YRKESHÖGSKOLAN NOVIA

Travel Data as a Decision Base for Workforce Planning

Case: Wärtsilä Field Services

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Degree Thesis for Bachelor of Engineering

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EXAMENSARBETE

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Titel: Resedata som beslutsunderlag för arbetskraftsplanering
Fall: Wärtsilä Field Services

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Abstrakt

År 2015 registrerades mer än 15 000 gränsöverskridande resor inom Wärtsilä Field Services. Syftet med detta examensarbete är att utveckla en metod för att undersöka resedata, vilket ska resultera i bättre förståelse för reseflöden och deras syften. Metoden ska fungera som beslutsunderlag för resursplanering, och ska användas kontinuerligt i den operativa verksamheten. Målet är att optimera resandet med inverkan på både verksamheten och miljön.

Teorier som ligger till grund för arbetet är hantering av mänskliga resurser och arbetskraftsplanering. Datahantering och kunskapssökning har baserats på teorier om big dataanalys, informationsutvinning och visualisering.

Som bas för reseflödena användes data från reserapporter, men även kompletterande data från andra källor inom Wärtsilä. Verktyget som utvecklades är gjort i Excel med stöd av Visual Basic, och bygger på visualiserande av data. Scenarioanalys har använts för att få fram riktgivande resultat.

Arbetet resulterade i ett användarvänligt Excel-verktyg där resedata hanteras och visualiseras för att lättare kunna analyseras, både globalt och nationellt. En scenariomatris har tagits fram för att kunna tyda visualiseringen och ge riktgivande resultat. Med hjälp av verktyget får man fram information om var problem förekommer, hur kritiska problemen är och möjliga korrigerande åtgärder. På detta sätt ska man kunna minimera onödigt resande och skapa effektivare service på fältet.

Språk: Engelska Nyckelord: arbetskraftplanering, resedata, dataanalys, Excel

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BACHELOR'S THESIS

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Abstract

In 2015, more than 15 000 cross-border travels were registered within Wärtsilä Field Services. The purpose of this thesis is to develop a method to analyze travel data, to get a better understanding of the travel flows and their purpose. The method should act as a decision base for resource planning and should be used continuously in the operational business. The goal is to optimize travelling with impact on both business and environment.

Theories being the basis for this thesis are human resource management and workforce planning. Data management and knowledge discovery are based on theories about big data analysis, data mining and visualization.

Travel flows are based on data from travel reports, but complementing data has also been sourced from other sources within Wärtsilä. The developed tool is made in Excel with the support of Visual Basic and the concept is data visualization. Scenario analysis has been used to generate indicative results.

The result of the thesis is a user-friendly Excel-tool, where travel data is processed and visualized to be easily analyzed, both globally and nationally. A scenario matrix has been developed to interpret the visualizations and give indicative results. Using the tool, it is possible to get information about where the problems are, how critical the problems are as well as corrective actions. This way it is possible to minimize unnecessary travelling and improve the efficiency of the field service.

Language: English Key words: workforce planning, travel data, analysis, Excel

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List of Abbreviations

ERP = Enterprise Resource Planning, the integrated management of core business processes.

FS = Field Services, a department within Wärtsilä Services.

KPI = Key Performance Indicator, a type of performance measurement to evaluate the success of an organization or of particular activities.

Resource = A travelling service engineer within the Wärtsilä Services network.

SAP = Systems, Applications & Products in Data Processing. German ERP software used in Wärtsilä to manage business operations and customer relations.

SONAD = Standardization Of Network And Desktop, IT environment used within Wärtsilä for hardware, software and networks.

SU = Service Unit, collaborative unit of countries in the Wärtsilä Services network.

1 Introduction

This chapter will present and overview the background of this thesis, as well as discuss the problem area and purpose. Thereafter the delimitations and confidentiality of the paper are discussed. Finally, a brief disposition is presented to give a better understanding of the composition of the paper.

1.1 Background

Globalization has made the world smaller. Today people, goods and money can move more freely than ever between countries and continents. The single customer can do business all over the world, and companies everywhere can use the world as its market place. Low educated and labor intensive jobs have moved to the developing countries, and industrialized countries have become more service focused. In the industry, the product itself is getting decreasing attention, and instead life cycle management is getting more and more important. The services need to be where the customers need it when they need it.

The power industry is one market that has developed a lot over the last few decades. The world's energy consumption is continuously rising, and technological findings are as common as new environmental restrictions. Wärtsilä is a global leader within the power industry, which is understandable as 1 % of the world's energy is produced by and every 3rd ship sailing the seas is driven by Wärtsilä engines. Wärtsilä also services every second ship sailing the world's seas, which means they also services competitor's engines. This says a lot about the quality of their service network. Wärtsilä's service network is among the broadest in the industry, with more than 4 500 service engineers available in 200 locations in 70 countries. (Wärtsilä, 2017d).

Service work in the power industry is not a constant phenomenon. New technological inventions as well as constantly changing customer demand creates a great need for a flexible workforce. To cope with this Wärtsilä Field Services' network is organized as a matrix structure, with Areas and Service Units on the horizontal axis and Product lines on the vertical axis. Areas and Service Units are based on the geographical location of each service location, and acting as the frontline against the end customer. Product lines are based on the different product portfolios, and are there to support the Areas with expertise knowledge and quick actions. This organizational structure has led to a network with high competences and quick actions, close to the end customer.

1.2 Problem Area

In 2015 Wärtsilä Field Services registered over 60 000 travels globally, of which about 15 000 were cross-border travels. This indicates that a quarter of all travels are between different countries, service units or service areas. Cross-border travelling is not considered a negative thing if it is kept on a reasonable level and within certain units or areas. High cross-border travelling can be a result of a well working service network, but it might also indicate poor management or competence gaps within the network.

Within Wärtsilä no previous effort has been made to follow up the travels. An overflow of data is collected and available, but there is no method to utilize it. Therefore, it is not possible to determine if the great amount of cross-border travelling is justified or not.

1.3 Purpose

The purpose of this thesis is to develop a method to analyse travel data, to get a better understanding of the travel flows and travelling purposes. The method should indicate if unnecessary travelling exists, and if it depends on poor management or competence gaps. The method should be a decision base for strategic workforce planning, and should be applied regularly in the operative business. The long-term aim is to optimize travelling with impact on business and environment.

1.4 Delimitation

Wärtsilä Field Services ordered this thesis to get an understanding of the travelling among their service engineers. Hence no account is taken for movements of goods or similar.

The paper will only investigate billable trips, and to some extent training, within the field service network. Therefore, travels within the rest of the Wärtsilä Corporation won’t be considered.

The focus area of this thesis is the travelling flow within the service network, as well as competence demand and supply. This means cultural, ethnical, religious and economic factors have been overlooked.

1.5 Confidentiality

This thesis handles sensitive information that must not be shared outside of Wärtsilä. Therefore, all data included in the official version of this thesis, is made up of random numbers and names. All enclosures (if any) will be classified, and will not be included in the official version. The Excel-tool resulting from this thesis work, will only be shared within the Wärtsilä corporation.

1.6 Disposition

The first chapter has introduced the reader to the background, the problem area and the purpose of the thesis. Confidentiality and delimitations were also briefly discussed.

The second chapter will present Wärtsilä in brief and also discuss the organizational structure.

The third chapter will create a theoretical framework for the thesis. Some basic information about human resource management, workforce planning and data collection and analysis will be discussed.

The fourth chapter will introduce the reader to the research approach used in this thesis. It will also discuss the methods used to get to the final result.

The fifth chapter will present the final result. The main functions will be evaluated, discussed and analysed.

The sixth chapter will discuss the completed thesis. Theory, methods and results will be critically reviewed. Some proposals for further research will be presented and a final conclusion will be made.

2 Wärtsilä in Brief

Wärtsilä is a Finnish corporation established 1834 in Tohmajärvi, Finland. The company started out as a small milling company, but has changed markets many times since that. Today Wärtsilä is a global supplier of advanced technologies and complete lifecycle solutions towards the energy and marine markets. The company is well positioned on the global market due to its integrated offering of both services and products. Industry leading multiple fuel products combined with a superior global service network helps Wärtsilä reach their main objective: to achieve growth by offering their customers new and innovative solutions. In 2016, Wärtsilä's net sales totalled EUR 4.8 billion with approximately 18,000 employees. The company has operations in over 200 locations in more than 70 countries around the world. (Wärtsilä, 2017d; Wärtsilä, 2017e).

2.1 Company Segments

The Wärtsilä corporation is divided into three main segments: Energy solutions, Marine solutions and Services. *Energy solutions* offer internal combustion engine based power plants and solar power plants, as well as LNG terminals and distribution systems. *Marine solutions* offer manoeuvring systems for vessels including multiple fuel engines, thrusters and propellers, but also maintenance agreements and complete ship designs. *Services* is focused on supporting Wärtsilä's customers throughout the lifecycle of their installations. They provide the most comprehensive portfolio of services and broadest service network in the industry, for both energy and marine markets. Looking at net sales, Services stand for almost 44 % of the business (2015). Looking at net sales by market, Asia stands for the biggest part with more than 40 % of the business. (Wärtsilä, 2016).

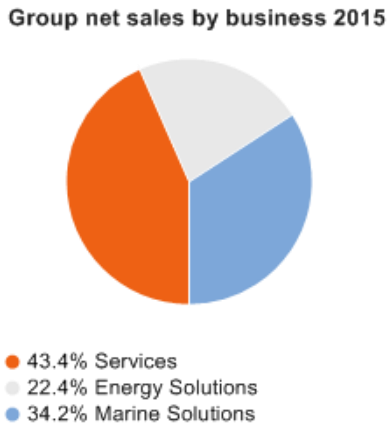

Figure 1 Wärtsilä: Net sales by business.

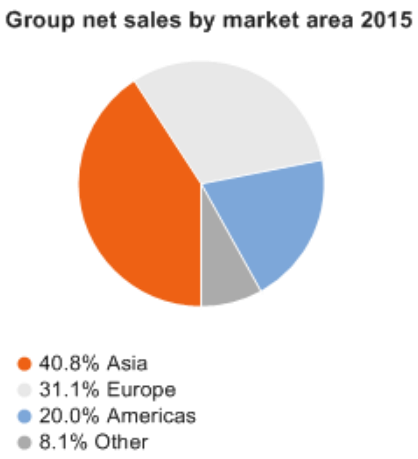

Figure 2 Wärtsilä: Net sales by market area.

2.2 Field Services

Field Services is Wärtsilä's global network of service centres, workshops, and service professionals. Field Services' objective is to offer qualified expertise, high response capabilities, high proximity and availability whenever and wherever needed. Over 4 500 Field Service professionals are spread around the world in 70 countries, always ready to perform works such as overhauls, troubleshooting and reconditioning. (Wärtsilä, 2017a).

Figure 3 Wärtsilä: Global presence.

Field Services is a function within 4-Stroke Engine Operations in Services, and its two main roles and responsibilities are:

- To develop and maintain Field Services expertise, know-how and superintendent level support, through a pool of highly skilled engineers and selected specialized support workshops and
- To define, monitor and review strategies, procedures, the way of working, and KPIs for the global Field Services organization.

(Saenz, 2016).

2.3 Field Services Organization

Wärtsilä Field Services is a complex function with global operations, being part of each Product line as well as four geographical Areas. The interaction between the different organisations is the basis to ensure a global standardised approach and performances towards the customers. The organization can be described as a matrix, with Areas and Service Units crossing the matrix horizontally and Product lines crossing vertically. (Wärtsilä, 2017c).

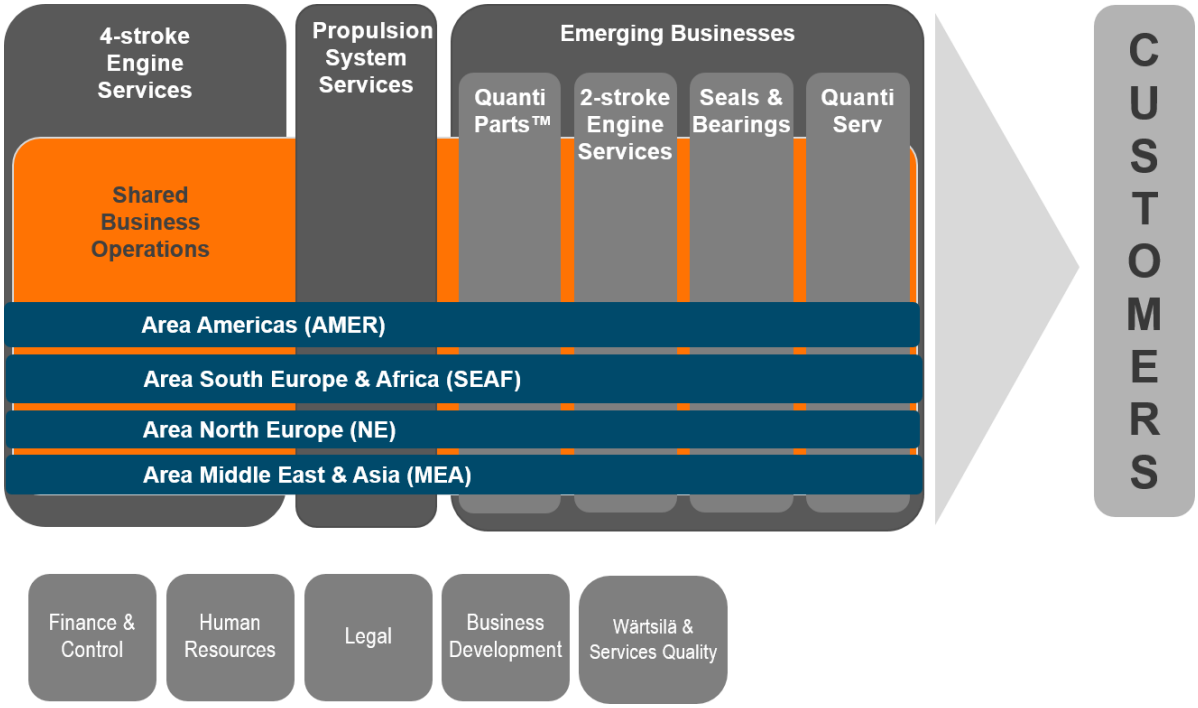

Figure 4 Wärtsilä: The Services organization.

2.3.1 Global Field Services

Global Field Services is responsible for securing the way of working throughout the different Product lines and Areas. The Global Field Services team consists of participants from all Product Lines and Areas and is led by 4-Stroke Field Services in line with the agreed Shared Business Operations responsibilities. (Saenz, 2016).

2.3.2 Product line Field Services

Product line Field Services is responsible for global Field Services expertise, know-how and superintendent level support, through a pool of highly skilled engineers and selected specialized support workshops. (Saenz, 2016).

2.3.3 Service Unit Field Services

Service Unit Field Services are responsible to provide all Field Services activities (utilizing available competent resources and assets, tools and workshops facilities, etc.) in their geographical area according to market requirements. One Area Field Services General Manager per Area is the link between the Service Unit Field Services and the Global Field Services. (Saenz, 2016).

3 Theory

This chapter will build the theoretical framework being the foundation of this thesis. First the concept of workforce planning will be presented. Thereafter the data collection process is discussed, followed by data analytics.

3.1 Workforce Planning

In today's globalized world competition is continuously getting more challenging within business. As all competing organizations can access the same raw materials, plants, finances, hardware and software, the differences in performance must be due to differences in people performance. Furthermore, to gain a competitive advantage, organizations must develop and apply human resource management systems (HRM) to better utilize the personnel available. (Bratton & Gold, 2007).

The use of human resource management systems, in one form or another, are essential in most organizations. According to Armstrong & Taylor (2017) human resource management is concerned with all aspects of how people are employed and managed in organizations. It covers the activities of strategic human resource management, human capital management, knowledge management, corporate social responsibility, organization development, resourcing (workforce planning, recruitment and selection and talent management), learning and development, performance and reward management, employee relations, employee well-being and provision of employee services.

The purpose of this thesis is to find a method to analyze the travel data collected in Wärtsilä Field Services. This is a process to get a better understanding of the abilities and challenges of the workforce available. This chapter will give a presentation of the workforce planning concept as described in the literature available today.

3.1.1 Definition

Perhaps the simplest and most commonly used definition describes workforce planning as:

> *Getting the right number of people with the right competencies in the right jobs at the right time.* (Sinclair, 2004).

This definition pretty much sums up the highest aim of Wärtsilä Field Services. However, the field of human resource management is very broad, and the number of definitions is as great as the number of people interested in the field. Another definition, that indicate some of the basic issues involved, describes workforce planning as:

> *The process in which an organization attempts to estimate the demand for labor and evaluate the size, nature and sources of supply which will be required to meet that demand.* (Reilly, 1996).

This definition is more specific and indicates the quantitative issues often faced within workforce planning. Qualitative issues, such as skills and competencies, are not included in the previous definition, but the definition in Martin (2010) has a wider view:

> *HR planning represents the process of analyzing and identifying the need for, and availability of, human resources so that an organization can meet its objectives. HR planning is about making sure that an organization has available the appropriate number of people with the appropriate skills in the appropriate places at the appropriate time, ensuring that this is done in a way that encourages the organization to regard people as a source of competitive advantage.*

This definition indicates both qualitative and quantitative issues involved in, as well as the strategic aspects of workforce planning. Although the definitions are many, most of them agree upon the cornerstones presented above.

3.1.2 Approach

So, what is the actual content of workforce planning? Workforce planning, or manpower planning as it was called then, grew in the 1960s and 1970s when unemployment was low and corporations needed ways to better utilize their personnel (Reilly, 1996). The early concept of manpower planning was almost entirely about numbers in the shape of quantitative supply and demand forecasts. The challenge of producing accurate forecasts often failed, which led to meaningless plans for the companies (Armstrong & Taylor, 2017). The failure to prove manpower planning profitable combined with general decentralization of corporations, led to a decrease in manpower planning (Sinclair, 2004).

From the end of the 1990s until today workforce planning has returned as an even stronger part of the human resource activities. The emphasis has moved from “head count” to “head content”, which means the concept has become more qualitative (Sinclair, 2004). Where the traditional approach only covered pure supply and demand numbers, the new concept covers a wider range of activities such as succession planning, smart working, flexible working and talent planning (Armstrong & Taylor, 2017).

Thus, based on above descriptions, workforce planning is a simple concept: it is about matching the organization’s demand for labor with the supply of labor over time. The complications arise from how the demand is specified and then satisfied, especially during periods of change and uncertainty. Simply specifying workforce demand in numerical terms, as used to happen, will not be sufficient: we also need to know something about the labor profile required, for instance skills (Reilly, 2015).

3.1.3 Methods

There are countless different methods to use within the area of workforce planning. Although different methods have different terminology and orders of process, the models are very much alike. Essentially, the workforce planning process involves following steps:

1. Analysis of present workforce,
2. Identification of future competency needs,
3. Comparison of present workforce and future needs to identify competency gaps

(Sinclair, 2004)

In Hendry (2011) the different steps have been connected together as a cycle, see figure 5 below.

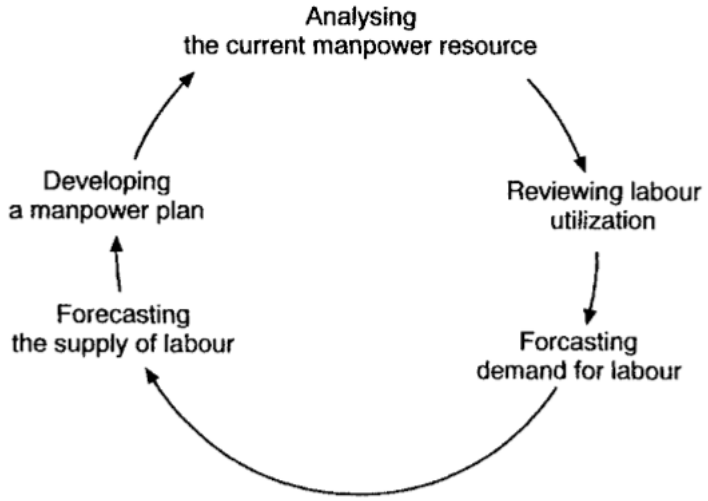

Figure 5 The manpower planning cycle.

Armstrong & Taylor (2017) and Bhattacharyya (2006) also supports this model, with the addition of a follow-up step. Most models in workforce planning builds on this concept, but each model is outlined for its own specific purpose. Depending on the aim of each model, the differences may be significant. Also, considering the changing environments and the fact that each organization is unique, it is hard to apply ready-made models on a different corporation (Sinclair, 2004).

According to Reilly (2015) the problem with workforce planning is its execution. Organizations get the concept, but the hard thing is putting it to practice. The most argued reason is that the methods are too complicated: processes asks for information managers don't have or have a difficult time to produce. The solution proposed is to keep the process simple:

1. Only concentrate on essential data and work hard to keep it accurate,
2. Identify important business issues and work backwards from them,
3. Then more specific techniques can then be applied to illuminate smaller problems.

Specific techniques can be for instance statistical calculations or expert advice. As previously mentioned the older ones are more quantitative, while the newer ones are putting

greater emphasis on qualitative aspects. These techniques are countless, but in Gómez-Mejía et al. (2001) some examples of both are given:

Quantitative methods of forecasting supply and demand	Qualitative methods of forecasting supply and demand
Regression	Delphi technique
Linear programming	Nominal group technique
First-order Markov model	

3.2 Data Collection

Data and conclusions of data are everywhere today: newspapers, magazines, online resources and professional publications. The question is: what data and conclusions are trustable? A primary goal of most statistical studies is to collect data that can be used to make informed decisions. The quality of the decisions is hence completely depending on the quality of the information available. (Peck, et al., 2012). Baesens (2014) points out that data are the key ingredients for any analytical exercise and if we take a look at the knowledge discovery process presented in Han et al. (2011), it becomes very clear that the data collection process is key to come up with real knowledge:

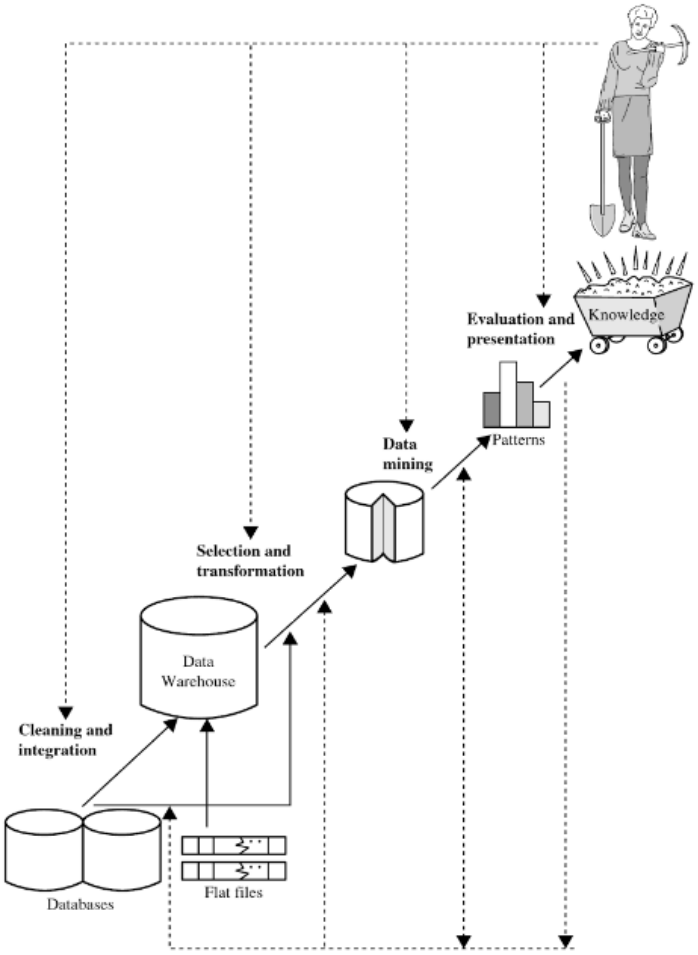

Figure 6 Knowledge discovery process.

3.2.1 Data

To better understand the collection of data, we first need to define the concept *data*. According to Peck et al. (2012) data is *a collection of observations of one or more variables*. The word *observation* is here used in its philosophical sense, that is as referring to the use of the human senses to produce "evidence" about the "empirical" world. Data can also be of different types and forms. The data type is determined by the researcher's relationship to the data:

- **primary data** is data collected directly by the researcher,
- **secondary data** is data already collected by someone else (often for different purposes),

- **tertiary data** is data that has been already analyzed by a researcher (and the raw data may not be available).

(Blaikie, 2003).

The forms of data are generally divided into two main forms: *numbers* (quantitative) and *words* (qualitative). Quantitative data is often seen as a necessity to perform statistical analyses, but qualitative data is also becoming increasingly accepted in modern research. The problem with qualitative data is that it often need significant preprocessing before it is usable in analyses. The different forms can further be divided in to different sub-categories such as categorical, numerical, continuous, nominal, ordinal and so on. (Baesens, 2014).

3.2.2 Sources

According to Baesens (2014) it is important to consider all available sources before starting an analysis: the more data, the better. Most statistical researchers support this opinion. But what sources can be used to collect data? Some commonly used sources in data analytics are:

- **Database data**, electrically stored and structured collection of interrelated data.
- **Transactional data**, consists of structured, low-level, detailed information capturing the key characteristics of for instance customer transactions. Often recorded in databases.
- **Qualitative data**, expert advice or similar that can help steering the analysis in the right direction.
- **Unstructured data**, consists of information included in stand-alone documents or multimedia.
- **Publicly available data**, data publicly available such as gross domestic product (GDP), inflation and so on.

(Baesens, 2014; Han, et al., 2011).

3.2.3 Pre-processing

As previously pointed out, the quality of the analysis result directly depends on the quality of the underlying data. Therefore, researchers always strive to get as clean data as possible. Unfortunately, today most databases contain some extent of noisy, missing or inconsistent data, due to their size or the fact that data is often coming from multiple heterogenous sources.

So, what techniques can be used to clean data and make it more manageable? According to Han et al. (2011) there are four main steps for data preprocessing: data cleaning, data integration, data reduction and data transformation. *Data cleaning* is using different methods to process missing data, smooth out noise and correct inconsistencies in data. *Data integration* is different processes for merging data from different sources. *Data reduction* is methods to reduce data size by for instance eliminating redundant features or selecting a sample. *Data transformation* is different processes to normalize or standardize data in a set. Baesens (2014) is on the same track mentioning the following methods: sampling, standardization, categorization, missing data and data visualization.

3.3 Data Analytics

Terms such as *analytics*, *data mining* and *knowledge discovery* are often used interchangeably today, but the distinctions between them are not clear cut. The common denominator for all these terms are their purpose: to extract useful business patterns and mathematical decision models from pre-processed data. (Baesens, 2014).

3.3.1 Data Analysis Process

In Peck et al (2011) the Data analysis process is divided into five steps:

1. **Understanding the nature of the problem**, effective data analysis requires a thorough understanding of the research problem.

2. **Deciding what to measure and how to measure it**, what information is needed to answer the questions of interest?

3. **Data collection**, the use of old or new data and pre-processing (previous chapter).

4. **Data summarization and preliminary analysis**, insights to select appropriate method for further analysis.

5. **Formal data analysis**, select and apply statistical methods.

6. **Interpretation of results**, should address new questions and lead back to the research question.

Steps one to three in this process is only preparing steps for the analyses. The real statistical analyses are performed in steps four to six. If the preparing steps are well done, the final steps will be easier to perform and the result will be better. This process is almost the same as the *Knowledge discovery process* presented earlier and the Analytics process model presented in Baesens (2014):

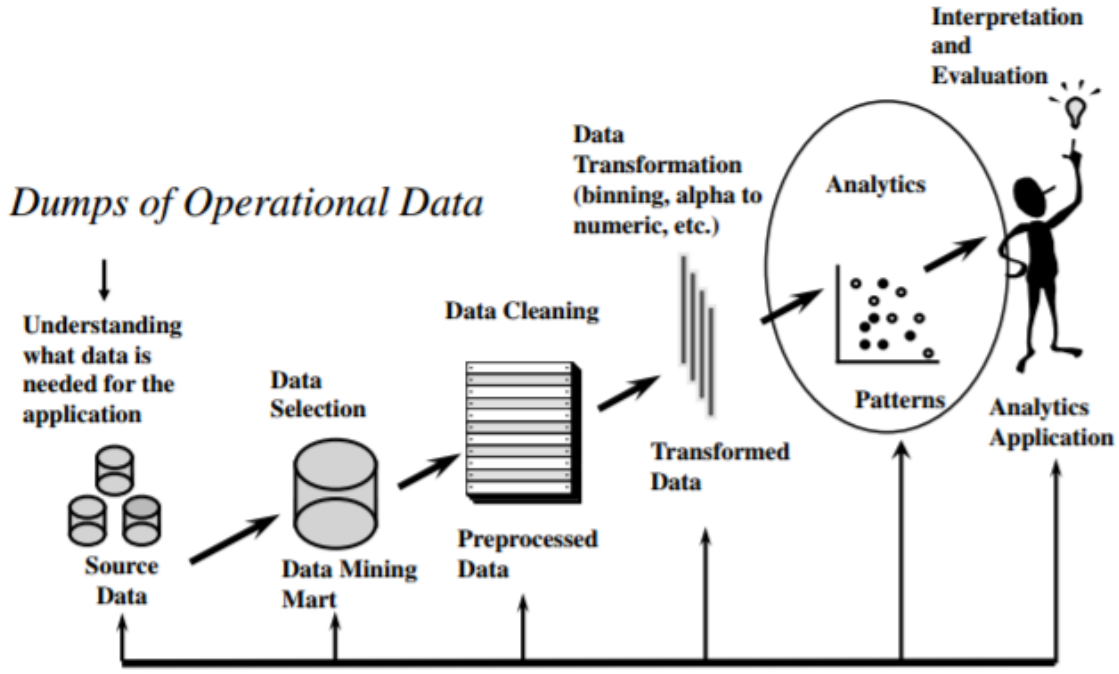

Figure 7 Analytics process model.

3.3.2 Descriptive and Predictive Analytics

Analytics can be divided into two main branches: descriptive and predictive analytics. The aim in *descriptive analytics* is to organize, summarize and find patterns in current data to get a better understanding of the current situation. This can be used to for instance find competency gaps within a service network. In *predictive analytics*, the aim is to build an analytical model predicting a target measure of interest. This means the current data set, or a sample of it, is analyzed and generalized as a model of the future. This can be used to for

instance try to predict the man-power needs in a certain country in the future. (Baesens, 2014).

As discussed in the chapter about workforce planning, statistical predictions are often not successful in human resource planning. Generalization often means the risk of incorrect conclusions. If such techniques are used, the risk of incorrect conclusions must be accounted for. (Peck, et al., 2012).

3.3.3 Tools and Techniques

So, what tools, techniques or approaches should you apply on your data? There is no correct answer to that question. The tools and techniques available are countless.

In Han et al. (2011) some commonly used techniques within data mining are presented. Statistical modelling, machine learning, database systems and visualization are all techniques from different domains that can be applied together or separately. Figure 8 show some of the techniques that could be applied in analytics.

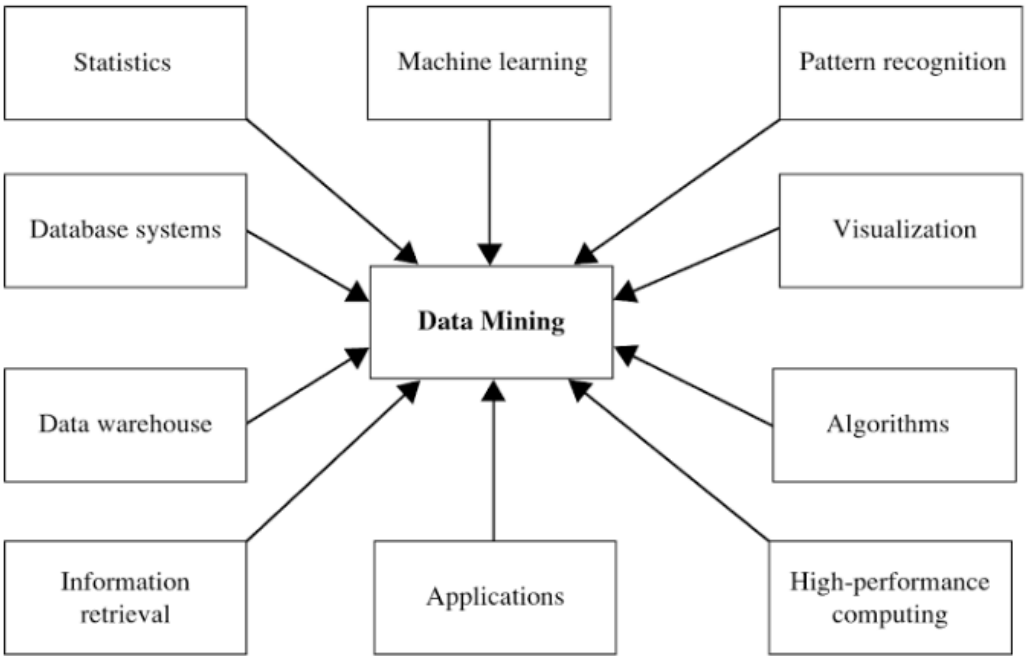

Figure 8 Processes used in data mining.

In Russom (2011) a survey has been performed among 325 respondents. The question was: *What kind of technique and tool types is your organization using for advanced analytics and big data, both today and in three years?* The respondents could select from a list of fairly new, established and old techniques and tools and the result is presented in figure 9.

Although this is just a sample of techniques, the results are pretty even. As there are so many factors to consider in analytics, the most foundational is to know the available options. This is key to making good decisions.

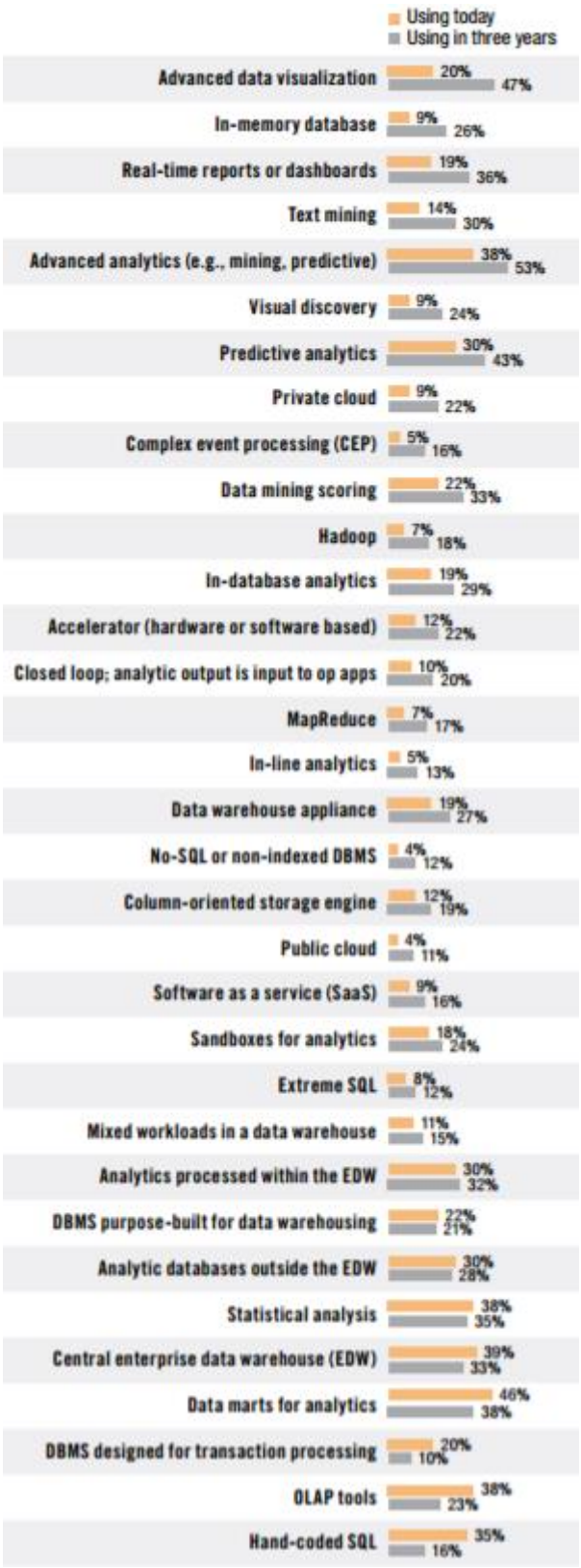

Figure 9 Tools and techniques for advanced analytics and big data.

3.3.4 Data Visualization

Fayyad, et al. (2002) points out that most data mining and knowledge discovery systems in use today, requires experts to be utilized. As seen in the previous section, tools and techniques available for just the data mining are countless. To further get the results of those analyses easily understandable requires additional experts, that can utilize the results and apply them where needed. It is often hard, or even impossible, to find all these skills within a company.

As stated in the previous chapter, the common denominator of data mining and knowledge discovery is to extract useful business patterns and mathematical decision models from pre-processed data. One way to do this is through data visualization, as shown in Figure 8 (Han, et al., 2011). Visualization can provide a qualitative overview of large data sets, can summarize data and can assist in identifying regions of interest and appropriate parameters for more focused quantitative analysis.

In Fayyad, et al. (2002) visualization is defined as *the graphical (as opposed to textual or verbal) communication of information (e.g. data, documents, structure)*. Visualization is also divided into different techniques depending on its purpose: to explore data, to confirm a hypotesis or to manipulate a viewer.

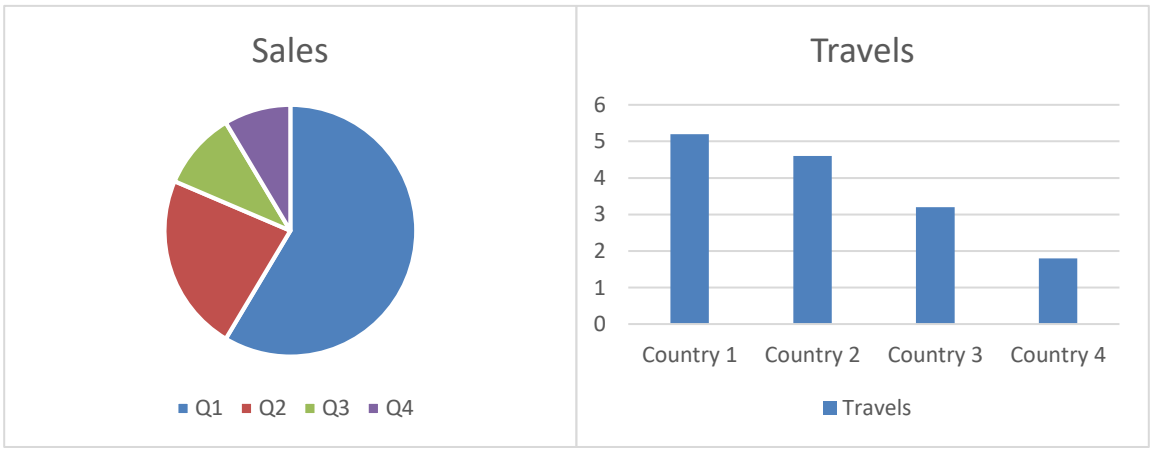

Figure 10 Example of Pie chart and Bar chart.

In Few (2004) seven types of quantitative messages are presented. A quantitative message almost always consists of a quantitative and a categorical (qualitatative) data. In a standard staple diagram, the categorical data is the text describing each staple (what) while the quantitative data is the size of the staple (how much). Depending on the relationships between the categorical data and the quantitative data, different visualization tools should be

applied. These are the seven types presented, as well as the recommended type of diagrams or charts for each type:

- **Nominal Comparison**, a simple comparison of the categorical subdivisions of one or more measures in no particular order.
    - **Bars.**
- **Time Series**, multiple instances of one or more measures taken at equidistant points in time.
    - **Lines, Bars, Points connected by lines.**
- **Ranking**, categorical subdivisions of a measure ordered by size (either descending or ascending).
    - **Bars.**
- **Part-to-Whole**, measures of individual categorical subdivision as ratios to the whole.
    - **Bars, Pie chart.**
- **Deviation**, a categorical subdivision of a measure compared to a reference measure.
    - **Lines, Points connected by lines, Bars.**
- **Frequency Distribution**, counts of something per categorical subdivisions of quantitative range.
    - **Vertical bars, Lines.**
- **Correlation**, comparison of two paired sets of measures.
    - **Points and trendline, Bars.**

4 Methodology

This chapter will introduce the methods used to come up with the final result. The chapter starts with a brief discussion of the research approach and continues with a more thorough presentation of the different methods used in the solution approach.

4.1 Research Approach

This work was ordered by Wärtsilä Field Services in the spring 2016. A meeting was arranged with the supervisors from Wärtsilä and the purpose of the work was decided. As the work was ordered with a specific aim, the paper can be categorized as applied research. According to Kothari (1990) *applied research aims at finding a solution for an immediate problem facing a society or an industrial/business organization*.

The approach of the work is mainly inductive. According to Bernard (2011) *inductive research involves the search for pattern from observation and the development of explanations - theories - for those patterns through a series of hypotheses*. This corresponds very well with the aim of this thesis: unreasonably big amounts of cross-border travelling have been observed and explanations are being developed through analyses of the data. The hypotheses are that the high travel activity is a result of bad resource management or lack of competencies. In Bryman & Bell (2015) inductive reasoning is criticized because no amount of empirical data will necessarily enable theory-building. Considering this critizism, the paper can also be considered abductive. Abduction involves the researcher selecting the "best" explanation from competing explanations or interpretations of the data.

Looking at the data used in the paper, it can be categorized both quantitative and qualitative. According to Kothari (1990) *quantitative is applicable to phenomena that can be expressed in terms of quantity, while qualitative is concerned with qualitative phenomenon, i.e. phenomena relating to or involving quality or kind*. The first part, where only travel flows are mapped, is mostly quantitative: the amount of travels to and from different locations are analyzed. The other part, where the characteristics of the travels are analyzed, is more qualitative: the origin and purpose of the travels are considered in the analysis.

4.2 Solution Approach

In this section, all methods applied to come up with the final result will be thoroughly presented. All included data tables and illustrations are anonymized, since the information is sensitive and therefore confidential.

4.2.1 Data Sources

In the theory section, it was noted that all data sources available should be considered before starting an analysis: *the more data, the better*. In the autumn of 2016 I received the first set of data from my supervisors at Wärtsilä. The data was in the form of an Excel-file with travel records for the interval 1.1.2015 to 30.6.2016. The data was supplied by the HR department at Wärtsilä and based on the travel reports done for each completed travel.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	Personnel	Employee Name	Company Code	Cost Center	Trip	From	Ends On	Trip Country	Reason	Trip Activity Ty	Meals per Diems	Currency	M/Km	Total Costs	Currency	Days
2	10002345	Anders Andersson	Wärtsilä Danmark A/S	43529	1234567890	08.01.2015	12.01.2015	Sweden	Service on DF50	Service work	838,78	DKK	0	784,00	DKK	5
3	10002345	Anders Andersson	Wärtsilä Danmark A/S	43529	1234567891	14.01.2015	17.01.2015	Sweden	Gearbox training	Service work	2703,05	DKK	0	3803,05	DKK	4
4	10002345	Anders Andersson	Wärtsilä Danmark A/S	43529	1234567892	26.01.2015	02.02.2015	Sweden	Servicework/inspection	Service work	2520,19	DKK	0	1458,37	DKK	8
5	10002345	Anders Andersson	Wärtsilä Danmark A/S	43529	1234567893	06.02.2015	09.02.2015	Sweden	Servicework Imagination 1	Service work	0,00	DKK	0	2835,16	DKK	4
6	10002345	Anders Andersson	Wärtsilä Danmark A/S	43529	1234567894	10.02.2015	12.02.2015	Denmark	Servicework Imagination 2	Service work	0,00	DKK	0	784,00	DKK	3
7	10002345	Anders Andersson	Wärtsilä Danmark A/S	43529	1234567895	19.02.2015	24.02.2015	Denmark	Servicework Imagination 3	Service work	0,00	DKK	0	737,50	DKK	6
8	10002345	Anders Andersson	Wärtsilä Danmark A/S	43529	1234567896	25.02.2015	26.02.2015	Denmark	Servicework Imagination 4	Service work	0,00	DKK	0	1704,18	DKK	2
9	10002345	Anders Andersson	Wärtsilä Danmark A/S	43529	1234567897	27.02.2015	02.03.2015	Denmark	Servicework	Service work	883,12	DKK	0	3685,30	DKK	4
10	10002345	Anders Andersson	Wärtsilä Danmark A/S	43529	1234567898	09.03.2015	11.03.2015	Denmark	Workshop training	Service work	0,00	DKK	0	1764,72	DKK	3
11	10002345	Anders Andersson	Wärtsilä Danmark A/S	43529	1234567899	12.03.2015	15.03.2015	Denmark	Servicework/inspection of Cpp	Service work	427,82	DKK	0	784,00	DKK	4
12	10002345	Anders Andersson	Wärtsilä Danmark A/S	43529	1234567900	16.03.2015	19.03.2015	Denmark	Servicework Imagination 5	Service work	569,11	DKK	0	359,37	DKK	4
13	10002345	Anders Andersson	Wärtsilä Danmark A/S	43529	1234567901	24.03.2015	01.04.2015	Denmark	Servicework Imagination 6	Service work	871,35	DKK	0	3736,74	DKK	9
14	10002345	Anders Andersson	Wärtsilä Danmark A/S	43529	1234567902	06.04.2015	17.04.2015	Finland	Sevicework Imagination 7	Training	294,37	DKK	0	3240,45	DKK	12
15	10002345	Anders Andersson	Wärtsilä Danmark A/S	43529	1234567903	27.04.2015	01.05.2015	Finland	"Servicework Imagination 8	Service work	0,00	DKK	0	3574,70	DKK	5
16	10002345	Anders Andersson	Wärtsilä Danmark A/S	43529	1234567904	10.05.2015	17.05.2015	Finland	LT 7000 Controls Training	Service work	0,00	DKK	0	764,37	DKK	8
17	10002345	Anders Andersson	Wärtsilä Danmark A/S	43529	1234567905	18.05.2015	19.05.2015	Finland	Alignment of Main engine and sterntut	Service work	733,97	DKK	0	4255,01	DKK	2
18	10002345	Anders Andersson	Wärtsilä Danmark A/S	43529	1234567906	20.05.2015	27.05.2015	Denmark	training	Service work	471,00	DKK	0	1466,13	DKK	8
19	10002345	Anders Andersson	Wärtsilä Danmark A/S	43529	1234567907	28.05.2015	29.05.2015	Denmark	Service Work	Service work	0,00	DKK	0	1160,48	DKK	2
20	10002345	Anders Andersson	Wärtsilä Danmark A/S	43529	1234567908	04.06.2015	08.06.2015	Denmark	Warrenty	Service work	0,00	DKK	0	1473,98	DKK	5
21	10002345	Anders Andersson	Wärtsilä Danmark A/S	43529	1234567909	29.06.2015	04.07.2015	Denmark	Service	Service work	723,53	DKK	0	54,50	DKK	6
22	10002345	Anders Andersson	Wärtsilä Danmark A/S	43529	1234567910	05.07.2015	21.07.2015	Denmark	Service work	Service work	0,00	DKK	0	738,44	DKK	17
23	10002345	Anders Andersson	Wärtsilä Danmark A/S	43529	1234567911	22.07.2015	25.07.2015	Denmark	Service dismantling of turbo charger	Service work	0,00	DKK	0	3785,01	DKK	4
24	10002346	Bengt Bengtsson	Wärtsilä Finland Oy	40038	1234567912	03.08.2015	09.08.2015	Finland	M/S Imagination 9, DG2-3. exchange	Service work	200,00	EUR	0	6113,58	EUR	7
25	10002346	Bengt Bengtsson	Wärtsilä Finland Oy	40038	1234567913	10.08.2015	15.08.2015	Finland	M/S Imagination 9, exhaust casings	Service work	560,00	EUR	36	3818,29	EUR	6
26	10002346	Bengt Bengtsson	Wärtsilä Finland Oy	40038	1234567914	07.09.2015	30.09.2015	Finland	M/S Imagination 9, sea trial	Service work	0,00	EUR	0	3521,02	EUR	24
27	10002346	Bengt Bengtsson	Wärtsilä Finland Oy	40038	1234567915	02.10.2015	14.10.2015	Finland	Aloite palaveri yms.	Service work	0,00	EUR	24	1688,67	EUR	13
28	10002346	Bengt Bengtsson	Wärtsilä Finland Oy	40038	1234567916	16.10.2015	30.10.2015	Finland	Imagination 10, CAC+HP-Pumps	Training	120,00	EUR	0	8084,75	EUR	15
29	10002346	Bengt Bengtsson	Wärtsilä Finland Oy	40038	1234567917	30.10.2015	31.10.2015	Finland	M/S Imagination 11,main bearings	Training	102,00	EUR	0	16152,00	EUR	2
30	10002346	Bengt Bengtsson	Wärtsilä Finland Oy	40038	1234567918	05.11.2015	09.11.2015	Finland	power station, conversion	Service work	80,00	EUR	0	25480,90	EUR	5
31	10002346	Bengt Bengtsson	Wärtsilä Finland Oy	40038	1234567919	10.11.2015	29.11.2015	Finland		Service work	701,50	EUR	0	2756,71	EUR	20
32	10002346	Bengt Bengtsson	Wärtsilä Finland Oy	40038	1234567920	03.12.2015	12.12.2015	Finland	power station, conversion	Service work	40,00	EUR	46	165,64	EUR	10
33	10002346	Bengt Bengtsson	Wärtsilä Finland Oy	40038	1234567921	15.12.2015	24.12.2015	Korea	M/S Imagination 12, Twin needle, field	Service work	640,50	EUR	46	164,14	EUR	10
34	10002346	Bengt Bengtsson	Wärtsilä Finland Oy	40038	1234567922	06.01.2016	07.01.2016	Korea	M/S Imagination 13, cam shaft failure	Service work	204,00	EUR	42	975,88	EUR	2
35	10002346	Bengt Bengtsson	Wärtsilä Finland Oy	40038	1234567923	08.01.2016	11.01.2016	Korea	M/S Imagination 14, Napier overhaul	Service work	433,50	EUR	0	3872,70	EUR	4
36	10002346	Bengt Bengtsson	Wärtsilä Finland Oy	40038	1234567924	26.01.2016	09.02.2016	Germany	Imagination 12, cam shaft failure	Service work	0,00	EUR	0	2321,69	EUR	15
37	10002346	Bengt Bengtsson	Wärtsilä Finland Oy	40038	1234567925	15.02.2016	03.03.2016	Germany	Cylinder head stud thread repair	Service work	510,00	EUR	0	4279,89	EUR	18
38	10002346	Bengt Bengtsson	Wärtsilä Finland Oy	40038	1234567926	06.03.2016	12.03.2016	Germany	Fuel valve exchange	Service work	0,00	EUR	42	2976,26	EUR	7
39	10002346	Bengt Bengtsson	Wärtsilä Finland Oy	40038	1234567927	22.03.2016	24.03.2016	Germany	Imagination plant: DG3.Prepare of cra	Service work	160,00	EUR	44	112,16	EUR	3
40	10002346	Bengt Bengtsson	Wärtsilä Finland Oy	40038	1234567928	31.03.2016	30.04.2016	Germany	Imaginara Power Station, reset to zero	Service work	153,00	EUR	0	7608,46	EUR	31
41	10002346	Bengt Bengtsson	Wärtsilä Finland Oy	40038	1234567929	11.05.2016	05.06.2016	Germany	Imaginara Power Station, reset to zero	Service work	0,00	EUR	0	40,00	EUR	26
42	10002346	Bengt Bengtsson	Wärtsilä Finland Oy	40038	1234567930	14.06.2016	17.06.2016	Germany	IMAGINATION 15	Training	153,00	EUR	72	89,68	EUR	4
43	10002346	Bengt Bengtsson	Wärtsilä Finland Oy	40038	1234567931	23.11.2015	07.12.2015	Germany	Imagination 15	Service work	76,50	EUR	0	18,00	EUR	15

Figure 11 Raw travel data provided by Wärtsilä HR.

As seen in Figure 11 each employee at Wärtsilä has a unique employee number. Cost center is the specific organizational unit the employee belongs to. Each trip has a unique running number, and each line is a separate travel record. The *Reason*-field is the reason for the job as described on the work report or work order.

To support the raw data, some information was also collected from the Wärtsilä intranet. As seen in Figure 11, only the destination country is mentioned in the raw data. Therefore, information about which countries belongs to which service units and areas needed to be connected to the table. As also seen in the raw data, no departure country was mentioned.

This information could be found out based on the sending cost center, but then information about all available cost centers needed to be collected too.

Except the raw travelling data, we also used data from the *Professional Skills Management* (PSM) tool on the Wärtsilä intranet. PSM is a tool to implement a professional skills management process for billable personnel in Field Services. In the PSM tool service engineers are connected to different skill sets and each skill set is defined with a certain training path needed to possess the skill.

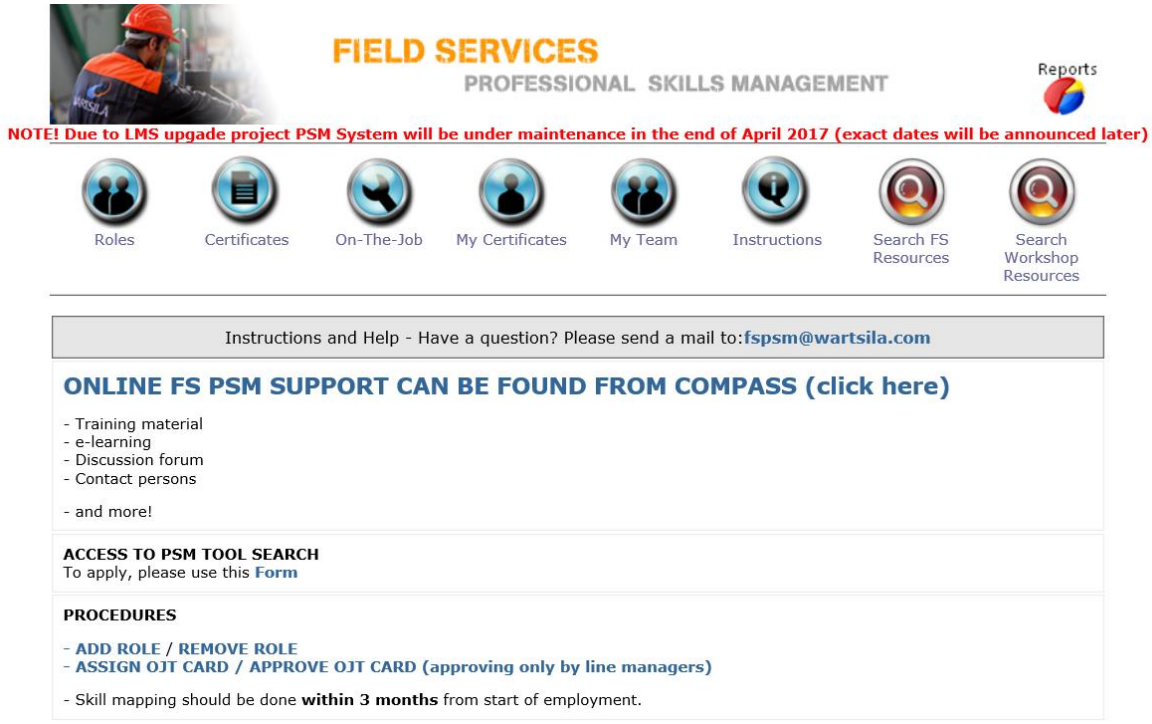

Figure 12 The PSM dashboard.

In the PSM tool it is possible to list all resources that possesses a certain skill, a specific person's accomplished skill set, training paths needed for different skills and what skill sets are connected to which product. This way it is easier to select the correct resource for a specific job, if the skill set needed is known. (Wärtsilä, 2017b).

4.2.2 Platform Selection

When it came to selecting a platform to perform this thesis work on, Microsoft Excel was the most natural choice. The main reason for this decision is the Wärtsilä IT environment called SONAD. SONAD stands for *Standardization Of Network And Desktop* and is the standard used for all software, hardware and networks within Wärtsilä. In SONAD only a

small selection of programs is possible to install on the operating system, and none of those are statistics programs.

Another reason for this choice is that Wärtsilä uses Office365, which contains all the different office tools that have become standard in most offices today, including Excel. As Excel is one of the most widely used spreadsheet programs right now, most people are more or less familiar with it. This means no new software needs to be installed to use the analysis tool and no or minimal education is needed to put it into use.

4.2.3 Data Processing

Once all the data was collected and the platform selected, it was time to start processing the data. First of all, we needed to find out the origin and destination of each trip. As seen in Figure 11 each trip record only contains the destination of the trip. To find out the origin of each trip, we needed to connect the cost centers to their destinations.

	A	D	J	K	L
1	Cost Ctr	CoCd	AreaCode	Dep.	Type
2	40038	FI14	40-15-0013	4-stroke	PRODUCTLINE
3	40039	FI14	40-15-0013	4-stroke	PRODUCTLINE
4	40043	FI14	40-15-0013	4-stroke	PRODUCTLINE
5	40065	FI14	40-15-0013	4-stroke	PRODUCTLINE
6	40108	FI14	40-15-0013	4-stroke	PRODUCTLINE
7	40117	DE10	40-11-0010	NE	AREA
8	40126	DE10	40-11-0010	NE	AREA
9	40159	CH10	40-18-1010	2-stroke	PRODUCTLINE
10	40179	DE10	40-11-0010	NE	AREA
11	40194	DE10	40-11-0010	NE	AREA
12	40203	NO10	40-11-0010	NE	AREA
13	40205	IT10	40-12-0010	SEAF	AREA
14	40207	FR11	40-12-0010	SEAF	AREA
15	40210	FI14	40-15-0013	4-stroke	PRODUCTLINE
16	40211	FI14	40-15-0013	4-stroke	PRODUCTLINE
17	40253	IT10	40-12-0010	SEAF	AREA
18	40254	IT10	40-12-0010	SEAF	AREA

Figure 13 Cost center information.

	A	B	C
1	40-10-0010	MEA	AREA
2	40-10-0013	MEA	AREA
3	40-11-0010	NE	AREA
4	40-11-0013	NE	AREA
5	40-12-0010	SEAF	AREA
6	40-12-0013	SEAF	AREA
7	40-13-0010	AMER	AREA
8	40-13-0013	AMER	AREA
9	40-15-0013	4-stroke	PRODUCTLINE
10	40-15-0014	4-stroke	PRODUCTLINE
11	40-14-0024	Propulsion	PRODUCTLINE
12	40-14-0025	Propulsion	PRODUCTLINE
13	40-14-0026	Propulsion	PRODUCTLINE
14	40-18-1010	2-stroke	PRODUCTLINE
15	40-18-4010	Multibrand	PRODUCTLINE
16	40-18-4014	Multibrand	PRODUCTLINE
17	40-18-4012	Multibrand	PRODUCTLINE

Figure 14 Cost center types.

As seen in Figure 13 each cost center has a unique number and is connected to a certain *Country code* and *Area code* depending on geographical origin and business area. In Figure 14 all different Area codes are divided into either Area or Product line, and thereafter into their specific geographical areas or business areas. The two different tables have been connected by VLOOKUP-functions to connect each cost center to its specific type and area.

In the next step three new columns were added to the cost center list to divide the different cost centers on a more detailed level: *Country*, *SU* and *Area*. If a cost center is of the type *Area*, the country will be decided by the country code. Thereafter the Service unit and Area

it belongs to will be checked from the list of countries, service units and areas (see Figure 17). If a cost center instead is of the type *Product line*, the country will be a combination of the country code and the concerned business area (from Figure 14). In that case, Service unit and Area will be the same as previously taken from Figure 14.

	A	D	J	K	L	M	N	O
1	Cost Ctr	CoCd	AreaCode	Dep.	Type	Country	SU	Area
2	40038	FI14	40-15-0013	4-stroke	PRODUCTLINE	FI 4-stroke	4-stroke	PRODUCTLINE
3	40039	FI14	40-15-0013	4-stroke	PRODUCTLINE	FI 4-stroke	4-stroke	PRODUCTLINE
4	40043	FI14	40-15-0013	4-stroke	PRODUCTLINE	FI 4-stroke	4-stroke	PRODUCTLINE
5	40065	FI14	40-15-0013	4-stroke	PRODUCTLINE	FI 4-stroke	4-stroke	PRODUCTLINE
6	40108	FI14	40-15-0013	4-stroke	PRODUCTLINE	FI 4-stroke	4-stroke	PRODUCTLINE
7	40117	DE10	40-11-0010	NE	AREA	DE	SUDECH	NE
8	40126	DE10	40-11-0010	NE	AREA	DE	SUDECH	NE
9	40159	CH10	40-18-1010	2-stroke	PRODUCTLINE	CH 2-stroke	2-stroke	PRODUCTLINE
10	40179	DE10	40-11-0010	NE	AREA	DE	SUDECH	NE
11	40194	DE10	40-11-0010	NE	AREA	DE	SUDECH	NE
12	40203	NO10	40-11-0010	NE	AREA	NO	SUNO	NE
13	40205	IT10	40-12-0010	SEAF	AREA	IT	SUIT	SEAF
14	40207	FR11	40-12-0010	SEAF	AREA	FR	SUFR	SEAF
15	40210	FI14	40-15-0013	4-stroke	PRODUCTLINE	FI 4-stroke	4-stroke	PRODUCTLINE
16	40211	FI14	40-15-0013	4-stroke	PRODUCTLINE	FI 4-stroke	4-stroke	PRODUCTLINE
17	40253	IT10	40-12-0010	SEAF	AREA	IT	SUIT	SEAF
18	40254	IT10	40-12-0010	SEAF	AREA	IT	SUIT	SEAF

Figure 15 Cost centers divided into different categories.

Once the origin of each trip has been decided, the destination should be specified. As seen in Figure 11 the *Trip country* was already specified, but the problem is that the destinations are only the countries mentioned in the travel reports. As pointed out in the theory part, the quality of the results directly depends on the quality of the underlying data. To avoid inconsistencies and noise in our data, the steps described in Baesens (2014) and Han, et al. (2011) can be applied. First of all, this data is not standardized which means that for instance United States can be found as United States, United States of America, USA and so on. This also means that some destinations mentioned can't be connected to a certain country. To

	A	B	C	D	E
1	Trip Country	Country	CoCd	SU	Area
2	Africa	OTHER	OTHER	OTHER	SEAF
3	America	OTHER	OTHER	OTHER	AMER
4	Antigua/Barbuda	ANTIGUA AND BARBUDA	AG	SUCCA	AMER
5	Antilles	OTHER	OTHER	OTHER	AMER
6	Athen, Greece	GREECE	GR	SUGC	SEAF
7	Bolivia	BOLIVIA, PLURINATIONAL STATE OF	BO	SUAND	AMER
8	Bosnia-Herzegovina	BOSNIA AND HERZEGOVINA	BA	SUIT	SEAF
9	Brazil, Rio de Janeiro	BRAZIL	BR	SUBRA	AMER
10	Brazil, Sao Paulo	BRAZIL	BR	SUBRA	AMER
11	Brunei (Darussalam)	BRUNEI DARUSSALAM	BN	SUIS	MEA

Figure 16 Sample of non-standardized destinations.

solve this problem all countries that could not be connected to a certain country in a standardized list of Wärtsilä destinations (Countries, Service units and Areas), were filtered out. The resulting list of non-standardized countries was then checked for doublets. Out of about 60 000 travel records, 93 doublets were found. Each doublet was then manually connected to the corresponding country, and if that was not possible it was only connected to the correct area. Destinations that could not be connected to any standardized entry, were classified as *OTHER*.

To keep everything in order, a new worksheet was created to hold only the information necessary for the analysis (Figure 18). Each row in the new worksheet corresponded to a trip at the same row in the raw data. The origin fields get their information by a VLOOKUP-function based on the cost center, as presented in figure 15. The destination fields get their information by first looking through the standardized list of Wärtsilä destinations (Figure 17). If no matches are found there, the search continues in the list of non-standardized destinations (Figure 16). If no matches at all are found, the destination field will be left empty.

	A	B	C	D
1	CoCd	Country	Area	SU S
2	AD	ANDORRA	SEAF	SUIBERICA
3	AE	UNITED ARAB EMIRATES	MEA	SUME
4	AF	AFGHANISTAN	MEA	SUME
5	AG	ANTIGUA AND BARBUDA	AMER	SUCCA
6	AI	ANGUILLA	AMER	SUCCA
7	AL	ALBANIA	SEAF	SUGC
8	AM	ARMENIA	NE	SURU
9	AO	ANGOLA	SEAF	SUEAFRICA
10	AQ	ANTARCTICA	MEA	SUAA
11	AR	ARGENTINA	AMER	SUAND
12	AS	AMERICAN SAMOA	MEA	SUAA
13	AT	AUSTRIA	NE	SUBB
14	AU	AUSTRALIA	MEA	SUAA
15	AW	ARUBA	AMER	SUCCA
16	AX	ALAND ISLANDS	NE	SUBB
17	AZ	AZERBAIJAN	SEAF	SUTC
18	BA	BOSNIA AND HERZEGOVINA	SEAF	SUIT
19	BB	BARBADOS	AMER	SUCCA
20	BD	BANGLADESH	MEA	SUSA

Figure 17 List of standardized Wärtsilä destinations.

	A	B	C	D	E	F
1	From CoCd	From SU	From Area	To CoCd	To SU	To Area
21160	FI	SUBB	NE	BD	SUSA	MEA
21161	FI	SUBB	NE	FI	SUBB	NE
21162	FI	SUBB	NE	US	SUUSA	AMER
21163	FI	SUBB	NE	FI	SUBB	NE
21164	FI	SUBB	NE	US	SUUSA	AMER
21165	FI	SUBB	NE	FI	SUBB	NE
21166	FI	SUBB	NE	FI	SUBB	NE
21167	FI	SUBB	NE	FI	SUBB	NE
21168	FI	SUBB	NE	FI	SUBB	NE
21169	FI	SUBB	NE	FI	SUBB	NE
21170	FI	SUBB	NE	FI	SUBB	NE
21171	FI	SUBB	NE	FI	SUBB	NE
21172	FI	SUBB	NE	FI	SUBB	NE
21173	FI	SUBB	NE	FI	SUBB	NE
21174	FI	SUBB	NE	FI	SUBB	NE
21175	FI	SUBB	NE	FI	SUBB	NE
21176	FI 4-stroke	4-stroke	PRODUCTLINE	US	SUUSA	AMER
21177	FI 4-stroke	4-stroke	PRODUCTLINE	GB	SUGBIE	NE
21178	FI 4-stroke	4-stroke	PRODUCTLINE	GB	SUGBIE	NE
21179	FI 4-stroke	4-stroke	PRODUCTLINE	NG	SUWAFRICA	SEAF
21180	FI 4-stroke	4-stroke	PRODUCTLINE	NG	SUWAFRICA	SEAF
21181	FI 4-stroke	4-stroke	PRODUCTLINE	FI	SUBB	NE
21182	FI 4-stroke	4-stroke	PRODUCTLINE	FI	SUBB	NE
21183	FI 4-stroke	4-stroke	PRODUCTLINE	US	SUUSA	AMER
21184	FI 4-stroke	4-stroke	PRODUCTLINE	US	SUUSA	AMER

Figure 18 List of trip origins and destinations.

To further support the analysis, columns were inserted to compare trip origin and destination. The comparison checks if the origin country, service unit and area are the same as the destination, and also marks if the organization is Area or Product line. The markings between areas are *Same* and *Different*, and from Product line to area *Same PL* and *Different PL*.

	A	B	C	D	E	F	G	H	I
1	From CoCd	From SU	From Area	To CoCd	To SU	To Area	Country	SU	Area
21173	FI	SUBB	NE	FI	SUBB	NE	Same	Same	Same
21174	FI	SUBB	NE	FI	SUBB	NE	Same	Same	Same
21175	FI	SUBB	NE	FI	SUBB	NE	Same	Same	Same
21176	FI 4-stroke	4-stroke	PRODUCTLINE	US	SUUSA	AMER	Different PL	Different PL	Different PL
21177	FI 4-stroke	4-stroke	PRODUCTLINE	GB	SUGBIE	NE	Different PL	Different PL	Same PL
21178	FI 4-stroke	4-stroke	PRODUCTLINE	GB	SUGBIE	NE	Different PL	Different PL	Same PL

Figure 19 Comparison between trip origin and destination.

To make it possible to sum days of each trip, sort trips based on organization and filter out trips based on purpose, three additional columns were added (Figure 20).

	A	B	C	D	E	F	G	H	I	J	K	L
1	From CoCd	From SU	From Area	To CoCd	To SU	To Area	Country	SU	Area	Days	Type	Activity
21173	FI	SUBB	NE	FI	SUBB	NE	Same	Same	Same	3	AREA	Service work
21174	FI	SUBB	NE	FI	SUBB	NE	Same	Same	Same	1	AREA	Service work
21175	FI	SUBB	NE	FI	SUBB	NE	Same	Same	Same	3	AREA	Service work
21176	FI 4-stroke	4-stroke	PRODUCTLINE	US	SUUSA	AMER	Different PL	Different PL	Different PL	1	PRODUCTLINE	Project related
21177	FI 4-stroke	4-stroke	PRODUCTLINE	GB	SUGBIE	NE	Different PL	Different PL	Same PL	40	PRODUCTLINE	Project related
21178	FI 4-stroke	4-stroke	PRODUCTLINE	GB	SUGBIE	NE	Different PL	Different PL	Same PL	15	PRODUCTLINE	Project related

Figure 20 Information base for analysis.

4.2.4 Data Analysis and Visualization

To get some information out of the raw data, five new worksheets were created in the Excel-file. To make the information extracted from the data easily understandable and interpretable, we decided to use data visualization. The first two worksheets were created to get an understanding of the total amount of cross-border travelling and net travelling (incoming minus outgoing) in different countries, while the three others were created to get more detailed information about travelling on area, service unit and country level.

In the worksheets containing cross-border and net travelling we decided to use bar charts, as it was about comparisons between different countries, service units and areas. According to Few (2004) descending bar charts are the best to highlight high values in comparisons, and that is just what we want to do.

To get the data to base the visualization on, separate datasheets were created for the numerical comparisons. As the comparision should cover all countries, service units and areas, all unique entries in each of these categories were listed in the datasheets. To count amount of travels and travelling days, COUNTIF- and SUMIF-functions were used. As there are so many countries and service units, only the ones with the highest values were selected to be shown in the visualization. INDEX- and MATCH-functions were used to create descending lists, from which top 10 service units and top 25 countries were selected.

F	G	X	Y	Z	AA	AB	AC
AREAS			TOP 10 SU			TOP 25 Country	
Area S	Travels		SU S	Travels		CoCd	Travels
Area1	5919		ServiceUnit1	3284		Country1	2723
Area2	5744		ServiceUnit2	2620		Country2	2139
Area3	3465		ServiceUnit3	2256		Country3	1682
Area4	3175		ServiceUnit4	1694		Country4	1681
Area5	1931		ServiceUnit5	1682		Country5	1584
Area6	284		ServiceUnit6	1578		Country6	1528
			ServiceUnit7	1428		Country7	1508
			ServiceUnit8	1420		Country8	1424
			ServiceUnit9	1243		Country9	1391
			ServiceUnit10	1235		Country10	1295
						Country11	1270
						Country12	1122
						Country13	1026
						Country14	1019
						Country15	951
						Country16	948
						Country17	729
						Country18	677
						Country19	579
						Country20	573
						Country21	521
						Country22	482
						Country23	389
						Country24	353
						Country25	350

Figure 21 Amount of cross-border travels.

F	G	X	Y	Z	AA	AB	AC
AREAS			TOP 10 SU			TOP 25 Country	
Area S	Days		SU S	Days		CoCd	Days
Area1	62239		ServiceUnit1	15960		Country1	34244
Area2	59406		ServiceUnit2	15943		Country2	20036
Area3	41291		ServiceUnit3	15492		Country3	16004
Area4	41197		ServiceUnit4	14339		Country4	15810
Area5	29619		ServiceUnit5	13224		Country5	15418
Area6	3816		ServiceUnit6	13128		Country6	14580
			ServiceUnit7	13087		Country7	14301
			ServiceUnit8	12900		Country8	14262
			ServiceUnit9	11920		Country9	14238
			ServiceUnit10	11570		Country10	14039
						Country11	11920
						Country12	11538
						Country13	10285
						Country14	9575
						Country15	8746
						Country16	8345
						Country17	6478
						Country18	6166
						Country19	5614
						Country20	5475
						Country21	5265
						Country22	5221
						Country23	5182
						Country24	4820
						Country25	4470

Figure 22 Amount of cross-border travel days.

On the worksheets with more specific information about certain areas, service units and countries, a similar method was used. The difference was the possibility to choose what area, service unit or country to focus on. This was solved by creating drop-down lists with the *Data validation* function. Macros were connected to the drop-down lists, so that when for instance a specific area is chosen, only service units within that area are shown. These macros were created with the *Advanced filtering* functions. The reason this solution was chosen, is because of the many parameters impacting on the resulting lists. With advanced filtering, it is possible to let other functions change parameters in the filtering function, to modify the resulting lists. This would not be possible with for instance Pivot tables.

The background data on which the visualization is constructed, are calculated based on the selections in the drop-down lists. Macros are connected to the drop-down lists, so that if for instance the *country* value is changed, all background data is updated according to the new selection. All macros use the advanced filtering function in Excel, and the output of the

macros are created in hidden datasheets. Once the macro has updated the hidden datasheets, new values are calculated based on the new parameters. The functions used in these worksheets are similar to the previous ones: only COUNTIF-, SUMIF-, INDEX- and MATCH-functions have been used. As origins and destinations can be divided into different areas, service units and countries, and also be categorized as Areas or Product lines, a lot of calculations are triggered by the macros if a parameter change. This makes the calculation process very heavy and demands a quick processor to have it running smoothly.

In the first two worksheets bar charts were used, as they were concerning comparisons between different geographical places. For the three worksheets focusing on specific areas, service units or countries, pie charts are used instead. This is because these results should show what travels have the biggest part of the total amount of travels to and from a certain area. As previously stated in the theory chapter, pie charts are best to show parts-to-whole. In this case, all travelling to and from a certain geographical is seen as *the whole*, while travelling for instance from a certain service unit within the area is seen as *a part*.

5 Results

This chapter will present the final results of this thesis work. First the Excel-tool resulting from this thesis will be thoroughly presented. Thereafter the outcomes of the different visualizations will be discussed and analyzed as a scenario-based action plan.

5.1 Excel-tool

This section will present each of the functions available in the final Excel-tool. The output of each function will also be discussed and results analyzed.

5.1.1 Start Page

The first page visible to the user of the Excel-tool contains buttons to import and pre-process the raw data used in the analysis (Figure 23). The tabs at the bottom are categorized by color: *green* tabs are concerning the raw data, *blue* tabs are comparisons of travelling between geographical areas while *yellow* tabs are visualizing the type of travelling to and from specific geographical areas.

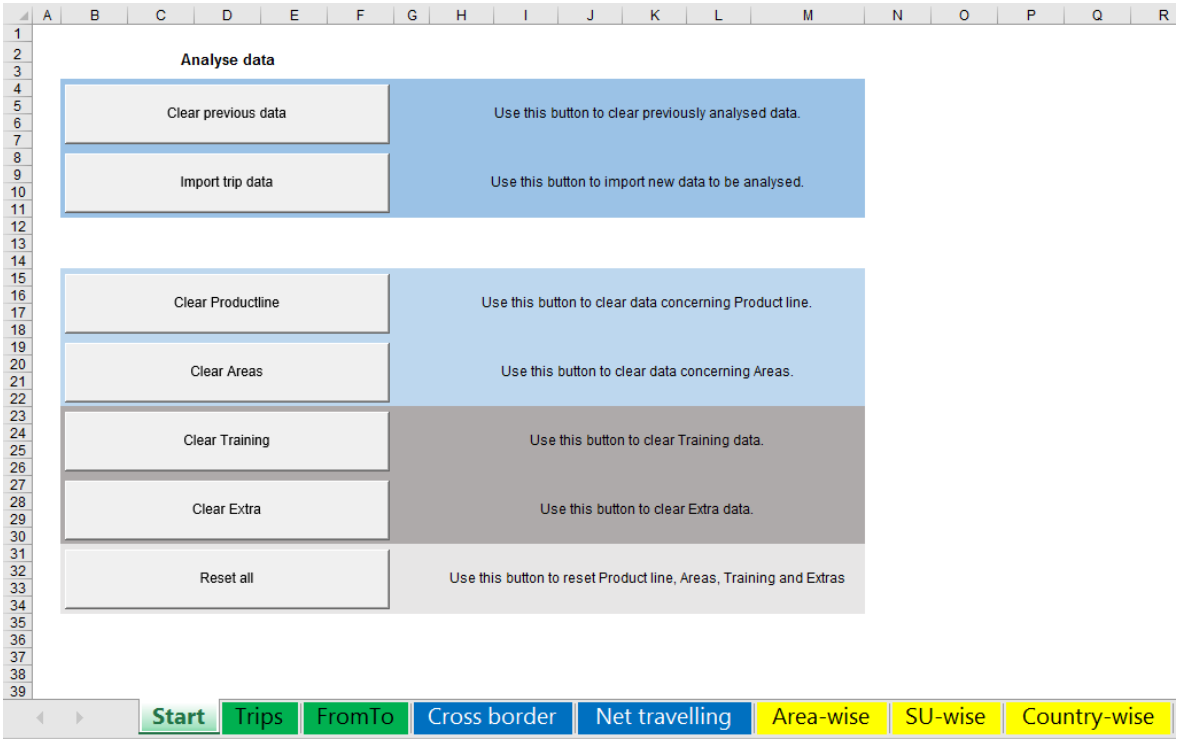

Figure 23 Excel-tool: Start page.

Each button on the start page has a specific function. The first two are directly interfering with the raw data, while the rest of the buttons are only different filters applied on the pre-processed data:

- **Clear previous data**. This button will clear all raw data currently imported in the Excel-file.
- **Import trip data**. This button will open a pop-up window to choose a file containing the raw data to be analyzed. The raw data must have the file extension *.xlsx* and be formatted as seen in Figure 11. The raw data must not exceed 100 000 lines.
- **Clear Product lines**. This button will remove all trips of type *Product line* from the trip origin and destination data.
- **Clear Areas**. This button will remove all trips of type *Area* from the trip origin and destination data.
- **Clear Training**. This button will remove all trips with activity *Training* from the trip origin and destination data.

- **Clear Extras**. This button will remove all trips where activity is other than *Service work* and *Training* from the trip origin and destination data.

- **Reset all**. This button will reset all the trip origin and destination data to its original format. All filters applied will be removed.

5.1.2 Cross-border Travelling

On the cross-border travelling tab the total amount of cross-border travelling is compared between different geographical areas (Figure 24). Cross border travelling is calculated as the sum of all travels coming in to a specific geographical area and all travels leaving it. This sum shows the total amount of travels crossing the border for a specific geographical area.

A high amount of cross-border travelling may indicate that something is not working as it should within a specific geographical area. The reasons can be surplus or lack of resources, missing or wrong competencies, or bad management of resources. This can only be concluded in conjunction with net travelling. A more detailed analysis is presented in the end of this chapter.

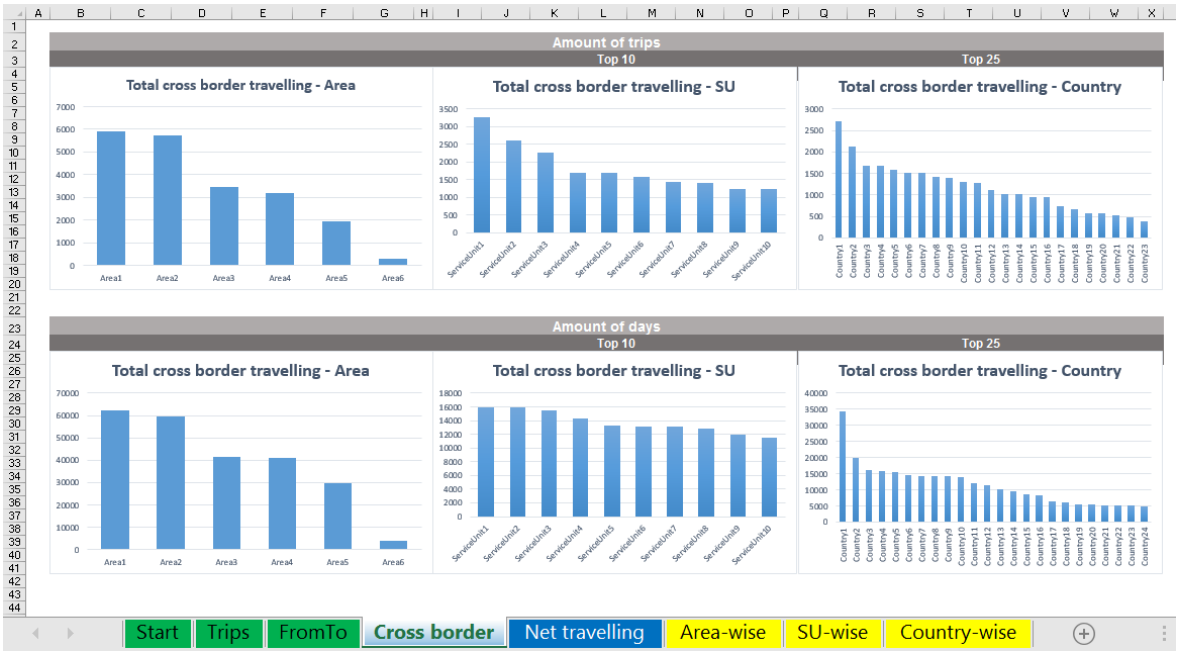

Figure 24 Excel-tool: Cross-border travelling.

5.1.3 Net Travelling

On the net travelling tab, the amount of net travelling is compared between different geographical areas (Figure 25). Net travelling for a specific area is calculated as all travels with the destination in that area, minus all travels departing from that area. This calculation shows the net amount of resources in a specific area.

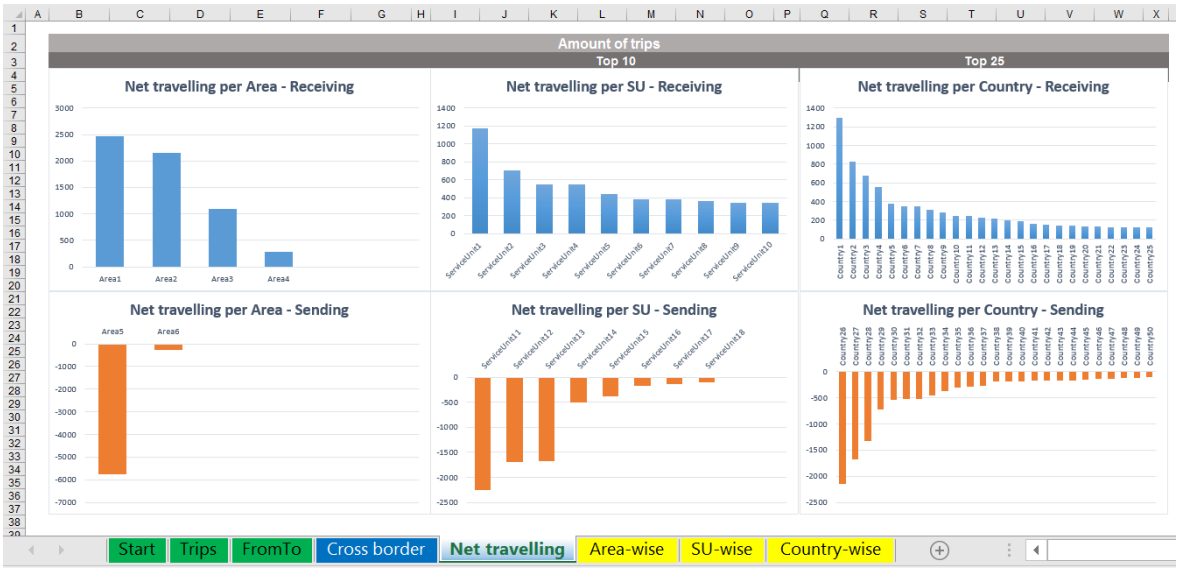

Figure 25 Excel-tool: Net travelling.

If net travelling in a country is positive it means more resources are coming than are leaving, and vice versa. Positive net travelling indicates a lack of resources in that specific area, while a negative value indicates a surplus of resources. If net travelling is close to zero it might indicate that the correct amount of resources is available, but it can also indicate that wrong competencies are available or resources are poorly managed: the amount of resources imported is as big as the amount exported. This can only be concluded in conjunction with cross-border travelling.

5.1.4 Area-wise Travelling

Area-wise travelling shows detailed information about travelling to and from a selected area. The desired area is chosen from the drop-down list, then macros update the data used in the pie charts accordingly. The first pie chart shows an overview of the travelling on area level, while the two smaller ones show which areas are sending most resources to the selected area, and which are receiving most from it (Figure 26).

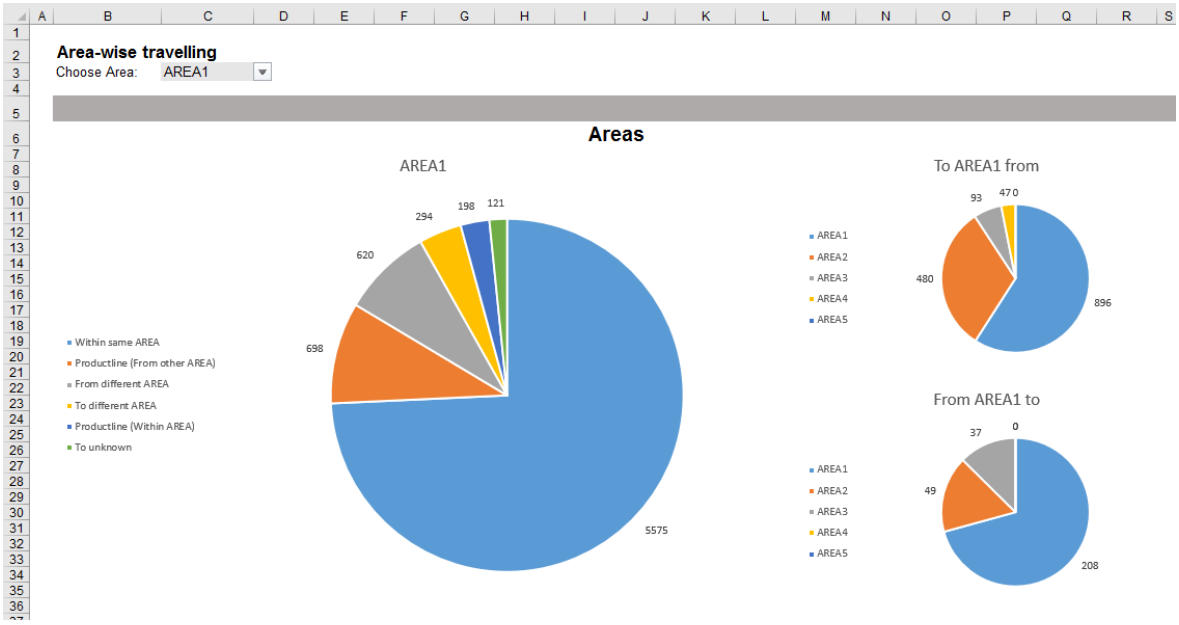

Figure 26 Excel-tool: Area-wise travelling; area level.

To get a more detailed view, pie charts have been created also at service unit and country level (Figure 27). This way it is possible to see which service units and countries, within and outside the selected area, are sending and receiving most resource from and to the selected area.

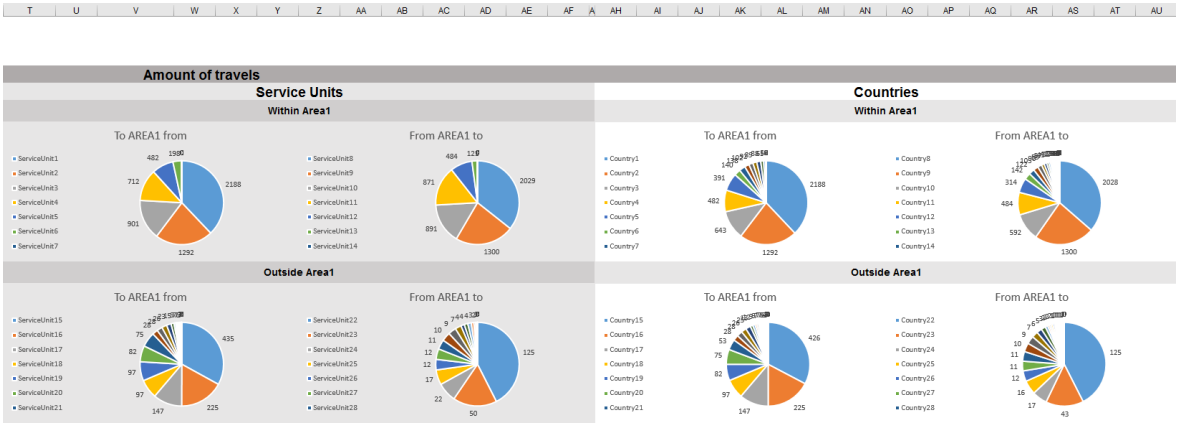

Figure 27 Excel-tool: Area-wise travelling; service unit and country level.

5.1.5 SU-wise Travelling

SU-wise travelling shows detailed information about travelling to and from a selected service unit. The desired area and service unit is chosen from the drop-down lists, then macros update the data used in the pie charts accordingly. The first pie chart shows an

overview of the travelling on service unit level, while the four smaller ones show which service units within and outside the area are sending most resources to the selected service unit, and which are receiving most from it (Figure 28).

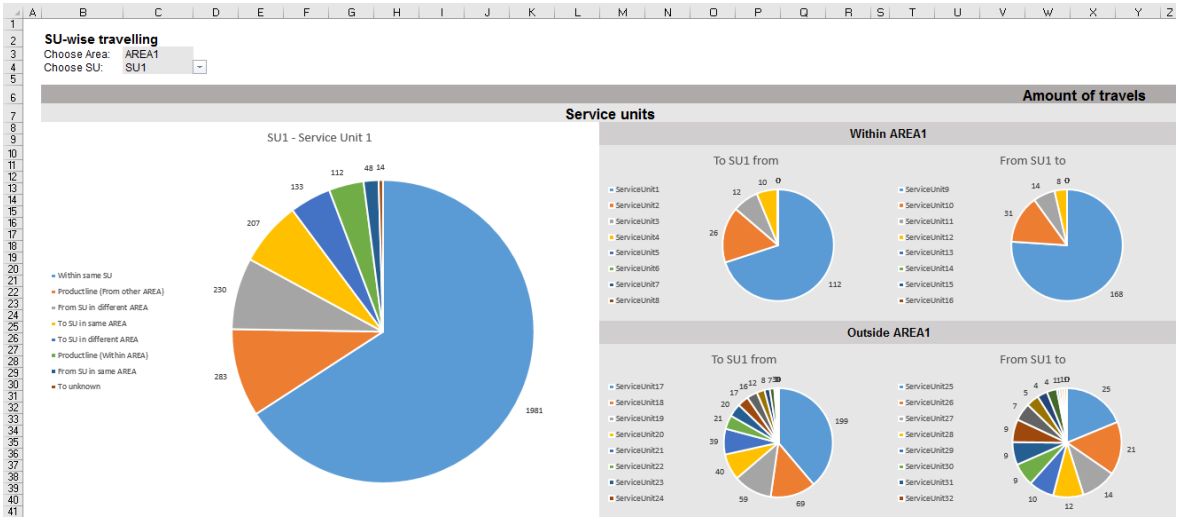

Figure 28 Excel-tool: SU-wise travelling; service unit level.

To get a more detailed view, pie charts have been created also at country level (Figure 29). This way it is possible to see which countries within the selected service unit, outside the service unit but inside the selected area, and outside the selected area are sending and receiving most resource from and to the selected service unit.

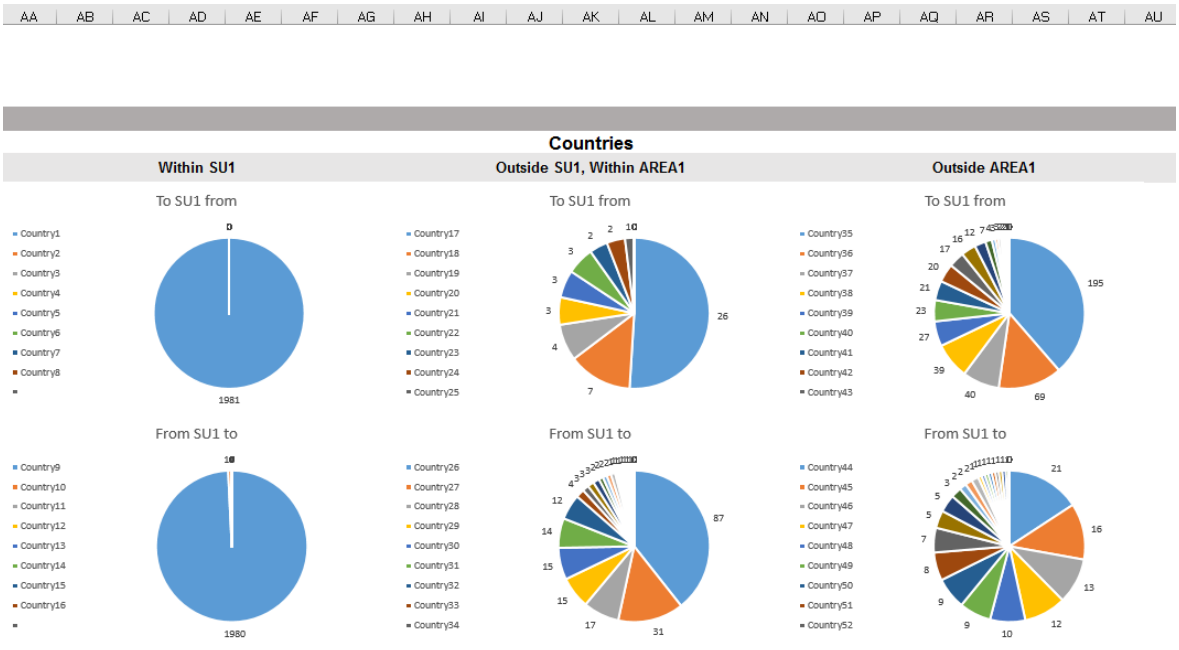

Figure 29 Excel-tool: SU-wise travelling; country level.

5.1.6 Country-wise Travelling

Country-wise travelling shows detailed information about travelling to and from a selected country. The desired area, service unit and country is chosen from the drop-down lists, then macros update the data used in the pie charts accordingly. All pie charts seen in this tab are on country level, which is the lowest level. The first pie chart shows an overview of the country level travelling, while the six smaller ones show which countries within the selected service unit, outside the service unit but inside the area and outside the area are sending most resources to the selected country, and which are receiving most from it (Figure 30).

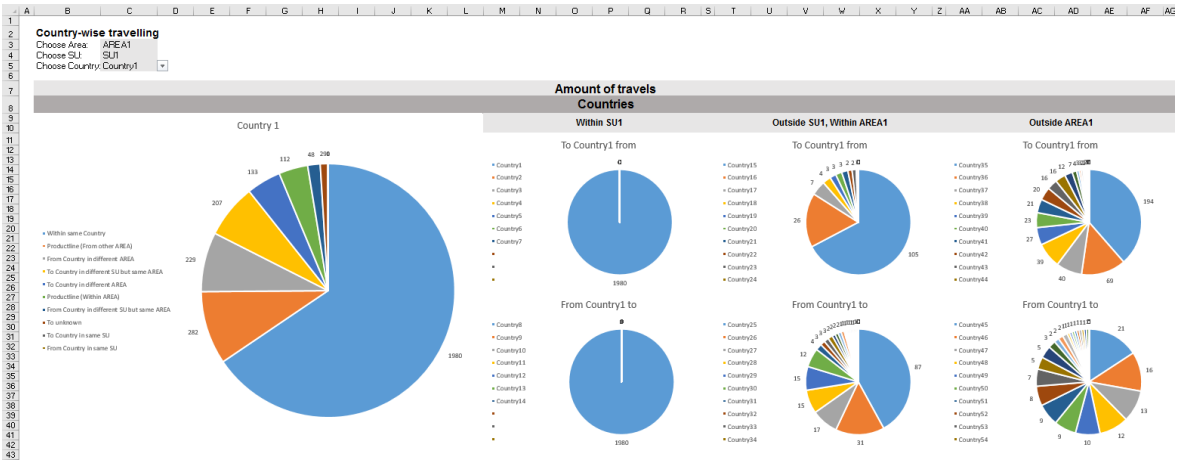

Figure 30 Excel-tool: Country-wise travelling; country level.

5.1.7 Functionality Overview

A diagram has been created to get a better understanding of the main functionality of the Excel-tool (Figure 31). The big gray box enclosing most of the smaller boxes, represents the Excel-tool itself. The blue boxes represent choices that the user can make to change the presentation of data. Red boxes represent data of different kinds, such as Excel files and databases. The green boxes represent the final visualized data, as previously presented in this chapter.

The arrows show the relationships between the different boxes. Solid lines indicate functions that are manually triggered, while dashed lines indicate automatically triggered functions.

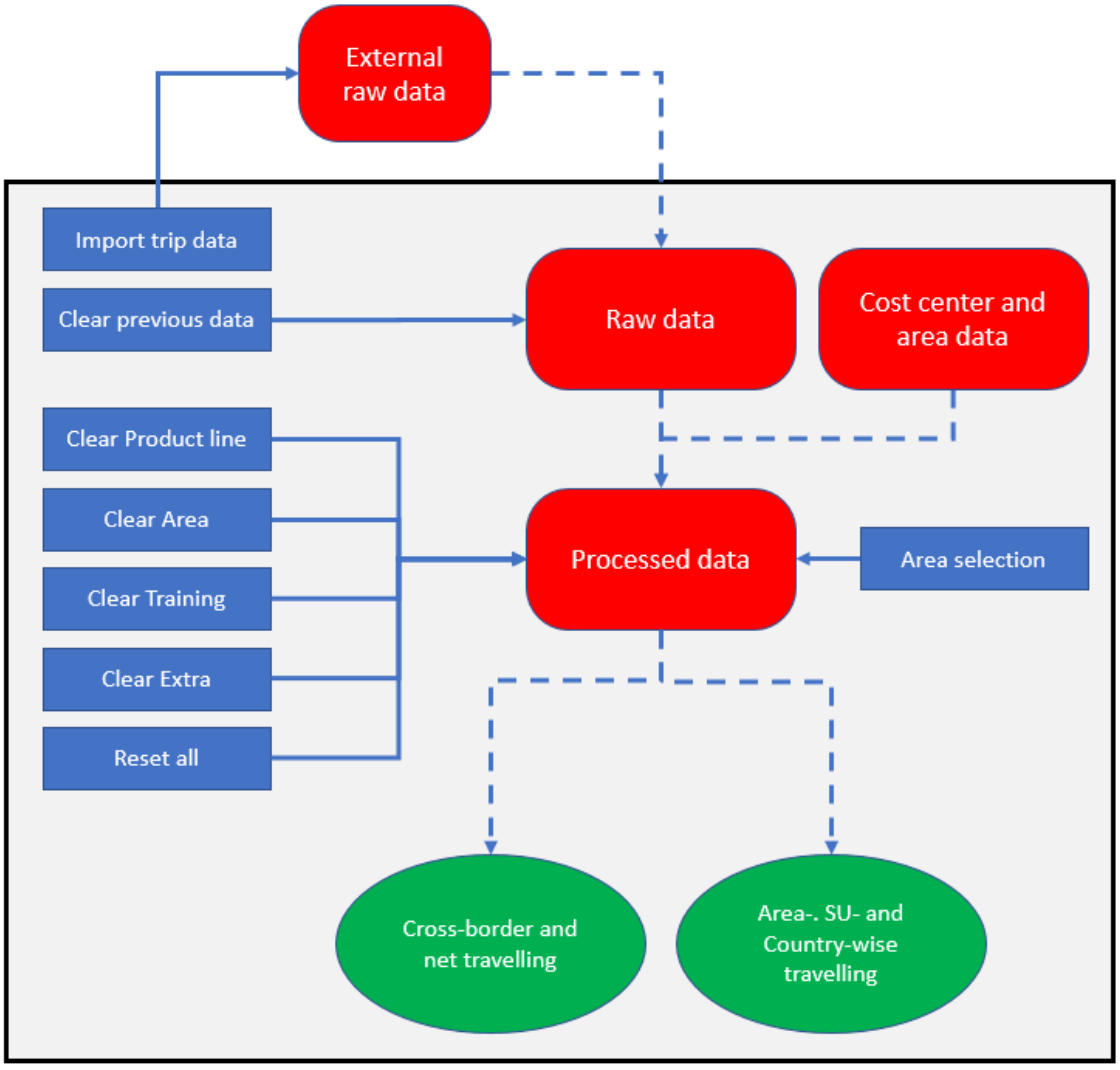

Figure 31 Excel-tool: Process overview.

5.2 Scenario-based Action Plan

In this section, different analyses are presented to understand the information provided by the visualizations discussed in the previous section. As there are no definitive right or wrong answers to the different visualizations, four different scenarios are presented to get an understanding of the general concept. The different scenarios won't give one unambiguous answer, but proposals of the most probable solutions.

As the borders between the different scenarios are diffuse, a scenario matrix is the easiest way to conclude the different issues. The scenario matrix (Figure 32) contains concentrated information about necessary actions, indications and possible solutions/explanations for the different scenarios. More detailed explanations will follow in the sections below.

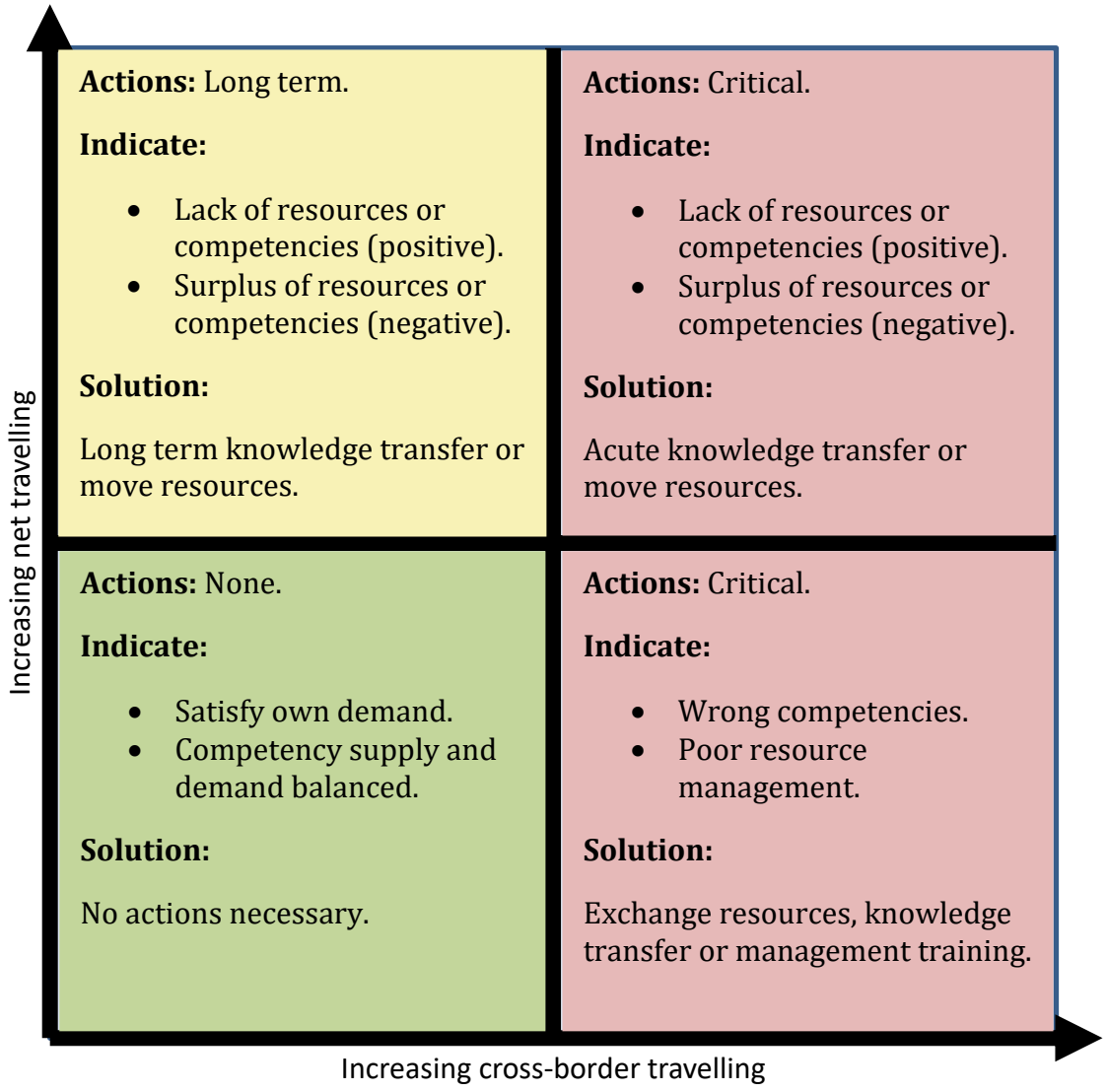

Figure 32 Scenario matrix.

5.2.1 Scenario 1: High Cross-border, High Net Travelling

In scenario one a certain country has both a high amount of cross-border travelling and high net travelling. As net travelling can be both positive or negative, this scenario has two different outcomes.

If a country has both high cross-border travelling and high **positive** net travelling, it means that the country is receiving more resources than it is sending out. This indicate that the country either has too few resources or a lack of competencies. The best way to find out the reason is by checking the specific country in the *Country-wise* (Area-wise or SU-wise in case areas or service units are investigated) worksheet. If Product line is sending most of the resources, the problem is lack of competencies. If most of the resources are coming from other Areas, the problem is lack of resources.

If a country has both high cross-border travelling and high **negative** net travelling, it means that the country is sending out more resources than it is receiving. This indicate that the country has a surplus of resources or competencies. If the country belongs to Product line, this is just normal (Product line only sends out expertise, which means net travelling will always be high).

In case net travelling goes down, but the cross-border activity is still high: see Scenario 2.

5.2.2 Scenario 2: High Cross-border, Low Net Travelling

In scenario two a certain country has a high amount of cross-border travelling while net travelling is low. Low net travelling means net travelling being close to zero.

A country that has a high cross-border activity but low net travelling, means that the same amount of resources that are received are also sent out. This could either indicate that the country has the wrong competences available, or poor management of available resources. As no information about job specific skill demand is available in the current data, it is not possible to decide which of these solutions are correct. If Product line is sending a big amount of resources to the concerned country (checked in *Country-wise* worksheet), it could indicate lack of competencies.

5.2.3 Scenario 3: Low Cross-border, High Net Travelling

In scenario three a certain country has a low amount of cross-border travelling while net travelling is high. As previously discussed, net travelling can be both positive or negative which gives this scenario two different outcomes.

If a country has low cross-border travelling and high **positive** net travelling, it means that the country is receiving more resources than it is sending out. This indicate that the country either has too few resources or a lack of competencies. The best way to find out the reason

is by checking the specific country in the *Country-wise* (Area-wise or SU-wise in case areas or service units are investigated) worksheet. If Product line is sending most of the resources, the problem is lack of competencies. If most of the resources are coming from other Areas, the problem is lack of resources.

If a country has low cross-border travelling and high **negative** net travelling, it means that the country is sending out more resources than it is receiving. This indicate that the country has a surplus of resources or competencies. If the country belongs to Product line, this is just normal (Product line only sends out expertise, which means net travelling will always be high).

As cross-border activity is low in this scenario, no acute actions are necessary. If net travelling stays high during many investigation periods, long-term actions could be discussed.

5.2.4 Scenario 4: Low Cross-border, Low Net travelling

In scenario four a certain country has a low amount of cross-border travelling as well as low net travelling. Low net travelling means net travelling being close to zero.

This is the ideal scenario. When a country has low cross-border activity and also low net travelling, it means that the country can satisfy its own demand and also that the competency supply and demand is balanced. In this scenario no corrective actions are necessary.

6 Discussion

The purpose of this thesis was to develop a method to analyse travel data, to get a better understanding of the travel flows and travelling purposes within Wärtsilä. The method should be a decision base for strategic workforce planning, and should be applied regularly in the operative business.

Looking at the results, the thesis has very well succeeded to fulfil its purpose. An Excel-tool has been developed to visualize travel flows and a scenario matrix has been created to facilitate decision-making based on the visualizations. Using the Excel-tool it is possible to find areas of interest and also to identify possible problems within those areas. This way it is possible to take necessary actions to optimize the workforce.

As workforce planning is a very extensive and continuous process, the scope of this thesis could have been a lot bigger. Due to lack of time and data, we had to make some limitations. The result of the first part of the workforce planning project at Wärtsilä has turned out successful, so now the process can continue to evolve. A big first step has been taken in the process of workforce planning, but there is still a long way to go.

The thesis has gained a lot of attention from different parties during the project time, as no such project has previously been done within Field Services. Already during the development process, two Asian service units showed interest in using it for planning future resource recruitment. This confirms that there is a need for workforce planning.

6.1 Problems

Although a working method has been developed for utilizing travel data, the road to the final results has not been uncomplicated. Here below are a few major points which could have been done differently or improved.

6.1.1 Data Standardization

A problem we faced early in the data pre-processing step, was the lack of data standardization. As previously discussed in the methodology, the raw data used to develop the Excel-tool contained a lot of inconsistencies. One main issue was the fact that the destination country for each trip was filled out manually, which resulted in several different names for one single country.

One way to avoid this problem is through standardized reporting. When choosing the destination country in the travel reporting tool, only a list of standardized country names should be available to pick from. This would both facilitate the pre-processing step, and also make the reliability and validity better for the result.

6.1.2 Platform Selection

A problem faced later in the process of developing the Excel-tool, was the limitations of using Excel as platform. As discussed in the methodology, Excel is a good choice because of its user-friendly yet advanced interface, and also because everyone in the Wärtsilä network has direct access to it through SONAD. However, if big data sets are processed or more advanced functionality is needed, Excel might not be enough. In cases of further research, another more specialized software could be considered.

6.1.3 Data Availability

One major problem in the thesis project, was data availability. From the beginning the plan was to make the thesis in two steps: a first step to create a method to map travel flows and point out where problems existed, and a second step where focus would be put on specific areas to investigate competency gaps. The first step succeeded, but the second step could not be performed due to lack of data.

In the theory chapter, it was discussed that one main process in workforce planning involves comparing competency supply to demand: finding competency gaps. In Wärtsilä Field Services, all resources are registered in the Professional Skills Management tool which means the competency supply is well documented. The problem is to find reliable data for competency demand. In Wärtsilä a system is already available to connect each job to a certain skill level (role in PSM), but the function is not used and therefore no data is created.

6.2 Further Research

As already discussed in the previous section, the second phase of the original scope could not be carried out in this thesis, due to lack of data. One proposal for further research is to investigate the collection and utilization of competency demand data. Maybe some new way of working could be implemented to get the right data?

The tool developed in this thesis is analyzing past data to point out probable problems. The focus is only on the current workforce. A proposal for further research would be to investigate the possibility to compare future competency demand and supply. How big is the future competency demand, and what competency supply do we have at the moment?

The previous proposals have focused on competencies, but future research could also take other approaches. One important thing to investigate is the utilization of resources. In case cross-border travelling is high, is it only due to lack of resources? Could it be that the right resources available, but not utilized? What is the reason for this behavior?

In this thesis competency supply and demand has been discussed as absolute things. The Professional Skills Management describes skill requirements to acquire a certain skill level, which makes competency supply pretty accurate. Looking at competency demand however, there are no good methods that classify jobs to a certain skill level. As all resources possess many different competencies, one challenge is to match the most suited resource with the correct job. A proposal for further research would be to investigate some method to classify different job tasks and operations to facilitate the matching of supply and demand.

6.3 Final Conclusion

In the search for a topic for my thesis work, I wished that the task would be something that could both challenge my thinking as well as have a real impact on the employing company. This thesis has fulfilled both my wishes.

Both before and during the thesis process, I have worked as a Service Coordinator in Wärtsilä Field Services. This has been very interesting as I have gotten to enjoy two different perspectives of Field Services. The good insights in the operative activities have helped a lot to get the most out of the thesis work, and my insights from the thesis work have supported my operative work.

The tool developed to optimize travelling will have impact on Wärtsilä Field Services in many ways. One benefit is the reduction of unnecessary travelling, which could save a lot of money each year. Another benefit is the improved workforce responsivity, which will improve the service towards customers and thus increase the profitability. These are just benefits experienced by the company, but optimized travelling will also have a positive impact on the service engineers themselves as well as the environment.

I would like to thank my supervisors at Wärtsilä, Jukka Kauppinen and Diego Mazzonetto, for a challenging but educative project and for their good support. I would also like to thank my supervisor in operational work, Jos Beukelman, who has acted as a mentor in many different situations, as well as all others involved in the thesis process. Last, but not least, I would like to thank my supervisor at Novia UAS, Ray Pörn, for his extraordinary support and feedback at all times.

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