Bachelor thesis

PET600 Petroleumslogistikk

Distribution model - Algea Case

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Total number of pages: 28

Molde, 02.06.2020

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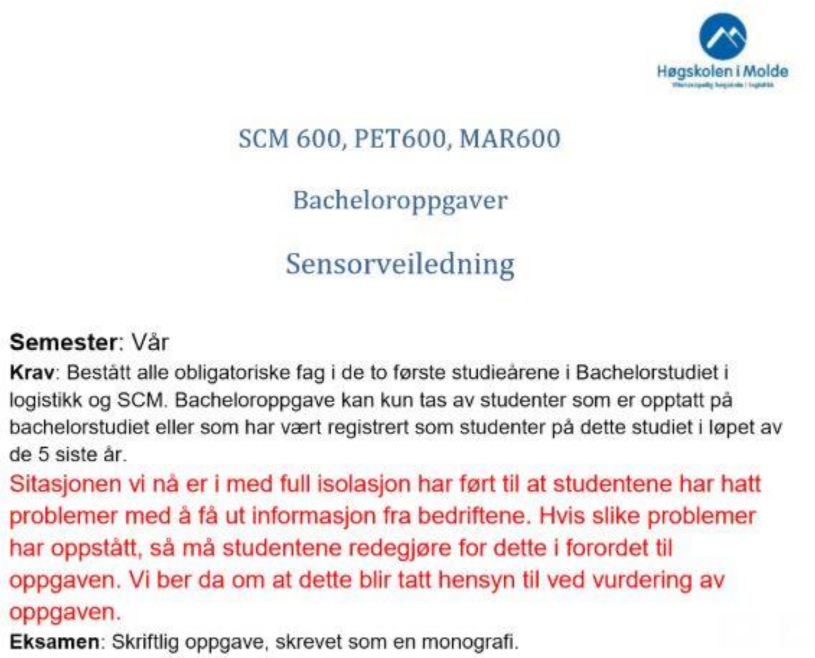
Preface

This thesis marks the end of the university bachelor level program in petroleum logistics from Molde university college We would like to express our gratitude to our supervisor's assistant professor, Bård-Inge Petersen, and Associate professor, Per Kristian Rekdal, for their relentless effort in making this research possible. They guided us very well and provided us with relevant information and feedback. Furthermore, we would like to thank Professor Harald Hjelle for his valuable time and his professional assistance for making the environmental aspect of our thesis more understandable. We would also like to thank Algea, the participant company and Michel Guajardo , for his willingness to participate in this thesis.

During our work on bachelor thesis we received a following e-mail:



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Sitasjonen vi nå er i med full isolasjon har ført til at studentene har hatt problemer med å få ut informasjon fra bedriftene. Hvis slike problemer har oppstått, så må studentene redegjøre for dette i forordet til oppgaven. Vi ber da om at dette blir tatt hensyn til ved vurdering av oppgaven.

Eksamen: Skriftlig oppgave, skrevet som en monografi.

Picture 1 Coronavirus situation:

In short: the effects of coronavirus has had an influence on our ability to communicate with participating company. We would like to ask you to consider this in evaluation of our thesis.

Summary

Algea is a company that collects seaweed from suppliers in the North Sea for further processing at two facilities located in Kristiansund and Brønnøysund. These two facilities are geographically located far away from the majority of the customers. Algea outsources the transport of their products to third-party logistic providers. These providers operate at three different ports located in Bergen, Ålesund and Gjemnes. Products are delivered in bulk to these ports by either boat or truck. After unloading and loading in to 20 or 40 feet containers, the products are shipped to customers abroad. In this process Algea must deal with several issues related to transport. In the present thesis we will address and discuss some of these issues, namely:

- Customers are located in different countries around the world.
- Algea has many customers that order products with various quantities and frequency. This is a challenge, e.g. in regards to forecast.
- Price of shipping a container to customer is various for each port and logistic provider combination. Because of this, optimal transport solution is most likely not the same for every customer.
- The ports also serve/have different accessibility to the customers, which narrows our choices when it comes to affordable alternatives regarding ports.
- The loading and unloading costs at the ports various as well. Gjemnes induce a cost while Bergen and Ålesund are free of charge.
- Algea's customers seek out greener transport solutions.

Complexity as mentioned above cause high transportation costs. Reducing these costs are the main subject of this thesis.

The main potential for cost reduction is the significant price differences between the ports. We have formulated a mathematical distribution model that aims to minimize transportation costs. In order to make our model feasible we consider only 13 of Algea's customers. These customer order frequently. In addition, we simplified the supply chain by restricting to the most commonly used ports and logistic providers.

We have investigated Algea's supply chain by receiving information from their logistic manager. This was done through personal interview, phone calls and e-mails. We have obtained shipping reports for the period from 2018 to 2020. This information was basis for our thesis. We have processed those datasets in order to make it feasible for our model.

Environmental impact caused by transport is a hot topic. Because of this many companies, including Algea, are seeking out greener transport solutions. This is true for their customers as well. We perform an carbon audit for two representative routes to see how much domestic transport impacts the CO2 emissions from distribution. Carbon audit shows that choice of transport mode within Norway has an impact on the total amount of CO2 emissions. Despite small CO2 reduction for one trip it adds up to more significant reductions over a longer periods of time.

Our analysis shows that there is a potential to reduce transportation costs by choosing affordable logistics provider for each customer. We have formulated our model and it may be used as a good foundation to further simulate and compare it to historic costs.

Contents

1.0 Introduction

1.1 Introduction to Algea

Picture 2 Algea Logo(website)

Within the coastline of Norway, in the city of Kristiansund, there is a manufacturing company called Algea. They produce a variety of products at two production sites located in Kristiansund and Brønnøysund. Algea produces animal food and fertilizers from seaweed, by adding chemicals and processing raw materials. The acquiring of the seaweed is done within the coastline of Brønnøysund by boats. Since the company cares about the environment, the seaweed is collected in a way that make as low as possible environmental impact to the ocean. Then the seaweed is distributed between the two production sites, and the manufacturing of the product continues with various processes at the plants.
When the manufacturing is completed, the product is transported to three central ports in Norway for stuffing in containers and to be shipped abroad to end costumers around the world. The distribution of the finished goods abroad is outsourced to external logistics providers. Serval companies are involved such as Schenker, Kuehne & Nagel(K&N) and Freja. All of the transportation companies have different cost, availability schedules and may offer additional services, such as tracking and emission chart with their transport. Algea chooses their providers based on these criteriums above and standardised incoterm agreements. Some of incoterms used are “EX Works”(EXW) and “Free carrier”(FCA) under both of those agreements customer takes responsibility for transport.

From the shipments reports we found that Algea produced and sent 6 409 748 kg of their products in total.

PRODUCTION SITE	PRODUCTION: 2019	PRODUCTION: 2018 FROM WEEK 25 -52

KRISTIANSUND	4 710 656 kg	2 767 366 kg
BRØNNØYSUND	1 699 092 kg	903 580 kg
TOTAL	6 409 748 kg	3 670 946 kg

Table 1: Total production capacity half of 2018 and entire 2019 (data sample from 2018 starts at week 25 therefore is much smaller)

Our thesis is about Algea's distribution challenges, their customers are complaining about high transportation cost. We have being given the opportunity to get an insight in to their supply chain, and found that it may be possible to optimise distribution costs with the use central theories about aggregated planning and linear programming. Distribution contains use of transport modes, which they all make an environmental impact to our globe. The environmental aspect of distribution is a hot topic within governments and companies. Therefore we include a separate carbon audit. The purpose with that audit is to see if the environmental impact can be reduced by choosing different types of mode in certain routes.

1.2 Ports and distribution

In this part we explain details about Algea distribution. All figures are drawn by us with use of lucid chart which is an online tool for drawing charts. Our knowledge is based on interviews with Algea's supply chain specialist. Algea's supply chain starts with two production sites. First one located in Brønnysund, where they have access to raw materials from the sea. When the raw materials are collected some of it is processed and shipped from Brønnøysund, and some of them are shipped to the second production plant in Kristiansund to be processed in to different products. When the manufacturing is completed at the production plants, Algea has the option to send the finished gods to three different ports, transport is carried out in bulk and involves either truck or boat. These ports are Bergen, Ålesund, and Gjemnes. They are important hubs than connect domestic with international distribution and all of them have advantages and limitations that must be accounted for. Gjemnes has the advantage of being close to the production plant in Kristiansund. That makes it possible to prepare multiple shipments abroad, using terminal located in Gjemnes. The disadvantages are high stuffing costs when preparing containers, the other limitations is that only smaller boats can lay by the port. This also limits the distances the boat can travel abroad after being loaded. Ålesund is also located close to the production plant in Kristiansund. The advantage of this port is that bigger boats can be operated and used for further distances abroad. The downside of using this port are high shipping cost. Bergen has the advantage of being affordable to ship products from Norway and further abroad. The problem with using this port is that it transport towards Bergen requires use of truck and boat. This results the excessive need of manual handling for unloading the vessel with forklift and loading the truck before arriving Bergen ready for stuffing into containers. Products are unloaded and stuffed in containers on arrival at ports. They are stuffed either in 20 feet or 40 feet containers. One 20 feet container has a payload of 10 tons while 40 feet can hold up to 26 tons with Algea's products. Only exception is America where 40 feet container is restricted to 19 tons. All transport further transport from ports to customers is carried out by boats. Algea's customers are located in Europe, Asia, Africa and America. In all three ports there are different logistics providers available.

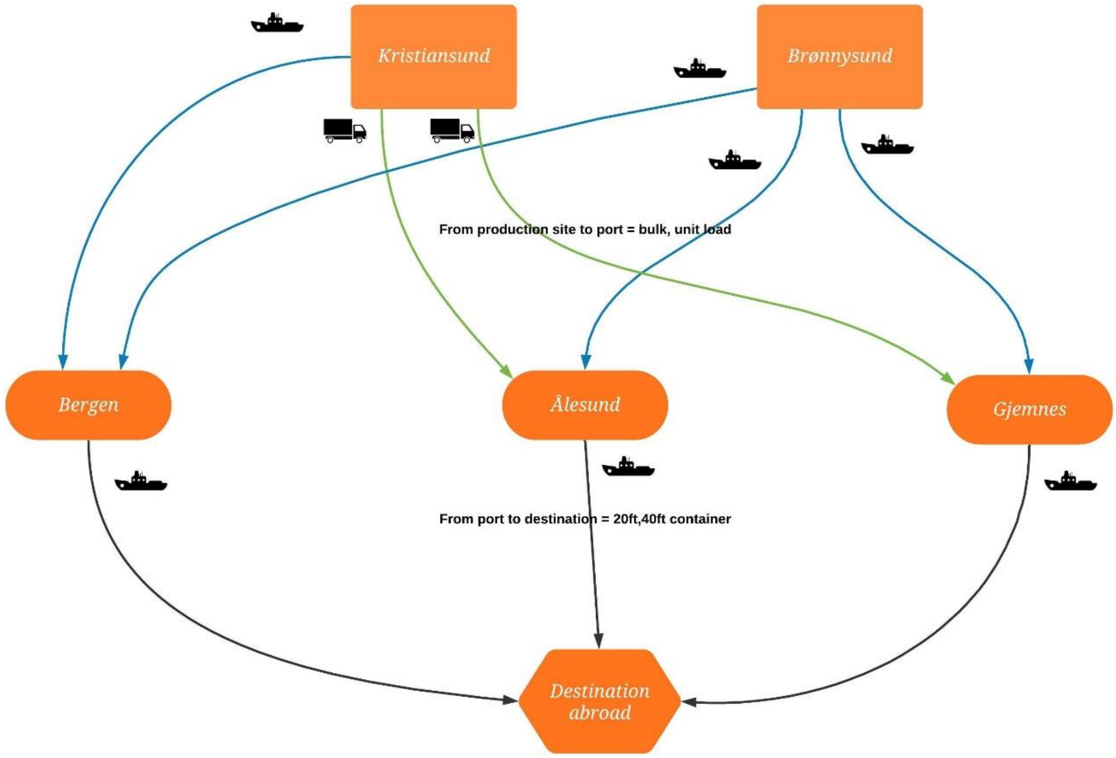

Figure 1: Graphical representation - Algea distribution

2.0 Model section

In this section we investigate the following subtopics step by step

- Research question
- The scope of model
- Mathematical modelling
- Green aspect

2.1 Research questions

Our challenge is to create a distribution model for Algea's routes using existing theories such as aggregated planning and linear programming. That makes it possible to find the optimal route with minimal cost. Our first goal is to make a distribution model based on Algea's supply chain, to see if there are improvements to be made. Since green logistics is a hot topic recently and Algea is a company that cares about the environment, we perform a carbon audit to look at the impacts of transport mode choice. Main research questions are as follows:

- Can we minimize transportation costs by formulating a distribution model?
- How much does the choice of a transport mode in Norway impact total emissions from transport?

2.2 Limitations for our model

Algea's demand pattern is very complex. They have many customers who order rarely and with different quantities of products. Because of this it is hard to forecast how much each customer will order every year, we do not have big enough samples of data. In order to make our model feasible we need to take some assumptions and simplify some parts of the model. Some of the assumptions are based on information's that are confirmed by Algea´s logistic manager during the individual interview, telephone interview and through conversation by Email´s. Whereas others are taken by us to our best understanding of Algea's supply chain and from the document analysis (5)(6)(7). Documents we gained access to contain following information: date, size of shipment, customer and route used.

The first assumption we took into consideration is to define demand for our model. We have shipments data from 2018 to 2020. Demand pattern seems to be random and it is hard to find any clear trends. We choose therefore to use shipments from the first quarter (16 weeks) of 2020 as our sample demand for the model. Based that since it's the newest data, we assume it represents customers demand the best.

Our second assumption is to limit area of distribution responsibilities by Algea and other parties under incoterms agreement. As mentioned in the introduction part Algea produces yearly about six thousand tons, table(1). However, not all shipments are done by Algea. Algea is responsible only for 23 percent of all of the shipments. Some customers take responsibility over their products and arrange the shipment themselves. For example, customers under the EXW agreement. Whereas other customers take responsibility over their products after product is staffed and loaded to a container vessel or cargo under FCA agreement. In this case sellers Algea arranges the pre-carriage (shipment) up to the nearest depot or terminal. In addition to this Algea also ships its product to Europe with Trucks but since we do not have enough data like price per ton for each customer, we don't consider this in our model. In this model we only account the transports that Algea is responsible for, for shipments with full containers, for the period of the first 16 weeks in 2020.

Responsibility for distribution	Incoterms agreement	Amount shipped in weeks (1 to 16) 2020
Algea (full container)	-	431 500 kg
Customer	EXW	284 500 kg
Customer	FCA	1 043 243 kg
Algea (by truck)	-	114 700 kg

Table 2 Responsibility for distribution

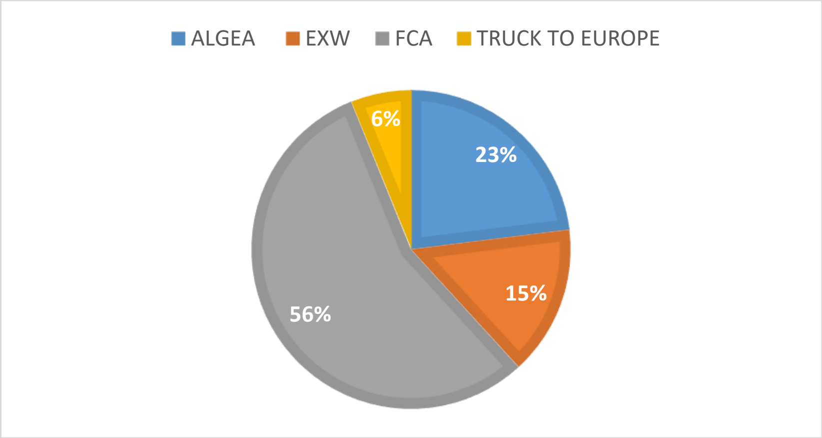

Figure 2:Transport responsibility - donut chart

Third assumption, production capacity: We have a limited knowledge about production capacity but we know that Algea usually can fulfill all customers orders in reasonable time. We assume that all placed orders in our dataset (7) can be fulfilled.

Our fourth assumption is lead time: Lead time and production time is usually an important factor in a supply chain. In our case we only know when the products are shipped to customers. We do not know exactly how much time it takes for the shipment to be delivered to customer. Lead time depends on the customers location but usually takes from 1 to 3 months, from production in Norway up to customer abroad. With this long lead time, customers usually don't mind delays up to 1 week. Considering this information, we choose to assume that all products are delivered in reasonable time and we don't include lead time in our model.

Fifth assumption is selection of customers: Algea has many customers spread all over the world (Asia, Europe, Africa, Oceania, North &South America). Spreadsheet of shipments for 2020 contains many customers but for this model we are taking only 13 customers that order bigger quantities and require international transport with ships. All of them ordered at least one full container in the period of 1-16 weeks 2020.

		CONTAINERS SENT WEEK (1-16)		
NUMBER	DESTINATIONS	20 FEET	40 FEET	COUNTRY
1	MOJI	-	2	JAPAN
2	KOBE	-	1	JAPAN

3	TOKYO	-	1	JAPAN
4	TOMAKOMAI	-	1	JAPAN
5	NAVA SHEVA	1	1	INDIA
6	KEELUNG	2	1	THAIWAN
7	BANKOK	2		THAILAND
8	COLOMBIA	1		COLOMBIA
9	SANTOS	3		BRAZILE
10	MELBOURNE	2		AUSTRALIA
11	WELLINGTON		1	NEWZLAND
12	KAOHSIUNG		1	THAIWAN
13	HUANGPU		1	CHINA

Table 3: Containers send to customers 2020

The sixth assumption is choice of ports and routes: Algea uses several routes and ports to deliver their products, depending on where the customers are located. In our model we included three ports, see figure (1). Those are the ones used most frequently, and the ones that we have enough data for and therefore we think they represent their options best. It is also important to mention that some of the ports do not deliver to all 13 customers.

The last assumption is the choice of third part transport companies: As mentioned in the introduction above several logistic providers are involved to deliver Algea`s product. However, we restrict our model to only three of these companies that Algea`s uses most often. The companies are listed below in tubular form with Availability matrix. The three transport providers in our model have different availability. Kuehne& nagel is always available but often has the highest price per container. Schenker is available once's in two weeks, whereas Freja is available once's a month. Availability of transport providers is more complex and depends on other factors like for example boat delayed by bad weather. We choose to simplify it and set up a availability table. With this we can see which company is available for each week, table (4)

week	Companies Availability/week				
	K&N (Gjemnes)	Schenker (Gjemnes)	Schenker (Ålesund)	K&N (BERGEN)	FREJA (Bergen)
1	1	0	0	1	0
2	1	1	1	1	0
3	1	0	0	1	0
4	1	1	1	1	1
5	1	0	0	1	0
6	1	1	1	1	0
7	1	0	0	1	0
8	1	1	1	1	1
9	1	0	0	1	0
10	1	1	1	1	0
11	1	0	0	1	0
12	1	1	1	1	1
13	1	0	0	1	0
14	1	1	1	1	0
15	1	0	0	1	0
16	1	1	1	1	1

Table 4 Availability.

(1 = Company is available for transport this week, no matter the quantity, 0 = company not available for this week)

2.3 Model

In this part we formulate our problem using mathematical modelling. The goal of this model is to minimize transportation costs. It does so by choosing optimal port and logistics provider combinations. There is a significant variance in costs of sending a container to different customers.

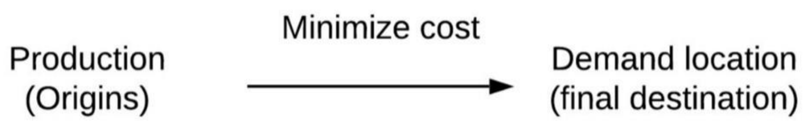

Figure 3: Minimize cost

Index:

We start by describing our indexes.

i = production site i (1)
where $i \in 1 = \text{Kristiansund}, 2 = \text{Brønnysund}$

j = port j (2)
where $j \in 1 = \text{Bergen}, 2 = \text{Ålesund}, 3 = \text{Gjemnes}$

k = transport mode k (3)
where $k \in 1 = \text{truck}, 2 = \text{boat}$

t = week period t (4)
where $t \in \{1 \dots 16\}$

n = customer destination n (5)
where $n \in \{1 \dots 13\}$

m = container type m (6)
where $m \in 1 = 20\ feet, 2 = 40\ feet$

o = logistics provider o (7)
where $o \in 1 = Kuhene\ \&\ Nagel, 2 = Schenker, 3 = Freja$

Data:

Under data we formulate our costs and demands.

d_{nt} = demand for a single customer destination n in period t (8)

p_i = The capacity the two production plants i have in total for the entire time horizon (9)

c_{ijk} = transport cost per ton, for route from production i to port j via modi k (10)

c_{jnom} = container price from company o for container type m, for route from port j to customer n (11)

s_{jm} = stuffing cost per container type m in port j (12)

h_j = handling cost pr ton at port j (13)

Decision variables:

Decision variables are the unknowns in programing a model. In our case those are ton quantities and containers shipped through various port and logistics provider combinations. The followings are the decision variables we used for this case.

x_{ijknt} = tons shipped in week t, from production i to port j via modi k (14)

y_{jnmt} = number of containers m shipped in week t, from port j to customer n (15)

Objective Functions:

The purpose of this model is to find minimum transport costs c. It can be found by summarizing all the best alternatives for transport to each customer. We summarize all costs described in our model.

$$\min c = domestic\ transport + stuffing\ cost + +handling\ cost + container\ transport\ abroad$$

$$\min c = \sum_{i=1}^{2}\sum_{j=1}^{3}\sum_{k=1}^{4}\sum_{n=1}^{13}\sum_{t=1}^{16} c_{ijk}x_{ijknt} + \sum_{j=1}^{3}\sum_{m=1}^{2}\sum_{t=1}^{16} s_j y_{mt} + \sum_{j=1}^{3}\sum_{t=1}^{16} h_j x_{jt} + \sum_{j=1}^{3}\sum_{n=1}^{13}\sum_{o=1}^{3}\sum_{m=1}^{2}\sum_{t=1}^{16} c_{jnom}y_{jnomt} \quad (16)$$

Constraints:

$$d_{tot} = \sum_{j=1}^{3}\sum_{n=1}^{16} d_{nt} \quad (17)$$

d_{tot} = total demand in all destinations n over all time periods t

$$d_{tot} = \sum_{i=1}^{2}\sum_{j=1}^{3}\sum_{n=1}^{16}\sum_{k=1}^{2}\sum_{t=1}^{16} x_{ijnkt} \quad (18)$$

Total demand d_{tot} is fulfilled

$$m_1 \leq 10 \quad (19)$$

10 feet container has a payload up to 10 tons

$$m_2 \leq 26 \quad (20)$$

20 feet container has a payload up to 26 tons

$$\sum_{i=1}^{2} p_i \geq d_{tot} \quad (21)$$

Production capacity in both plants i is greater or equal to total demand d_{tot}

Availability matrix :

$$q_{jot} \quad (22)$$

This data value tells us which weeks companies are available and not available to provide transport service table (4)

$q_{221} = 0$ $\quad$ $q_{229} = 0$

$q_{223} = 0$ $\quad$ $q_{2211} = 0$

$$q_{225} = 0 \qquad q_{2213} = 0$$
$$q_{227} = 0 \qquad q_{2215} = 0$$
$$q_{3211} = 0 \qquad q_{321} = 0$$
$$q_{3213} = 0 \qquad q_{323} = 0$$
$$q_{3215} = 0 \qquad q_{325} = 0$$
$$q_{131} = 0 \qquad q_{327} = 0$$
$$q_{132} = 0 \qquad q_{329} = 0$$
$$q_{133} = 0 \qquad q_{329} = 0$$
$$q_{135} = 0 \qquad q_{1314} = 0$$
$$q_{136} = 0 \qquad q_{139} = 0$$
$$q_{137} = 0 \qquad q_{1310} = 0$$
$$q_{1311} = 0 \qquad q_{1313} = 0$$
$$q_{1315} = 0$$

The rest of the values is one, meaning that transport provider is available

$$x_{jot} \leq q_{jot} \tag{23}$$

This constrains regulates the availability matrix

$$q_{jonm} \tag{24}$$

This data value tells us which customer destinations are operated by port and logistic provider combinations, and what types of containers can be sent (3)

$$q_{3181} = 0 \qquad q_{32111} = 0$$
$$q_{32112} = 0 \qquad q_{2271} = 0$$
$$q_{2272} = 0 \qquad q_{22111} = 0$$
$$q_{22112} = 0 \qquad q_{2282} = 0$$
$$q_{1181} = 0 \qquad q_{1351} = 0$$
$$q_{1352} = 0 \qquad q_{13101} = 0$$
$$q_{13102} = 0 \qquad q_{13111} = 0$$
$$q_{13112} = 0 \qquad q_{1382} = 0$$

$$x_{jomn} \leq q_{jomn} \tag{25}$$

Same as with equation (23) this constraint regulates which port and logistic provider combinations are available for each customer. This table defines the cases when those combinations are not available, the rest of the values is one, meaning that the transport service may be provided.

2.4 Green aspect – carbon audit

The focus on reducing emissions and become more sustainable as a business is a trending topic, and since more of Algea's costumers request emission charts and overview of the environmental impact it is appropriate to make a small carbon audit of their distribution model. Such an audit is usually complex, and accounts for different types of emissions such as NOx, Sulphur, Co2 and particles from combustion engines, but in this thesis we focused on the Co2 emissions from the transport modes to simplify it. Our purpose with this audit is to find out if choosing between boat and truck for transport can have an influence on total emissions from Algea's distribution activity. Since Algea has serval customers in different countries all around the world, it is relevant to make a selection of customers that represent the population. Our carbon audit model is therefore limited to two destinations abroad from the process plant in Kristiansund, through the port of Bergen and Rotterdam before shipping abroad. This route is selected based on highest number of total shipments abroad through 2018 and 2019, and data were collected from shipping reports we gained from the Algea. (5)(6)(7) We have counted how many times Algea ships to each customer and found that destinations that show up regularly are Nava Sheva and Santos.

We use some published principles to maintain the accuracy of our calculations, then followed the carbon foot printing process outlined from "British standard Institution and WBCSD, WRI". (3)

Guidelines:

Relevance

Since distribution is needed to maintain the main activity within Algea, we choose to make a carbon audit of the transportation. Data such as emission factors are available for that type of audit, and established guidelines is used for calculation.

Completeness

The limitations we conduct are well descripted before the calculation of this audit, and elements that is excluded from the calculations are mentioned.

Consistency

Our calculations are based on published research articles, which we compare through a relevant sources to ensure the calculations is relevant for our model. The calculation ensures the methodology, data used are relevant and consistent.

Transparency

Calculations needed for this audit is based on guidelines provided from our textbook(3). Additional source for emission factors are five science reports from research with Molde University College. The calculation is preformed manually by using emission factors and distances between ports.

The carbon footprint process

This process contains five steps and is outlined by the British Standards Institution (211b) and WBCSD/WRI (2004)(3). This audit uses these steps to make an accurate, and legit report.

Step 1. Process map

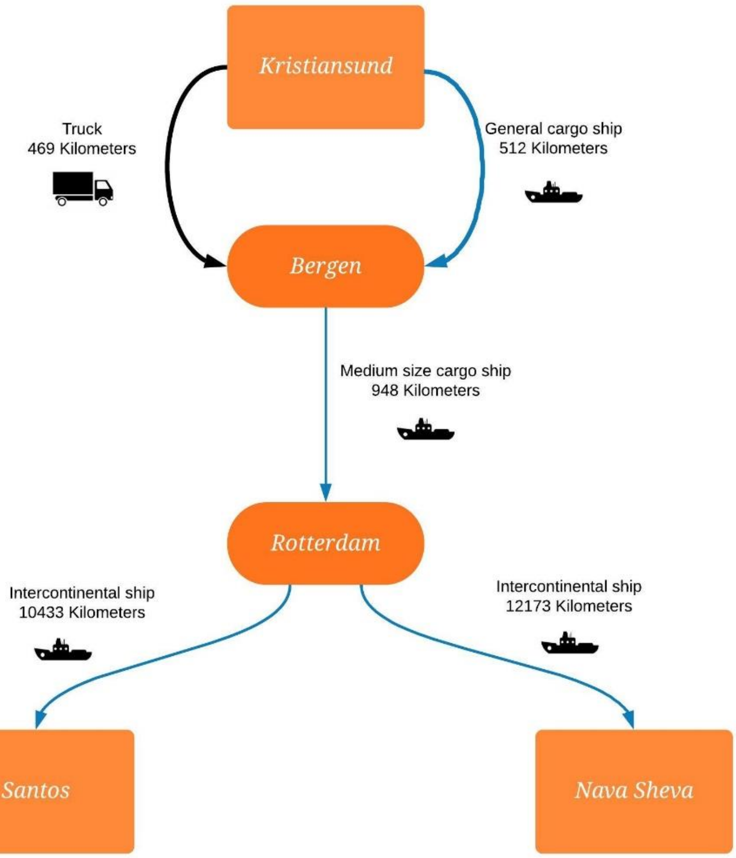

Figure 4: Carbon audit process map

Step 2. Calculation approach and boundaries

Our limitations (boundaries) within this audit.

- Only the transportation is accounted for when calculating emissions
- Using standardized emission factors
- Unloading, stuffing, loading, warehousing is not in the calculations
- Wheel to tank calculation is carried out.
- Emissions factors are based on relevant article (2) and book (3)
- Our abroad destinations are Nava Sheva and Santos
- We use some published principles to maintain the accuracy of our calculations, then followed the carbon foot printing process outlined from "British standard Institution and WBCSD, WRI."
- Backhaul is indirectly accounted for through the utilization factors.
- All shipments abroad from Rotterdam is through the Suez channel.

Capacity utilization	
Mode of transport	Utilization factor
General cargo ship	62%
Medium size cargo ship	62%
Intercontinental ship	70%
Road	
Truck	62%

Table 5: Capacity utilization

Step 3. Data collection:

To create a calculation there is some data that needs to be collected. Such data as distances between ports, type of modes and the emission factor, and the routes that is used for our calculation. The data collection is performed by using the personal interview with Algea and some published scientific articles online.

Distances		
Route	Distance	Mode of transport
Kristiansund - Bergen	469 km	Sea
Kristiansund - Bergen	512 km	Road
Bergen - Rotterdam	948 km	Sea
Rotterdam - Nava Sheva	12173 km	Sea
Rotterdam - Nava Sheva	10433 km	Sea

Table 6: Route distances

Emission factors and capacity utilization		
Ship type	Emission factor	Used for destinations between
General cargo ship	0.061	Kristiansund - Bergen
Medium size cargo ship	0.026	Bergen - Rotterdam
Intercontinental ship	0.015	Rotterdam - Abroad
Road		
Truck	0.085	Kristiansund - Bergen

Table 7: Emission factors

Step 4. Calculations:

The calculations is relative straight forward. We choose two routes, with different choice of mode. Then we multiply the distances with payload(10 ton) and emission factor. When that is done, we compare the results when choosing different mode of transport at the same route.

Route	Mode of transport	Distance (D in (km)	Emission factor (E) (Kg Co_2/ton km)	Shipment (S) pr (ton)	Total emission (D*E*S) in (Kg Co_2)
Kristiansand → Bergen	Truck	512	0.085	10	312,32
	General Cargo ship	469	0.061	10	398,65
Bergen → Rotterdam	Medium Size Cargo ship	948	0.026	10	246,48
Rotterdam → Nava Sheva	Intercontinental ship	12173	0.015	10	1825.95
Rotterdam → Santos	Intercontinental ship	10433	0.015	10	1564,95

Table 8: Calculations, this table shows the amount of emission for each route

	Emissions					
Mode of transport	Kristiansund → Bergen	Bergen → Rotterdam	Rotterdam→ Nava Sheva	Total emission in (Kg Co_2	Emission d/nce truck vs boat (Kristiansund →Bergen)	% d/nce Truck vs Boat
Truck	398.65	246.48	1825.95	$\mathbf{2471.08}$	86.33 $kg\ co_2$	3,5% higher
Boat	312.32	246.48	1825.95	$\mathbf{2384,75}$		

Table 9 Calculations, this table shows the total amount emission from Kristiansund to Nava Sheva in India

	Emissions					
Mode of transport	Kristiansand → Bergen	Bergen → Rotterdam	Rotterdam → Santos	Total emission in (Kg Co_2	Emission d/nce truck & boat (Kristiansand →Bergen)	% d/nce Truck vs Boat
Truck	398.65	246.48	1564.95	$\mathbf{2210.08}$	86.33 $kg\ co_2$	4 % higher
Boat	312.32	246.48	1564.95	$\mathbf{2123.75}$		

Table 10 Calculations, this table shows the total amount emission from Kristiansund to Santos in Brazil

Step 5. Verification and disclosure

By following the procedure for carbon audit and use scientific sources such published articles for the calculation, this audit is completed within the guidelines. All data for calculation in this model is available to the public and are listed in our reference list. The approach of the report are discussed within our group, and verified by all members.

This audit shows that the environmental impact is present when choosing transport mode for a distribution system. In this case the difference is only marginal, but it does affect the total CO2 emissions slightly. And since other externalities such as handling, stuffing is not accounted for, the difference could be even greater. Other factors that can influence the emissions is capacity utilization, which mean how much of the available capacity are used when transporting goods. Higher capacity utilization equals lower emissions per ton, and contribute to more efficient use of transport modes. It may also tribute to a better economy within the transport company, since new legislations are most likely to be implemented based on the emissions from the transport activity. This audit could be a part of a more complex environmental research, or a sustainability analysis.

3.0 Discussion

3.1 Thesis

It takes a long time to model a distribution mathematically and put it in use. To make it reflect the actual situation, it requires big samples of relevant data and good understanding of the supply chain. The purpose of our model is to meet customers demand with the lowest possible transport costs. Algea has many customers that order different quantities and often with long time gaps between orders. This makes it difficult to make an accurate forecast for the upcoming periods of time. In order to use our model Algea has to integrate with their customers so that they can understand their demand pattern and make a good forecast. There are some customers who have more predictable demand patterns than others, it would be a good start point to make forecasts only for them and modify our model so it fits the that case. The scope of our model does not include production, which plays a big part in the distribution. Knowing how fast you can produce orders makes it easier to plan ahead of time. This increases the chances to find the optimal transport solution for each customer with our model.

Carbon audit plays an important part in our thesis although it is not directly connected to our model. It shows that Algea has some influence over how much emissions they produce. Green solutions are often expensive. Thus it might be relevant to set a goal of how green Algea wants to be, and include this in our model. If we make an accurate analysis of how much emissions each distribution route produces we set an constraint for our model. This constraint would tell the model that we would like our emissions not to go over a certain number, our model would then still prioritize minimizing the costs but would also optimize so that we can meet our constraint.

3.2 Third party logistics

Since Algea doesn't transport the product itself, it's important to discuss how third part logistics providers are embedded to their supply chain. What criteriums must be met, what other factors than cost can influence the decisions on choosing logistics provider. We have gathered some information about the transport companies, and picked some criteria's for discussions. Criteria's :

Lead time is defined as the time when the order is placed, and when a costumer receive the order. The costumers are from different parts of the world, and the time it takes to receive product depends on the distance the shipment needs to travel. The logistics providers need to have an order placed in a certain time before they can offer transport. The time aspect an order needs to be placed from Algae to transport companies varies, from 1 week ahead until 3 weeks. Depending on customers demand, Algea can benefit when forecasting three weeks ahead. Benefits such as reduced transportation costs, and increasing customers satisfaction by reduced lead time.

Pricing is different among the logistics providers that Algae uses, some are more expensive than others and can offer different services additional to the transport. Services such as gods tracking, fixed price over time, flexibility and shorter noticed before being able to provide transport. These are nice features to have, but not all are necessary for every destination. Sometimes the more affordable logistics providers are preferred, that's typically when they operate in a stable market such as in Europe. When transporting to other continental such as Asia and USA the market can fluctuate more, and by adding extra services such as tracking, and extra insurance the transport process is more reliable. All this comes with a cost, but due to the forecast and demand pattern there is a balance between when different pricing strategies should be applied. Below you can find an example of price difference for one container.

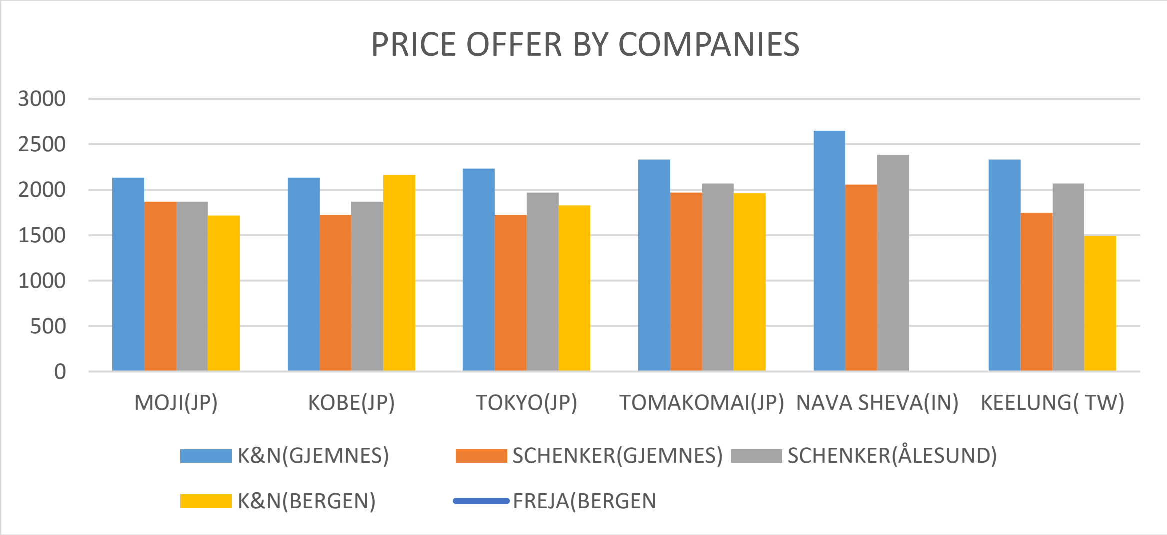

Figure 5: Price difference example (dollars)

Availability is when a logistics company are available to Algea's disposal. The transport companies have different time periods when they are available and may at some point not offer a transport when needed. In our case we can see that K&N are available anytime, while other companies have periods they cannot provide their services. Algea has a different booking deadline which means that they have to book transportation serval weeks before. The reason for that is so the transport provider can start scheduling some time ahead and make an offer in terms of pricing and estimate an adequate timeframe. Our case have serval transport companies in use, but we compared few of them such as Kuehne & Nagel, Freia, Schenker and we can see the difference in agility they have. The deadline for booking goes from 1 week to 3 weeks.

Integration between Algea, logistics providers and their network is important. This can give Algea benefits by making them able to share additional data to their customers, data such as location of the gods, temperatures while in transport, delays and more. The big logistics providers usually have bigger networks within their supply chain, and are able to handle sudden challenges that appear, faster and more affordable than smaller logistics providers. Algea is aware of that and uses big established companies in the market for that reason.

4.0 Conclusion

In the present thesis we have analyzed Algea's supply chain and we have made some boundaries in order to make this task feasible. We have formulated our model based on historic data from shipments and interviews with the companies logistic manger. This distribution model gave an overview over Algea's shipping ports, routes, and location of their customers. The next step would be to simulate the model versus historic data in order to find out how much money we can save. We have looked at which ports and providers Algea was using for the first quarter of 2020 and calculated transport costs using excel. By analyzing this data we also found that cheaper transport options were available for some customers. We have also began coding necessary data for the simulation. Although we have not been able to calculate costs with the use of our model, it is a good foundation for a future development, for example in a Master's thesis. After we have formulated our model we have concluded an carbon audit for transport to two representative customers. From this audit we found that Algea can save up to 4% emissions by choosing a greener transport mode which in this case was boat. This was calculated per one trip, over a longer periods of time kilograms of CO_2 emissions could rise to a substantial number. Purpose of this audit was to find out how much influence and control Algea has on CO_2 emissions when distributing their products.

5.0 References

(1) Eirill Bø, Stein Erik Grønland *"Moderne Transportlogistikk"*

(2) Svindland, Morten, and Harald M. Hjelle. *"The comparative CO2 efficiency of short sea container transport."* Transportation Research Part D: Transport and Environment 77 2019

(3) Alan McKinnon, Michael Browne "*Green Logistics"* 2015

(4) Excel file 1: *"pricelist"*

(5) Excel file 2: *"Shipping report 2018(week 25-52)"*

(6) Excel file 3: *"Shipping report 2019"*

(7) Excel file 4: *"Shipping report 2020"(week 1-16)*