Creating a cost overview of the transport process for Eurofins Food Safety Solutions

Bachelor thesis

Industrial Engineering & Management

University of Twente

July 2025

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eurofins

Preface

Dear reader,

I would like to present you my bachelor thesis, titled as: *"Creating a cost overview of the transport process for Eurofins Food Safety Solutions"*. This thesis marks the final step in completing my bachelor Industrial Engineering & Management at the University of Twente.

This research was conducted at Eurofins Food Safety Solutions. The research focuses on the incurred costs during the transport process to ship the product samples to their destination. I am very grateful to have had the opportunity to conduct my thesis at Eurofins Food Safety Solutions. The assignment really matched my interests and allowed me to gain valuable experience by working in this business environment.

I would like to thank my supervisor at Eurofins, Virginie Korteling, for answering all my questions and providing feedback along the way. I would also like to thank the employees for their help and support during this research. I really appreciated that I could always ask questions, and I enjoyed the pleasant atmosphere.

I want to thank my supervisor at the University of Twente, Stephan Meisel has been very helpful in guiding me during this research. I could always ask questions and advice on how to tackle problems. I would also like to thank my second supervisor Mahak Sharma for sharing her valuable feedback.

Finally, I would like to thank my family and friends for their support during the thesis, both mentally and in giving advice.

Enjoy reading the thesis!

Best regards,

Twan Bouwman

Management summary

Introduction

This thesis aims to provide insights into the variable transport costs incurred by Eurofins Food Safety Solutions (FSS). FSS helps retailers in ensuring and enhancing food safety. This thesis is conducted for the Retail Operations department, which supports the retailers on testing the food safety of their private label products. FSS is responsible for organising and shipping the product samples across Eurofins' global testing network. Eurofins has 950 laboratories worldwide, each specialised in performing specific tests. This thesis is based on one year of historical data, a dashboard will be developed to visualise the transport costs incurred by FSS.

Problem specification

Although sales at FSS keeps growing, the profit margin is slightly decreasing compared to previous years. Because of this decrease, FSS wants to investigate the transport costs incurred when sending samples to laboratories. This investigation is relevant because the costs are not actively tracked and there is currently no clear overview of these costs. As a result, the company lacks insight into what is paid per package or sample, which courier services are used, and to which laboratories the samples are sent.

The core problem is formulated as: *"The cost side of the transport process is a black box."*

Research question

To solve this core problem, the following main research question is formulated: *"In what way can Eurofins FSS increase their profit margin by gaining insights into and reducing their transport costs?"*

Approach

First, the current transport process that products go through is identified by discovering how the process is organised that a package must go through, and what the associated costs are. Additionally, more knowledge regarding the problem is obtained, and what the stakeholders' expectations are regarding this research. To answer this, interviews are conducted with FSS employees, and multiple days are spent observing them. The cost drivers and Key Performance Indicators (KPIs) that should be included in the dashboard are also identified during these sessions.

After identifying the current process, the next step is to obtain and prepare the data. The data is retrieved from the Eurofins database. Thereafter, the data is cleaned by removing irrelevant and unusable data. Then, the data is transformed in a way that best supports visualisation, ensuring no valuable data is lost during this process. In addition, the validity of the data is checked to make sure the data is reliable and ready for use in modelling.

The dashboard is modelled using Power BI. This modelling phase consists of creating relationships between the data tables and, consequently, visualising the KPIs. Some KPIs can be calculated and visualised directly using the build-in functions and features of Power BI. Other KPIs require additional coding before they can be displayed in the dashboard.

Deliverable

After the first draft of the dashboard is developed, a feedback session is held with the company supervisor and several employees. Based on their input and further evaluation, several improvements are made. *Figure 1* presents the final version of the dashboard.

Figure 1 – Final version of the dashboard pages

The first page displays the total transport costs for the three courier services, based on the historical data. In addition, these costs are shown per retailer and per laboratory. The names of the retailers have been omitted due to confidentiality.

The second page shows the transport costs and number of packages per day. The days can be compared to identify patterns in the data. Moreover, filters can be applied on the date and courier to focus the analysis on specific periods or couriers, making it easier to detect trends or anomalies.

The third page contains the prices per transport company for both package and sample levels. The filter button in the top right corner enables filtering on laboratory, after which the dashboard shows the corresponding package and sample prices, as well as the average number of samples and a table with relevant sample information.

The final page displays the costs of the materials required to send the product samples to the laboratories. The data is divided into three packaging methods, each showing the average cost for all items needed for shipment.

Conclusion & recommendation

During the execution of the research, some striking findings appeared that could have significant impact on FSS' profit margin in the future. Eurofins Logistics Benelux bases their price on the number of stops per day, regardless of the number of packages sent. Therefore, it is recommended to start experimenting with lowering the number of shipment days. 30% to 40% decrease of the shipment cost for Eurofins Logistics Benelux can be achieved by lowering the shipment days from five to three days a week. This reduction is

only based on transport costs. Any other costs that could arise by lowering the shipping days are not taken into account.

It is also recommended to carry out more systematic and advanced checks on the received invoices. Based on the data, Eurofins Logistics Benelux and Jetpak do not always invoice the correct amount. Additionally, price changes are not always noted.

In addition, the dashboard supports FSS in decision-making regarding the price they charge to clients. The dashboard provides a clear overview of the average cost per package and per sample. Additionally, it visualises the average cost of the three types of shipping packages, including the required items to send samples to laboratories.

The dashboard provides FSS with useful information about their transport costs, making sure they can set prices more accurate and save money. By creating transparency, FSS can improve their profit margin. By conducting more research into other cost areas in the future, more effective choices can be made to improve efficiency.

Contents

1. Introduction

This first chapter introduces the company where this thesis is conducted. Moreover, it introduces the problem the company faces, and the intended path to solve the problem.

In section *1.1*, the company will be introduced. Section *1.2* contains an introduction to the problem, the causes and underlying effects. Section *1.3* will elaborate on the research design and the approach used to tackle the problem. Section *1.4* explains what will be delivered as a solution to the problem. Section *1.5* discusses how the validity and reliability of the project are guaranteed, as well as potential pitfalls.

1.1 Eurofins Food Safety Solutions (FSS)

This research is performed at Eurofins Food Safety Solutions, abbreviated as Eurofins FSS. FSS is a part of Eurofins and the branch Eurofins Food, Feed, Water. Worldwide, Eurofins is owner of 950 laboratories, has 63,000 employees across 60 countries, and is still expanding. Eurofins was founded in 1987 under the name Eurofins Scientific. The company was originally founded to test the origin and purity of wine, and by this, preventing fraud. In the last four decades, the company has grown into a leading listed company (Eurofins, n.d.). All different branches of the company are separate companies, but all belonging to Eurofins. Hence FSS is part of Eurofins Food, Feed, Water.

The objective of FSS is to help retailers to ensure food safety and take it to a higher level. The mission is to *"Contribute to global health and food safety by providing our customers with high-quality laboratory and advisory services"* (Eurofins, n.d.). Whether the retailer needs advice on sourcing, the production process, the final product, or food safety legislation, FSS can help the retailer out. In ways like consultancy, supplier audits, label checks and advice and support for retailers (Eurofins, n.d.). All laboratories that Eurofins owns are specialised in their own testing. Therefore, multiple laboratories are needed to test a product on several specifications.

Within FSS, there are different departments. All departments contribute to supporting and helping retailers regarding food safety. This research is conducted within the Retail Operations department, which is responsible for performing food safety tests on retailers' private label products. Other departments focus on consulting, performing label verification checks and the last department is specialised in microbiology. The market segment Retail Operations focuses on consist of retailers that sell private label products. It is mandatory by law for retailers to have their private label products tested on food safety. Making sure that the private label products are tested on food safety legislation is a major part of the Retail Operations team's daily activities. The tasks that must be performed to be able to test the private label products are creating a monitoring plan for the products to be tested, obtaining the products from the retailers, shipping the products to the laboratories and evaluating the results from the laboratories. This will be discussed in more detail in section *2.1*.

1.2 Problem context

Over the last years, FSS grew rapidly since more and more retailers found FSS as their partner for testing their private label products against food safety legislation. Over these years, FSS grew so fast that they could not handle all the work and needed to prioritise the daily activities over the less urgent activities. Because of this growth, sales were the main priority, and less attention was paid to the costs. Currently, the sales growth has stabilised compared to the previous years, but overhead costs are increasing; for

instance, by attracting more employees to distribute the workload over more employees. This causes a decrease of the profit margin per product; the profit margin per product is below the norm. Therefore, FSS wants to gain more insight into the causes of the variable costs. This mainly consists of all costs regarding transport in their supply chain of sending the products to the laboratories. The entire process of what happens with the samples after they are shipped will be explored in chapter *2*. Several problems occur in FSS' transport process that have a negative impact on the profit margin:

1. *Sample is lost.* After sending the product sample with one of the transport companies, the sample should arrive at the laboratory in question. The laboratory has a deadline per product test before they should return the test results to FSS. Currently, FSS starts reminding these laboratories when the due date for testing the products has passed. This will result that when reminding the laboratory, FSS discovers that the sample did not even arrive to the laboratory. This will cause delays and querulous customers. So, because FSS does not have a way to track the products, there is a greater chance that products will get lost, which happens every now and then these days.
2. *Samples do not stay within temperature boundaries when transporting.* About half of all products FSS receives from the retailer are refrigerated. FSS must make sure that these samples stay within the temperature boundaries when transporting to the laboratories. Sometimes, the temperature exceeds these boundaries, with the consequence of invalid test results or that the laboratory not even accepts testing the sample. This will result in delays and disgruntled customers.
3. *Mapping all the costs.* Currently, multiple transport companies are used. The overview of the costs per transport company is lacking clarity. Because of this, FSS does not know what is paid per product, with the result that the price is not charged accurately to the customer. This may affect either the competitive position or profitability of the company.
4. *Hygiene problems.* The transport process is executed by external parties. Therefore, there is no insight into the hygiene conditions during transport. For some products and tests, it is crucial that the transport environment is clean so it will not affect the quality of the product.

All these problems are part of the transport process in the supply chain in which FSS operates; more details about this process are provided in chapter *2*. If all these problems are investigated and solved, the process will be much more transparent. However, it is not possible to solve all problems within the timeframe of this research. Each of the four problems has its own focus and scope of this research. Therefore, a discussion was held with the company supervisor to determine which problem was most crucial for FSS to address. As a result, the decision was made to focus on cost efficiency. This includes transport costs and consumables used during transport. The term 'consumables' refers to the required materials used to send product samples to laboratories, such as cooling elements, cardboard boxes and Styrofoam boxes. The costs related to logistics staff and other expenses, such as IT devices, are excluded on the advice of the supervisor. Therefore, only the direct transport costs and the materials required to ship the samples are included in this research.

1.2.1 Action problem

An action problem can be described as a perceived discrepancy between norm and reality. Within an action problem, the goal is to change the reality that it ends up above the norm. This goal will be achieved by changing reality (Heerkens & Van Winden, 2017).

The problem FSS wants to tackle is the low profit margin per product. In the last years, this profit margin per product has remained relatively stable, but this value is still below the norm that FSS wants to achieve.

Possible factors that may influence the profit margin will be discussed in section *1.2.2*. Currently, this margin is noticeably lower than FSS' target. These percentages of the profit margin per product are confidential. Therefore, it cannot be mentioned in the report. The objective is to increase this percentage again, but by how much is not known yet. Since the impact of reduced variable costs on the profit margin per product is unknown, the exact effect cannot be determined at this stage. This effect on the profit margin will be explored in this research. Currently, the impact of the variable transport costs is unknown because FSS never actively researched the variable costs, and they do not have a clear overview of what the variable costs are and where they arise in the process.

Therefore, the action problem for this research is:

"The profit margin per product is too low"

1.2.2 Problem cluster

Based on the action problem and unstructured interviews with colleagues and the problem owner, a problem cluster is constructed. A problem cluster is a visualisation of the action problem, and its corresponding cause and effect relationships. In this way, core problems can be identified. The core problem is a problem in the problem cluster which does not have a cause (Heerkens & Van Winden, 2017). Furthermore, it should be an attainable problem to solve. *Figure 2* shows the problem cluster, including the action problem and the selected core problem.

Currently, the profit margin per product is lower than the standard that is set by the company. The decrease of the profit margin has three direct causes. As explained before, the company was growing rapidly, with only increasing sales, because more retailers found their partner in FSS for food safety testing. But now, the sales growth has stabilised. Also because of this growth over the last years, the overhead costs are increasing – more employees, ICT devices such as laptops, and service fees – which together lead to a decrease of the profit margin per product. The final cause of a lower profit margin per product is a lack of insight into the variable costs. Most sources of the variable costs are known, but perhaps not all sources are known. The known causes are transport and consumables costs, additional costs for samples that exceed temperature boundaries, lost samples and hygiene issues as depicted in *Figure 2*. These problems occur too often now. Because FSS was growing this fast, they were more focused on sales compared to costs, with the result of losing insight into the costs overview. Therefore, FSS wants to change that by gaining more insight into the overall cost of the transport process.

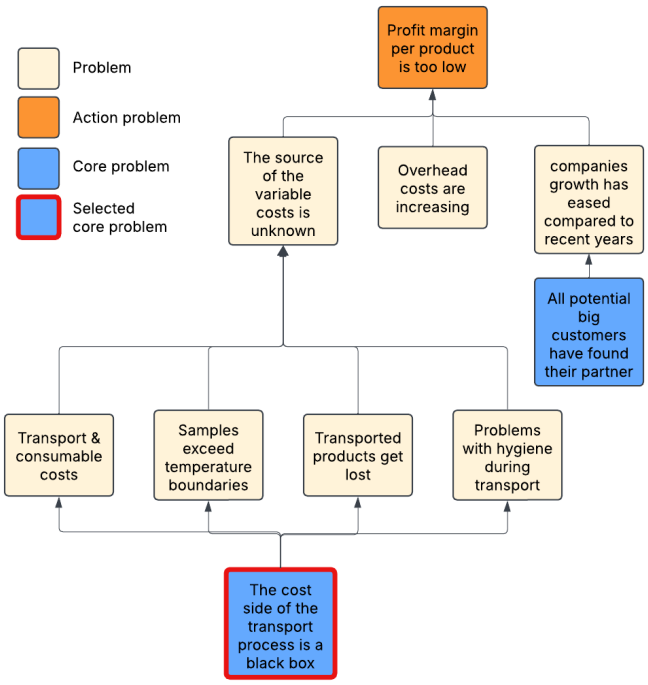


Figure 2 – Problem cluster.

1.2.3 Core problem

According to the criteria discussed by Heerkens & Van Winden (2017), there are two possible core problems visualised in *Figure 2*. However, the problem *'All potential big customers have found their partner'* is not influenceable. This results in one suitable core problem associated with this action problem. The core problem is stated as:

> *"The cost side of the transport process is a black box."*

This problem describes that currently FSS has no clear overview of the costs regarding the entire transport process in which FSS is involved. In chapter *2*, it will be further elaborated on what aspects of the costs within the transport process are known and unknown. As discussed in section *1.2* and visualised in *Figure 2*, at least four factors are part of the variable costs that are related to the transport process. The path that will be researched is via the transport & consumable costs. By solving this, costs can be charged to the retailer more accurate to become more profitable and competitive.

1.3 Problem solving approach

1.3.1 Research design

The main research question should be formulated to identify a suitable solution to the core problem, as discussed in section *1.2.3*. This main research question is formulated as follows:

> *"In what way can Eurofins FSS increase their profit margin by gaining insights into and reducing their transport costs?"*

To be able to answer this main research question, a methodology will be used to walk through several steps to finally answer the research question. The methodology that will be used for answering this

research question is the Cross-Industry Standard Process for Data Mining (CRISP-DM). CRISP-DM guides the researcher through all phases of planning, organising, and implementing the data mining process in a structured way (ProGlobalBusinessSolutions, 2023). This methodology is chosen since it fits best to this research to visualise an unclear process by creating an overview based on gathered data. Moreover, this methodology was advised by the lecturer of the subject methodology. *Figure 3* shows the steps for the CRISP-DM methodology.

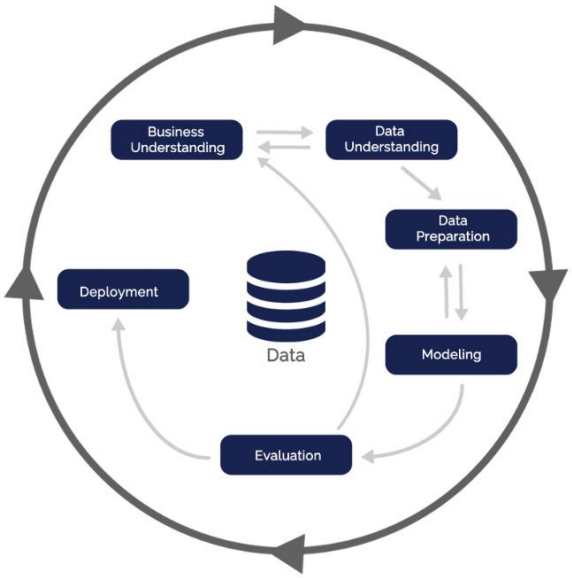


Figure 3 – Steps for CRISP-DM methodology.

1. Business understanding

The first step of the CRISP-DM methodology is understanding the business. This contains understanding the current process of the business, setting objectives of what the researcher wants to accomplish during the research, develop a project plan and defining criteria for success (ProGlobalBusinessSolutions, 2023). To apply this to the research case, the following investigative question is formulated to identify the current transport process:

Question 1: *"What does the current transport process look like for FSS?"*

With this broad question, answers will be given on the current process flow of goods in which FSS is involved. Moreover, the information flow and cost flow within the process are identified.

Question 1a: *"What is the current process flow of goods where FSS is involved?"*

Question 1b: *"What does the current information flow look like?"*

Question 1c: *"Where are the costs made and where do they arise in the process?"*

2. Data understanding

Within the data understanding phase, the necessary data needs to be collected first. Next to this, the characteristics of the desired data need to be clarified (ProGlobalBusinessSolutions, 2023). For this research case, the necessary data of the costs, products, and retailers should be gathered. A literature review will be performed to investigate what data is important to include. This will be compared with the

collected data to determine whether any crucial data is missing. The investigative question that will follow for the data understanding phase is:

Question 2: *"What factors of the data are important to consider when visualising a cost overview in a dashboard?"*

This question helps to identify the important data by clarifying what data is available, and what data is useful for this research.

Question 2a: ***"****What data is important for visualising a cost overview in a dashboard, according to literature?"*

Question 2b: *"What are the different cost drivers for FSS?"*

Question 2c: *"What data is available for this research purpose?"*

3. Data preparation

After the crucial data is identified, it is essential to decide which information will be used for the execution. The researcher should set criteria based on relevance and the goals of the research. This includes selecting Key Performance Indicators (KPIs), as well as cleaning and transforming the collected data (ProGlobalBusinessSolutions, 2023). These steps will be carried out in this part of the methodology, as well as defining the KPIs for the cost drivers.

Question 3: *"How to measure the KPIs and cost drivers with the available data?"*

Question 3a: *"What KPIs are important to measure the costs?"*

4. Modelling

When having selected and cleaned the data, the modelling of the deliverable can start. A proper modelling tool should be used that fits the requirements and expectations of the business. The reliability and validity must be ensured (ProGlobalBusinessSolutions, 2023). When all data is ready for implementation, the data sources should be integrated into one database to be able to start visualising. Thereafter, a dashboard will be constructed according to FSS' needs.

Question 4: *"How to integrate structured data into a unified relational database?"*

Question 5: *"How to implement the solution in a dashboard with respect to FSS' needs?"*

5. Evaluation

In this step, the results of the model are discussed and evaluated. The accurateness of the model will be checked by integrating different data, as well as whether the model provides a clear and useful overview. It is necessary to review the process for activities that are not incorporated (ProGlobalBusinessSolutions, 2023). The evaluation is done carefully to make sure it meets the expectations of the stakeholders and that the tool can be used in the future.

Question 6: *"To what extent does the solution contribute to the insights into the transport costs?"*

6. Deployment

The final model and information must be presented to the stakeholders to ensure it fulfils the requirements they expect. Moreover, the model should be easy to use, and a guide should be made for the employees to work with the model, so it is guaranteed that it will be used in practise

(ProGlobalBusinessSolutions, 2023). How to use the dashboard is already included in section *5*, so it is redundant to write another question.

Appendix A includes the research design framework, shown in *Table 4*. This framework shows per investigative question what steps will be taken to successfully execute the research. This framework includes the research type, research population, subjects, research strategy, method of data gathering, method of data processing, and the activity plan.

1.3.2 Limitations

There are certain limitations that can influence the outcome of the study. The first limitation is that there are only 10 weeks scheduled to conduct the research. Another constraint is the data availability. FSS does not have a database that contains all information for the research. Therefore, it is important to obtain all different sources that may involve costs, as well as any other additional information required to conduct the research as reliably and validly possible.

1.4 Deliverables

1.4.1 Theoretical perspective

When having clear insight into the problem that FSS faces now and FSS wants to achieve, the IEM toolbox is used to investigate what solution is most applicable to this problem. FSS wants to gain more insights into the costs regarding transport. To provide more insight, a dashboard seems to be the most appropriate tool to tackle this problem. In this way, FSS has a visualisation tool that shows the costs per product or retailer, so they can charge the costs more precisely to become more competitive with an increasing profit margin. So, the theoretical perspective will contain the CRISP-DM methodology, with a prototype dashboard as intended deliverable.

1.4.2 Intended deliverables

The intended deliverable consists of a prototype dashboard. This consists of the necessary KPIs that should be visualised on the dashboard. Furthermore, an explanation will be provided on what is shown and how to use the dashboard, to ensure FSS understands how it works and can continue using it in the future. Moreover, a summary will be provided with the most notable conclusions and recommendations from this research to increase FSS' profit margin.

1.5 Validity and reliability

According to Middleton (2019), reliability and validity are concepts used to evaluate the quality of research. They indicate how well a method, technique or test measure something. Reliability tells how consistently a method measures something. For example, when a sample is tested multiple times under the same conditions, it should yield the same results. Validity tells how accurate a method measures something. It is considered as valid when a method measures what it claims to measure.

1.5.1 Ensure reliability

During research process, several phrases may become unreliable if they are not checked and verified. One part of the research consists of analysing the current process. The method of data gathering consists of interviewing and observing. A potential barrier could be that one employee says something different than another employee. To prevent this, additional questions will be asked to the interviewee when the answer differs from a colleague's explanation, or the interviewer expected something else.

Another possible hindrance for reliability may be the solution implementation and consequently evaluating the results. It is helpful to make an expectation beforehand and evaluate whether this expectation aligns with the result. In this case of designing a cost overview on a dashboard, it can also be verified by checking the invoices for different samples.

Next to this, every now and then, the progress will be discussed with the company supervisor. On the one hand for ensuring reliability – that the gained knowledge is verified and correct. And on the other hand, to give an update what the status is, together with what they can expect from the graduation assignment.

1.5.2 Ensure validity

A thorough check for validity is mainly necessary at the data gathering and implementation part of the research. The implementation part consists of designing the dashboard and inserting the data into the dashboard. This data must be valid to use it. When inserting this data into the dashboard, the validity must be checked multiple times to ensure the accuracy of the dashboard.

To assess the validity of the data, the results will be checked with the invoices FSS receives for transport and consumable costs. For assessing the performance of the dashboard, multiple checks will be done on the validity of the dashboard performance. These checks will be performed by inserting the same data multiple times, to test whether differences occur between the attempts. Also, minor adjustments will be made to check whether these changes are included in the outcomes of the dashboard.

1.6 Scope

To ensure the feasibility of the research within the given ten-week timeframe, the scope of this research has been deliberately narrowed down. Instead of trying to map and analyse the entire supply chain – which was the assignment given by the company at the start – this research will focus only on the identification and analysis of the transport and consumable costs. The scope was limited to allow a more detailed investigation within the available time. Focusing on these specific cost components, the research aims to provide useful insights, since it is not possible to carry out a full analysis of the entire supply chain within the ten weeks available.

2. Current process analysis

The following question is defined to identify the current transport process:

"What does the current transport process look like for FSS?"

This broad question will provide answers regarding the transport process in the supply chain in which FSS is involved. Moreover, the information flow within the process and the costs flow within the process will be investigated. In section *2.1*, the following sub-questions will be answered: *"What is the current process flow of goods where FSS is involved?"*, and *"What does the current information flow looks like?"*. Section *2.2* will discuss all costs related to transport that are made currently and how these costs flow through the process. This section, *2.2*,will answer the following question: *"Where are the costs made and where do they arise in the process?"*. Section *2.3* addresses the current data systems used by FSS and the functions they serve.

2.1 Current process

FSS' location in the supply chain can be seen as an intermediate step between retailers and laboratories. Not only in terms of product flow, but also as information flow. *Figure 4* shows a simplified version of the supply chain of goods. The transport process will be elaborated upon in the next sections where the entire process is discussed with respect to *Figure 4. Figure 5* shows a BPMN[1] process overview that supports the explanation written below about all steps in the transport process of FSS. This process is also visualised in *Appendix B*.

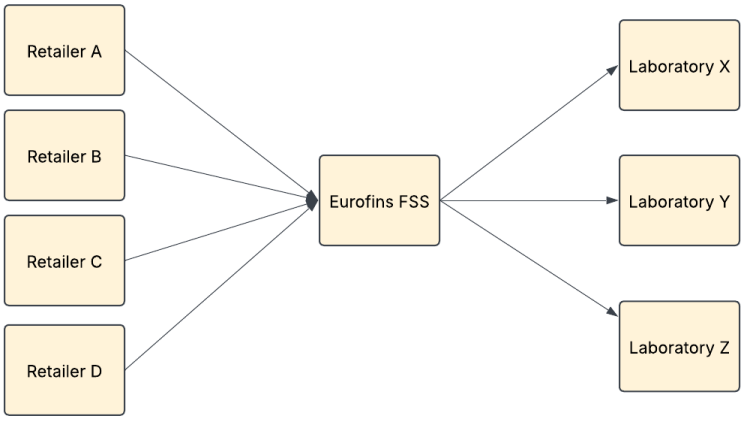


Figure 4 – Simplified version of supply chain of goods.

[1] Business Process Model and Notation (BPMN) is used to visualise processes to identify inefficiencies.

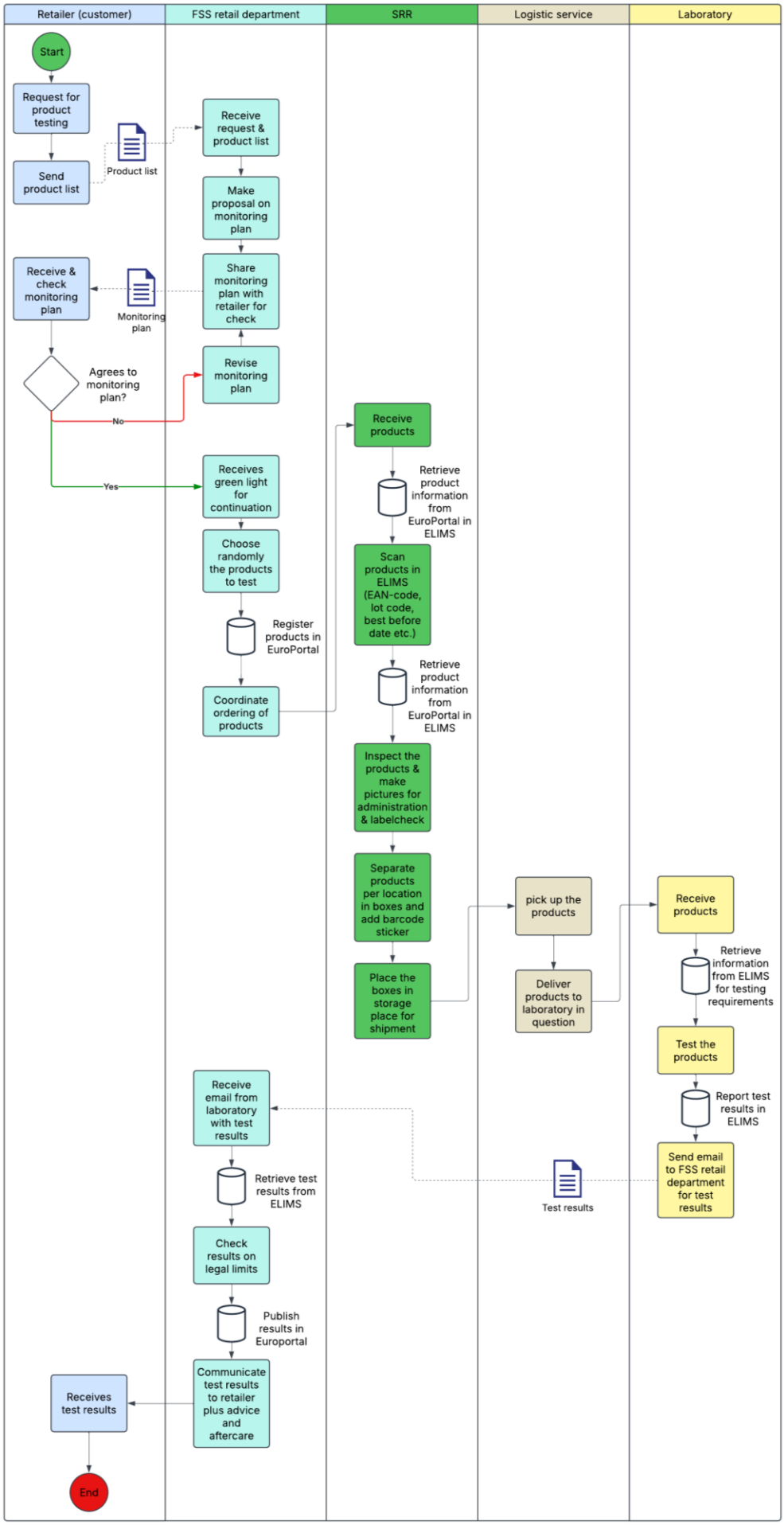


Figure 5 - Process flow products FSS

Retailer & FSS retail department

The process starts with the retailer. The retailer is a customer of FSS and has to test their products on food safety legislation. The retailer sends the product list with the products that must be tested. This differs per retailer, e.g. retailer X sends only a specific list of products that must be tested, and retailer Y sends the entire product list and subsequently FSS samples randomly some products that must be tested with the $\sqrt{n}$ rule, where n is the number of products. For example, if a supplier supplies nine private label products that belong to the same product class to a retailer, $\sqrt{9}$, three products from this supplier and product class must be tested per cycle. This cycle is usually per month, but it may vary depending on agreements with the retailer. In this way, it is legally determined how many products must be tested per product group.

When receiving the product list from a retailer, the list is imported into a template of a monitoring plan. Thereafter, the employees of FSS will sort the products on supplier and product class. From this division, the $\sqrt{n}$ rule is applied. The tests that must be performed on food safety are automatically assigned to these products per product class. This is already programmed in the template, so this saves effort and time, which is beneficial for the employees. Once the monitoring plan is finished, it is sent to the retailer for verification whether the retailer agrees with the tests to be performed on the products. If the retailer does not agree, the monitoring plan is refined until the retailer does agree. Thereafter, the plan is put into action, consisting of randomly selected products that will be tested per product class and supplier. These products are picked up and brought, or delivered by the retailer, to the freight forwarder of FSS, dependent on what is agreed with the retailer. The freight forwarder is also called sample registration and reception (SRR). This is a separate department within FSS that collects all products and make sure to ship the products to the designated laboratory. More on their activities in the next section. Simultaneously to ordering the products, the FSS employees register the products in EuroPortal. EuroPortal is an online environment Eurofins uses, where the retailers can find their test results and view dashboards showing their products' performance.

When the laboratory publishes the results of the tests, FSS employees will check all the results based on the legal limits. Thereafter, FSS employees write a conclusion of the results. This final report is sent to the retailers. If the results of the tests are exceeding the legal limits that the result may have, further advice is given to the retailer on what to do. A notification must also be sent to the Netherlands Food and Consumer Product Safety Authority, after which they will determine the consequences for the product.

Sample registration & reception (SRR)

SRR is the term used for the logistic staff of the FSS department. They receive and send all products samples from the retailers that have to be tested. Four employees work at this department, with in total 3.4 FTEs[2].

SRR has a weekly meeting with the FSS retail department to discuss the coming week. From this meeting, SRR receives an overview of the products that will arrive and the corresponding retailers. From this overview, a planning per day is made based on the shelf life and delivery dates of the products.

The day itself is split up into two parts.

[2] An FTE (Full-Time Equivalent) shows the workload of one full-time employee, usually 40 working hours a week.

Before the lunchbreak, all products that will be shipped that day are scanned. By scanning the products, the information is retrieved from EuroPortal and taken over by ELIMS[3] automatically. ELIMS is the system used by SRR and all laboratories to communicate with each other which tests are required per product sample. In ELIMS, all information of the products and tests is entered so the laboratories know what tests need to be performed on the product samples. SRR makes pictures of all products they received. On the one hand for their own administration to proof they shipped the product in a sufficient state. On the other hand, for another department within Eurofins[4]. This department is named product compliance and performs label checks for the retailer among other things. SRR also inspects the products for damage and shelf life. Usually, multiple products need to be sent to different laboratories for the specific tests that must be performed. After scanning and inspection, the products are stored at a location designated for the laboratory in question.

During the afternoon session, all laboratories are processed one by one. Usually, one box will be used per location, so the size of the box varies per location due to the number of products and the size of the products that have to be shipped to that location. Three types of packages are used to transport the product samples to the laboratories. The choice of the type of box depends on the products that will be shipped. If the products are refrigerated, a Styrofoam box is used, since it can retain the cold better compared to any other box type. This is done to make sure that the refrigerated products stay within the temperature limits, otherwise the validity of the test results can be affected. When the products do not require refrigeration, cardboard boxes or envelopes are used, since these materials are cheaper compared to the Styrofoam boxes. Envelopes are only used for sending small samples and they are hardly used. All products are scanned and put into the box. Next to this, cooling elements – in case of refrigerated products – and polystyrene will be added in the box. The last step is to print a barcode and stick it on the box. Each barcode is unique and tells the courier where the box should go when scanned. Finally, the list of barcodes and designated laboratories is sent as an email attachment to Eurofins Logistics Benelux's customer service for the boxes shipped by Eurofins Logistics to laboratories within the Benelux[5]. Once these steps are completed for each box, the box is stored where the courier can pick it up for shipping. There are three companies that transport the products, which will be discussed in the next section.

Logistic service

FSS works with three transport companies to send the product samples to the different laboratories. Eurofins has their own logistics centre, named Eurofins Logistics Benelux. Within the Benelux network, laboratories like Heerenveen, Graauw, Barendrecht, Barneveld and Nazareth are served. Next to their own logistics centre, FSS uses Jetpak as their transport partner to other laboratories in Europe. The third transport company FSS uses is DHL. The three transport companies will be discussed in the following sections.

Eurofins Logistics Benelux

Most of the boxes are transported by the logistic service of Eurofins. They own a fleet of 40 vans, each equipped with a large cooler box. The cooler box provides a significant advantage over other transport companies, which do not offer refrigerated transport for products.

[3] ELIMS: Eurofins Laboratory Information Management System.
[4] This department is called product compliance – Their main activity is checking the label of products on legislation and give advice on improving the label if it is insufficient.
[5] Benelux is an abbreviation for Belgium, Netherlands, Luxembourg.

The customer service receives the list of barcodes and designated laboratories from SRR and subsequently communicates this information to the courier who will pick up the products in the evening. Once the courier has picked up the products, the boxes will be dropped at one of the depots where the packages spend the night. The next day the boxes will be shipped to the final destination. Eurofins Logistics Benelux does not have a track and trace system, with the result that occasionally a package gets lost. Eurofins Logistics Benelux is a non-profit organisation within the Eurofins network. This allows them to keep the prices as low as possible for an excellent competitive position against other transport companies, and an advantage for the Eurofins companies. *Figure 6* displays Eurofins Logistics Benelux' process flow. This process flow is also shown in *Appendix C*.

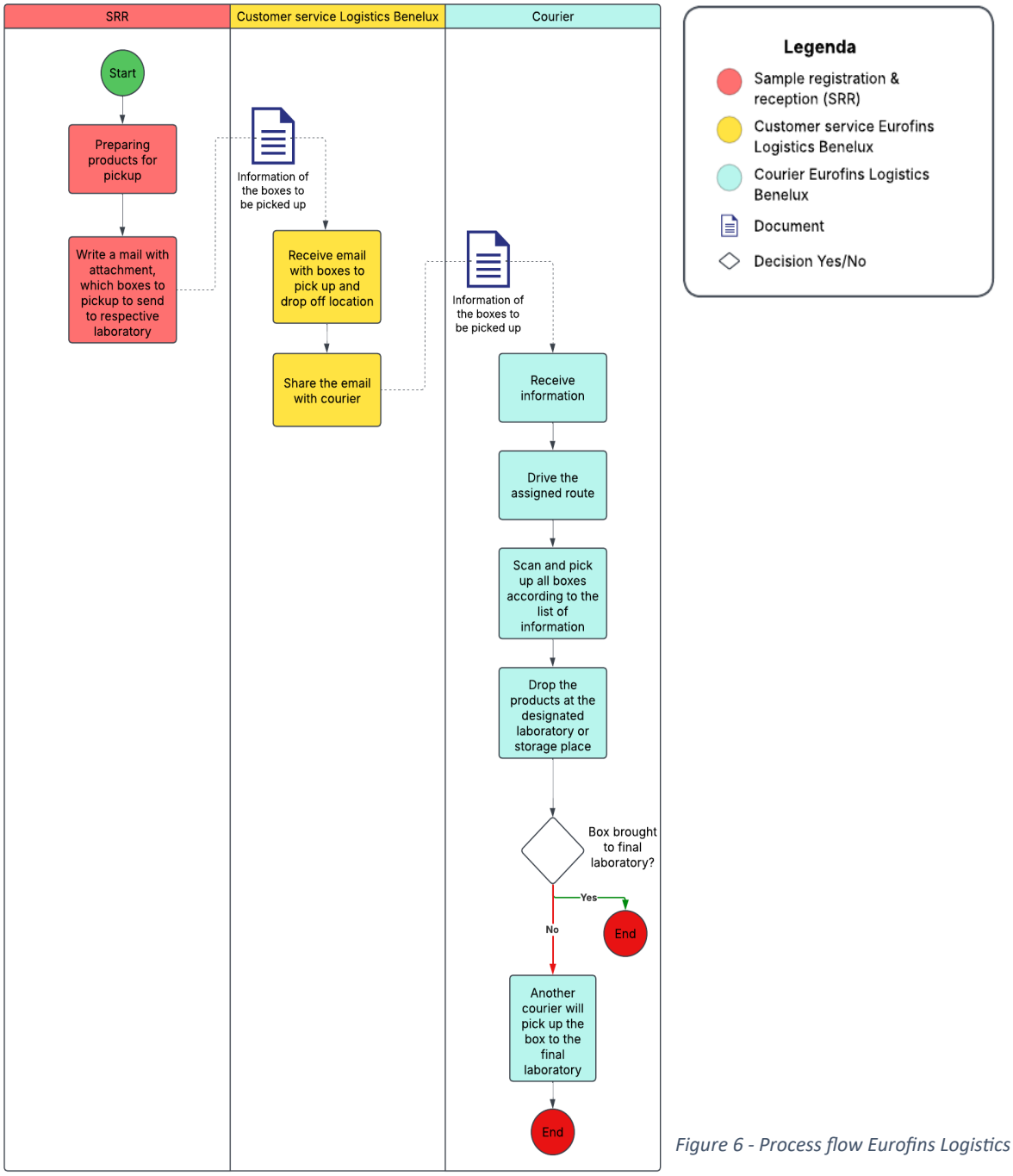


Figure 6 - Process flow Eurofins Logistics Benelux

Jetpak

Jetpak is an independent logistics company originated from Sweden (Jetpak, n.d.). Jetpak works together with Eurofins; they have a logistics collaboration with each other. They have an agreement that the boxes being transported by Jetpak will first be moved by Eurofins Logistics Benelux to Heerenveen. From there, Jetpak picks up the products and transports the packages all over Europe. The products will arrive in Heerenveen in the evening, transported by Eurofins Logistics Benelux. During the night – that is, in the early hours of the next day – Jetpak collects the products and delivers them to the laboratories across Europe.

DHL

Transport by means of DHL is only used for urgent delivery, and the transport to laboratories that cannot be served by either Eurofins Logistics or Jetpak. This mainly applies to laboratories outside Europe. An advantage of DHL over the other transport companies is that DHL has an accurate track and trace system. This track and trace system allows a box to be closely monitored. Therefore, it is rare that a package is lost. However, it is much more expensive, especially sending with DHL Express, which ensures that the package arrives as soon as possible. Moreover, the boxes cannot be sent refrigerated with DHL.

Laboratory

The laboratory receives the products and scans their barcodes to retrieve the required information into ELIMS. In ELIMS, they can retrieve the information that SRR has entered, such as what products are in the box, and what tests they need to execute per product. After testing, the results are shared by email and ELIMS to the FSS retail department.

2.2 Cost transparency

The focused costs consist of the costs incurred during the transport process. This includes the rates for transporting the products per courier service, but also consumables that are used to send the products, e.g. cooling elements, cardboard and Styrofoam boxes. This part of the transport process mainly consists of shipping the products from FSS to the laboratories as shown in *Figure 4.* Depending on the retailer, agreements are made on receiving the products at FSS. Depending on the retailer, Eurofins Logistics Benelux will pick up the products at the retailer's distribution centre, or the retailer will deliver the products by themselves to FSS.

As discussed in section *2.1*, FSS works with three transport companies: Eurofins Logistics Benelux, Jetpak and DHL. There is no general cost overview associated with the various carriers. For all transport companies, cost administration is either not tracked or tracked in various overviews across different places in the database. This results in no clear insight and thus no transparency into the costs for the employees.

Eurofins Logistics Benelux

For Eurofins Logistics Benelux, FSS receives an invoice together with an Excel overview per month including the costs for delivering packages via their transport network. Other orders for which the logistics department is called upon are also visualised in this invoice, e.g. picking up products from retailers and bring the products to FSS. This is neatly and clearly shared in an Excel file with the associated prices by the Eurofins Logistics Benelux. However, the excel file needs some manual adjustments to be able to visualise the data on the dashboard. These invoices are not checked for any mistakes, as the logistics department is a part of the Eurofins network. Eurofins Logistics Benelux charges a fixed price per stop they make on a

certain day, independent of volume and weight of a package. Therefore, the daily price will be divided by the number of products that will be transported with Eurofins Logistics on the day. Only for the stop in Heerenveen, a separate calculation will be made, since the products of Jetpak are also transported to Heerenveen first with Eurofins Logistics Benelux.

DHL

The prices of the packages containing products that are shipped with DHL are being tracked by SRR. This is carefully monitored in an Excel file. This list shows the date, destination and price of the shipment. This is monitored transparently and therefore clearly shows the costs that are involved with a shipment via DHL. However, it is not monitored what products are shipped. Therefore, the costs per product are not transparent. Unique package numbers are also not listed. Because of this, it is still a challenge to identify which packages and shipped by DHL, especially when multiple packages are sent to one laboratory on one day by multiple courier services.

Jetpak

The costs associated to Jetpak are not tracked. Only the invoices are kept and paid, but besides this there is no overview of all prices stored in one location. This is currently not transparent, since there is no clear overview. Jetpak invoices six days a week. SRR only ships products 5 days a week. This discrepancy is unknown for the employees. However, Jetpak charges the price based on the proportion of products that FSS sends via Jetpak, relative to the total number of packages Eurofins sends using Jetpak. Jetpak adjusts the price for all Eurofins companies every now and then. As a result, it makes no difference whether Jetpak invoices six days a week or five, since invoicing only five days simply leads to a higher price per day, so the total amount per week stays the same. For this reason, the cost per package is calculated on a weekly basis by summing the fixed daily rate over the six days and dividing this total by the number of packages transported by Jetpak that week.

Consumables

The consumable costs are closely tracked and monitored in an online system. The online system that is used is called Coupa. The data from the system can be extracted and saved in an Excel file. This can be further organised and cleaned to end up with the prices per product that are ordered to support the shipment process.

Box information

The boxes sent to the laboratories contain product samples that must be tested on food safety. These products can be all kinds of food products from different retailers, as long as it is a private label product. The ELIMS contains information on which products are sent in each box to the respective laboratory; this is because SRR scans all products assigned to a laboratory and product box. However, initially it was not possible to extract this information from the system. The available source for gathering this data is a PDF file that is sent with the box to the laboratory, so the laboratory knows what products there are in the box and what tests needs to be performed. This is not transparent, since no simple overview can be made from the PDF files. The data first has to be converted to a database, subsequently leaving out the irrelevant data and cleaning the data. This would take a lot of time and does not make the solution future proof, since the data has to be retrieved manually from ELIMS. Moreover, because 1100 boxes are sent in the first four months of 2025. Therefore, there are 1100 PDF files available with the required information in it. Luckly, a data expert was able to extract the unique package numbers from the ELIMS, so there is no need to convert the data from the PDF file.

In short, the cost overviews of some courier services are very transparent since the details are clearly monitored and tracked in separate Excel files. This is not the case for all courier services. These services only provide invoices in PDF versions. This makes it difficult to gain insights and a clear transparency in the total costs issued to the courier companies.

2.3 Data systems

FSS does not use one general database system or ERP[6] system where all the data is saved. This has both pros and cons, but regarding this research, mainly drawbacks occur with not having just one ERP system. This results in multiple files stored in various locations for all costs associated to transport, meaning that other steps must be taken before the dashboard can be assembled. The systems that FSS uses are ELIMS, EBIS, Coupa and the hard drive.

- Eurofins Laboratory Information Management System (ELIMS) is a software system designed to manage laboratory operations. Eurofins has its own LIMS that is aligned over all their laboratories. A LIMS is used to effectively manage laboratory samples and the associated data, thus standardising operations by maintaining and automating workflows, managing tests, and handling reporting procedures (CloudLIMS, 2024). FSS uses ELIMS to register the samples that will be sent to the laboratory in question. The registration contains the product specifications, sample number, laboratory that will conduct the test, required test to perform. The laboratories acquire all the information via ELIMS to be able to test product samples.
- EBIS is a software system that has similarities with Power BI. In this system, data is stored for across all laboratories in the Netherlands. From this data, specific information can be retrieved to visualise in a clear overview. However, this system is not completely used by FSS. For instance, the transport costs data is not stored in this system, making this system unusable for this research.
- Coupa is the system SRR uses for ordering the consumables. The system keeps track of the latest orders. The information can easily be converted into a excel file.
- The hard drive contains all other information in folders to keep an organised structure. The majority of all data on the hard drive is irrelevant for this research, since it has nothing to do with the research topic. However, the files that are relevant to the topic can be found in these folders. Nevertheless, it is a challenge to discover where all files are located. For example, the 1100 PDF files and DHL shipping costs are stored on the hard drive.

In short, FSS uses multiple databases that all contain a part of the information that is required for this research. First must be ensured that the obtained data is located in a general database to be able to analyse it.

2.4 Conclusion

In section *2.1* is discussed in detail how FSS' supply chain is constructed. This contains all parts of the supply chain FSS takes part in. In short, the retailer has to test private label products on food safety. They send the products to FSS. FSS makes sure the right tests are assigned to the products and that the products are shipped to the laboratory in question. The laboratory tests the products and returns the results of the tests to FSS. Finally, FSS communicates the results to the retailer.

[6] Enterprise resource planning (ERP) is a software that is used in organisations to support all processes within a business. All the data that a business uses can be saved in the ERP system.

As discussed in section *2.2*, multiple cost data must be identified to be able to execute the research. The transport cost data is not stored in the same file format or location. Some data, such as the costs for DHL, Eurofins Logistics Benelux, and the consumables is kept in Excel files. The cost data for Jetpak is stored in a separate folder and consists only of PDF invoices for the shipments. Furthermore, the products in the boxes that have been sent to the laboratories are saved in the ELIMS, and in PDF files. This makes it more difficult to create a clear overview of the transport costs, due to the data being stored in different locations and formats. Section *3.3* presents practical methods from the literature that are used to achieve greater cost transparency.

Section *2.3* reviews the data systems FSS currently uses for all practical purposes regarding the transport costs. As discussed, multiple data systems are used. This results in a lack of clarity and oversight, making it challenging for the employees to efficiently access the required information. Moreover, identifying all information necessary for designing a dashboard of the transport costs is challenging. Section *3.4* will identify in literature the methods used to integrate different data sources into one database.

Up to now, only the costs of packages are identified, but not how those costs relate to the products inside the boxes. Moreover, a package can contain products from different retailers. This makes it hard to identify the costs per product or per retailer in general. The challenge for visualizing the data requires a general database with all information about the costs, to be able to show the costs per product and/or retailer. Existing literature will be reviewed on how to execute this visualisation in an efficient and effective way in section *3.1*.

The selection of KPIs will also be reviewed in the literature, which will be presented in section *3.2*. Several methods will be discussed that support the selection of KPIs that are most appropriate for visualising a cost overview. The selection of KPIs will be discussed in section *4.4*.

3. Literature review

This chapter reviews the existing literature that is helpful for executing this research. The goal of this chapter is to lay the foundation for the challenges, tools and information necessary in the upcoming chapters for the solution design & implementation.

Section *3.1* discusses the data that is important for visualising a cost overview in a dashboard. In section *3.2*, literature will be reviewed for existing techniques to select KPIs for visualising a cost overview. Additionally, optional activities will be discussed that can be performed after selecting KPIs. Section *3.3* will provide information from literature about cost transparency within supply chains. Section *3.4* will discuss the practices for integrating multiple types of data into one unified database.

3.1 Data visualisation

In this section, the knowledge question – *"What data is important for visualising a cost overview in a dashboard, according to literature?"* – is discussed by reviewing existing literature. The answer to this question forms the basis for the data needed to create a visualisation. The upcoming chapters will look at whether this data is also available and how this data can best be applied based on the findings in this section.

Data is indispensable when it comes to tracking the performance of a company. KPIs are often used for measuring data. KPIs are essential for organizations to track and supervise current performance, define areas of improvement, assess the effects of implemented changes, and measure critical aspects of project performance, monitor systems, ensure service quality, detect issues, and trigger appropriate actions. KPIs ensure that businesses can continuously track the progress and make informed decisions based on data (Ed-daymouni et al., 2024). Fradi et al. (2017) further elaborates that KPIs in cost visualisations are generally built from mathematical origin such as rates, quotients, percentages and averages. However, it is project specific what data is important and whether the data is available. Additionally, the stakeholders should steer the project in the right direction by stating requirements that the model with the KPIs should contain (Wood et al., 2021).

The selection of effective visualization tools is essential for presenting the data in an understandable and user-friendly way. According to Ed-daymouni et al. (2024), many current visualization tools can be costly, time-consuming to develop, and require specialized programming skills, which may limit their accessibility. However, these tools cannot be underestimated, since they can explain the complex cost data in a clear manner. Tools such as reports, histograms, pie charts, and regression curves are frequently used in data visualization to display the results of data analysis (Peral et al., 2017). These tools help in comparing costs across different periods, departments, or categories, which is crucial for cost overviews. Furthermore, Fradi et al. (2017) emphasizes that data visualization involves the graphical representation of both quantitative and qualitative data, allowing the detection of trends and evolutions that might otherwise are not noticed.

Dashboards are the preferred method for visualising business performance. A dashboard is a data visualization tool that displays metrics and KPIs for a company on a single screen (Fradi et al., 2017). Dashboards created with tools like Power BI help with tracking KPIs related to safety, cost, and scheduling in real-time, simplifying complex data and enabling faster, better-informed decisions (Al-Sulaiti et al., 2021). But for any dashboard to be effective, it is crucial that the visualizations are user-friendly. The analytical results should be presented in an accessible and straightforward manner, to make sure that the

results are easily understood by the intended users (Peral et al., 2017). Therefore, it is essential to stay in close contact with the stakeholders. It is important to tailor visualizations to the audience's technical expertise and the specific context of the data. Static charts are commonly used for their simplicity, but interactive visualizations can provide deeper insights, especially when dealing with dynamic data such as a cost overview (Wood et al., 2021).

Visualizing cost data presents challenges. Wood et al. (2021), observes a lack of standardization in the graphical methods used to present cost data. Although literature about cost engineering provides examples of visualizations, there is no consistency, nor explanation regarding why certain methods are chosen. The cost visualisation methods are generally tailored to suit specific purposes and cost applications.

3.2 KPI selection

In this section, literature will be reviewed to identify existing techniques for selecting KPIs regarding a cost overview of a transport process. Especially choosing KPIs focusing on the shipment of products by a transport company. Furthermore, the activities that could be performed after selecting the KPIs are reviewed in literature.

To develop an effective performance measurement system (PMS), it is important to include only a limited number of KPIs that together offer a comprehensive view of the company's performance. Limiting the number of KPIs helps to prevent information overload, reduces the risk of confusion for users, highlights the most critical factors affecting the organization’s competitiveness, and makes the overall measurement process more manageable (Carlucci, 2010). The selection of performance indicators is a complex decision-making process that can be understood and addressed as a multi-criteria decision-making (MCDM) problem (Carlucci, 2010). According to Podgórski (2015), performance indicators that have a logical relationship with what is to be measured must be defined before performing a MCDM. After developing an initial list of potential indicators, the next step involves evaluating each indicator against a set of predefined criteria. These criteria are intended to ensure the quality, relevance, and overall usefulness of the selected indicators (Carlucci, 2010). After executing the respective MCDM, certain performance indicators are more important compared to others based on the established criteria (Podgórski, 2015), these most important performance indicators can also be named as KPIs.

Once the performance indicators and criteria have been selected, various methodologies can be employed to evaluate and rank their relative importance. These methodologies are also named as the aforementioned multi-criteria decision-making (MCDM). One such method is the Analytic Hierarchy Process (AHP), which consists of a pairwise comparison to assess the significance of one criterion relative to another (Saaty, 1987). This method has been widely used in all kinds of areas, but due to the scope of this research, will only be focused on determining the relevance of the KPIs. Through systematic pairwise comparisons, a hierarchy of importance among the KPIs is established. The AHP method assigns a numerical weight to each KPI, thereby quantifying and visualizing its relative significance. With the AHP, decisions are based on a rigid, hierarchical structure where elements are uncorrelated and only affect each other in one direction (Nathnail et al., 2016).

Another method is the analytic network process (ANP). According to Carlucci (2010), the ANP is a generalisation of the AHP, but instead of the hierarchy, ANP follows a network structure, as shown in *Figure 7*. This results in more flexibility, since using a network allows for both interactions and feedback between all elements – goals, criteria, sub-criteria, alternatives – in the decision-making process.

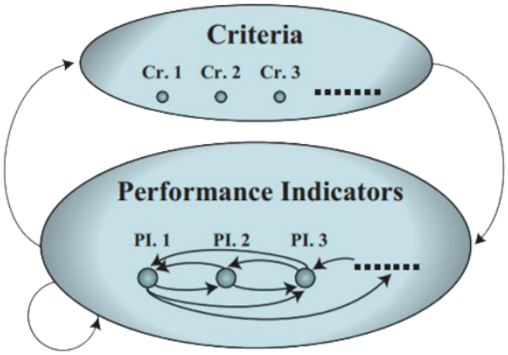


Figure 7 – The ANP model for selecting performance indicators

Another MCDM method is decision-making trial and evaluation laboratory (DEMATEL). It is a comprehensive technique for creating and analysing a structural model involving causal relationships among complex factors. The main goal of DEMATEL is to create a visual representation that shown the relationships between different criteria, highlighting which criteria are the most influential and which are influenced by others (Alvandi et al., 2012).

The Stepwise Weight Assessment Ratio Analysis (SWARA) method is another MCDM technique used to determine the relative importance of various KPIs (Radovic & Stević, 2018). The SWARA method involves experts first ranking the KPIs in terms of importance based on their expertise and understanding of the decision context. Then, for each KPI, the comparative importance ratios are calculated by assessing how much more important one KPI is compared to the next in the ranking. These ratios are used to assign relative weights to each KPI, reflecting their significance in the overall decision-making process. This helps ensure that the most critical KPI are given higher importance in evaluating potential options or outcomes for a specific purpose (Radovic & Stević, 2018).

3.3 Cost transparency

In this section, a literature review is performed to investigate the already known knowledge in terms of cost transparency in supply chains. This literature review tries to answer the question: "*What does cost transparency look like in supply chains?".* By answering this question, the existing techniques are studied to gain more knowledge that may be of importance for this research.

For supply chain transparency, it is essential that companies know what is happening upstream in the supply chain so they can communicate this knowledge within the company as well as to their customers. One of the reasons that this has become increasingly important is that more customers and companies are demanding this transparency (Kraft et al., 2018). For example, regarding food companies, more and more interested parties demand for supply chain related information such as ingredients, food fraud, animal welfare and child labour. According to Gardner et al. (2019), transparency can clarify complex supply chains, and it can help different actors with identifying and minimising risks. In addition, it informs stakeholder about whether, and where, progress is being made. Bai & Sarkis (2020) discusses that supply chain transparency is the practice of sharing detailed and accurate information about operations and products, such as their origin and sourcing, manufacturing processes, costs, and logistics. According to Cui et al. (2024), transparency reduces inefficiencies, fraud, and conflicts within supply chains that is been enabled by blockchain technology. It ensures that all parties in the supply chain have access to real-time, accurate data. This increased transparency helps to optimise costs and improve decision-making. However, this will mainly occur with partners who have been working together for a long time, not with customers to who the business is selling the products to.

Blockchain is a technology that records transactions in a secure and permanent way across multiple computers, making it difficult to influence or change the information. The blockchain technology helps improving transparency, traceability, and trust in supply chains by allowing real-time tracking and automating tasks through smart contracts (Tabatabaei et al., 2022).

Transparent cost structures lead to better cooperation and mutual trust between partners (Yang et al., 2018). When partners in a supply chain have clear insights into the cost structures involved in a transaction, it supports with strategic decision making and helps with negotiating better prices for all partners, which ultimately benefits all stakeholders in the supply chain by lowering overall costs. This is in line with what Hoffjan et al. (2011) addresses. Hoffjan et al. (2011) elaborates on the strategic benefits of cost transparency. It outlines the value of publicly sharing the transport costs among suppliers and consumers. It mitigates the risk of unforeseen expenses and boosts the accuracy of cost forecasting and the overall transparency within the supply chain. This all increases the competitive position in the market.

To achieve cost transparency, businesses should follow four key steps according to literature:

1. *Define the scope and objectives*. Businesses must establish clear goals for their cost transparency efforts, identifying the primary purposes and expected benefits. It is essential to determine which stakeholders and audiences will be involved or impacted by the initiative and understand their expectations and needs (Schnackenberg & Tomlinson, 2016). In this way, transparency contributes to trust and organisation effectiveness.
2. *Collect and organise relevant data*. Organizations need to gather and store data that accurately reflects the costs, revenues, and profits associated with their activities, processes, and products. It is crucial to ensure that the data is complete, accurate, and consistent. Moreover, the data should be accessible and organized for analysis (Hueller et al., 2024).
3. *Analyse and communicate the data*. Businesses should utilize appropriate tools and methods to process and interpret the data, and to draw actionable insights from it. KPIs should be used to evaluate the costs of activities, processes, and products, as well as identifying the factors that influence them. Additionally, visualization tools like dashboards, charts, and graphs are essential for presenting the data clearly and effectively. Weinberg & Faccia (2024) explored the integration of machine learning with triple-entry – a system used for financial bookkeeping – that resulted in benefits such as improved transparency and improved decision-making.
4. *Monitor and improve the data*. It is important for businesses to continuously review and update their data, tracking the results and impact of their cost transparency efforts. Regular monitoring allows businesses to adjust when necessary, ensuring that the data remains relevant and meets stakeholder needs (Joosse et al., 2023).

ERP systems can be a good tool for making costs more transparent. Organisations use ERP systems to integrate and manage their core business processes efficiently and effectively though a single, centralised system that all departments in a company can access. According to Poston & Grabski (2001), ERP systems are, among others, designed to visualise a clear overview of all activities and to reduce costs by improving inefficiencies through computerisation. Moreover, ERP systems provide real-time access to financial data, enabling informed decision-making and improved financial reporting. These effects are associated with improved firm performance, underlining the role of ERP systems in achieving cost transparency.

Identifying the key cost drivers can also be helpful to improve the transparency in terms of costs. A cost driver is a factor that causes a change in the cost of an activity, product or service (Cokins, 2010). In other

words, it is something that influences or determines how much a company spends on a particular process. For example, the number of packages shipped can be a cost driver for transport costs.

Moreover, Cokins (2010) discusses some important factors to consider when choosing cost drivers:

- *Easy to identify, use, and understand*. To find a cost driver, one needs to look at how it relates to indirect costs. After identifying the activities involved, one creates a cost model that shows where resources are used and how costs are allocated.
- *Direct relationship between indirect costs and cost drivers*. By correctly identifying cost drivers, one can link indirect costs to specific activities, which helps to determine the true costs of things like products or services.
- *Impact on staff*. When managers and employees understand cost drivers, they can see how costs change and what causes these changes. This understanding improves cooperation between employees and management, leading to better business performance. It also helps companies accurately analyse profit margins for decision-making.

By identifying the key cost drivers within the business' operations, companies can better manage their spending and optimise their profitability.

3.4 Data integration

When using data from many sources with different formats, such as Excel and PDF files, it is of crucial that the integration process is done as carefully as possible. This section explores the best practices for data integration, as well as cleaning and transformation the data so it can be used for further analysis.

The most widely used practise for data integration, cleaning and transformation is *Extraction-Transforming-Loading* (ETL). ETL is the process of collecting data from different sources, converting it into a useful format, and then storing it in a data warehouse or system for analysis (Vassiliadis et al., 2002). A *data warehouse* (DW) is a database that collects and stores data from other databases (Fradi et al., 2017). In *Figure 8*, the general ETL process is described. In the bottom layer, the involved data stores during the process are visualised. The *Data Staging Area* (DSA) is the location the data is stored when it is cleaned and transformed (Vassiliadis et al., 2002). So first, the required data is extracted from sources or databases. Thereafter, the data is transformed and cleaned. Finally, the cleaned and transformed data is loaded into the data warehouse, after which it can be further used for in-depth analyses.

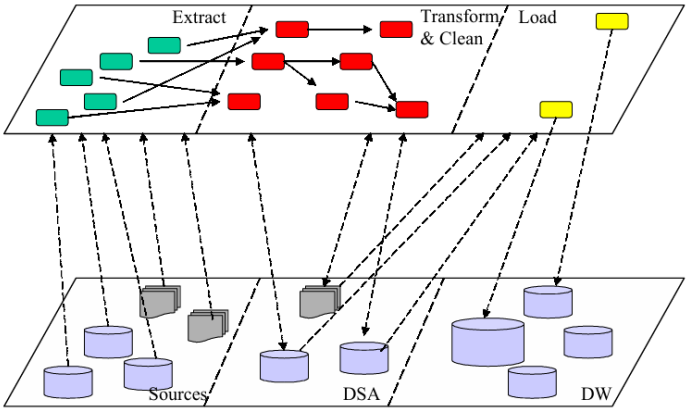


Figure 8 – ETL process explained (Vassiliadis et al., 2002)

During the data cleaning and transforming part, it is essential that this is done accurately and with care, to ensure that irrelevant data is removed without losing valuable information. The method that is primarily used for transforming the data is normalisation. The objective of normalising a relational database is to minimise data redundancy and maintain data integrity (Maingi et al., 2023). According to Bahmani et al. (2008), *"The goal of normalisation is to create a set of relational tables with a minimum amount of redundant data that can be consistently and correctly modified.". D*atabase normalisation consists of seven so-called normal forms: first normal form (1NF), second normal form (2NF), third normal

form (3NF), Boyce-Codd normal form (BCNF), fourth normal form (4NF), fifth normal form (5NF), and domain-key normal form (DKNF). Most of the database systems are normalised up to 3NF (Piza-Dávila et al., 2017). For this reason, the other normal forms will not be addressed in this research. According to Piza-Dávila et al. (2017), certain properties must be satisfied to ensure that the normal forms hold, starting with the 1NF:

- No cell has more than one value.
- All values in the same column belong to the same domain (integers, string, dates, …)
- No duplicate rows or groups of data.
- Each column is unique.
- The table has a primary key (makes sure each row is unique).

The following two rules must be true to argue that a table is in the 2NF:

- The table is in 1NF.
- Non-prime attributes (keys that are not part of the primary key) are fully dependent on the primary key of the table.

The prerequisites for the 3NF are that:

- The table is in 2NF.
- There may not be transitive dependencies. This means that no non-prime attribute is dependent on another non-prime attribute. In this case, a new table should be created consisting of a new primary key, on which the other non-prime attributes depend. This process continues until all non-prime attributes depend only on primary keys.

3.5 Conclusion

Section *3.1* answers the following knowledge question: *"What data is important for visualising a cost overview in a dashboard, according to literature?".* This section underscores the importance of KPIs, suitable visualization tools, and user-friendly dashboards for visualizing cost data. Since there is no standard method for visualising cost overview, the dashboard should be tailored to stakeholders needs, both content and design related. Stakeholders will be consulted multiple times to define relevant KPIs and visualisation preferences. These interactions and evaluations will be discussed in detail in section *4.3*, *4.4* and chapter *5* respectively.

Section *3.2* explains that KPI selection depends on the stakeholder and company's needs and expectations. Experts and stakeholders first identify potential indicators, which are then ranked using MCDM techniques such as AHP, ANP, SWARA, or DEMATEL, each with their own pros and cons. Usually, criteria weights help rank KPIs, but for this research, all KPIs are considered as equally important and visualised separately on the dashboard. The focus is on visualising costs, where no cost type is prioritised over another. Therefore, none of the MCDM techniques will be applied in this research. The KPI selection in collaboration with FSS employees, KPI measurement, and prototype visualisation will be discussed in section *4.4*, *4.5* and *4.6* respectively.

The key conclusion of the investigative question addressed in section *3.3* – "*What does cost transparency look like in supply chains?*" – is that transparency is essential for providing insight and clarity about an organisation's products to all stakeholders. Environmental concerns and other factors have made transparency increasingly important, especially cost transparency, which focuses on clearly understanding internal costs and their origins. Cost transparency can also extend to collaborations with supply chain partners. This enables companies to identify inefficiencies, reduce costs, and improve profitability. The

deliverable visualised in section *4.6* supports the internal cost transparency, since the dashboard will provide insight into the variable transport costs.

Section *3.4* describes methods for integrating data to enable visualisation. The data must first be collected from various sources, cleaned and transformed before being loaded into a data warehouse for analysis.
The cleaning and transformation process is based on database normalisation, which ensures removing redundant data, maintain data integrity and improves analysis accuracy and reliability. Data normalisation follows a series of steps, known as normal forms. These steps include: 1NF, 2NF, 3NF, BCNF, 4NF, 5NF and DKNF. In most cases, transforming the database into 3NF is sufficient to avoid anomalies.
The ETL process and normal forms will be used in the report. Only the 1NF, 2NF and 3NF will be applied, as most databases are typically normalised up to 3NF to eliminate inconsistencies. Section *4.2* elaborates on both the ETL process and normal forms that will be used for the dashboard design.

4. Data processing and visualisation design

In this chapter, the prototype of the dashboard is developed. There are still several stages that need to be completed before the prototype can be developed. The following investigative questions discuss these stages in the upcoming sections. First, the question *"What data is available for this research purpose?"* will be discussed to have clarity about which data is available for conducting the research in section *4.1*. Subsequently, in section *4.2*, the data will be cleaned and transformed to leave out the irrelevant data and ensuring the data is ready to use. Thereafter, section *4.3* and *4.4* elaborate on the identified cost drivers, and a selection of KPIs is made by answering the following questions: *"What are the different cost drivers for FSS?"* and *"What KPIs are important to measure the costs?"*. Afterwards, the KPIs and cost drivers will be measured by modelling the prototype of the dashboard. This will be answered by the following two investigative questions: *"How to measure the KPIs and cost drivers with the available data?"* and *"How to implement the solution in a dashboard with respect to FSS' needs?"*. This is addressed in section *4.5* and *4.6.*

4.1 Gathering the data

As discussed in section *2.3*, FSS uses several data systems where all information is stored. This results in a challenge to retrieve all relevant data for the research, but it is also questionable whether all data is available. Therefore, it is first determined which data is needed to execute the research. To arrive at the deliverable, the following information is necessary to extract from the data systems:

- Courier; Which of the three transport companies is used to ship the product to the laboratory in question.
- Laboratory; To which laboratory the product samples are sent.
- Package information; Each package has a unique number to distinguish all packages that are sent to the laboratories, and that one knows what products are in a package.
- Sample; Which product samples are sent.
- Date; The date that a package is shipped to the laboratory. In this way, the shipments can be sorted by date to gain transparency on how many boxes were sent and when.
- Retailer; Having an overview of the product's retailer is crucial to assign a retailer to a product.
- Refrigerated transport; This refers to whether the samples are shipped under refrigerated or normal temperature conditions. Transporting refrigerated requires additional consumables, such as cooling elements and Styrofoam boxes, described in section *2.1*.
- Transport costs; The costs involved in the transport process that are related to the courier service and the package that is sent.
- Consumable costs; The prices of the consumables that are used for transporting a package.

The first step that is taken for gathering the required data consists of retrieving data from ELIMS. This contains the packages sent to the specific laboratory and the products these packages contain. The requested information consists of the unique package number, sample number, retailer, date and the corresponding laboratory.

This information has all been extracted from the ELIMS, except the unique package number; these numbers where not directly extractable from the system. The dataset that is obtained includes information on all tests required to be conducted at the designated laboratory. In some cases, multiple tests may be carried out on a single sample at different laboratories. Each of these tests is represented by

a separate row in the dataset. To ensure a more accurate overview to link the transport costs to the retailers and products, it is important to include the unique box numbers and link the box numbers to the corresponding sample codes and laboratories. The dataset comprises 105,412 rows, each representing a test conducted within the period from 01-05-2024 to 29-04-2025.

For gathering the sample numbers that a package contains, contact was established with an application manager. He helped with gathering this information from the database of ELIMS. The unique package numbers, also called PurchaseOrderCode, were extracted from the ELIMS system in an Excel file with the associated sample numbers, laboratories and date. This dataset comprises of 4046 rows, that is equal to 4046 packages sent between 01-05-2024 to 29-04-2025.

The crucial information that is still missing and cannot be retrieved from ELIMS consists of whether the products are transported refrigerated, the courier service that shipped the products, the prices of the transport costs and the consumable costs.

It is challenging to accurately determine which transport company shipped the package and whether the products were transported refrigerated, because there is no data about this. However, as mentioned, SRR keeps track of all shipments with DHL, together with the date and destination. In this way it can be determined for most of the packages whether they were transported by DHL. The boxes with the destination in the Netherlands, Belgium and Luxembourg were sent with Eurofins Logistics Benelux. For the other boxes, it is assumed that they were transported with Jetpak. Regarding the refrigerated transport, there is no data available. Besides this, no logic can be derived whether a product is transported refrigerated or under normal conditions. Therefore, the decision is made to visualise the consumable costs separately from the samples. This will have no impact on the accuracy of the dashboard visualisations, because this visualisation will be created to provide insight into the costs of consumables. This is done so it can be taken into account in the future when determining more accurate prices for customers.

As addressed in section *2.2*, the costs FSS makes for transporting the products to the laboratories is not transparent. The costs assigned to DHL are kept in an Excel file. When a new order is placed, the date, destination and price are added to the file. For Jetpak and Eurofins Logistics Benelux, no clear overview is there, only invoices, in PDF format and Excel file respectively. It stands out that for Jetpak, the prices are the same per day. For Eurofins Logistics Benelux, the costs are charged per stop each day. It does not matter if one or ten products are sent, the price is the same. This is a striking conclusion on which will be continued in chapter *6*. Eurofins has a price agreement with Jetpak for transporting the product over Europe. It was agreed that a fixed amount will be invoiced per day for six days a week. However, this invoice takes into account the volume transported. From time to time, the invoice amount is adjusted based on how much FSS has transported with Jetpak compared to all other Eurofins companies. In short, the volume transported is considered when Jetpak creates an invoice. The amount is periodically adjusted accordingly.

The prices of the consumable costs are extracted in an Excel file from the online system Coupa. As mentioned, this is where the purchases for the consumables are made. The columns consist of *purchase order ID*, *requested by*, *date shipped*, *status*, *products* (including price per product) and *total price per order*. This still needs to be cleaned up and transformed before it can be used.

4.2 Data cleaning & transforming

During the data cleaning part, it is of utmost importance that this is done accurately and carefully. As discussed in literature section *3.4*, the ETL process is most commonly used for data integration practices, transforming and cleaning the data to ultimately be able to analyse the data. This ETL process will be used during this research, as well as the normal forms. This step-by-step approach of the normal forms ensures the data quality for finally visualising the data.
The Power Query editor in Excel will be used to clean and transform the dataset to the 3NF. The Power Query Editor in Excel is a tool used to clean, structure, and transform data. It functions as an ETL tool that allows users to connect to a wide variety of data sources and apply numerous transformations while previewing the data (Microsoft Learn, 2025).
The dataset with the information about the product samples, consisting of 105,412 rows and 30 columns, was obtained after applying several filters before the extraction from the system. The first filter selected the rows where the source type is FSS. Since the system contains data from all Eurofins locations in the Netherlands, this filter makes sure that only data from FSS was included. The second filter restricted the dataset to only include rows designated for commercial use. Additionally, two more filters were applied: the sending laboratory must be FSS, and the receiving laboratory must be a different location than FSS. In some cases, additional reserve products are ordered in case issues arise in later stages of the process. However, since these products are not used for transport, they were excluded from the dataset.

With the Power Query editor, columns that are not relevant to this study have been removed, such as whether a test is overdue, including the number of days, comments on a sample and the customer's reference sample codes. Moreover, the cells are trimmed; the trim function in Power Query is used to remove all leading and trailing whitespace characters from text values. This function is applied to prevent that inconsistencies occur, that can lead to duplicates in the final dataset.

Packages that were lost during the transport process are not considered. These packages have been transported but have been lost during the transport. Therefore, the transport companies have not invoiced these packages. Packages that had problems with samples exceeded temperature boundaries are taken into account. These packages have been sent with the transport companies, and it is not the courier's fault that the samples exceed the temperature limits. Therefore, these costs are considered.

The Power Query editor is also used in the table containing the related package numbers and sample numbers. The extracted data from the database was not yet in 1NF. One row contained one PurchaseOrderCode, with multiple sample numbers in one cell. With the help of Power Query editor, this data has been modified to one row per sample number with the corresponding PurchaseOrderCode. This resulted in 20,731 rows.

Next, the PurchaseOrderCode is integrated into the sample number table using the power query editor by matching sample codes and lab names in both tables. After the cleaning phase, eight columns are left. The columns that are left are shown below in *Table 1* with explanations.

Sent on	*Lab-P Name*	*Lab-P*	*ClientCode*
The date that the sample was sent.	The full name of the laboratory.	The abbreviation name of the laboratory.	The unique code per client.

ClientName	*Sample code*	*SampleReference*	*PurchaseOrderCode*
The full name of the client.	The unique code per product.	The full name of the product being tested.	The unique package number.

Table 1 – Columns in the product data.

Two extra columns have been added to this table, the Retailer Codes and Retailer Names. This is done because the Client Code and Client Name columns also contain suppliers of some retailers. An agreement has been made with these retailers by FSS that the suppliers will also receive the reports with the results and pay the invoices. That is the reason that these suppliers are in this list. The added columns generalise the Client Code and Client Name list to only retailers, under the header Retailer Codes and Retailer Names.

To get the data from the 1NF to the 2NF and 3NF, the columns will have to be split up and distributed over multiple tables so that the columns of non-prime attributes become completely dependent on a primary key. For the 3NF, it must be ensured that no primary key can be dependent on another primary key. If this is the case, a new table must be created for it. The large datasheet is divided over several tables that all have a relationship with each other. This is how the data is put in 3NF. This resulted in six different tables. The tables are visualised in *Figure 9*.

For DHL, unique box numbers were linked to shipments based on the delivery date and laboratory. Most orders could be clearly distinguished; however, on certain days, multiple boxes were sent to the same laboratory, making it unclear which boxes were transported by DHL and which by Jetpak or Eurofins Logistics Benelux. For these shipments, the content of all packages on that day is analysed. It is assumed that the content that most matched the price of the DHL service is transported with DHL. In general, it was straightforward to match a price from the DHL Excel list to the correct package among the different packages sent to the same laboratory. This was done by looking at the contents of the packages and linking them to the corresponding price. The PurchaseOrderCode of this package is assigned to the respective DHL shipment.

The invoices of Eurofins Logistics Benelux are more generalised and extended in an Excel file to make sure it is usable for the visualisation part. The same goes for the invoices of Jetpak. It is noticeable that all Jetpak's invoices charges FSS the same price per day. So apparently, it does not matter how much packages are sent on a day with Jetpak.

Subsequently, the three logistic companies are integrated in the PackageNumber table and connected to the PurchaseOrderCode. The PurchaseOrderCodes that are transported by DHL are connected to the DHL table. With a query, the laboratories that are served by Eurofins Logistics Benelux are assigned to all PurchaseOrderCodes with one of the labs in the Benelux as destination. The other laboratories are assigned to Jetpak.

In the same way, the costs of the logistic companies are connected to the PurchaseOrderCodes. The direct costs of DHL are taken from the DHL table. For Eurofins Logistics Benelux, the price per package is calculated by counting the number of packages sent on one day and dividing by the total price for all stops on one day. The same is done for Jetpak, only then a week. The available invoices show that six out of seven days a week are charged with a fixed price. These costs are divided by all boxes that are sent a week with Jetpak. In this way, the prices per box are calculated as accurately as possible for both Eurofins

Logistics Benelux and Jetpak. This was all done using the Power Query editor in Excel. After all these steps, the data is in 3NF and ready to be used for the visualisation phase.

The consumable costs must be cleaned and transformed to be able to use it in the dashboard. This is done by entering one product per row instead of one order per row. Moreover, it is extended by adding the price per product, since most of the products are bought in batches. This makes it easier to calculate the price per product and eventually determine the costs per package sent.

Figure 9 illustrates the ER diagram integrated in Power BI, including the connections between the tables. The table *PackageNumber* serves as the main table, which contains for each shipment the courier, laboratory destination, cost, and date. The samples are linked to the packages via the *Sample_Package* table, showing the samples in a package. Furter, *SampleCode_ClientCode* connects the samples to clients, and *Client_Retailers* shows which client belongs to the retailer in question. The *LabNames* table includes the codes and names of the laboratories, and is connected to PackageNumber, since one package is sent to a designated laboratory. The table *CoupaOrders* does not have a connection with any other table, since there is no connecting data available.

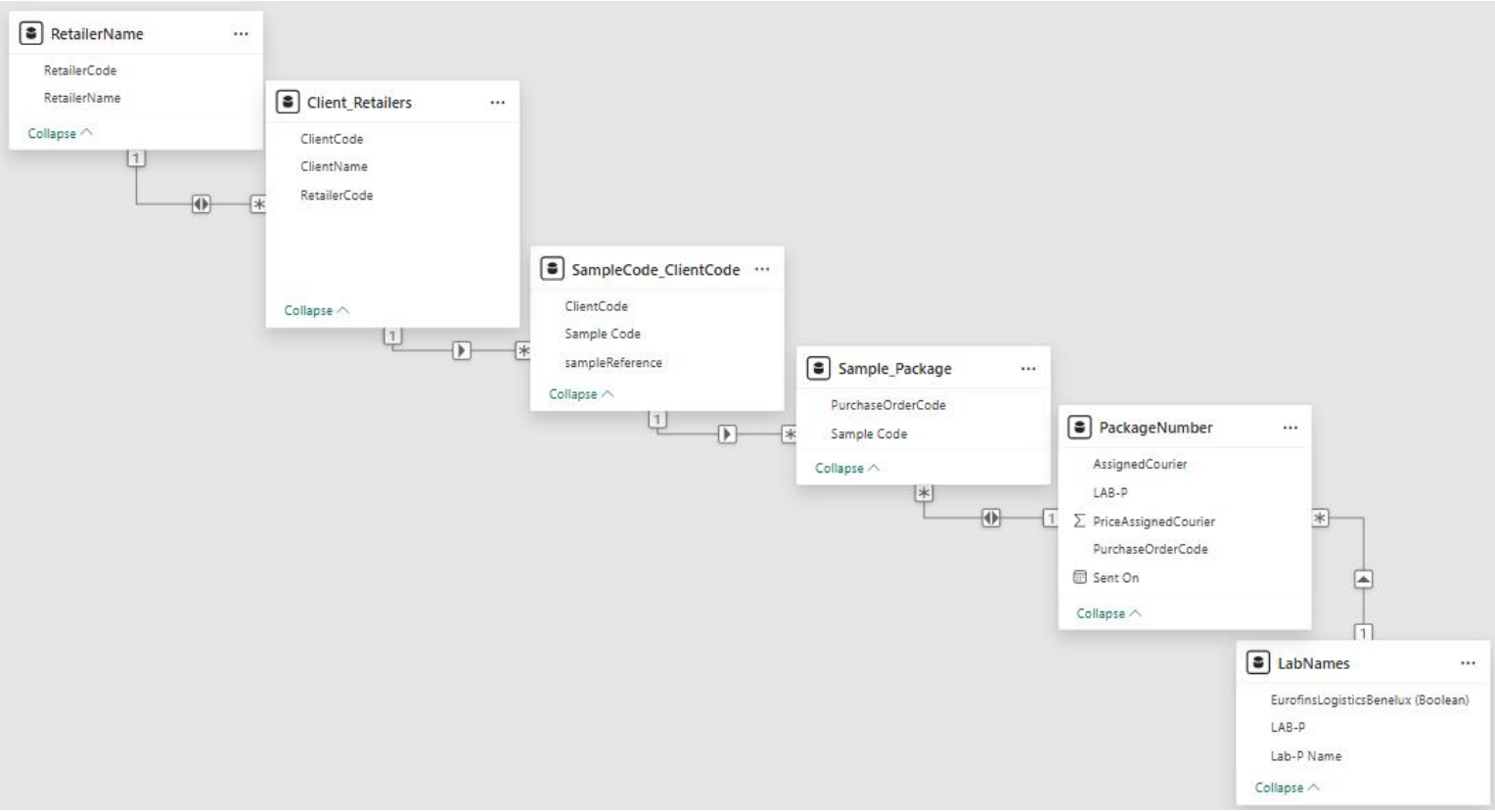


Figure 9 – Overview of tables integrated in Power BI in 3NF.

4.3 Cost drivers

Companies can better manage their spendings and increase the profitability by identifying the key cost drivers within the operation of the business. As discussed by Cokins (2010) in section *3.3*, a cost driver is a factor that influences or determines how much a company spends on a particular process. Therefore, it is important to first understand what the cost drivers in the process are, before determining the KPIs and creating visualisations, as the KPIs may depend on these cost drivers. The cost drivers are discovered by conducting unstructured interviews with the employees. Due to the scope of this research, the cost drivers

discussed either influence or are exclusively part of the supply chain between FSS and the laboratories, as shown in *Figure 4*. This corresponds to the steps involving the SRR, the logistic service, and the laboratory in the BPMN model shown in *Figure 5*.

For FSS' activities regarding the transport sector, several cost factors influence the total expenses associated with product shipments. These factors range from number of packages sent, to the weight and the choice of courier service. Below, the key cost drivers for FSS are examined with their justifications in *Table 2*.

Cost driver		**Justification**
Number of boxes sent per day		The more packages sent, the higher the total transport cost is.
Weight of the packages		For some courier services, the price depends on the weight.
Number of retailers		More retailers mean more products, which means more performed tests and therefore, more product shipments, so a higher total costs.
Type of courier service		The courier services do not charge the same rates.
Dedicated laboratory		The distance from FSS to the laboratory in question influences the price.
Number of laboratories		An increase in the number of laboratories used leads to more packages being sent.
Normal vs. refrigerated conditions		Refrigerated products require more consumables, such as cooling elements to keep the products refrigerated, which costs extra money.
Number of products in a box		The more products that are in a box, the cheaper the shipment is per product.

Table 2 – Key cost drivers

4.4 KPI selection

As examined in the literature review section *3.2*, KPIs are measurable values that support organisations assess and track their performance on specific business objectives (Ed-daymouni et al., 2024). Moreover, a limited number of KPIs should be selected to have a comprehensive overview of the company's performance (Carlucci, 2010).

For FSS, the key cost drivers have been addressed in terms of KPIs to gain insights into the cost drivers via the KPIs in the dashboard. The KPIs are presented and justified in *Table 3*. The KPIs are developed based on unstructured interviews conducted with internal stakeholders by discovering the cost drivers and KPIs. During these interviews, the stakeholders shared their expectations for the project and discussed the essential elements the dashboard should contain, which were then translated into KPIs. These KPIs provide a general overview of all activities that can significantly impact transport related costs and are therefore essential to include in the dashboard. The same applies to the KPIs as to the cost drivers; they are only part of the supply chain between FSS and the laboratories shown in *Figure 4*.

The decision was made to not apply one of the weight criteria methods described in section *3.2*. This has been decided since all KPIs are evenly important, because the KPIs do all describe a separate part of the cost overview. Additionally, it is about costs. Costs already do have a value, on which one is not more important than another.

KPI		Justification
The costs per shipment (per package)		This is one of the most important KPIs because it shows the basic cost per shipment.
The costs per product		This gives one insight into how much it costs to ship a specific product, helping with cost optimization per product.
The costs per retailer		To charge the costs accurately to the retailer, then there must be a clear view of the costs per retailer.
Shipping cost per weight		This is especially useful for companies that take the weight into account to determine the price.
Packaging costs		All packing materials necessary for shipping. Especially with the difference between refrigerated and non-refrigerated products.
Shipping cost per laboratory		This gives insights into the costs for sending a package to specific laboratories, dependent on the distance.
The costs per shipping company		This helps to determine the most efficient carrier in terms of costs.

Table 3 - Selected KPIs

The KPI *'Shipping cost per weight'* will not be further discussed in the report, as no data is available regarding the weight of the packages shipped via the transport companies.

4.5 Measuring the KPIs

All the preparatory steps for the measuring and visualisation of the dashboard have been completed successfully. The dataset has been carefully prepared, cleaned, and transformed to ensure the accuracy and consistency. Moreover, the cost drivers have been identified and a set of KPIs is defined together with the stakeholders of this project. The interviews with these stakeholders provided valuable input to make sure the KPIs reflect the priorities that FSS wants to achieve with this research. The next phase of the project will focus on measuring the KPIs.

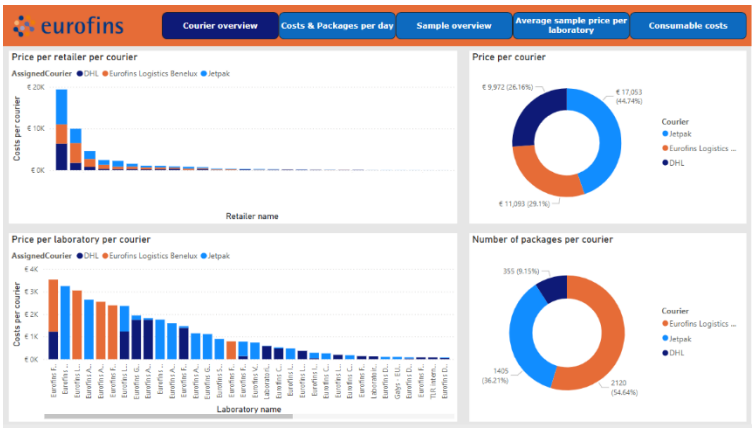
The KPIs are computed using the several visualisations in Power BI. However, not all KPIs where directly visualisable, since some extra computations had to be made first to be able to visualise the data. These additional computations are written with the DAX-measure tool in Power BI. This tool can be found in Power BI under *'calculations'* and *'new measure'*. The calculations are written in DAX code; the syntax of Power BI. An example of a computation that is formulated with the measure tool is the average price per sample. The prices per package are known, but to know what the price per sample is, a calculation must be made to extract the number of samples in a package and divide the price of the package over these samples. The code is shown below, with the explanation. All DAX-measures used for computing the KPIs in the visualisation are coded with these DAX-measures.

This DAX-measure is written using a step-by-step approach. First, the DAX-measure loops over each unique *PurchaseOrderCode*, and will take the average by using the AVERAGEX function for the part of the measure that is following. Th VALUES function returns a list of the unique *PurchaseOrderCodes* from the *PackageNumber* table. The next step in this DAX-measure is operating a division function.
In the nominator, the maximum price for the assigned courier (*PriceAssignedCourier*) is calculated for the current *PurchaseOrderCode* with the MAX function. Since each package has only one price, the MAX function returns that price.
In the denominator, the number of rows in the *Sample_Package* table that correspond to the current *PurchaseOrderCode* is counted. This is done by filtering the table to match the current package to the samples that are in the package and then applying the COUNTROWS function; counting the number of samples the package contains.
The DIVIDE function is then used to divide the courier price by the number of samples. Moreover, the DIVIDE function ensures that if the number of samples is zero, the result will also be zero, avoiding any division errors.

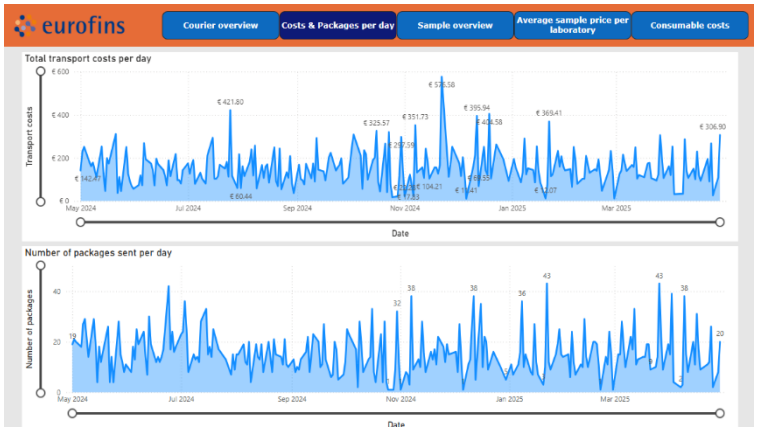
```
Average price per sample =
AVERAGEX(
    VALUES(PackageNumber[PurchaseOrderCode]),
    DIVIDE(
        CALCULATE(MAX(PackageNumber[PriceAssignedCourier])),
        CALCULATE(
            COUNTROWS(Sample_Package),
            FILTER(
                Sample_Package,
                Sample_Package[PurchaseOrderCode] = PackageNumber[PurchaseOrderCode]
            )
        )
    )
)
```

4.6 Prototype of the dashboard

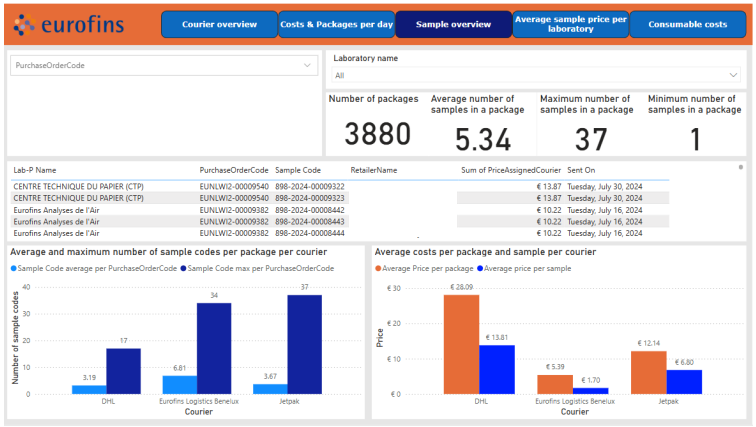
After calculating the KPIs, the format of the dashboard is developed. This includes visualising the KPIs by means of a dashboard in Power BI. This section explains what is visualised in the dashboard. *Figure 10* shows the screenshots of the dashboard. Appendix *D* shows the screenshots of the dashboard in full size.



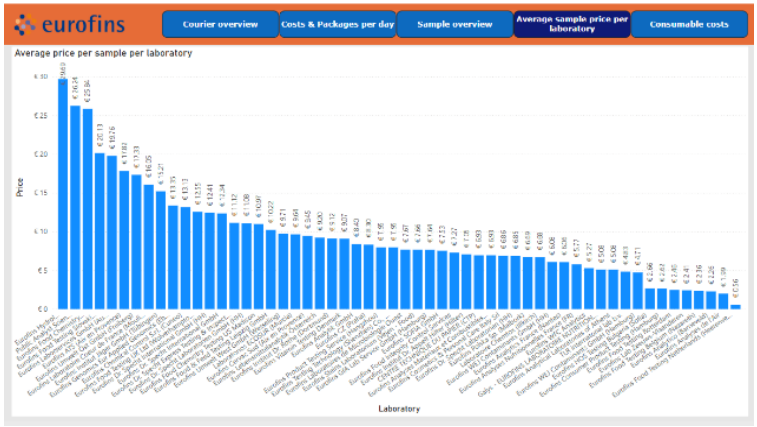
(a)



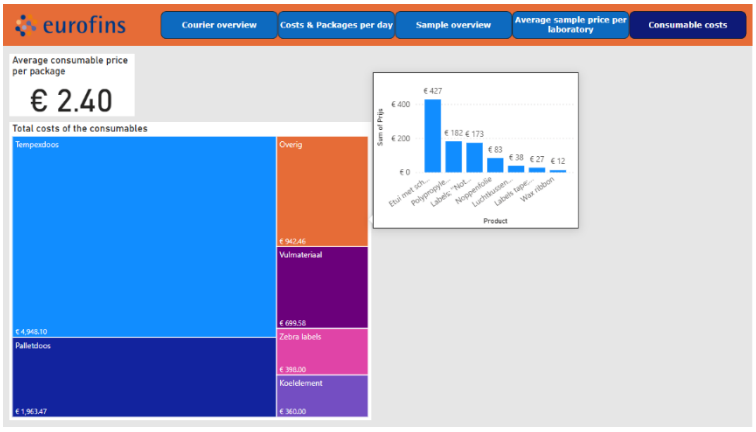
(b)



(c)



(d)



(e)

Figure 10 – First draft of the dashboard with (a) courier overview, (b) costs & packages per day, (c) sample overview, (d) Average sample price per laboratory, (e) consumable costs.

Courier overview

The following tiles are included on the first page of the dashboard:

- Donut chart with the number of packages per courier
- Donut chart with the total transport price per courier
- Stacked column chart with the price per retailer per courier
- Stacked column chart with the price per laboratory per courier
- Navigator

The *courier overview* page provides a visualisation of all costs related to transporting packages for the transport companies, so the cost of moving products from FSS to the laboratories. It shows how much FSS spent in one year sending the packages with the three transport companies, including the total costs per retailer and per laboratory. The names of the retailers have been omitted for confidentiality reasons.

The two charts on the right are donut charts. The total costs and the number of packages for each courier are displayed. This helps the company understand the expenses associated with each courier, as well as the number of packages sent. By comparing the percentages in the two donut charts, it is possible to estimate which courier is on average the most expensive and which is the least expensive.

The two stacked column charts on the left show the transport costs per retailer and laboratory, broken down by the three transport companies. These charts provide a clear overview of the total costs incurred across both laboratories and retailers. These visualisations help the company identify how costs are distributed per courier within the laboratories and retailers, making it easier to analyse spending patterns and pinpoint areas for potential cost improvements. Moreover, these insights are valuable for potential new retailers, as it allows FSS to estimate the costs they make for the transport part based on the number of products that they expect to test, by comparing with current retailers.

In the top left corner of the screen, the logo is positioned. The remaining part of the top bar contains the navigation menu that allows switching between the different pages of the dashboard. This top part of the screen will have the same layout on all pages of the dashboard.

Cost & packages per day

The second page of the dashboard includes:

- Line chart with the total transport costs per day
- Line chart with the number of packages sent per day
- Navigator

The *costs & packages per day* page displays the price and the number of packages for each day by two separate line charts. These visualisations enable an analysis on whether the prices correspond with the number of packages over time. Possible outliers can also be identified.

Sample overview

The third page of the dashboard includes:

- Laboratory name filter
- PurchaseOrderCode filter
- Card with the number of packages
- Card with the average number of samples in a package

- Card with the maximum number of samples in a package
- Minimum number of samples in a package
- A table with laboratory name, PurchaseOrderCode, sample code, retailer name, price, and sent on date
- Clustered column chart with the average and maximum number of samples per package per courier
- Clustered column chart with the average cost per package and sample per courier
- Navigator

The *sample overview* page contains all relevant information regarding a single sample. Users can first filter on laboratory name and PurchaseOrderCode, after which the entire page adjusts to the selected values. The KPIs that update based on the selected filters include four cards, displaying the total number of packages, the average number of samples per package, as well as the maximum and minimum number of samples per package. After filtering, these values can be analysed per PurchaseOrderCode and/or laboratory.

In addition, the page contains a table with relevant details for each sample code, as well as two clustered bar charts. The first chart displays the average and maximum number of sample codes per package per courier. The second chart shows the average costs per package and sample per courier.

With the help of the filtering tools on this page, FSS can gain valuable insights into the transportation costs per package and per sample. By filtering, the average number of samples per laboratory, the average transport costs for that destination, and the average cost per sample per courier are depicted. In this way, accurate cost estimations can be made per sample for each laboratory. The number of packages sent to a laboratory also gives an indication of how reliable the estimate is; the fewer packages, the smaller the sample size, and therefore less accurate the estimate is likely to be.

Average sample price per laboratory

The fourth page of the dashboard shows:

- Clustered column chart with the average sample price per laboratory
- Navigator

The *average sample price per laboratory* provides an overview of the average cost of all samples sent to each laboratory over the course of one year. This gives a clear view of the average price per sample per laboratory, allowing for easy insights into the associated costs.

Consumable costs

The fifth and last page of the dashboard includes:

- Card with the average consumable price per package
- Treemap with the total costs of the consumables
- Tooltip with the prices of products per product type of the consumables
- Navigator

The *consumable costs* page provides insights into the extra items that must be sent with the product samples to ensure the product will arrive at her destination. This is visualised on the page with a card that shows the average consumable price per package.

The treemap shows the total costs of the consumables, grouped by product type. For example, standard cardboard boxes used for transporting samples at normal temperature come in various sizes. These different sizes are grouped under a single product type, and the specific sizes are displayed in a tooltip. A tooltip is a small window that pops up when the user hovers the mouse over an item. In this way, all consumable items are taken into account, with only showing the main product types first, and revealing the product details in the tooltip.

This first draft of the dashboard will be presented to the employees and company supervisor. During this presentation, all pages will be shown and discussed in detail. Feedback provided by the employees will be elaborated and discussed in chapter *5*. For each visualisation, the employees can provide feedback by indicating what they think works well and what could be improved. They can also suggest additional visualisations if they feel something is missing on the dashboard.

5. Evaluation

In this chapter, the evaluation of the dashboard is described. The dashboard is presented to the company supervisor to receive feedback on the work. The evaluation phase is essential due to expectations that stakeholders have. Section *5.1* elaborates on the researchers own evaluation, together with the evaluation and feedback from the company supervisor. Section *5.2* discusses the improved dashboard and the changes that are made to the dashboard.

5.1 Feedback dashboard

After designing the prototype, it is time for evaluating. This is done in two ways: the researcher's own evaluation, and the evaluation based on feedback from company supervisor. The feedback is gathered through a meeting with the company supervisor to discuss the dashboard. Additionally, the dashboard is shown to some employees to gather their opinion and feedback.

No ranking method was used, such as assigning a score from 1 to 10 to each visualisation. Instead, participants were asked to share their feedback on the visualisations, including what looked good and what could be improved. This feedback was collected for both the individual visualisations and the overall design of the dashboard pages. It would have been better to use ranking methods, as these are more used in academic research. These ranking methods support the results, making them more measurable by quantifying the feedback. Therefore, it is recommended to use these methods in future research.

The following points of improvement are noted:

- The *average sample price per laboratory* displays the same information as the clustered column chart on the *sample overview* page. By using the filter for laboratory name on the *sample overview* page, it is possible to view data for one single laboratory. When this filter is applied, the average sample price shown in the clustered column chart is the same as on the *average sample price per laboratory* page. Since both charts present the same data, the average sample price per laboratory chart is redundant.
- The titles in the navigation menu are very specific, which may confuse the reader about the content of each page. For instance, the title *courier overview* might suggest that only information about couriers is shown. However, the page also includes data on courier costs related to the clients and laboratories served. Therefore, the feedback was to use more general terms for the navigation menu titles to better reflect the page content.
- The *consumable costs* page is relatively empty compared to the other pages. Additionally, there is currently no distinction made between packages transported under normal conditions and those requiring refrigeration. It was suggested to add extra charts that separately visualise the products used for normal and refrigerated transport, because there is a big price difference between Styrofoam boxes and cardboard boxes. In this way, a distinction can be made between transporting under normal and refrigerated conditions with the respective costs.
- The price per sample for the laboratory in Heerenveen is much lower compared to other laboratories. The transport is organised in this way, which is why it is also programmed like this. The packages transported with Jetpak are first sent to Heerenveen by Eurofins Logistics Benelux. After that, Jetpak picks them up and delivers them to their final destination. Since that prices that Eurofins Logistics Benelux charges are incurred per stop, more packages are delivered to

Heerenveen than any other place. Therefore, the price per sample is cheaper compared to other laboratories.

- It is more efficient in the *Cost & packages per day* page, to have the two line charts in one chart. This would be clearer, and extra filters can be added to zoom in on the selected items.
- Dutch and English are used interchangeably. This may be confusing or unpleasant for the reader. Therefore, it is recommended to translate all content into either Dutch or English to make sure it is consistent.

5.2 Revised dashboard

Based on the comments and suggestions, the first draft of the dashboard will be adapted and improved. In this section, the changes that are made will be discussed and justified. Appendix *E* shows the screenshots of the dashboard in full size.

(a) (b)

(c) (d)

Figure 11 – Revised dashboard pages with (a) Courier Costs, (b) Daily Transport Trends, (c) Sample Overview, (d) Consumable Costs.

Figure 11 shows the revised dashboard pages after implementing the feedback from the company supervisors and employees. On page (a) *Courier Costs*, minor modifications are made compared to the first draft. The title has been changed, as well as the entire navigation bar, since the *average sample price per laboratory page* is removed. The legenda title is also changed from *AssignedCourier* to *Courier* to

ensure more clarity. Moreover, a date slicer is added so FSS can focus on a certain timeframe. Because of this dashboard page, a cost estimate can be made of the total cost incurred from all three courier services over the year, resulting in approximately 35,000 euros. This estimate applies to data from May 1, 2024, to April 29, 2025.

Page (b) *Daily transport trends*: The two separate line charts are combined into a single line chart with two y-axes; one on the left and one on the right side of the chart. This design makes it easier to detect anomalies and outliers in the data. Additionally, two slicers are added to the page: one for the date, which allows filtering by year and month, and another for courier, which enables that a selection of specific couriers can selected to be displayed in the line chart. The name of the page is changed from *Cost & packages per day* to *Daily transport trends*. This is a more professional and general name that reflects the content of the page.

No major adjustments are made on page (c) *Sample overview*. The feedback received on this page was positive, clear and useful for the respondents. As mentioned in section *5.1*, the extra page is redundant and therefore removed from the dashboard. The clustered column chart in the bottom right corner shows the same information when filtering on a single laboratory.

The product types on page (d) *Consumable costs* were written in Dutch. These names are now changed to English. The products itself remain in Dutch, since it shows the names of the products from the suppliers, which is more beneficial for FSS to keep the product names in Dutch. Next to this, three cards and donut charts are added to display the three types of shipping: cardboard boxes, Styrofoam boxes, and envelopes. The cards show the average cost per shipping method, reflecting a more accurate view of the different transport options in terms of package sent. The donut chart displays the average costs of the product types used for sending a package. In this donut chart, a tooltip is added to visualise the average costs of the products within a product type. Based on this page, a relatively accurate estimate can be made for the materials required to send the product samples to the laboratories. SRR estimates that about 39% of the packages sent are cardboard boxes, 2% are envelopes, and 59% are Styrofoam boxes. Calculating the total costs of the packages with these percentages and average costs per type on the dashboard will result in approximately € 30,000.

5.3 Conclusion

Based on the meeting with the company supervisor and interactions with employees, suggestions were proposed on improving the draft of the dashboard, both content and appearance related. The most significant changes are that one page is removed from the draft version, two separate line charts are combined, the titles in the navigation menu are more generalised for the information it contains, and the consumable page is adjusted to FSS' expectations. The estimated cost for transport and materials of last year are € 35,000 and € 30,000 respectively. This results in a total of about € 65,000 for both transport and materials over one year.

6. Conclusion

In this chapter, the research question is answered based on the conducted research. Section *6.1* elaborates on recommendations for FSS based on the valuable results discovered during the research. The steps for using the dashboard are discussed in section 6.2. Section *6.3* discusses the recommendations based on the information uncovered in this research. Section *6.4* provides the constraints faced during the research and reflects on actions that have been done differently. Additionally, it addresses topics such as validity and reliability, as well as challenges encountered in this area.

6.1 Results and findings

The problem faced by FSS was defined as the lack of a clear overview of all costs incurred during the transport process. Therefore, it was requested to increase transparency in the transport process, and to identify areas where FSS can still improve. The research question was formulated as follows:

> *"In what way can Eurofins FSS increase their profit margin by gaining insights into and reducing their transport costs?"*

During the research, multiple notable activities are discovered that may help FSS to improve insight and to decrease the transport costs. These points will be addressed step by step.

During inspection of the data, together with the invoices of Eurofins Logistics Benelux, it became clear that for some days the number of stops did not correspond to the number of laboratories that Eurofins Logistics Benelux delivers to. Something similar happens to Jetpak as well. SRR works 5 days a week, which implies 5 days of shipping a week. However, Jetpak invoices 6 days a week. In addition, the prices Jetpak charges were increased last April, without someone noticing it. Therefore, it can be concluded that no one performs a regular check of the invoices. It would be recommended to regularly check the invoices received, to keep an overview of the incurred costs, and be able to act immediately when invoices are incorrect or when agreed or unannounced price adjustments are made.

While visiting Eurofins Logistics Benelux, it became clear how the cost structure specifically for FSS was organised. Their non-profit position allows them to offer lower shipping rates than their competitors. Additionally, they calculate the price based on the number of stops they make. This means that the price remains the same, regardless of how many packages are delivered at one stop. By sending as many packages as possible to one location on one day, the cost per package will decrease. This will lead to lower variable transport costs and, consequently, a higher profit margin.

Based on this data, a brief analysis was made to explore the potential savings for Eurofins Logistics Benelux and Jetpak when the same number of packages are shipped over less days a week. If the shipping days for Eurofins Logistics Benelux are reduced from five to three, weekly costs could decrease by 30% to 40%. This is possible because Eurofins Logistics Benelux delivers samples to the same laboratories almost daily, so in theory the samples can be shipped in less shipping days, which leads to significant savings. For Jetpak, using their transport options one day less can result in 20% cost reduction per day. However, invoices must be carefully checked, because currently the number of stops on the invoices do not always match the actual number of stops a day.

The transport and material costs over the past year were approximately € 65,000. When comparing this to the 3.4 FTE working at SRR, with an average annual salary of about € 50,000 (FNV, 2022), so in total € 170,000, the labour costs are 2.5 time higher than the transport costs. Therefore, it is recommended to

optimize the process of SRR, for example by conducting research into potential efficiency improvements within SRR.

Moreover, several insights were gained from the dashboard, as discussed and presented in section *4.6*. One key insight of the dashboard is that it is now possible to analyse the total transport costs per courier for the period from 01-05-2024 to 29-04-2025. Furthermore, the costs for each specific retailer of laboratory can be deduced from the dashboard.
There is an overview page of all prices for samples and boxes sent to the different laboratories, and which courier service was used. On this page, data for each laboratory can be filtered out. This includes the average cost per shipment and per sample, as well as the average number of samples per package for each laboratory. This allows FSS to determine the cost per sample and per package more accurately. This should be charged to the customer, based on the laboratory and courier service used.
Finally, additional items are required to transport the samples to their destination. These items are shown on the consumable page and are grouped by the three types of shipping packages used: cardboard box, envelope, and Styrofoam box. For each type, the average cost is shown, together with the average cost for the specific consumable items used with that shipping method. This provides FSS with more transparency on the consumable costs of sending the samples.

These insights allow FSS to make more accurate estimations of the transport costs that a new or existing customer will incur, based on the number of products they expect to test. This can help improve FSS competitive position and/or profitability.

6.2 Deployment

The dashboard itself is designed to be future proof, but not all the cleaning and transforming steps that are performed before are future proof. The raw data extracted from Coupa, for the materials used for shipping the samples, was not yet usable in the Power Query Editor, so had to be manually adjusted before uploading it to the dashboard. The data with information about the DHL shipments were also not usable without adjustments. Before uploading to the dashboard, the destination name had to be changed to the laboratory name, the unique package number had to be added in a separate column, and finally an extra column was added, that shows that the package was shipped with DHL. These modifications always must be done first before loading into the Query Editor to be able to use it. If this could be automated or adjusted from the beginning, the tool will be nearly future proof. With the experience of a data analyst, it should certainly be possible to achieve a future proof dashboard.

In short, the steps that have to be done manually before loading the data into the Query Editor are summed up below. These are also the steps that the data analyst should include in the Power Query Editor to ensure the model is future proof.

- SRR should slightly adjust the tracking file of DHL shipments, by changing the laboratory name to laboratory code, and two extra columns with the unique package number and courier service (DHL) respectively.
- Include the transformation of the Coupa orders Excel file into the Query Editor. So directly transforming from the raw data to a usable format in the Query Editor. Moreover, connect this page to the Query Editor to constantly update the data when new orders are placed.
- Include the transformation of the Eurofins Logistics Benelux invoices. The invoice received from Eurofins Logistics Benelux is not directly usable. This should first be transformed.

- Include the Jetpak invoices into the model. It is a fixed price, but it should be adjustable when the price changes. Currently, this is modelled in the Query Editor. However, it is not really user-friendly for quick adjustments. Therefore, it would be helpful to place the price adjustment option in a more visible location to make it easier for users to find and use.
- Connect the data from the ELIMS to the model, to make sure the data will be refreshed and can be used in the future. This includes the product specifications, and which products are included in each package.

After including these steps in the Power Query Editor, the model must be slightly changed to new input files. Next to this, all steps performed in the Power Query Editor tool must be checked whether everything is smoothly aligned so it is reliable and valid to use in the future.

6.3 Recommendations

In this section, a list will be provided with recommendations based on the conducted research:

- Perform systematic checks on the received invoices. Do the invoices align with the number of laboratories that product samples are sent to on a certain date for Eurofins Logistics Benelux?
- Start experimenting with reducing the number of shipping days a week for Eurofins Logistics Benelux. As described, reducing the number of shipping days from 5 to 3 days a week for Eurofins Logistics Benelux can lead to a decrease of 30% to 40% a week. This is only based on the reduction in transport costs. Other variables that could influence the total costs, such as shelf life, agreements with retailers, and available space for couriers, were not included. Therefore, further research is needed to confirm whether the reduction in transport costs outweighs any (possible) increase in these other variable costs.
- Comparing the total cost of € 65,000 for transport and material, and € 170,000 for 3.4 FTEs over year, it is recommended to investigate the optimisation options of SRR's process. For example, by conducting research into efficiency improvements within the SRR department.
- Additionally, it is recommended to slightly adjust the information in the DHL shipping cost file, so it can be directly integrated into the dashboard without requiring any other modifications. This includes, for example, adding the name of the laboratory, an additional column for the unique package numbers, and an additional column for the courier, which is DHL.
- Try to reduce the number of shipments with DHL, since their prices per package are by far the highest. Avoid the unnecessary shipments with DHL as much as possible.
- The dashboard can be used to make accurate estimates of the cost of sending a package or sample to a laboratory. As a result, the prices can be charged more accurately to the client.

6.4 Discussion & Limitations

Limitations

During the research, not many limitations occurred. However, always some limitations arise. It was unknown for quite some time whether the necessary data would be available. In the end, the data was available, but precious weeks had already been lost waiting for the data to be gathered. Because of this, less time could be spent on cleaning, transforming, coding and modelling. This is also the reason why the dashboard is not future proof yet. Only ten weeks were available within which the research had to be executed. With more time, the tool would have been future proof.

Reliability

The first paragraph will describe the aspects that contribute to the reliability of the research, followed by a discussion of the factors that may have affected reliability.

This research is considered as reliable for several reasons. First, the data with product specifications, designated laboratory, date, samples in a package were all obtained from the Eurofins database. The accuracy of the data was checked multiple times with the ELIMS software and with employees. This ensures that the data used are real and correct. Second, all cost figures used were checked multiple times against the original invoices to make sure the figures were accurate. Finally, the results were shown in Power BI. Visuals were also made using alternative values to test if the tool responded as expected, which it did. All Power BI visuals were based on FSS' data and invoices, making the results trustworthy.

However, there are also some factors that may affect the reliability of the research. *Figure 19*, displayed in appendix *E*, shows the price per laboratory per courier in the bottom left corner. For some laboratories, two courier services are listed. This is certainly possible, and it occurs for some of the laboratories, but there are cases where the majority of the costs are attributed to DHL, and only a small part is spent on Jetpak. One might wonder how reliable this is. It is possible that all packages to these laboratories were delivered by DHL, but that SRR did not accurately record all shipments in the data file. These inconsistencies can really impact the reliability of the model.

Another important point is the number of times a package is shipped to a single laboratory. In the model, some laboratories appear with only a few shipments over the past year. This means that only a few prices contribute to the average price of that destination. In these cases, the sample size is too small to derive reliable conclusions for these laboratories. Therefore, the reliability of the model for the laboratories with limited data remains uncertain.

Validity

This section explains why the research can be considered as valid, followed by a discussion of possible limitations to the validity.

The research is valid because it is based on real and verified data from FSS' ERP systems. These data reflect actual operations and costs, ensuring the relevance to the research topic and making sure that it is not based on estimates or other assumptions. Additionally, cost data were checked against official invoices, which helps ensuring the data is correct and consistent. Moreover, using Power BI to present and analyse the data improves the transparency of the process. The model is tested multiple times under different circumstances, making sure the model is consistent. This strengthens the validity of the model, as it shows that the results are not based on random patterns. Using a tool like Power BI also supports the validity of the research, because it has a clear overview when using, and it makes it easier to reproduce the analysis.

There are also some factors that may limit the validity of the research. First, the provided dataset by the company was not yet normalized. Because of this, normalisation had to be performed by hand first. This may have led to the removal of valuable information and a higher chance of incorrect data. The same applies to the data cleaning and transforming phases of the research, which may affect the overall validity of the model. Moreover, it is questionable whether the visualisations of the laboratories in the bottom left corner of *Figure 19*, in appendix *E*, are valid. As mentioned in the discussion on the reliability, the majority of transport costs from some laboratories are assigned to DHL, while a small portion is assigned to Jetpak. This raises questions on the validity of the small part of the cost that are assigned to Jetpak.

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Appendix

A. Research design framework

Investigative question	Research type	Research population	Subjects	Research strategy	Method of data gathering	Method of data processing	Activity plan
What does the current process look like?	Exploratory	Eurofins FSS, Logistics, Laboratories	Employees, transporters, laboratories	Qualitative	Interviewing, observing	BPMN model supported by descriptive text	Interview employees > observe process > construct BPMN model
What factors of the data are important to consider when visualising a cost overview in a dashboard?	Descriptive	Literature, Eurofins FSS	Academic articles, employees, managers	Qualitative	Literature study, discussing with colleagues & manager	Descriptive text, overview of the data set	Research > Literature study > compare with gathered data > overview of KPIs > discussing with colleagues for additional data
How to measure the KPIs and cost drivers with the available data?	Descriptive	Literature, software & Eurofins FSS	Academic articles, dataset & employees	Quantitative	Literature study, and analyse retrieved data	Descriptive text from information about literature and dataset	Research > Literature study > choose KPIs > prepare the available data for usage
How to integrate structured data into a unified relational database?	Descriptive	Literature	Academic articles	Qualitative	Literature study	Descriptive text	Research > Literature study > perform SLR > read articles > draw conclusions

How to implement the solution with respect to Eurofins needs?	Explanatory	Eurofins FSS, dashboard program	Employees, dashboard manual	Qualitative	Interviewing, observing, study research.	A prototype dashboard supported by descriptive text	Discuss what supervisor on companies needs > Decide on program to build the dashboard > Practise with modelling the dashboard > Finish dashboard
To what extent does the solution contribute to the improvement of transport costs?	Evaluative	Eurofins FSS	Employees, dashboard model	Quantitative	Evaluation talks with colleagues & show outcomes	Dashboard prototype	Testing > Evaluating > Modifying > Testing > Evaluating > etc.

Table 4 – Research design framework

B. BPMN process overview

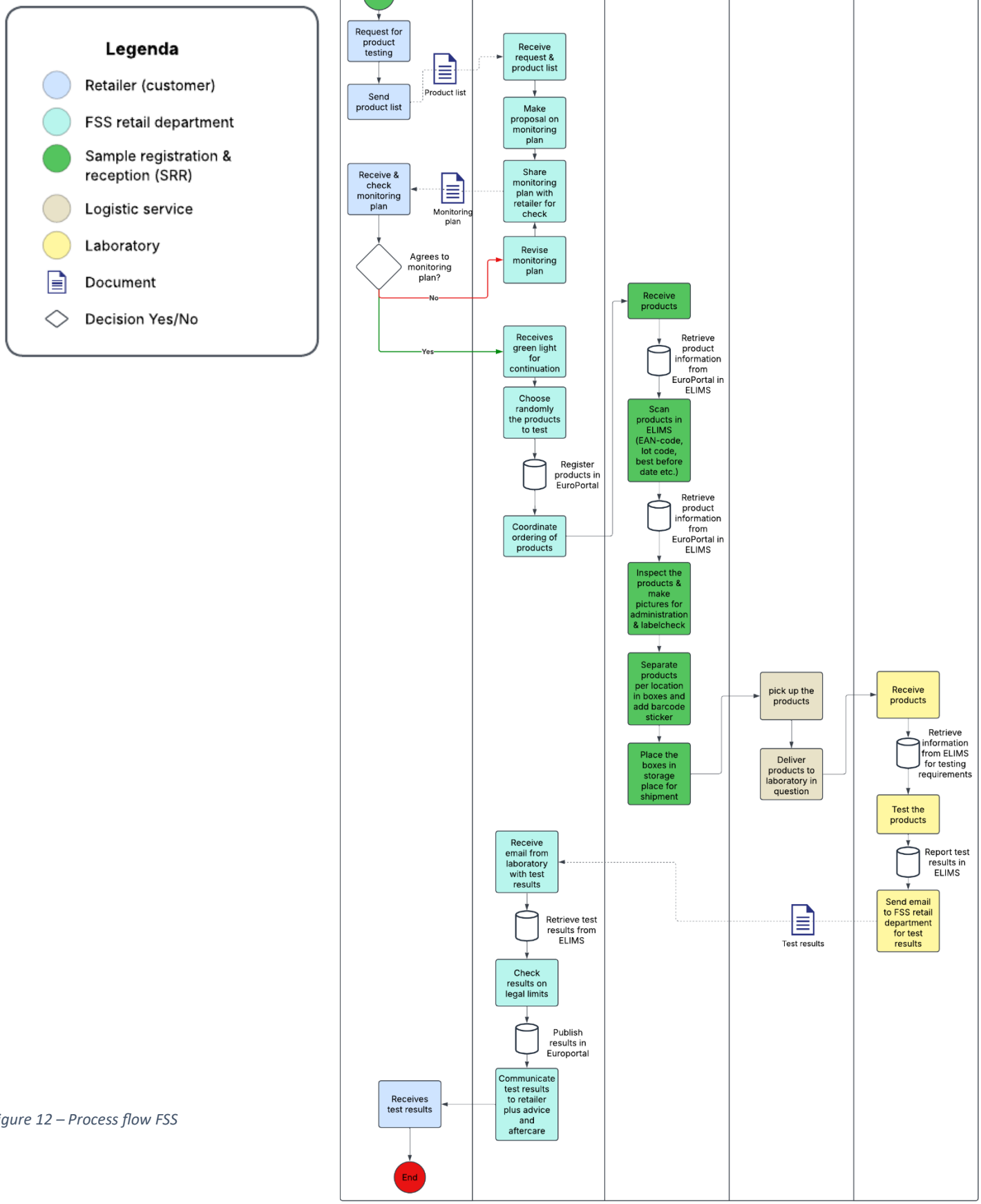

Figure 12 – Process flow FSS

C. BPMN overview Eurofins logistics Benelux

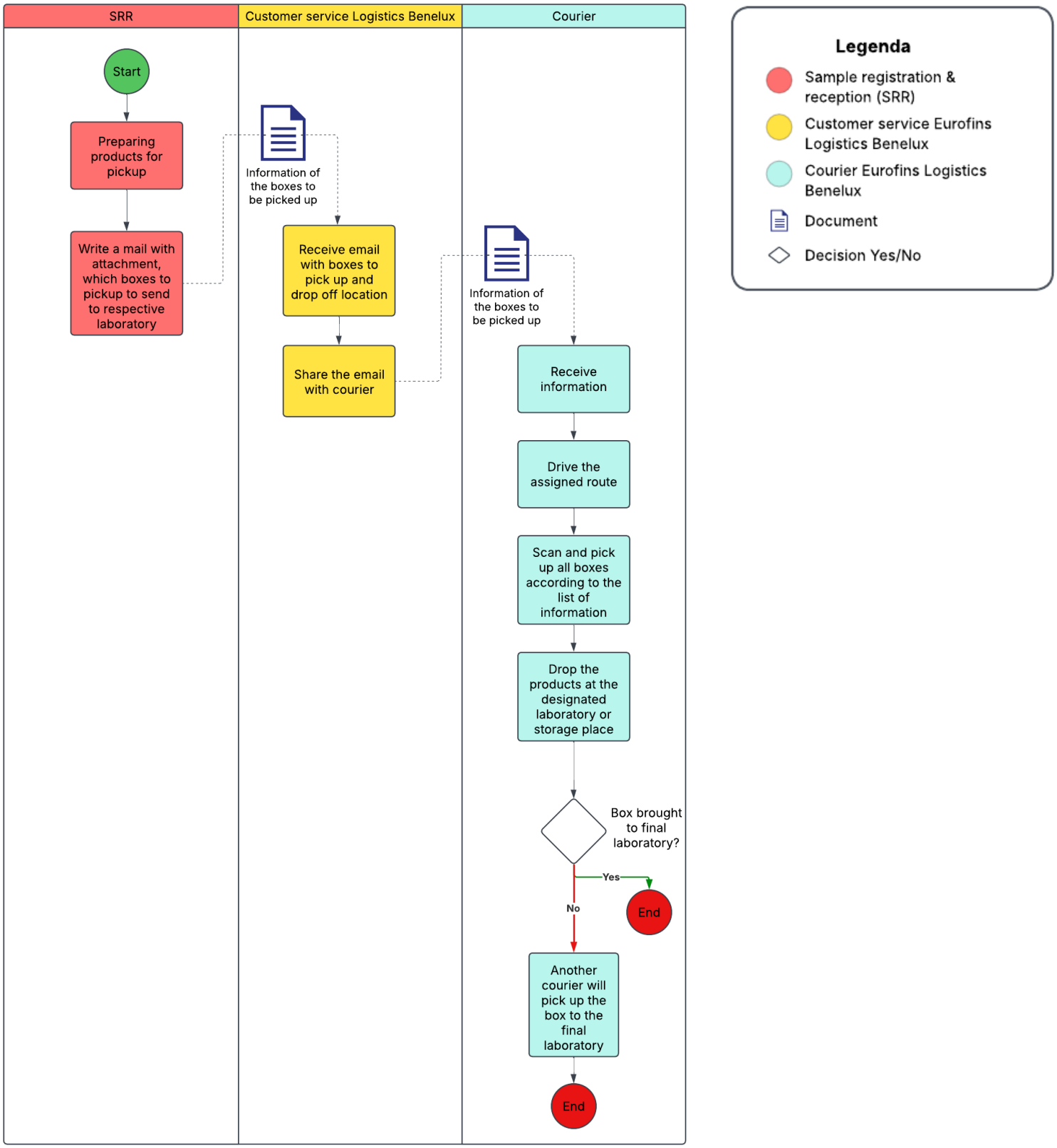

Figure 13 – Process flow Eurofins Logistics Benelux

D. First draft of the dashboard

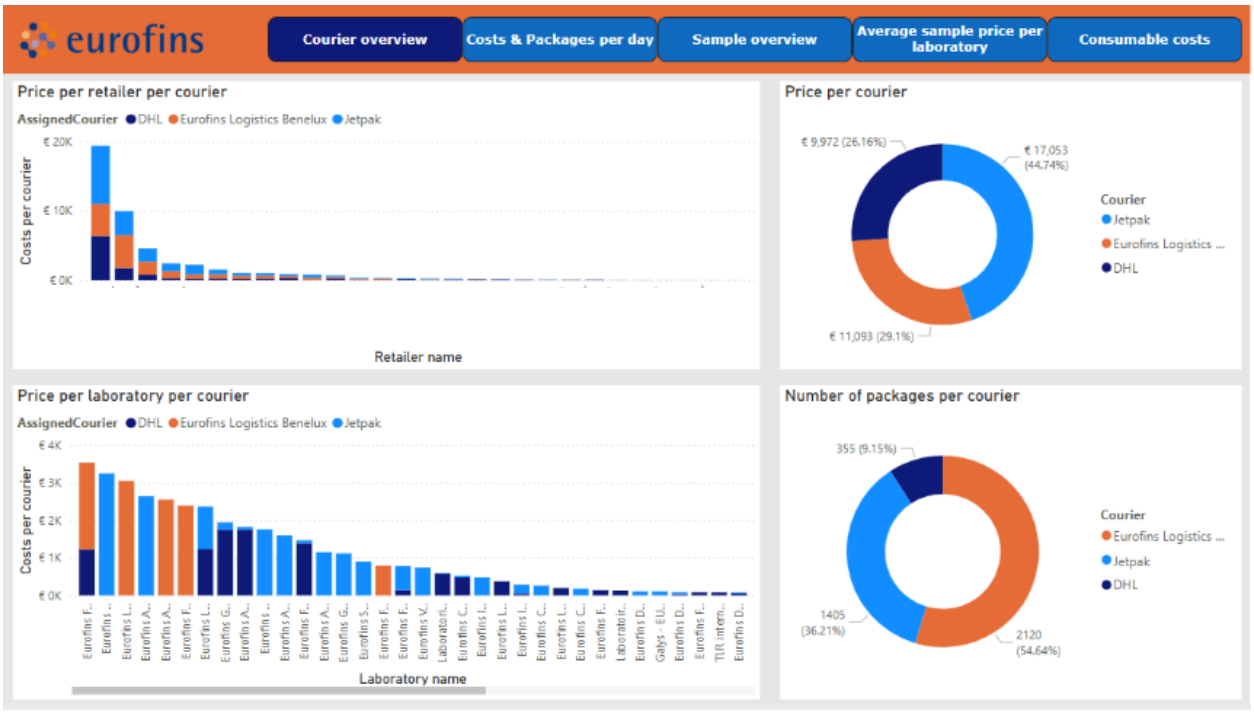

Figure 14 – First draft courier overview page

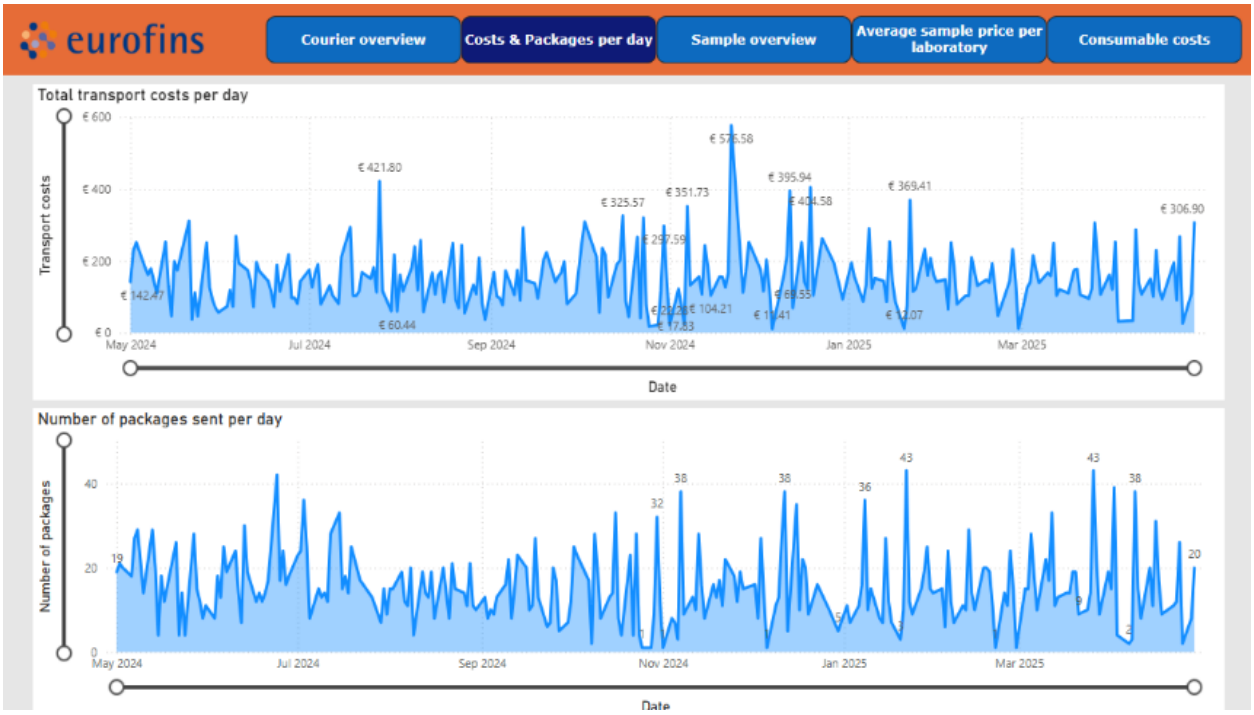

Figure 15 – First draft costs & packages per day page

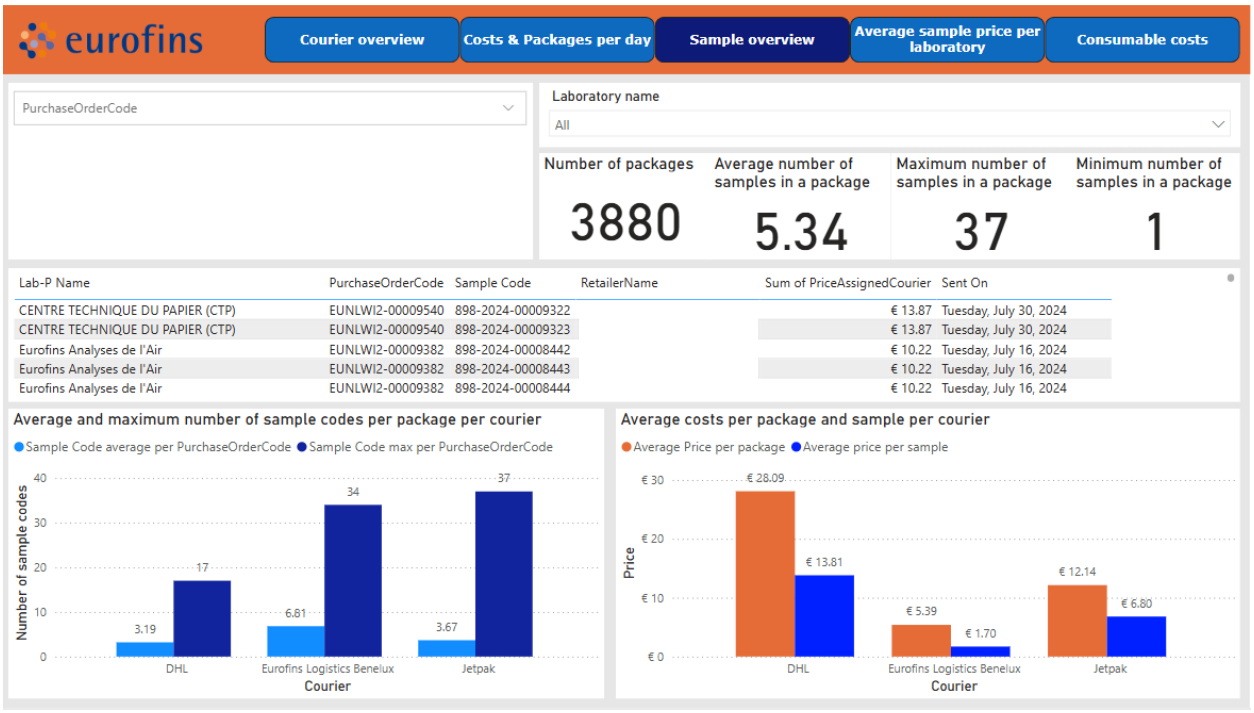

Figure 16 – First draft sample overview page

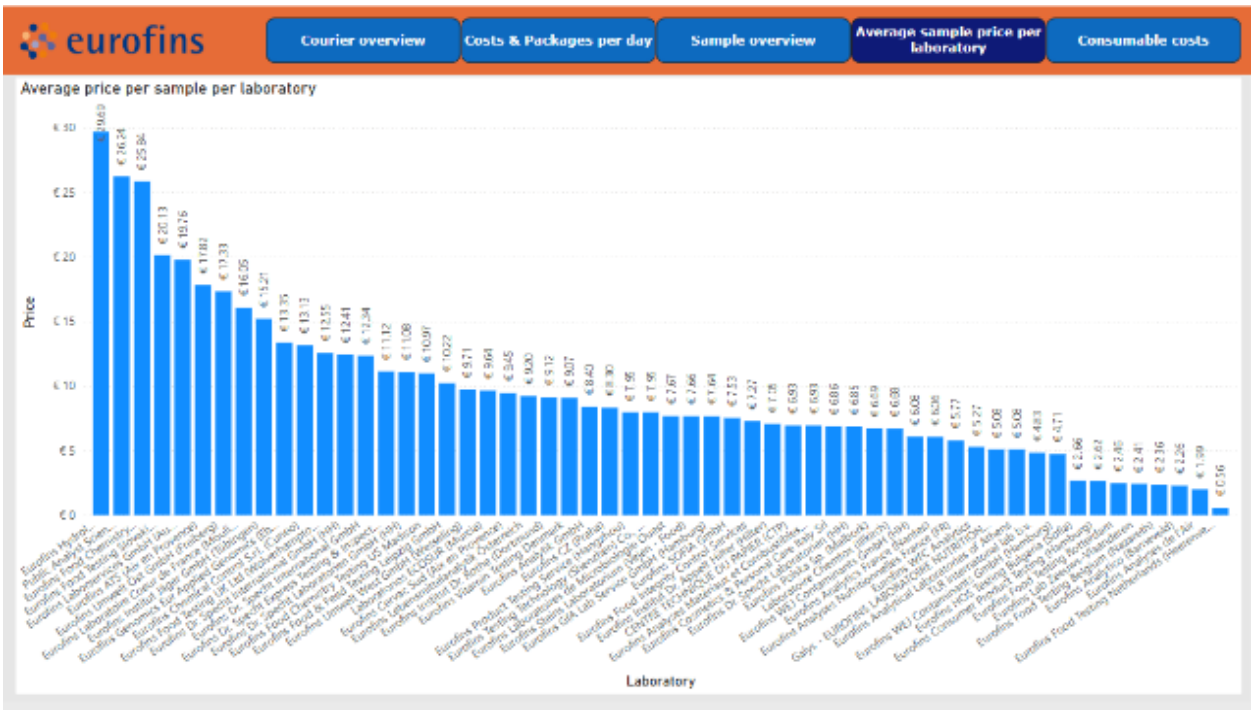

Figure 17 – First draft average sample price per laboratory page

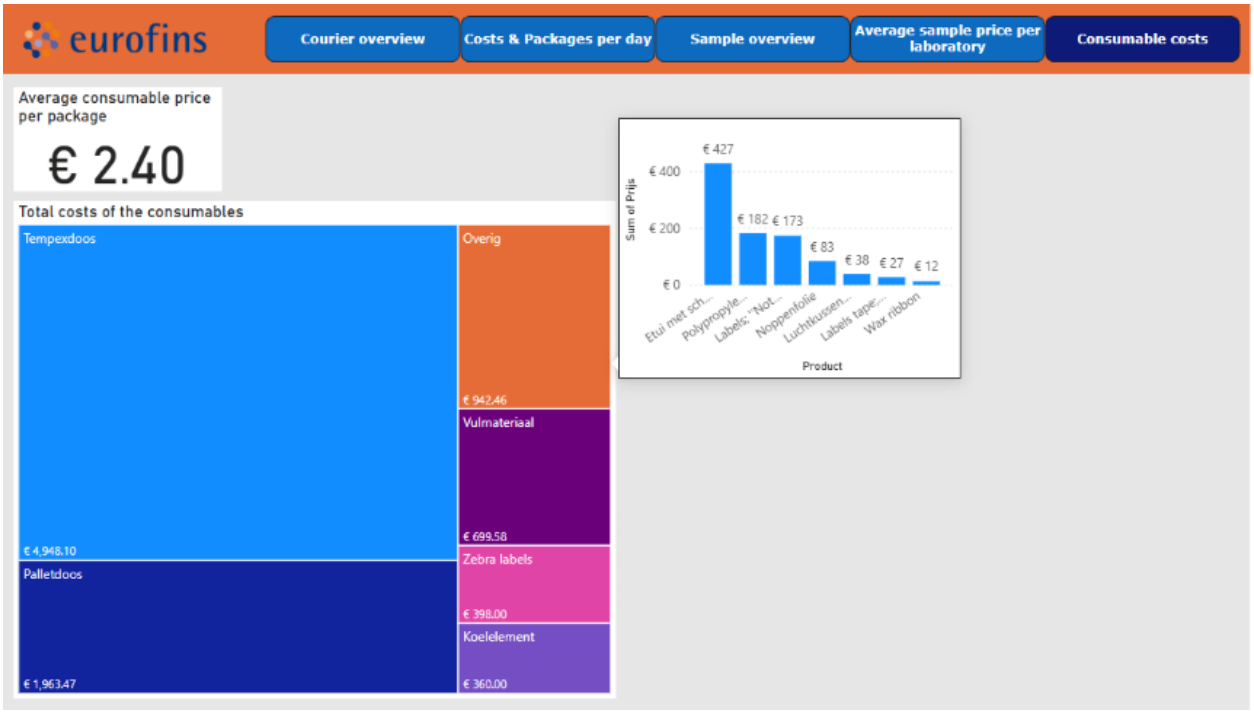

Figure 18 – First draft consumable costs page

E. Final prototype version of the dashboard

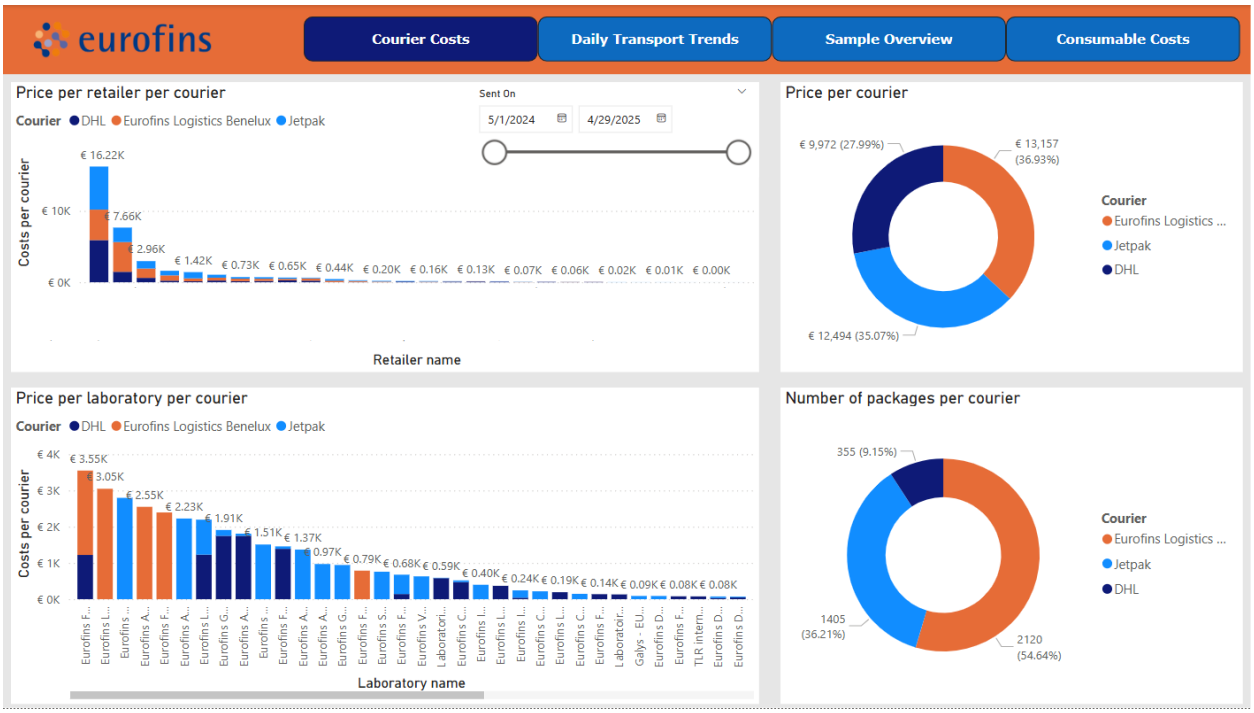

Figure 19 – Final prototype courier costs page

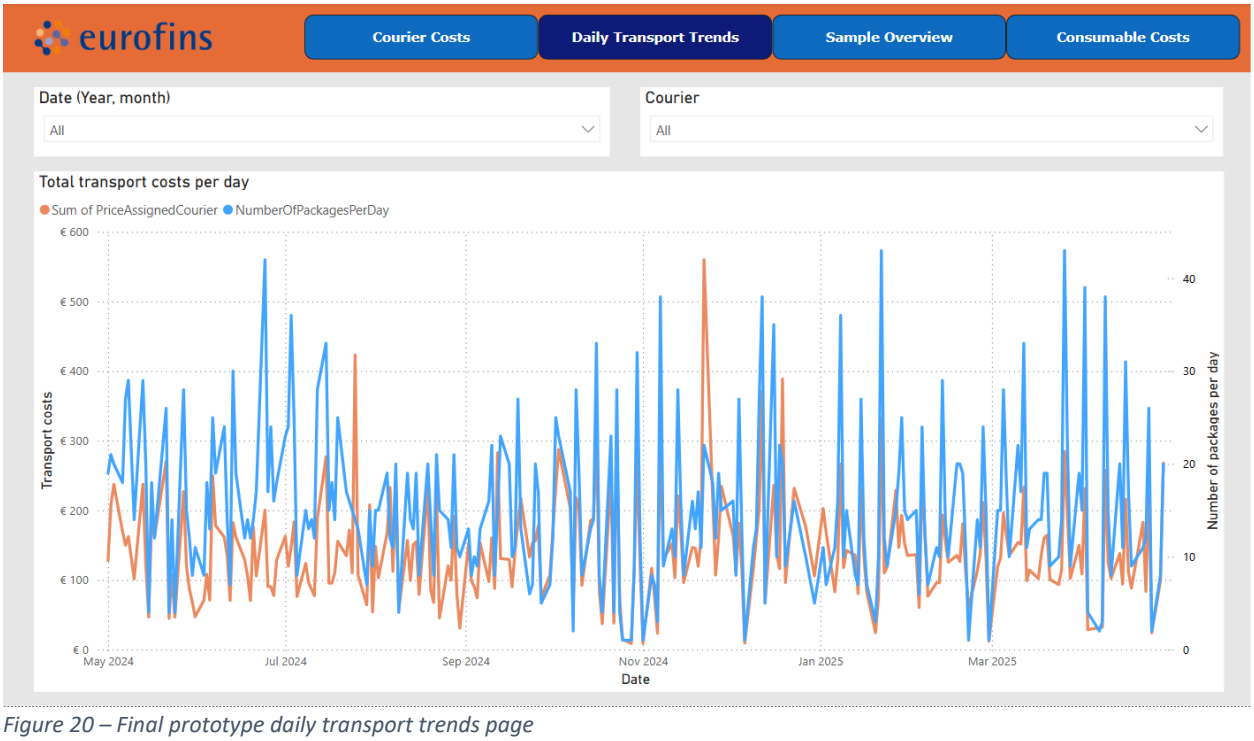

Figure 20 – Final prototype daily transport trends page

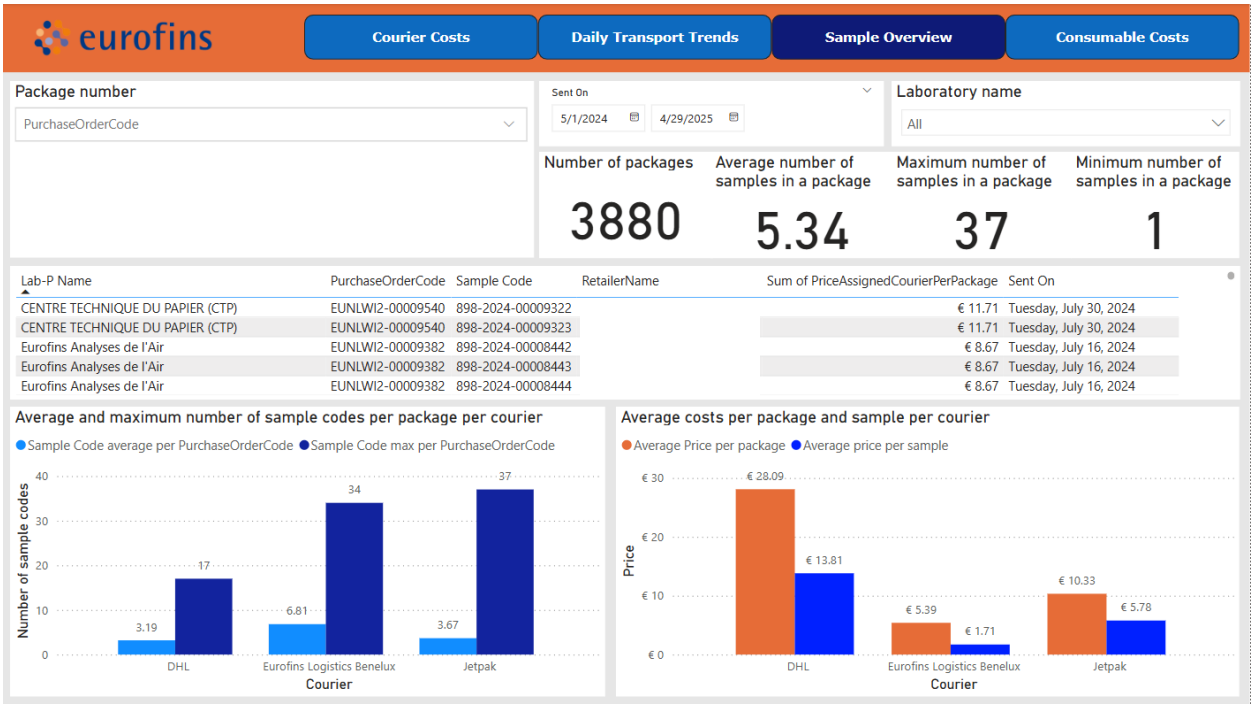

Figure 21 – Final prototype sample overview page

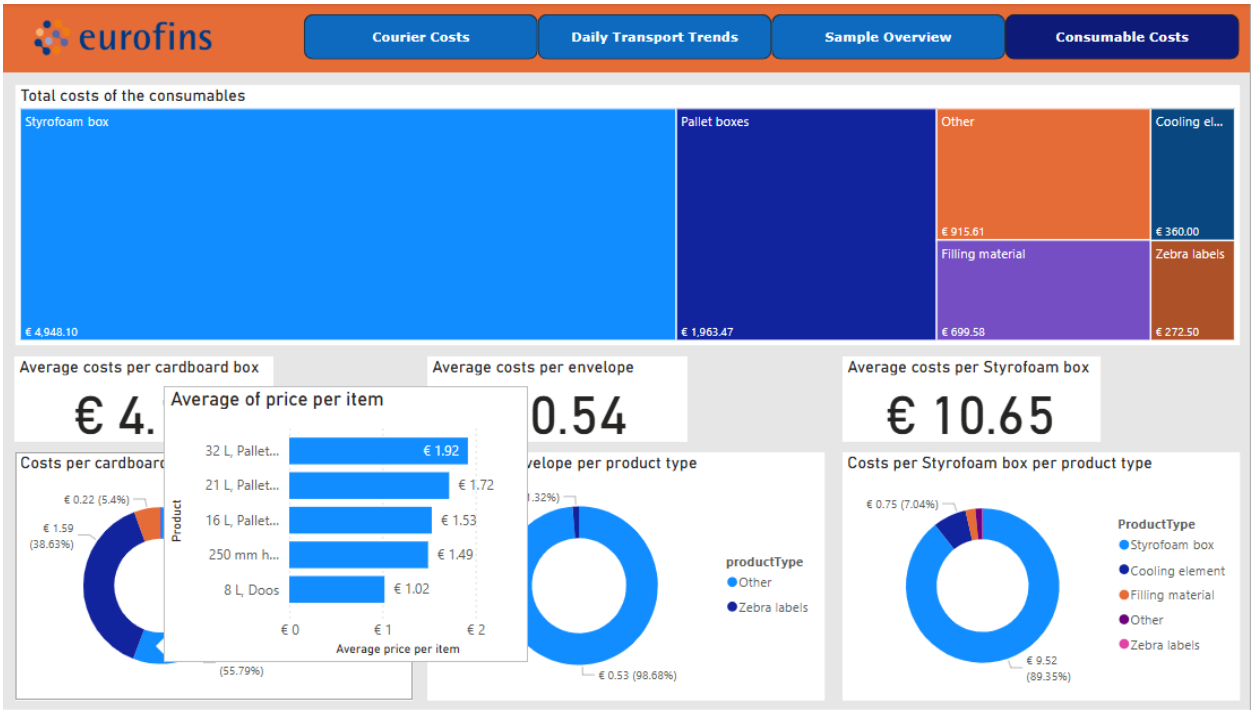

Figure 22 – Final prototype consumable costs page