hotel	YES	YES	YES	YES	YES	YES	YES	NO
Fishing in Iceland	YES	YES	NO	NO	YES	YES	YES	YES
Fishing in the Arctic	YES	YES	NO	NO	YES	YES	YES	YES
Coordinate CENTER response + rescue	YES	YES	YES	YES	YES	YES	YES	YES
Transport	YES	YES	YES	YES	YES	YES	YES	NO
Cruise Ships	NO	NO	YES	YES	YES	YES	YES	NO
Cargo	YES	YES	NO	YES	YES	YES	YES	NO
Ice breakers	NO	YES	NO	YES	YES	YES	NO	NO
Infra-structure	YES	YES	YES	YES	YES	NO	YES	NO
Tourism in Iceland	YES	YES	NO	YES	YES	YES	YES	NO
Tourism in Arctic	YES	YES	YES	YES	YES	YES	YES	NO
Increase in Population in the North	YES	YES	YES	NO	YES	YES	YES	YES
Hospital	YES	YES	YES	YES	YES	NO	YES	NO
Research	YES	YES	NO	NO	YES	YES	NO	YES
Maintenance	YES	YES	NO	YES	YES	NO	YES	NO

6.3 - **Cross Impact Matrix [mxm]**

In this cross impact matrix the rows and columns represent the sub-categories of economic parameters *m* and the cells suggest their possible interconnection with a simple yes or no. The interconnections have not been verified and they only serve to indicate the possible connection and the use of the matrix. This matrix was formulated from the findings in step 1 and 2.

Table 12 – Cross Impact Matrix indicating the interconnection of parameters.

	Oil & Gas in Russia	Oil & Gas in Greenland	Mines in Greenland	Energy to Greenland / Arctic	Oil in Iceland (Drekasvæði)	Tank Hotel	Fishing in Iceland	Fishing in the Arctic	Coordinate CENTER response + rescue	Transport	Cruise Ships	Cargo	Ice breakers	Infra-structure	Tourism in Iceland	Tourism in Arctic	Increase in Population in the North	Hospital	Research	Maintenance
Oil & Gas in Russia	NO	NO	NO	YES	NO	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Oil & Gas in Greenland	NO	NO	NO	YES	NO	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Mines in Greenland	NO	NO	NO	YES	NO	NO	NO	NO	YES	YES	NO	YES	NO	YES	YES	YES	YES	YES	YES	YES
Energy to Greenland / Arctic	YES	YES	YES	NO	YES	NO	NO	NO	NO	YES	NO	NO	NO	YES	NO	NO	NO	NO	NO	YES
Oil in Iceland (Drekasvæði)	NO	NO	NO	NO	NO	YES	YES	YES	YES	YES	YES	NO	NO	YES	YES	NO	NO	YES	YES	YES
Tank Hotel	YES	YES	NO	NO	YES	NO	YES	NO	YES	YES	YES	YES	NO	YES	YES	NO	NO	NO	NO	YES
Fishing in Iceland	YES	YES	NO	NO	YES	YES	NO	YES	YES	YES	NO	NO	NO	NO	YES	NO	YES	NO	NO	NO
Fishing in the Arctic	YES	YES	NO	NO	YES	YES	YES	NO	YES	YES	NO	NO	YES	NO	YES	YES	YES	NO	NO	NO
Coordinate CENTER response + rescue	YES	YES	YES	YES	YES	YES	YES	YES	NO	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Transport	YES	YES	YES	YES	YES	YES	YES	YES	YES	NO	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Cruise Ships	YES	YES	YES	YES	NO	YES	NO	NO	YES	YES	NO	NO	YES	YES	YES	YES	YES	YES	NO	YES
Cargo	YES	YES	YES	YES	YES	YES	NO	NO	YES	YES	YES	NO	YES	YES	YES	YES	YES	NO	NO	YES
Ice breakers	YES	NO	NO	NO	NO	NO	NO	YES	NO	YES	YES	YES	NO	NO	NO	YES	NO	NO	NO	NO
Infra-structure	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	NO	NO	YES	YES	YES	YES	NO	YES
Tourism in Iceland	NO	NO	NO	YES	YES	YES	YES	NO	YES	YES	YES	YES	NO	YES	NO	YES	YES	YES	NO	NO
Tourism in Arctic	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	NO	YES	YES	NO	NO
Increase in Population in the North	YES	YES	YES	YES	YES	NO	YES	YES	YES	YES	YES	YES	NO	YES	YES	YES	NO	YES	YES	NO
Hospital	YES	YES	YES	NO	YES	NO	NO	NO	YES	YES	YES	YES	NO	YES	YES	YES	YES	NO	YES	YES
Research	YES	YES	YES	NO	YES	NO	YES	YES	YES	NO	NO	YES	NO	NO	NO	NO	YES	YES	NO	YES
Maintenance	YES	YES	YES	YES	YES	YES	NO	NO	NO	YES	YES	YES	YES	YES	NO	NO	YES	YES	YES	NO

6.4 Cross-Impact Diagram

The findings from the total inquiry were used as input to construct the cross-impact diagram or the conceptual model shown below. The economic parameters *n* are represented with red circles and the size of the circle is in indirect context with their impact factor. The grey circles represent the sub-economic parameters *m* but the sizes of those circles are meaningless.

The dashed arrows suggest the possible interconnections between these parameters. Note that these interrelations were not verified in this research and serve primarily to give a visualization of the possible interrelation of the economic parameters impacting Iceland the next 20 years. As in the matrix, the connection between stated parameters might be regarded as positive and/or negative.

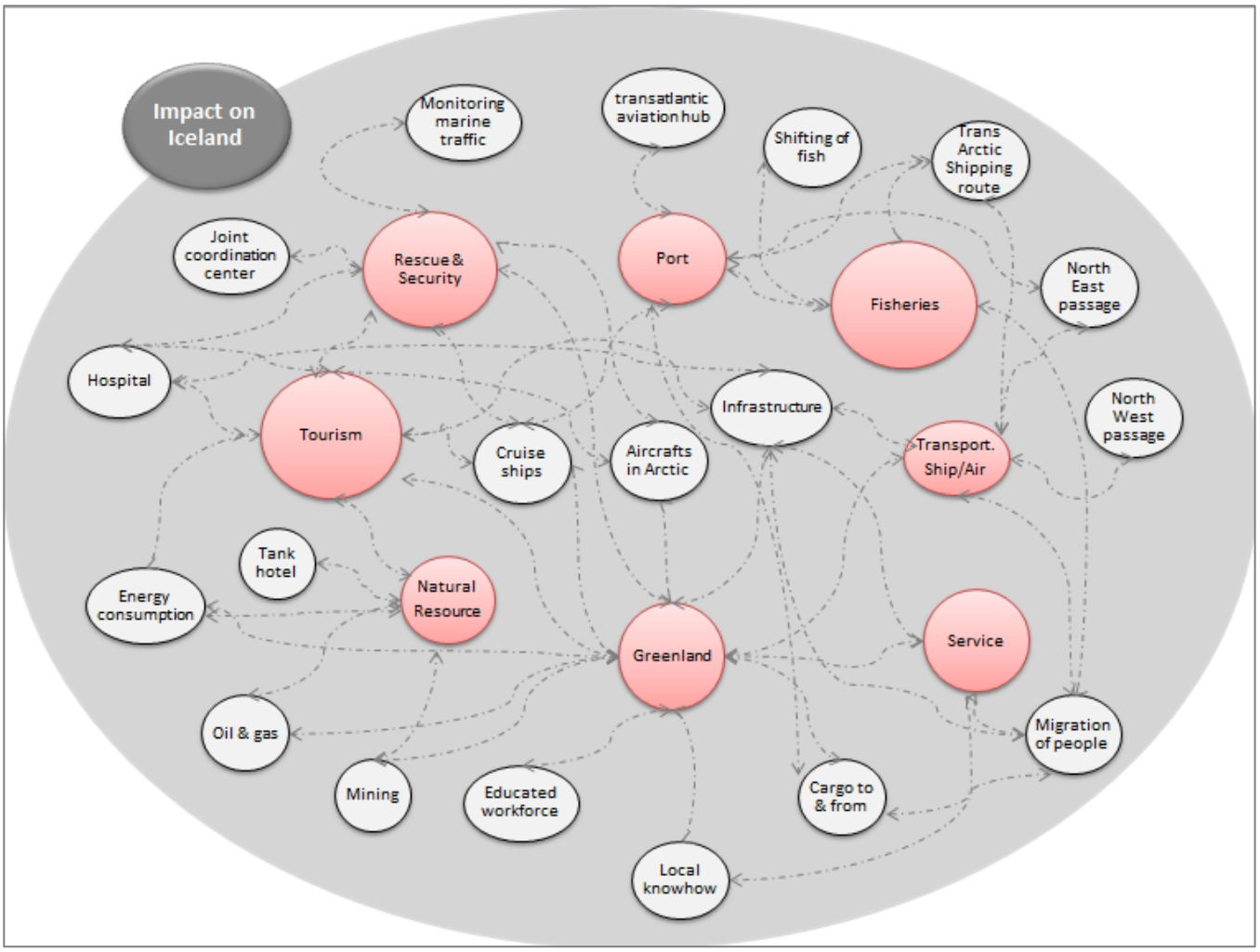

Figure 29 – Conceptual model of the economic parameters

6.5 Discussion of the results

The CIA method is a good technique to deal with ill-defined uncertainty and circumstances as is the case with in the Northern hemisphere. The conceptual model constructed in this chapter serves as an abstract of a model that will predicts future events by capturing the interactions among variables. The evaluation of the influence factor or the strength of the interrelation was not within the scope of this study. The next step would be to determine the connection between variables with cross-impact relationships. These relationships would then be categorized as either positive or negative to each other and used to determine which scenarios are most probable or likely to occur within a given timeframe.

The matrix and the conceptual model allow for modification in the future work of the DMA project and the analyst to find both the most influential variables and those variables that are impacted by the most other variables

6.6 Conclusion

Both the cross-impact matrix and the cross-impact diagram above give a good and easily understood visualization of the conceptual decision model of the strategic business planning of the Arctic Region. Though the strength of the interaction among the economic parameters where not define in this research the conceptual model clearly demonstrates the complications of the interrelation of these parameters and that they cannot be dealt with as isolated entities.

7 Results

This chapter is a summary of the key findings obtained in the total inquiry. The research objectives are revisited and it is stated where these were covered within the thesis.

The driver of this research was the creation of the requirements for the DMA project, which can be defined as the initial step of the decision analysis or the identification phase. This research therefore followed the first two steps of the identification phase of the decision analysis process, defined by Keeney (1982), as a framework to structure the decision problem and to assess possible alternatives for the economic parameters impacting Iceland due to business activities in the Arctic.

This study has additionally explained and utilized how requirement analysis can be applied in pursuing the input for the purpose of decision analysis, and described the conceptual models to be used as an abstract of the decision model for the Arctic Region.

The literature with focus on the identification phase of decision analysis, early requirement analysis in software- and system engineering and conceptual modeling supported the purpose of this study well.

This research was pragmatic and can be classified as mixed or multi-strategy design, combining both fix and flexible design elements. The priority of the study was on the qualitative data collection in step 1 that was followed by quantitative data collection in step 2. These two steps included:

- Step 1-Expert Interviews: to define with qualitative data the economic parameters impacting the Arctic Region (i.e. Iceland) due to future activities in the area. Information was collected with techniques including interviews and document analysis. The results of the interviews were investigated with the aim to define the most critical parameters to be included in the model. This part of the research is flexible design and is classified as exploratory. The objective is to answer all three research questions but focusing on the first.

- Step 2-Internet-based surveys: to validate the findings from previous step and to highlight the most critical economic parameters with quantitative data. Information was collected using a questionnaire via the internet. This part of the research is fixed and classified as exploratory. The objective is to answer all three research questions but focusing on the second.

The data collected with both methods were selected for further analysis and to form the conceptual model in step 3 but new and better options will be sought through the lifetime of the DMA project.

In matters of the Arctic Region, the uncertainty due to the melting of the icecap makes it difficult to grasp future outcomes or impact of these changes. In this study the pool of alternatives was therefore minimized by narrowing the focus of the requirement analysis to just the economic parameters influencing the Icelandic economy. The horizon for the decision problem was fixed by limiting the impact of the economic parameters, due to the future activities in the Arctic, to 20 years.

It can be concluded from the findings that there is an interdisciplinary agreement on the economic parameters impacting the Icelandic economy in the next 20 years. Based on this the following parameters have been defined:

1. Fisheries
2. Tourism
3. Rescue and Security
4. Service
5. Transshipment Port
6. Greenland
7. Transportation – ship and air
8. Natural resources

It can be concluded that the findings from step 2 did support the definition of the economic parameters in step 1 of this research since they are all assumed to have average to high impact. Even so, the conclusion of the data analysis in steps 1 and step 2 did not produce the same results concerning the parameters that had the greatest impact on the Icelandic economy. The following table compares the comparison of estimated priority found by analyzing the data from both steps. The table is in hierarchy order where the economic parameter in the top row is estimated to have to greatest impact.

Table 13 – Comparison of findings

Step 1 - Expert's Interviews	
1	Greenland
2 - 3	Tourism
2 - 3	Rescue and Security
4 -5	Fisheries
4 -5	Natural Resources

Step 2 - Survey	
1	Fisheries
2	Tourism
3	Rescue and Security
4	Service
5	Transshipment Port
6	Greenland
7	Transportation – ship and air
8	Natural resources

Transportation (new shipping routes and by air) and Transshipment Port are not thought to be of high importance to the Icelandic economy according to the experts.

All participants felt that business activities in relation to miscellaneous service and local knowledge would play an important role in the coming decades. This is classified as sub-categories of the economic parameters in the table above.

The calculated standard deviations for each economic parameter suggest some diverse opinion among the stakeholders on the importance since the data points in most cases are not clustered around the mean value for the relevant parameter. This indicates that there are some skeptics among the stakeholders regarding this high impact of the defined economic parameters on the Icelandic economy. It can also be concluded from the extreme values (minimum and maximum values) of the foreseen impact of each parameter, shown on the distribution diagrams in Appendix E, that there is uncertainty regarding the impact of the defined parameters. By calculating the discriminative power some diversity in the responses was discovered which also suggests that the respondents were not in total agreement regarding the impact of the economic parameters.

The analysis from step 1 of this research highlighted the greatest uncertainty or risks to all economic variables as the following:

- How Icelandic politicians and industry will response to all the future foreseen changes; that is in communication and preparation or planning due to the foreseen changes.
- Lack of infrastructure and credibility in equipment
- Uncertainty in politics
- Climate/extreme weather

In chapter 6 or step 3 of this research the output from the previous steps was used as an input to construct a cross-impact matrix and a diagram of cross-impacts (Figure 29). This allows users to visualize the application that will be constructed for the strategic business planning of the Arctic Region. Though the strength of the interaction among the economic parameters where not define in this research the presented conceptual model clearly demonstrates the complications of the interrelation of these parameters and that they cannot be dealt with as isolated entities.

It can be therefore be concluded that objectives of steps 1 to 3 in this research have been fulfilled.

- To define the economic parameters (step 1)
- To validate the definition of the economic parameters (step 2)
- To evaluate the impact of the foreseen economic parameters and identify the most critical ones (step 1 and 2)
- The methods and the sampling strategy provided answers to all research questions (step 1, 2 and 3)

These objectives have all been met with the analysis of the data collection from both methods and the construction of the conceptual model shown in chapter 6.

This study proposed the following working practice to be used as guidance for model abstraction:

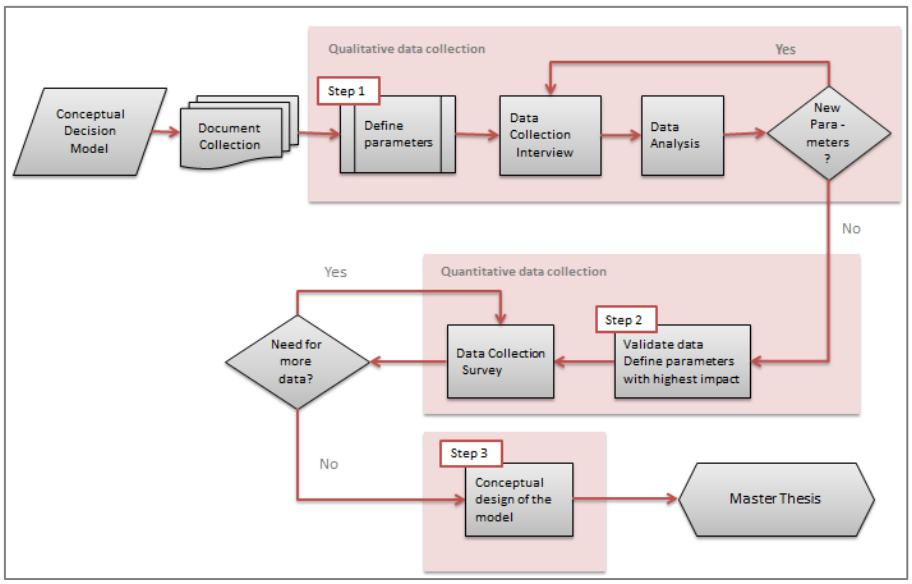

Figure 30 - General plan of the work method

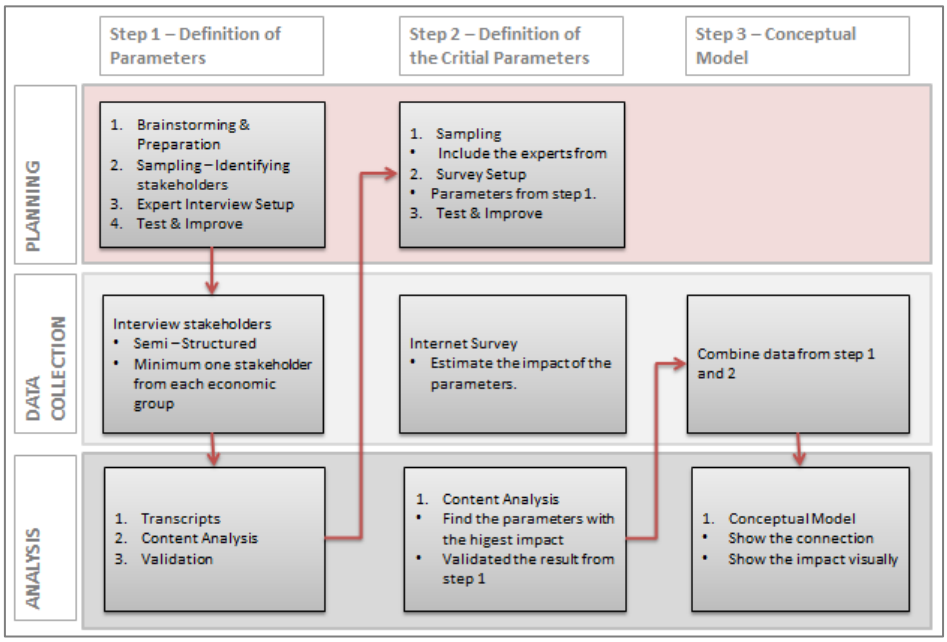

Figure 31 – Research Plan showing each step of the procedure.

This procedure has proven to be highly efficient for scoping the decision problem and to define the parameters needed to construct the decision model.

The findings yielded useful insights enabling all three research questions driving this research to be answered:

1. *What is the scope of an open access decision model for strategic business planning of the Arctic Region (i.e. Iceland)?*
2. *What are the parameters with the highest impact on business evolution in a specific area within the Arctic Region (i.e. Iceland)?*
3. *Is it possible to define the interconnection between these parameters and cross-functional influence?*

The findings also meet all the objectives set at the outset of this research:

- Using stakeholders from academia, industry and government, identify the parameters contributing to the economic development in the Iceland in the context of altered conditions in the Arctic. (step 1)
- Define the parameters in the Arctic development that will influence the Icelandic economy within the scope of this research. (step 1 and 2)
- Estimate the relative impact and statistical attributes (distributions) of the parameters. (step 2)
- Propose a conceptual model and definition of the connection between the parameters with the highest impact. (step 3)
- Present a guide of working practices of phase 1 for the DMA project. (figure 30 and 31)

8 Discussion

This chapter discusses the benefits of the enquiry and items to consider.

"Pragmatic approach views current truth, meaning and knowledge as tentative and as changing over time. What we obtain on a daily basis in research should be viewed as provisional truths." (Robson, 2011:)

This study attempts to do a requirement analysis for the decision model to benefit the business community and the government in making decisions. This research is the first part in research program arranged by CORDA (Centre of Risk and Decision Analysis) which is a part of School of Science and Engineering at RU. The DMA project aims at providing answers on how the rapidly growing human activities in the North Atlantic will affect the economy by developing a decision model. The design of the model can play an important part in understanding and clarifying the decision problem facing the states in the North Atlantic region. In the initial steps of any decision problem it is of highly importance to start by clearly defining what the decision is about, to identify the problems and opportunities to be able to forecast possible scenarios of the future. This is the aim of this study by defining the requirements needed for model to be constructed in the DMA project. The classification of the operational decision model and a detail definition of the development and evaluation phases of the decision analysis were not within the scope of this study.

This research was limited to Iceland. The resons for that were two-fold: first, to minimize the scope of this research and to prevent the study becoming too big; second, due to the data analysis of the interviews with experts in step 1, since the findings focused merely on the Icelandic economy. The findings of the total enquiry (steps 1 and step 2) are more generally applicable outside the specifics of the situation studied and can easily be scaled to include other countries.

There are clearly other parameters or activities influencing decision making in the Arctic Region than those defined in this research, for example environmental and political. Foreseen business activities in the Arctic might impose great risk to the Arctic environment if accidents occur: many dangerous scenarios can be outlined. This might result in negative public opinion which is not addressed in this thesis. There are also some legal and international uncertainties the research did not deal with. Therefore, the research regarded ethical or political norms as external and already fixed.

Another limitation is that the sample in the data collection in step 1 and 2 might not be representative of the population or the future stakeholders of an open access decision model for strategic business planning of the Arctic Region. The analysis of each economic parameter, e.g. sub-categories revealed there are some skeptics regarding the impact of these parameters on the Icelandic economy indicating the necessity of increasing the sample size. Also the findings of the data analysis in steps 1 and step 2 did not produce the same results concerning the parameters estimated to have the greatest impact on the Icelandic economy. The limited number of participants in the total inquiry could therefore be criticized. Nevertheless, limited numbers of respondents was regarded as sufficient for the purpose of this thesis, since the main goal at this phase of the DMA project is to identify and define the economic parameters due to business activity in the Arctic and to gauge their impact.

The discussion forum and work carried out today by various stakeholders associated with the Arctic Region is diverse and variously advanced. Often, experience-based techniques or solutions that are thought to be the most appropriate for a particular decision are used for modern problem-solving. In the case of the Arctic Region, the environment needs to be explored fully and has multiple uncertainties.

Therefore, unaided decisions for strategic business planning in the Region should be avoided. A way to improve judgment is to replace the human judge with an actual model, as is the objective of the DMA project. The decision model for strategic planning of the Arctic Region will be predicated on the assumption that decision makers want to make optimal decisions, but are unable to because of the lack of knowledge or cognitive overload in the face of a complex, risky situation. The use of the model can also serve demonstrate where the risk lies or as a hedging against possible risk.

The technique in step 1 for eliciting requirements to define the economic parameters was quite beneficial and added value to the research. By including different individuals in the process, a clear understanding of the substantive issues of the problem was developed. The use of triangulation to validate the qualitative data, collected in step 1, with quantitative data collection in step 2 enhances the validity of the definitions of the economic parameters or the findings of this research.

The work method introduced in this inquiry and shown in previous chapters has proved to be beneficial. The aim of the procedure was to identify problems and opportunities as well as to structure the decision problem. The designed work method served this purpose well and can be applied to establish the remaining requirements for inclusion in the ongoing work of DMA project, both to include a larger sample and to define new parameters in different fields. Also, the data collection in this study can continue with the aim of supporting the DMA project with more robust impact factors for each category and sub-category of the economic parameters.

The work procedure can also be beneficial in defining, structuring and assessing possible impacts of different alternatives for other decision problems in multiple fields.

9 Conclusions

This chapter revisits the decision problem and further recommendations for future research work and a prognosis of future practice are given.

This study attempts to do a requirement analysis for the decision model to benefit the business community and the government in making decisions The Northern hemisphere could reach a new climatic state in the coming decades. This could result in the Arctic Region being industrially utilized, with commercial shipping through the Arctic Ocean becoming an option in the foreseeable future. However, the area is relatively unexplored with considerable uncertainty with respect to economic, environmental, social, legal and political issues. Also, the attitude of the decision maker can highly affect the solution selected. It can therefore be claimed that the future of the Northern is exciting but is it subject to uncertainty and many outcomes and scenarios are possible so the need for a holistic picture is important.

The aim of the DMA project, which this study is part of, is to provide answers on how the rapidly growing human activities in the North Atlantic will affect the economy in the area. To be able to answer these questions and forecast possible scenarios of the future it needs to be clearly defined what the decision is about and what are the possible option that should be evaluated and selected. This was the objective of this research and the literature fitted well to this scope of this study. This study adopted the requirement analysis activities and iterated between the steps as the research proceeded.

Decision problems in general involve multiple objectives where possibly no course of action can achieve all of the desired options for the decision maker, who would have to consider tradeoffs between benefits. Any analysis of a decision must start with some kind of demarcation of the decision as discussed in chapter 2.2.5 of this thesis and y following the steps of the early requirement analysis the frame or the demarcation of the study was confirmed.

This research proposes an iterative work procedure to structure the decision problem (step 1) and to assess the possible impacts of different alternatives (step 2). Finally the outputs from those steps were used as an input to construct a cross-impact matrix and conceptual model (step 3) which enables a visual overview of the decision problem. However it is recommended to continue the work initiated in this study to refine these findings.

- The comparison of the findings regarding the most critical economic parameters in steps 1 and 2 of this research did not reveal the same outcome. This is considered to indicate that the data collection step 2 should be continued to increase the sample size in the DMA project.

- The interconnection suggested in the cross-impact matrix and the conceptual model in chapter 6 of this study are not confirmed and are tentative outcomes. It was not within the scope of this study to evaluate the strength of the interrelation. The next step would be to determine the connection between variables with cross-impact relationships. These relationships would then be categorized as either positive or negative to each other and used to determine which scenarios are most probable or likely to occur within a given timeframe. The matrix and the conceptual model allow for modification in the future work of the DMA project and the analyst to find both the most influential variables and those variables that are impacted by the most other variables

The conclusion of this study is therefore:

- It can be concluded that the findings from (step 2) did support the definition of the economic parameters in (step 1) of this research since all of the economic parameters were assumed to have average to high impact on the Icelandic economy the next 20 years. Therefore the definition of the economic parameters established in the total enquiry can be used as input to the DMA project carried out by CORDA.

- The evaluations of the expected value of the impact factor for the economic parameters do not reflect their real impact with statistical significance. The sample size in the quantitative data collection in step 2 is estimated to have been too small and analyses of the data indicate that there are some uncertainties among stakeholders regarding the impact.

- The conceptual model in this study visualizes in an informative way the application that will be constructed for the strategic business planning of the Arctic Region. Though the strength of the interaction among the economic parameters where not define in this research the presented conceptual model clearly demonstrates the complications of the interrelation of these parameters and that they cannot be dealt with as isolated entities.

- The iterative work procedure presented in this study is highly robust and will benefit the future work of the DMA project.

- All research questions were answered and the objectives of this research were met.

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12 APPENDIX

12.1 Appendix A – Work breakdown of the Research Questions

Below the research questions have been broken down to form the base of the semi structured interview.

1. What is the scope of an open access decision model for strategic business planning of the Arctic Region?

- What are the main Categories of economic parameters? *(first predefined and confirmed in interviews)*
- Who are the stakeholders of each category, why? *(Pre-defined by researcher)*
- What is the uncertainty in relation to each category and why? *(Interview)*
- Benefits / Profit of each category …why?

2. What are the parameters with the highest impact on business evolution in the Arctic Region (i.e. Iceland)?

- What parameters have the highest impact? *(interviews and survey)*

3. Is it possible to define the interconnection between these variables and cross-functional influence?

- What is the interconnection between these parameters? (*Researcher and survey)*

12.2 Appendix B – Interview Schedule

Characterization (Usability)

Could you tell me shortly what are your connection or interest in the Arctic Region?

Functionality

What do you think is the most influential economic parameters in regard to the general development in the Arctic?

What are the sub categories of the business activities you described previously?

What parameter do you think has the greatest benefits for Icelandic economy?

Now you've you have mentioned XXX, XXX and XXX as the economic parameters, could you give each and one of them a score from 1-5 where 5 is a parameter with a very high impact on the Arctic?

Uncertainty

What do you think are the most influential environmental parameters on these economic parameters?

What uncertainty has the highest influence on the sub categories of the business activities

Which uncertainty do you think is the most critical one and has the highest impact on all of these economic parameters??

Summaries

If I try to summarize what we have discussed so far, what are the highest impact economic parameters in your opinion?

12.3 **Appendix C – Questionnaire**

Table 14 – Questionnaire

1	How would you rate the impact factor of oil and gas exploration on the Icelandic economy in the next 20 years?
2	How would you rate the impact factor of mining activities in Greenland on the Icelandic economy in the next 20 years
3	How would you rate the impact factor of maritime activities in the North East passage on the Icelandic economy in the next 20 years?
4	How would you rate the impact factor of tourism in the Arctic region on the Icelandic economy in the next 20 years?
5	How would you rate migration of people to the Arctic Region would affect the Icelandic economy in the next 20 years?
6	How would you rate the impact of passenger's aircrafts in the Arctic Region on the Icelandic economy in the next 20 years?
7	How would you rate the need of local knowhow and experience in relation to miscellaneous service in Greenland on the Icelandic economy in the next 20 years?
8	How would you rate the impact factor of cruise ships in the Arctic region on the Icelandic economy in the next 20 years?
9	How would you rate the impact of fisheries in the Arctic Region on the Icelandic economy in the next 20 years?
10	How would you rate the impact factor of processing of oil and gas on the Icelandic economy in the next 20 years?
11	How would you rate the impact factor of energy consumptions in the Arctic on the Icelandic economy in the next 20 years?
12	How would you rate the impact factor of Joint Coordination Center for search-and-rescue operations on the Icelandic economy in the next 20 years?
13	How would you rate the impact of re-shifting of the fish stocks in the Arctic Region on the Icelandic economy in the next 20 years?
14	How would you rate the impact factor of maritime activities across the Arctic on the Icelandic economy in the next 20 years?
15	How would you rate the need of local knowhow and experience in relation to miscellaneous service in the Arctic would impact the Icelandic economy in the next 20 years?
16	How would you rate cargo aircrafts in the Arctic Region as an impact factor on the Icelandic economy in the next 20 years?
17	How would you rate the impact factor of processing minerals in the Arctic on the Icelandic economy in the next 20 years?
18	How would you rate the impact of cargo shipments to and from Greenland on the Icelandic economy in the next 20 years?
19	How would you rate the need of supporting infrastructure in the Arctic (public transport and accommodation) as an impact factor on the Icelandic economy in the next 20 years?
20	How would you rate the need of educated workforce in Greenland on the Icelandic economy in the next 20 years?
21	How would you rate the need of Coordination, collaboration, and interoperability among and between the Arctic nations would impact the Arctic economy in the next 20 years?
22	How would you rate the impact factor of transportation port in Iceland on the Icelandic economy in the next 20 years?
23	How would you rate the geographical closeness to Greenland on the Icelandic economy in the next 20 years?
24	How would you rate the need of monitoring marine traffic (fishing vessels, ice breakers, cruise ships etc.) on the Arctic economy in the next 20 years?
25	How would you rate the need of educated workforce in the Arctic region on the Icelandic economy in the next 20 years?
26	How would you rate the impact of processing oil and gas in Greenland on the Icelandic economy in the next 20 years?
27	How would you rate the impact factor from maritime activities in the North West passage on the Icelandic economy in the next 20 years?
28	How would you rate the impact factor of interaction and information sharing with the private sector, be it the global shipping industry, the cruise ship industry, or the oil and gas sector on the Arctic economy in the next 20 years?

12. 4 - **Appendix D - Overview of the data collected in step 2**

	What is your connection to the Arctic Region?				Categories:																								
	Academic	Industry	Government	Other (please specify)	Natural Resource	Greenland	Transportation - Sailing / Air	Tourism	Service	Transportation - Sailing / Air	Greenland	Tourism	Fisheries	Natural Resources	Natural Resources	Rescue and Security	Fisheries	Transportation - Sailing / Air	Service	Transportation - Sailing / Air	Natural Resource	Greenland	Service	Greenland	Rescue and Security	Transshipment Port	Greenland	Rescue and Security	Service	Greenland	Transportation - Sailing / Air	Rescue and Security
					Impact factor of oil and gas exploration	Impact factor of mining activities in Greenland	Impact factor of maritime activities in the North East passage	Impact factor of tourism in the Arctic region	Impact factor of migration of people to the Arctic Region	Impact factor of passenger's aircrafts in the Arctic Region	Impact factor of local knowhow and experience in relation to miscellaneous service in Greenland	Impact factor of cruise ships in the Arctic region	Impact factor of fisheries in the Arctic Region	Impact factor of processing of oil and gas	Impact factor of energy consumptions in the Arctic	Impact factor of Joint Coordination Center for search-and-rescue operations	Impact factor of re-shifting of the fish stocks in the Arctic Region	Impact factor of maritime activities across the Arctic	Impact factor of local knowhow and experience in relation to miscellaneous service in the Arctic	Impact factor of cargo aircrafts in the Arctic Region	Impact factor of processing minerals in the Arctic	Impact factor of cargo shipments to and from Greenland	Impact factor of the need of supporting infrastructure in the Arctic (public transport and accommodation)	Impact factor of the need of educated workforce in Greenland	Impact factor of the need of Coordination, collaboration, and interoperability among and between the Arctic nations	Impact factor of transportation port in Iceland	Impact factor of the geographical closeness to Greenland	Impact factor of the need of monitoring marine traffic (fishing vessels, ice breakers, cruise ships etc.)	Impact factor of the need of educated workforce in the Arctic region	Impact factor of processing oil and gas in Greenland	Impact factor from maritime activities in the North West passage	Impact factor of interaction and information sharing with the private sector
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
1	Academic	Industry	Government		4	3	4	4	2	3	4	3	5	4	4	3	4	4	5	3	3	3	3	4	3	4	3	3	4	4	3	4
2	Academic	Industry			2	3	3	4	3	5	4	4	3	2	3	4	4	4	4	4	2	3	0	3	5	3	5	5	4	2	3	4
3	Academic		Government	personal	4	3	4	4	4	4	5	3	3	3	4	3	3	4	4	4	4	4	4	4	5	5	5	4	5	4	4	5
4	Academic		Government		4	5	4	5	5	5	5	2	4	4	5	3	3	4	5	4	4	4	4	4	4	4	5	5	5	4	1	2
5	Academic		Government		2	2	3	4	2	3	4	3	4	2	3	3	4	3	4	3	3	3	3	4	4	3	3	3	3	2	2	4
6	Academic				3	4	4	5	5	5	5	5	5	3	4	5	5	5	5	4	4	4	4	5	5	4	5	5	5	3	3	5
7	Academic				4	3	4	4	4	2	3	4	4	4	3	3	3	4	4	4	2	2	4	3	4	4	4	4	3	2		0
8	Academic				2	2	2	4	1	2	2	2	4	1	1	2	4	1	1	2	1	2	1	2	2	2	2	2	2	2	2	2
9	Academic				2	2	4	5	3	5	3	5	5	1	4	3	5	4	3	3	2	2	2	2	3	4	3	4	2	2	2	2
10	Academic				4	3	3	4	2	3	3	4	3	2	2	3	2	3	4	3	2	2	3	2	3	3	4	3	3	3	1	3
11	Academic				1	2	3	4	3	4	3	4	4	2	3	3	3	3	4	3	2	2	3	2	5	3	3	3	2	2	2	4
12	Academic				5	5	5	5	4	5	5	5	5	4	4	4	4	4	5	5	4	5	5	5	5	5	5	5	5		5	5
13	Academic				2	3	3	4	3	2	3		4	2	3	3	4	4	3	2	2	3	3	2	4	3	3	4	2	2	3	3
14	Academic				3	3	3	4	3	2	3	4	4	3	2	2	4	3	3	2	2	2	2	3	3	3	4	2	4	2	3	3
15	Academic				4	2	2	5	1	3	3	4	3	3	0	4	4	2	4	2	2	4	2	5	4	2	5	3	4	5	2	4
16	Academic				3	2	2	3	3	3	3	3	4	2	2	3	5	4	4	3	2	3	4	2	4	2	2	3	2	2	1	2
17		Industry			4	4	2	4	4	4	5	4	3	4	4	3	4	4	5	3	4	5	5	5	5	5	5	5	5	4	3	5
18		Industry			4	3	2	2	2	2	3	1	3	5	4	3	3	3	4	1	3	3	3	3	5	2	3	5	3	3	1	4
19		Industry		cluster manag	4	3	5	4	3	4	4	4	4	4	4	4	4	4	4	3	3	3	4	5	5	4	4	4	5	5	3	5
20		Industry		Cooperation M	2	2	3	4	4	5	3	5	5	4	4	5	5	5	5	3	2	2	5	4	5	5	4	5	5	4	2	5
21		Industry		Shipping comp	4	4	3	3	3	3	4	3	4	3	2	3	4	4	4	3	4	4	4	3	4	4	4	3	4	4	4	4
22			Government		2	3	4	5	3	4	4	3	4	1	2	0	4	4	4	3	3	4	4	4	0	4	0	0	0	4	3	0
23			Government		4	4	4	4	3	4	4	4	4	4	3	3	4	4	4	4	3	3	3	3	3	4	4	5	3	3	2	4
24			Government		4	4	3	5	4	3	5	4	3	3	4	3	4	4	5	4	2	4	4	5	5	3	5	5	2	4	3	4
25			Government		4	2	4	4	3	3	4	4	4	2	3	5	5	4	4	2	2	3	4	3	3	2	4	5		3	4	5
	Weighted Average				3,24	3,04	3,32	4,12	3,08	3,52	3,76	3,63	3,92	2,88	3,08	3,20	3,92	3,68	4,04	3,08	2,68	3,16	3,32	3,48	3,92	3,48	3,76	3,80	3,42	3,13	2,58	3,52
	Standard Deviation				1,05	0,93	0,90	0,73	1,04	1,08	0,88	1,01	0,70	1,13	1,15	1,04	0,76	0,85	0,89	0,91	0,90	0,94	1,22	1,12	1,22	1,00	1,23	1,29	1,38	1,03	1,06	1,48

Figure 1 – Overview of the data collection in step 2.

12.5 Appendix E - Analysis per economic parameter

The following analyzes the distribution of the impact of each statement, e.g. sub-categories of the economic parameter, on the Icelandic economy in the next 20 years.

Most of the economic parameters receive an impact factor of average or higher. On the other hand, in most cases the extreme values or the minimum and the maximum points, on the distribution graphs below suggest that there is quite some variability and uncertainty involved. Majority or more than 90% of the calculated standard deviation are higher than 0.9 which suggest that the data points are quite spread and not clustered around the mean value.

12.5.1.1 Greenland

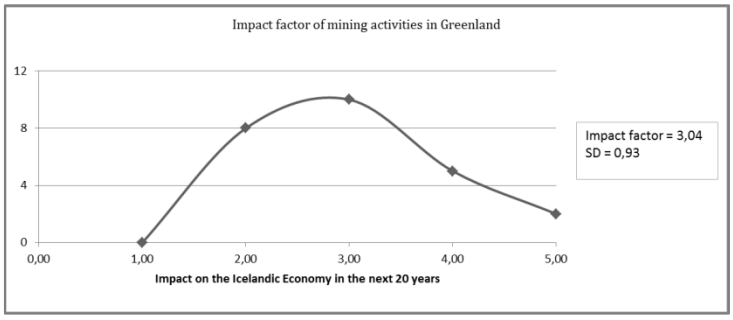

Figure 33 – Impact factor of mining activities in Greenland

The impact factor suggests an average impact on the Icelandic economy in the next 20 years. The extreme points, or the minimum and the maximum values, indicate uncertainty amongst the respondents and the standard deviation shows that the data points are quite spread and not clustered around the mean value.

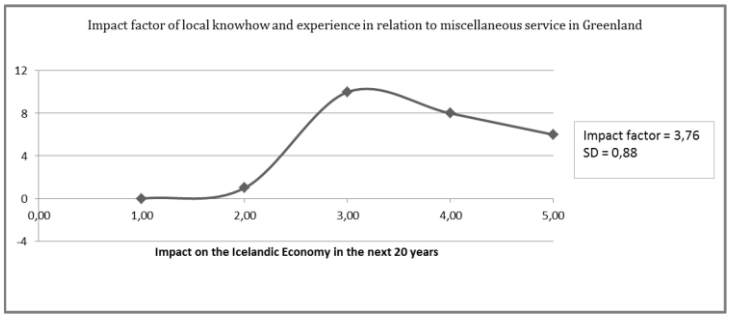

Figure 34 – Impact factor of local knowhow and experience in relation to miscellaneous service in Greenland

The impact is most likely to be average to very high on the Icelandic economy in the next 20 years. The minimum values suggest that there are not overall agreements amongst the respondents.

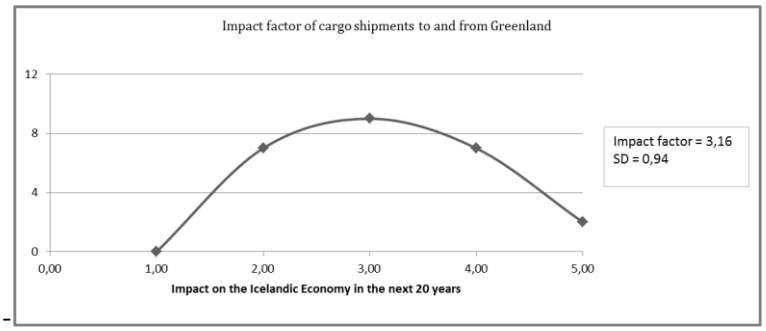

Figure 35 – Impact factor of cargo shipments to and from Greenland

The impact factor suggests an average impact on the Icelandic economy in the next 20 years. The extreme points, or the minimum and the maximum values, indicate uncertainty amongst the respondents and the standard deviation shows that the data points are quite spread and not clustered around the mean value.

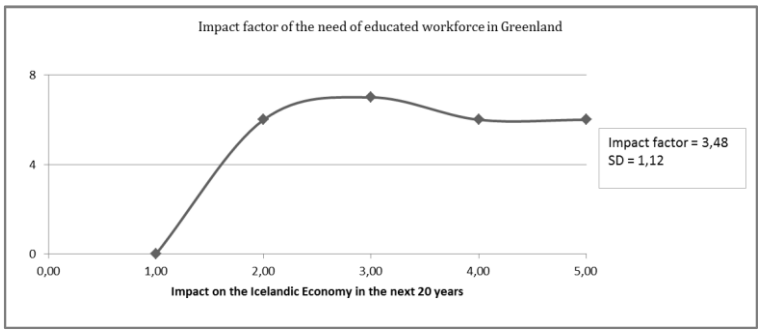

Figure 36 – Impact factor of the need of educated workforce in Greenland

The impact is most likely to be average to high on the Icelandic economy in the next 20 years. There extreme values suggest that there are not overall agreements amongst the respondents and the standard deviation shows that the all the data points are not closed the mean value.

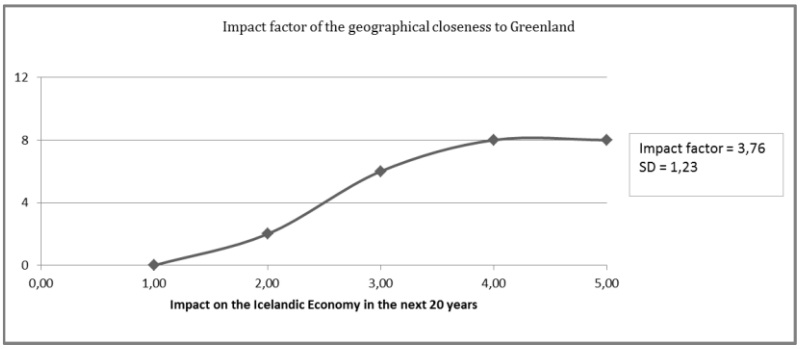

Figure 37 – Impact factor of the geographical closeness to Greenland

The impact factor is 3.76, suggesting high impact on the Icelandic economy in the next 20 years. on the other hand the minimum value suggest that there are some that have doubts regarding this impact and the standard deviation is relatively high.

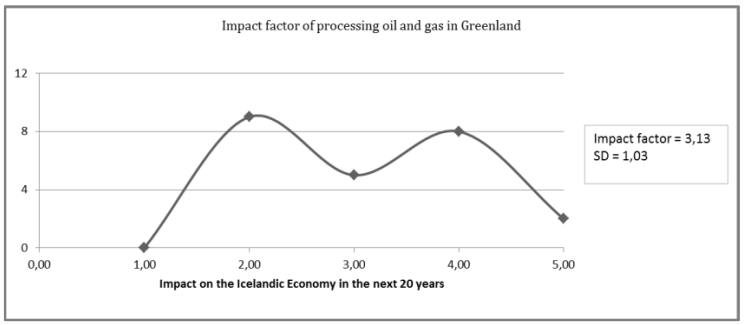

Figure 38 – Impact factor of processing oil and gas in Greenland

The impact factor is 3.13, suggesting average impact but, as the graph demonstrates, the impact factor 'low' and 'high' received the most responses. This and the minimum and maximum values suggests uncertainty among the respondents.

12.5.1.2 Transportation – Ship / Air

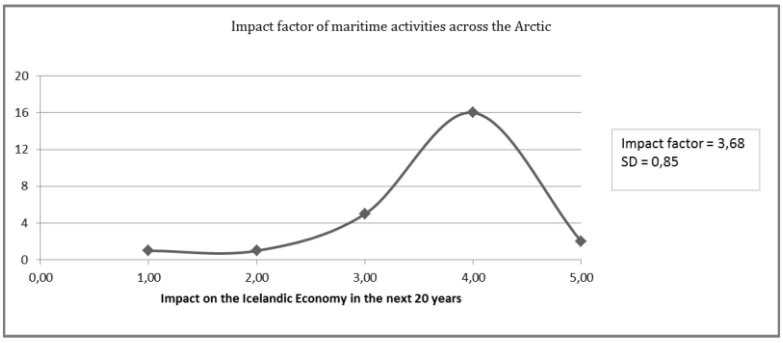

Figure 39 – Impact factor maritime activities across the Arctic

The impact is most likely to be high on the Icelandic economy in the next 20 years.

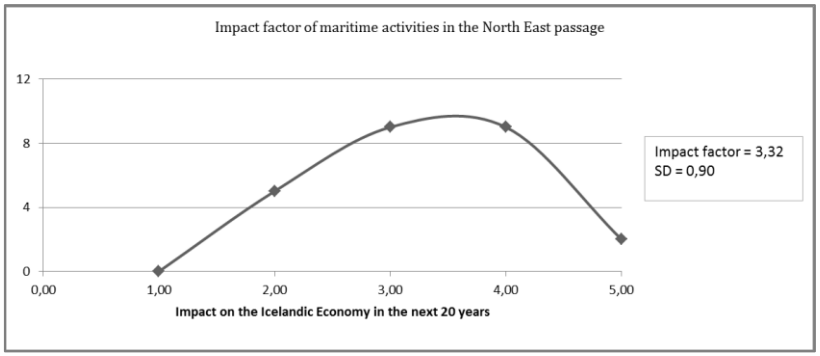

Figure 40 – Impact factor of maritime activities in the North East Passage

The impact factor suggests an average impact on the Icelandic economy in the next 20 years. Still the maximum values indicate uncertainty amongst the respondents and the standard deviation shows that the data points are spread and not clustered around the mean value.

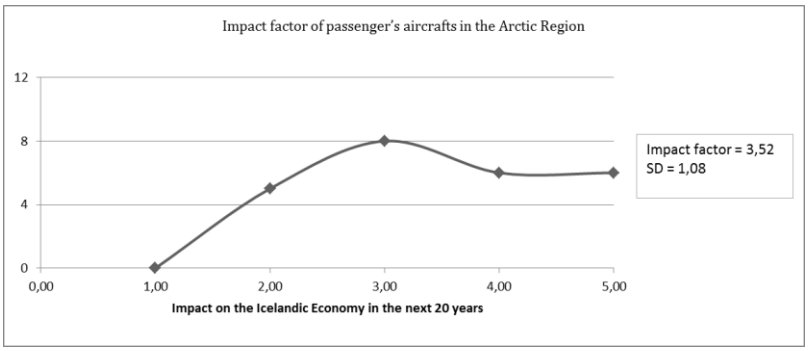

Figure 41 – Impact factor of passenger's aircrafts in the Arctic Region

The impact factor is 3.52, suggesting average to high impact on the Icelandic economy in the next 20 years. The standard deviation shows that the data points are not clustered around the mean value and as the graph demonstrates some of the respondents do have doubts about its impact.

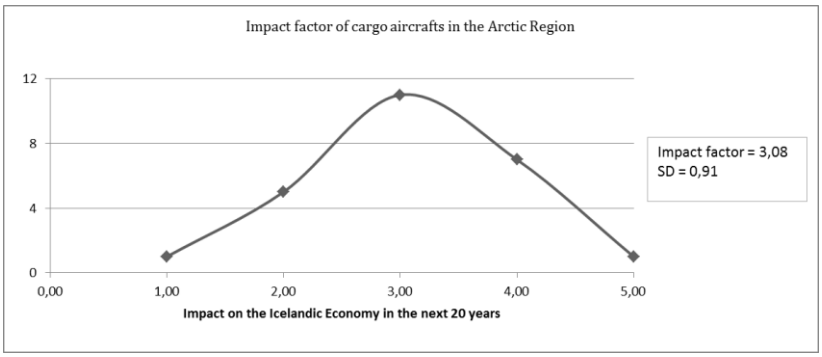

Figure 42 – Impact factor of cargo aircrafts in the Arctic Region

The impact is most likely to be average on the Icelandic economy in the next 20 years.

12.5.1.3 Natural Resources

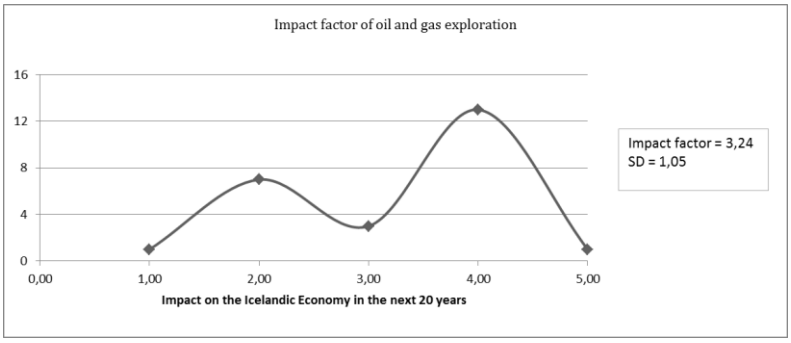

Figure 43 – Impact factor of oil and gas exploration

The impact factor is 3.24, suggesting average impact but, as the graph demonstrates; the impact factor 'high' received the most responses. The minimum values are of interest and suggests a disagreement amongst the respondents.

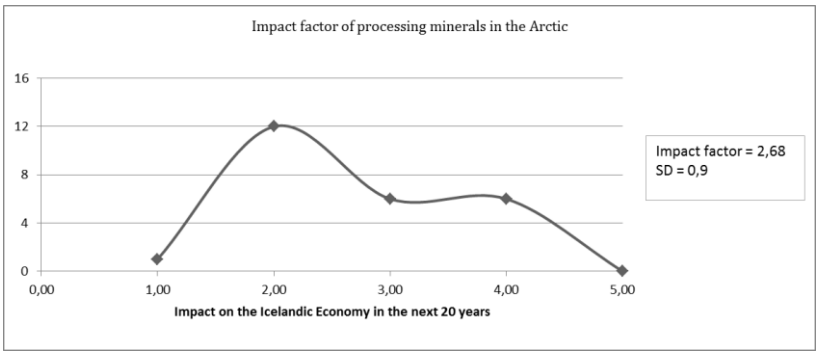

Figure 44 – Impact factor of processing minerals in the Arctic

The impact factor is 2.68, suggesting low impact on the Icelandic economy in the next 20 years. The maximum values are of interest and suggests a disagreement amongst the respondents.

12.5.1.4 Fisheries

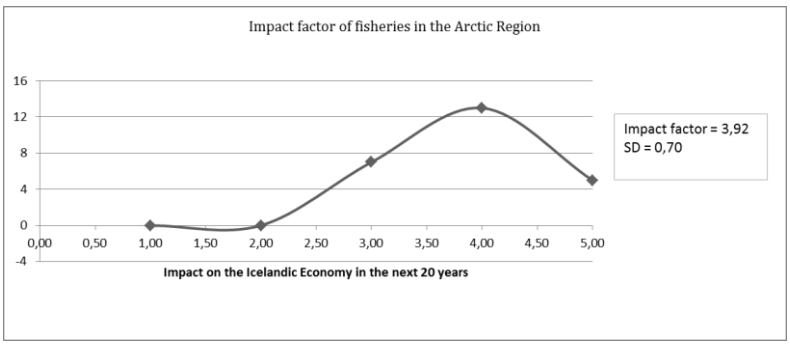

Figure 45 – Impact factor of fisheries in the Arctic Region

The impact is most likely to be high on the Icelandic economy in the next 20 years.

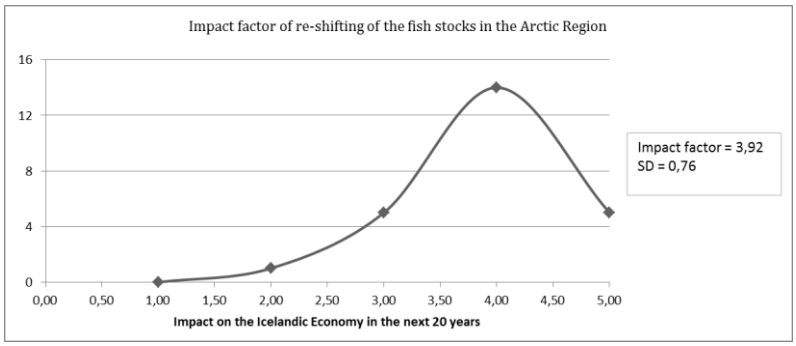

Figure 46 – Impact factor of shifting of the fish stocks in the Arctic Region

The impact is most likely to be high on the Icelandic economy in the next 20 years.

12.5.1.5 Tourism

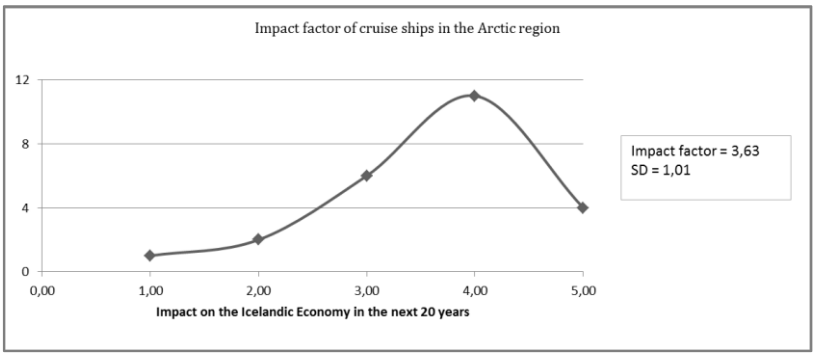

Figure 47 – Impact factor of cruise ships in the Arctic Region

The impact is most likely to be high on the Icelandic economy in the next 20 years.

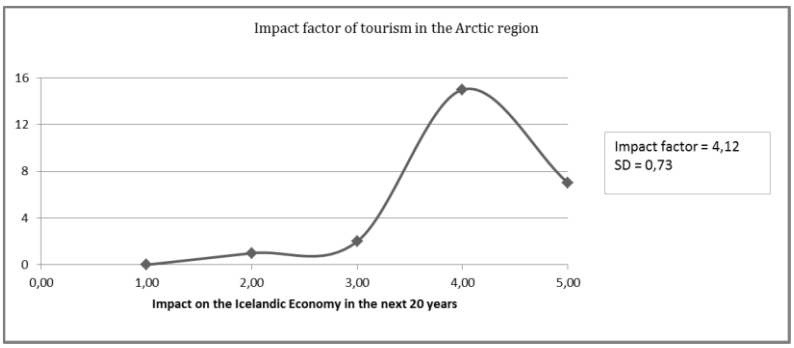

Figure 48 – Impact factor of tourism in the Arctic Region

The impact is most likely to between high and very high on the Icelandic economy in the next 20 years.

12.5.1.6 Transshipment Port

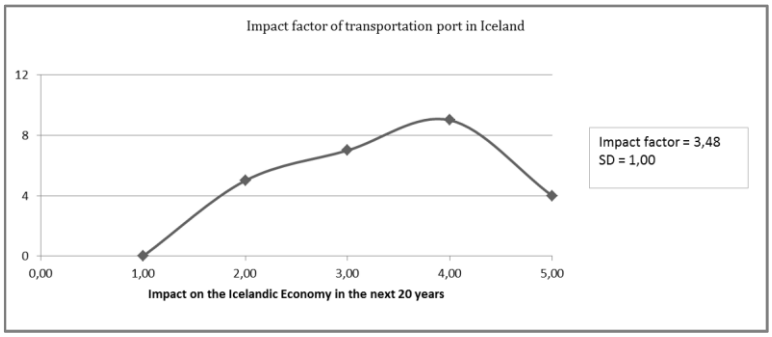

Figure 49 – Impact factor of transportation port in Iceland

The impact is most likely to be high on the Icelandic economy in the next 20 years. The minimum values are of interest and suggests a disagreement amongst the respondents.

12.5.1.7 Rescue and Security

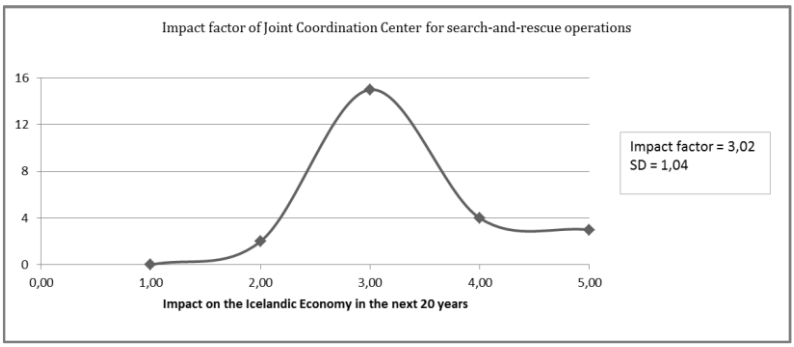

Figure 50 – Impact factor of Joint Coordination Center for search-and-rescue operations

The impact factor is 3.02, suggesting an average impact on the Icelandic economy in the next 20 years.

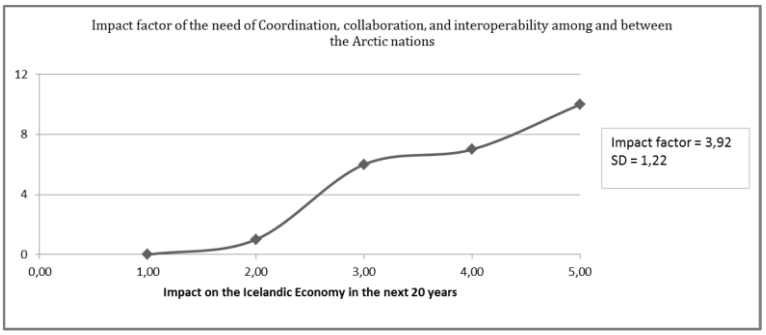

Figure 51 – Impact factor of the need of coordination, collaboration, and interoperability among and between the Arctic nations

The impact factor is 3.92, suggests high impact on the Icelandic economy in the next 20 years. The standard deviation shows that the data points are not clustered around the mean and the graph suggests that some of the respondents do have doubts about this impact being this high.

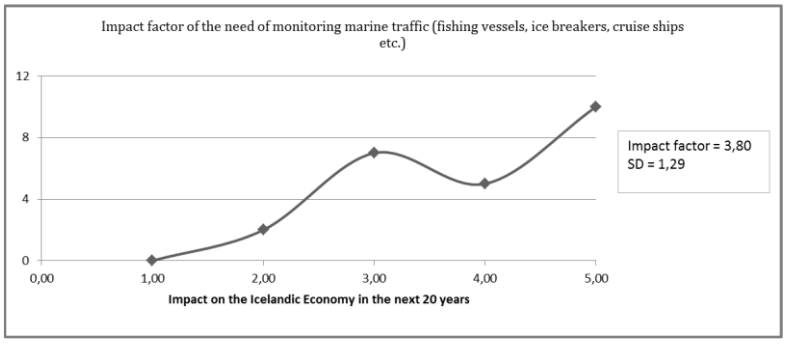

Figure 52 – Impact factor of the need of monitoring marine traffic (fishing vessels, ice breakers, cruise ships etc.)

The impact factor is 3.80, suggests high impact on the Icelandic economy in the next 20 years. The standard deviation shows that some of the data points are not close to the mean and the graph suggests that some of the respondents do have doubts about this impact being this high.

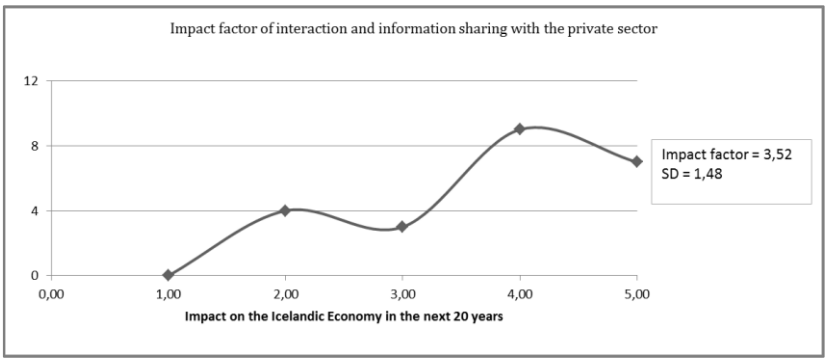

Figure 53 – Impact factor of interaction and information sharing with the private sector

The impact factor is 3.52, suggesting high impact on the Icelandic economy in the next 20 years. The standard deviation shows that the data points are quite spread and not all close to the mean. The graph suggests that some of the respondents do have doubts about this impact being this high.

12.5.1.8 Service

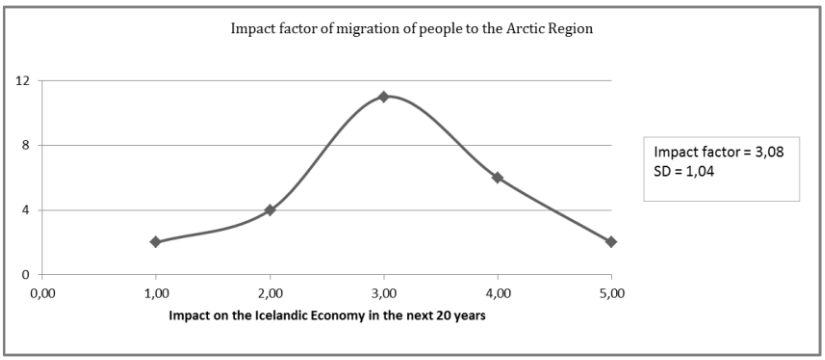

Figure 54 – Impact factor of migration of people to the Arctic Region

The impact factor is 3.08, suggesting average impact on the Icelandic economy in the next 20 years. The standard deviation suggests that some of the respondents are skeptic about this impact since the data points are quite spread.

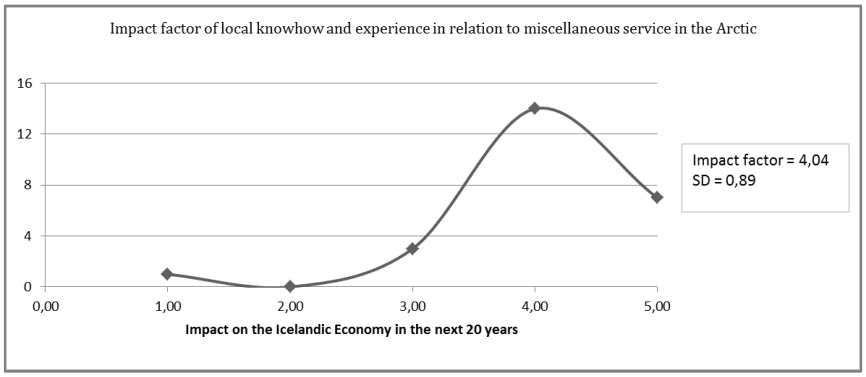

Figure 55 – Impact factor of local knowhow and experience in relation to miscellaneous service in the Arctic

The impact is most likely to between high and very high on the Icelandic economy in the next 20 years.

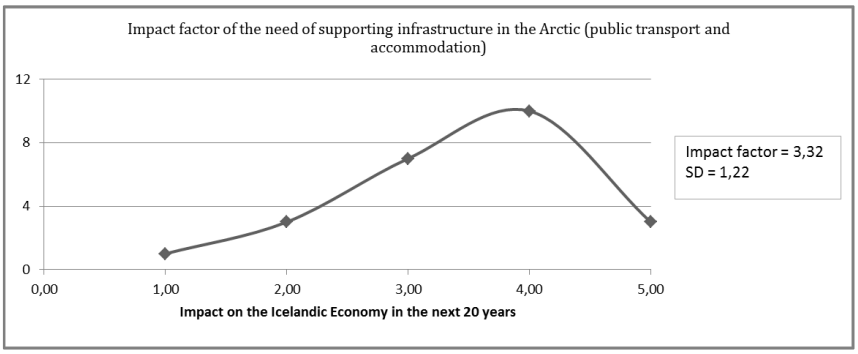

Figure 56 – Impact factor of the need of supporting infrastructure in the Arctic (public transport and accommodation)

The impact factor is 3.32, suggesting average to high impact on the Icelandic economy in the next 20 years.

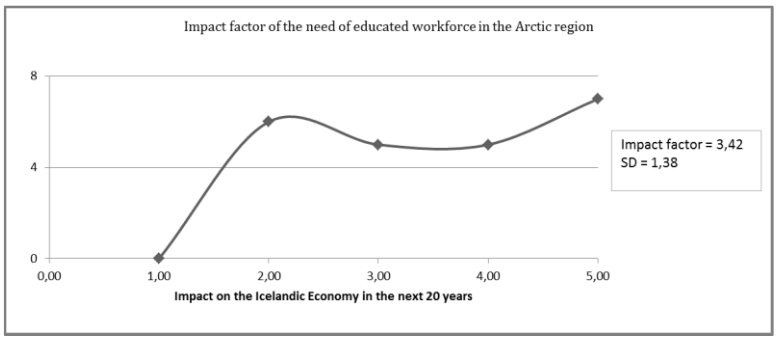

Figure 57 – Impact factor of the need of educated workforce in the Arctic Region

The impact factor is 3.42, suggesting high impact on the Icelandic economy in the next 20 years. Still the minimum values indicate uncertainty amongst the respondents and the standard deviation shows that the data points are spread and not clustered around the mean value.