UNIVERSITY OF TWENTE

A thesis by:
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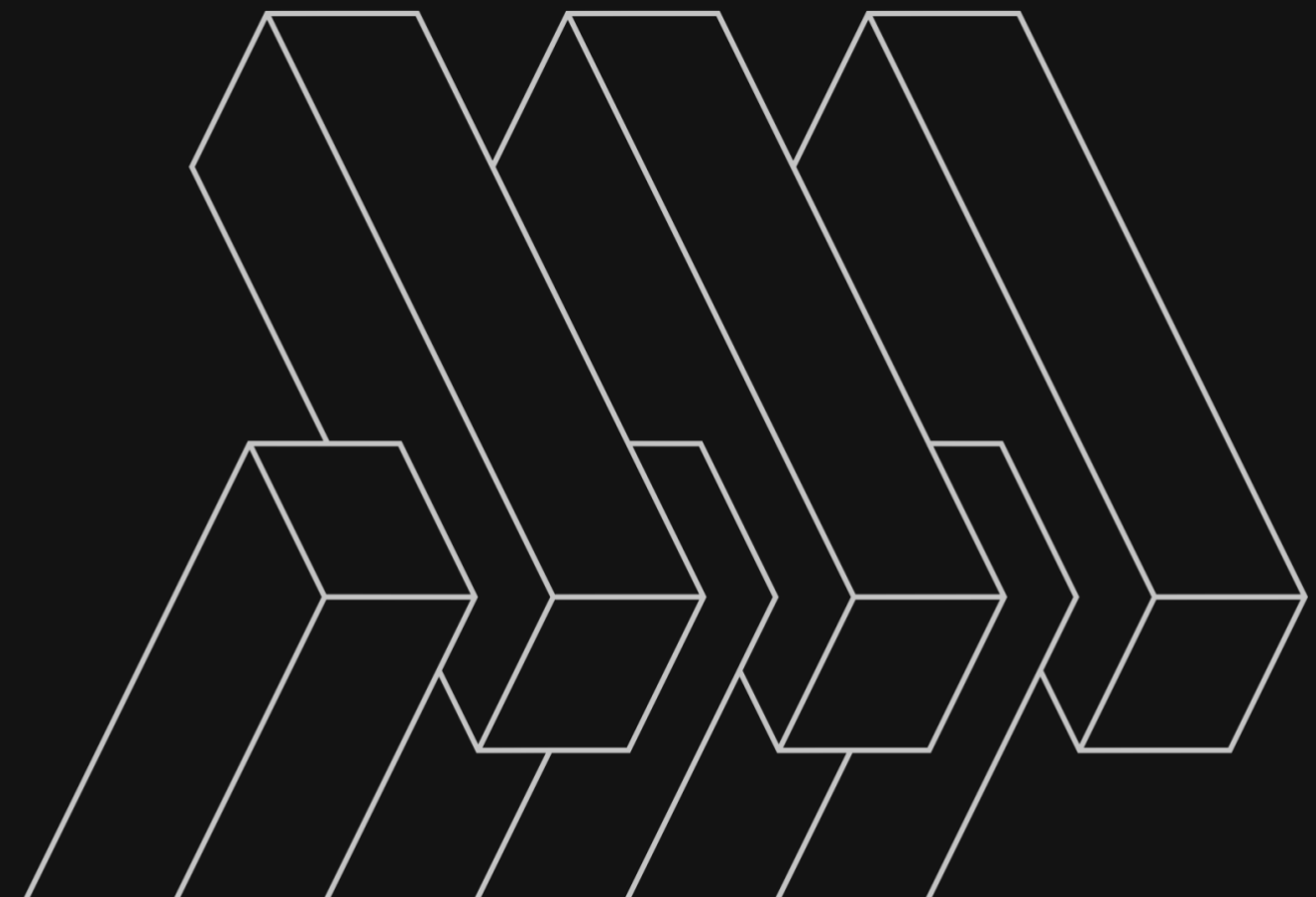
For:
Nijhof-Wassink Group

BACHELOR THESIS

OPTIMALISATION POST-CALCULATION PROCESS

FEBRUARY 2024



Optimalisation of the post-calculation process

Bachelor thesis

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Preface

Dear reader,

This document presents my bachelor thesis, which I have written to conclude my Bachelor of Industrial Engineering and Management at the University of Twente. Over the course of almost half a year I conducted this research at the Application Management department of Nijhof-Wassink in Rijssen. The research goal was to optimize the post-calculation process by designing a uniform model. During the research, I was able to apply the knowledge acquired in my bachelor into practise, which gained me a lot of valuable experience.

First and foremost, I would like to thank Nijhof-Wassink for giving me the opportunity to conduct this research. The guidance and support from my Nijhof-Wassink supervisor Jessica has played an important part in the successful completion of this research. Additionally, I would like to thank all other co-workers at Nijhof-Wassink for their assistance and support.

I would also like to thank my University of Twente supervisors Sebastian and Abhishta for their valuable help and detailed feedback which improved the quality of this thesis.
Furthermore, I would like to thank Iris, Yur and Camiel, my peers at the University of Twente, who supported me during the research and always made me laugh during our many thesis writing sessions.

Enjoy reading!

Kind regards,

Josefien Idzes
February 2024

Management Summary

Introduction

This research was conducted at Nijhof-Wassink Group as a graduation assignment for the Bachelor Industrial Engineering and Management at the University of Twente. This thesis centres three business units within the firm: Nijhof-Wassink Chemical Logistics, Nijhof-Wassink Feed Logistics and Wemmers Transport. Nijhof-Wassink cleans and assesses the data obtained from the trips for the purpose of invoicing and gaining insight in the company's performance. This process is referred to as the post-calculation process. The business units invoice based on the costs incurred upon the completion of the service of product. This way of invoicing accommodates personalization for each order; therefore, it is used in the mass customization service industry.

The current post-calculation process is time-consuming, with the execution time ranging from 9 hours per month up to 60 hours per week. The high execution times originate from the lack of uniform output for the three business units.

Therefore, the objective of this study is to design a standardized post-calculation model. Three models are proposed; a general model applicable across all companies that invoice based on the costs incurred upon completion, and two variations of the initial model tailored to the distinct business units within the company. The research objective results in the following research question: *"How can a uniform model be designed to make the execution and evaluation of the post-calculation process less time-consuming?"*

Approach

To systematically solve the problem, the steps of the Managerial Problem-Solving Method (MPSM) are followed. The MPSM is a general method, applicable to various problems encountered in various situations in all areas of expertise (Heerkens, 2017). The issue can be identified as a managerial problem since the solutions needs to be implemented companywide, spanning various departments within the organization. Moreover, the post-calculation yields data that is used by the management to navigate the company.

Model design

As a result of the literature research and interviews conducted among various employees involved in the post-calculation process, three models have been designed. The literature research yielded a universally applicable model, the conducted interviews resulted in two variations of the initial model tailored to the distinct business units within the company.

Conclusions and recommendations

The designed model eliminates irrelevant data in the post-calculation process. Implementing the model provides opportunities to further streamline the post-calculation process. Interviews conducted among stakeholders indicated that the models are sufficient for the executing the post-calculation process. As depicted in figure 1, the model is estimated to lead to a reduction in time by approximately 2 to 3 hours.

This research followed a top-down approach, beginning with the output of the post-calculation process. Re-evaluating the post-calculation process form a bottom-up perspective could uncover more inefficient steps in the process, enabling further streamlining of the entire process.

One of the designed models can be further streamlined. The Feed department applies various invoicing procedures tailored to the individual customers. Consequently, numerous indicators are required to accommodate for the various procedures. However, if the business unit adopts a unified invoicing approach, many indicators can be eliminated, reducing both the duration of the post-calculation process and the overall invoicing process. Currently, the department dedicates 1,5 FTE to assess the invoicing data. Implementing a standardized invoicing protocol will minimize the data and therefore shorten the duration of the assessment.

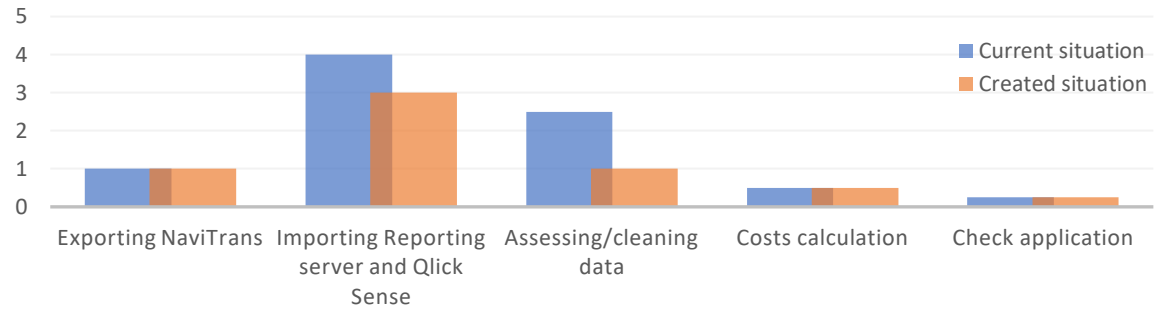

Figure 1 time reduction resulting from designed model.

Implementation

The uniform model functions like a filter, eliminating any irrelevant data from the post-calculation process. It is positioned in the final step before the output is imported in the reporting server and Qlik sense. Due to variations in the definitions across the company, the indicators used in the designed models are defined according to the guidelines suggested by ISO.

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Reader's guide

This thesis is written to conclude the Bachelor of Industrial Engineering and Management at the University of Twente. The research is conducted to optimize the post-calculation process by designing a uniform model streamlining the output.

Chapter 1 I Introduction provides a brief general introduction of the subject, followed by an overview of the company, business units, and problem. Additionally, a more detailed account of the structure and methodology of the research is provided.

Chapter 2 I post-calculation in literature provides literature on the cost-calculating processes in other businesses in the field. This section answers the research question "How do companies execute the post-calculation process?" through the examination and comparison of various case studies. The chapter presents a uniform post-calculation model applicable to mass customization businesses in the transport industry.

Chapter 3 I Existing post-calculation process moves on to describe in greater detail the origin, definition, and output of the post calculation process.

Chapter 4 I Designing the uniform model reviews the interviews conducted among several stakeholders involved in the post-calculation process, aimed at gaining insight in the main problems of the current situation. Moreover, the section maps out the requirements for a uniform post-calculation process which are then aligned, and compared to the general model in chapter 2, resulting in a uniform model.

Chapter 5 I Implementation and validation moves on in greater detail to describe how the model can be implemented and validated. The chapter presents an overview of the definitions used in the post-calculation process. Moreover, it includes an implementation approach and validation of the model.

Chapter 6 I Conclusions and recommendations summarizes the main findings, together with the recommendations resulting from the research.

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List of abbreviations

NW = Nijhof Wassink
BU = business unit
Chemical (Logistics) = Nijhof Wassink Chemicals Logistics
Feed (Logistics) = Nijhof Wassink Feed Logistics
Wemmers = Wemmers Transport

1. Introduction

The section below provides a brief general introduction of the subject, followed by an overview of the company, business units, and problem. Additionally, a more detailed account of the structure and methodology of the research is provided.

1.1 Context

This thesis focusses on the post-calculation process, which entails invoicing based on the costs incurred upon the completion of the service of product. This way of invoicing accommodates personalization for each order; therefore, the method can be applied in the mass customization service industry. Mass customization capability (MC) is the capacity to supply modified goods or services that fills the individual needs of each customer without making significant sacrifices in cost, delivery, or quality (Guan Hui, 2024).

1.2 Company introduction and the involved business units

Since the company's founding in 1967, Nijhof-Wassink has been a specialist in bulk transport by road, rail, and water. The company does not only provide transport, furthermore, they can coordinate the entire logistics process if desired. The company focusses on animal feed distribution, dry bulk logistics, liquid bulk logistics, fuel distribution and warehousing. (Nijhof-Wassink, 2018)

The company employs over 850 people through their primary activities, combined with the connected company activities, Nijhof-Wassink is responsible for over 1400 employees. The company operates in Germany, Poland, Hungary, Belgium, and the Netherlands. The logistics segment of the company is separated in several business units, this research involves the business units Nijhof-Wassink Chemical Logistics, Nijhof-Wassink Feed Logistics and Wemmers Transport.

Nijhof-Wassink Chemical Logistics specializes in warehousing and transporting chemical bulk products. It focusses on dry bulk logistics, liquid bulk logistics and fuel distribution. Chemical products cannot be combined in the same truck. Consequently, this business unit only transports between the warehouse and destination, without intermediate stops. Chemical logistics transports intermodal. Intermodal transportation may be defined as the transportation of a person or load from its origin to its destination by a sequence of at least two transportation modes. (Teodor Gabriel Crainic, 2007) In the case of Nijhof-Wassink, the load can be transported by ship, train, and truck.

Nijhof-Wassink Feed Logistics focusses on animal feed and fertilizer transport across Europe. The business unit provides bulk transport of dry raw materials and additives to produce animal feed. It offers second party logistics (2PL), third party logistics (3PL), and fourth party logistics (4PL). Two party logistics involves the use of one external company to execute the transportation.

Third party logistics involves the use of external companies to preform logistics functions that have traditionally been performed within an organization, the functions performed by the third part can encompass the entire logistics process or selected activities within the process (Lieb, 2004). Fourth party logistics is defined as an integrator that assembles its own resources, capabilities, and technology and those of other service providers.

Since 2022, Wemmers Transport is integrated in the Nijhof-Wassink group. The business unit specializes in transporting vegetable oils and fats, fruit juices, chocolate, sweeteners, wines, and dairy. The business unit is similar to Nijhof-Wassink Chemical Logistics, however Wemmers focusses on food while Chemical focusses on non-food transport.

A short overview of the differences between the business units is shown in table 1-1.

	Main product transported	Intermodal	Intermediate stops
Nijhof-Wassink Chemical Logistics	*Variety of chemical bulk products*	*Yes*	*No*
Nijhof-Wassink Feed Logistics	*Raw materials and additives*	*No*	*Yes*
Wemmers Transport	*Vegetable oils and fats*	*Yes*	*No*

Table 1-1 comparison table business units.

1.3 Problem introduction

As stated in section 1.1, the company invoices based on the actual costs incurred during the transportation process. The post-calculation process is conducted to calculate these costs, moreover, it serves to provide insight into the performance of the business units.

One of the main obstacles of the company concerns the time-consuming execution and evaluation of the post-calculation process. Searching for causes and results between the problem provides the problem cluster. The problem cluster, shown in figure 1- 1, identifies the core problem:

"There is a lack of uniform output generated from the post-calculation process".

As a result of the problem statement and research objective, the following main research question is formulated:

"How can a uniform model be designed to make the execution and evaluation of the post-calculation process less time-consuming?"

Two core problems are identified in the problem cluster. ''Each business unit works with a different business logic" and "There is a lack of uniform output in the post-calculation process". The business logic are custom rules or algorithms connected to the process within the business unit. The custom rules determine the data used and the outcome of the post-calculation process. Adjusting or rebuilding the business logic requires thorough knowledge on the way of working within each unit. Due to time limitations, this is not achievable.

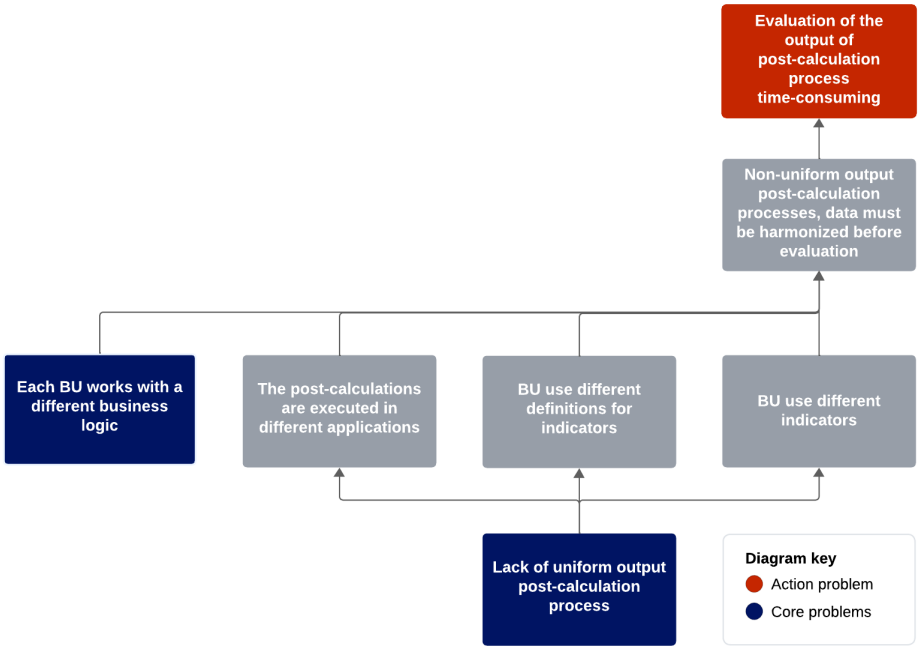

Figure 1-1 problem cluster identifying the core problem.

1.4 Relevance of the problem

As stated in section 1.1, the post-calculation process accommodates invoicing based upon actual costs, making it suitable for application in the mass customization industry. Consequently, the uniform model developed in this research is not only relevant for the current client, but also for other companies operating in the customization sector.

Furthermore, the post-calculation process is carried out monthly for Chemicals Logistics and Wemmers Transport, and continuously for Feed Logistics. While reducing the execution time marginally impacts Chemical Logistics and Wemmers Transport, it significantly benefits Feed Logistics due to their considerably more time-consuming post-calculation process. Another advantage of a uniform model is that it provides a smooth and easy implementation of newly acquired business units, thus reducing the time required to integrate a new business unit.

1.5 Methodology and research questions

To systematically solve the core problem, the steps of the Managerial Problem-Solving Method (MPSM) are followed. The MPSM is a general method, applicable to various problems encountered in various situations in all areas of expertise (Heerkens, 2017). The MPSM method provides a systematic problem-solving approach based upon a discrepancy between the norm and reality.

The issue can be identified as a managerial problem since the solutions needs to be implemented companywide, spanning various departments within the organization. Additionally, the post-calculation yields data that is used by the management to navigate the company.

A systematic literature review is a mean of identifying, evaluating, and interpreting all available research relevant to a particular research question, or topic area, or phenomenon of interest (Barbara Kitchenham, 2007). As demonstrated in appendix 8, a literature search is conducted on case-studies of post-calculation in transport. The literature sources used for this research will be reviewed according to the original guidelines as proposed by Kitchenham.

As mentioned in section 1.3, the main research question is:

"How can a uniform model be designed to make the execution and evaluation of the post-calculation process less time-consuming?

The main research question is solved with the aid of several sub questions based on the steps of the MPSM-cycle:

- How do customization companies execute the post-calculation process?
- How can a new model be designed?
- What are the main problems within the current post-calculation process according to the stakeholders involved?
- What are the requirements for a uniform post-calculation model?
- How can the model be implemented and validated?

1.6 Scope

This research is focused on comparing the existing post-calculations within the three business units and building a standardized process based on the existing models. The post-calculation process is aimed to generate invoices and measure efficiency, therefore the research focusses on financial post-calculation. The reader should bear in mind that the post-calculation is based in historical data instead of real time data.

The current post-calculation process is built based on the business logic. Due to time limitations, this is not achievable to adjust the business logic. Moreover, it is beyond the scope of this study to examine the emissions for the period a container spends on a ship or train during intermediate transport. Due to practical constraints, there is no data available on the emissions. Therefore, the emissions in the post-calculation of Feed Logistics are incomplete in case intermediate transport is used.

1.7 Structure of the thesis

Research question	MPSM-cycle	Research population	Research type	Method of data gathering	Research strategy
1. How do customization companies execute the post-calculation process?	2	Literature	Descriptive	Literature search	Qualitative
2. How can a new model be designed?	5	Data gathered during literature research/conducted interviews	Descriptive	-	Qualitative and quantitative
2.1 What are the main problems within the current post-calculation process according to the stakeholders involved?	3	Interviewing stakeholders	Explanatory	Semi-structured interviews	Qualitative
2.2 What are the requirements for a uniform post-calculation model?	4	Interviewing stakeholders	Descriptive	Semi-structured interviews	Qualitative
3. How can the model be implemented and validated?	6 and 7	Data gathered during previous research	Descriptive	-	Qualitative

2. Post-calculation in literature

In the literature, the term mass customization is frequently used to refer to customer-oriented and individualized mass production for a large market, meeting the different needs of each customer (Piller, 2001). As mass customization is quite common in the transportation industry, this chapter provides literature on the cost-calculating processes in other businesses in the field. This section answers the research question "How do companies execute the post-calculation process?". The chapter concludes with a general model, serving as a base for executing the post-calculation process. As depicted in appendix 8, the literature search is conducted according to the guidelines as proposed by Kitchenham (2007).

2.1 Post-calculation in Air transport

Research on cost calculation in Small Air Transport systems was undertaken by Iwaniuk (2018). Passenger transport by small aircraft is derived from the concept of a small aircraft following a similar path as passenger cars, for travelling distances exceeding 200 km. An important feature of the Small Air Transport system is personalisation, the transport process is adapted to the customer's needs and requirements. As shown in equation 2-1, tables 2-1 and 2-2, this business case researches the optimal aircraft type for executing a trip based on certain variables and constraints. Iwaniuk proposes a mathematical model for calculating the optimal aircraft for the transportation. The optimization problem is written as:

"Given the domain of the objective function D_{GC}
Objective function: $GC_{pax-km} : D_{GC} \rightarrow R$
Generalized costs for one passenger per kilometre

$$\text{"}Minimize: F(x) = GC_{pax-km}(X; A)$$
$$With\ respect\ to:$$
$$optimization\ variables: X \quad X_l \leq X \leq X_u$$
$$Subject\ to:$$
$$constraints:$$
$$G(X) < 0$$
$$H(X) = 0$$

Where:

$G(X)$ *= vector of the inequality constraints*
$H(X)$ *= vector of the equality constraints*
X *= vector of optimization variables*
X_l *= vector of the lower bounds of* X
X_u*= vector of the upper bounds of* X
A *= vector of design parameters"*

Equation 2-1 (Andrzej Iwaniuk, 2018)

The vector of optimization variables (X) and the vector of design parameters (A) are of high importance for the thesis, since the vectors represent the total costs of the executed

transportation process. A list of the optimization variables and design parameters are shown in table 2-1 and 2-2.

Symbol	Name
N_{pax0}	Nominal number of passengers
W_{TO}	Maximum take-off weight (kg)
W_E	Empty weight (kg)
W/S	Wing loading (kg/m^2)
W/P **or** T/W	Power loading (kg/hp) or thrust-to-weight ratio
V_{cr}	Cruising speed (km/h)
Alt_{crAB}	Cruise ceiling for the flight mission (ft)
Prc_{arp}	Aircraft price ($)

Table 2-1 List of optimization variables the mathematical model of small aircraft, cited from: (Andrzej Iwaniuk, 2018).

Symbol	Name
N_{cr}	Number of crew members
N_{att}	Number of flight attendants
M_{cargo}	Nominal cargo mass (kg)
N_{eng}	Number of engines (constant for a specific type of SAT aircraft)
n_p	Propeller efficiency (climb, cruise, and descent)
SFC	Specific fuel consumption (lb/h/lbf or lb/h/hp)
b_s	Wingspan (m)
N_{paxAB}	Number of passengers in the flight mission
$Dist_{AB}$	Distance between the start and the end of the journey (the flight mission) (km)
AH	Number of flight hours per year for a crew number (flt h)
U_{ann}	Annual utilization in block hours (bl h)
TEF	Travel expense factor ($/bl h)
SAL_{cr}	Annual salary of crew members ($/year)
SAL_{att}	Annual salary of flight attendants ($/year)
Prc_{eng}	Engine price ($)
Prc_{prp}	Propellor price ($)
Prc_f	Price of fuel ($/gallon)
R_{lab_maint}	Aeroplane maintenance labour rate per manhour ($/h)
H_{eng_maint}	Time between overhaul (TBO) for aircraft engine in block hours (bl h)
K_{IndC}	Flat rate of direct costs
c_{pax_h}	Value of time ($/h)

Table 2-2 List of design parameters in the mathematical model of small aircraft, cited from: (Andrzej Iwaniuk, 2018).

As the model is designed for calculating the costs of transport by aircraft, the model cannot directly be applied to other means of transport. However, the parameters can be classified into generalized categories, as shown in table 2-3, making the model applicable to additional means of transport.

Symbol	Name
Direct costs	
N_{cr}	Number of crew members
N_{att}	Number of flight attendants
AH	Number of flight hours per year for a crew number (flt h)
TEF	Travel expense factor ($/bl h)
SAL_{cr}	Annual salary of crew members ($/year)
SAL_{att}	Annual salary of flight attendants ($/year)
R_{lab_maint}	Aeroplane maintenance labour rate per manhour ($/h)
SFC	Specific fuel consumption (lb/h/lbf or lb/h/hp)
$Dist_{AB}$	Distance between the start and the end of the trip (km)
Prc_f	Price of fuel ($/gallon)
K_{IndC}	Flat rate of direct costs
Goods transported	
M_{cargo}	Nominal cargo mass (kg)
W_E	Empty weight (kg)
N_{pax0}	Nominal number of passengers
N_{paxAB}	Number of passengers in the flight mission
c_{pax_h}	Value of time ($/h)
Efficiency	
U_{ann}	Price of fuel ($/gallon)
H_{eng_maint}	Time between overhaul (TBO) for aircraft engine in block hours (bl h)
Fixed costs	
Prc_{arp}	Aircraft price ($)
Prc_{eng}	Engine price ($)
Prc_{prp}	Propellor price ($)
Small Aircraft specific	
N_{eng}	Number of engines (constant for a specific type of SAT aircraft)
n_p	Propeller efficiency (climb, cruise, and descent)
W/S	Wing loading (kg/m^2)
W/P **or** T/W	Power loading (kg/hp) or thrust-to-weight ratio
V_{cr}	Cruising speed (km/h)
Alt_{crAB}	Cruise ceiling for the flight mission (ft)
W_{TO}	Maximum take-off weight (kg)
b_s	Wingspan (m)

Table 2-3 classification parameters

Iwaniuk's model relies on 10 parameters covering the direct expenses: salary costs, fuel expenses, and other direct costs. Another set of 5 parameters provides details on transported goods, incorporating information such as weight/quantity. Furthermore, two parameters offer insights into operational efficiency, while three parameters represent the overall vehicle value (fixed costs). Additionally, 8 parameters are specific for aircraft transport. Apart from aircraft-specific parameters, all other parameters are generally applicable and therefore can be utilized in the uniform post-calculation model for Nijhof-Wassink.

2.2 Post-calculation in transport by car

McNamara and Caulfield (2013) suggest the use of the Personal Trading Scheme (PCTS) for calculating the CO_2 emission and costs in Dublin and the Western Border Region (WBR) of Ireland. The Personal Trading Scheme is a down-stream cap-and-trade scheme used to reduce carbon emissions from the household sector (Jin Fan, 2015).

The research of McNamara and Caulfield extends on the PCTS to determine the total travel calculation costs. The costs equations are distinguished across three separate peak time periods in which the consumer undertakes the trip:

$$Cost(7-8AM) = (Distance \times HWAY1) + (Trip\ time \times HWAY4) + (\frac{Toll\ costs}{HWAY7 \times VOT})$$

Equation 2-2 (David McNamara, 2013)

$$Cost(8-9AM) = (Distance \times HWAY2) + (Trip\ time \times HWAY5) + (\frac{Toll\ costs}{HWAY8 \times VOT})$$

Equation 2-3 (David McNamara, 2013)

$$Cost(9-10AM) = (Distance \times HWAY3) + (Trip\ time \times HWAY6) + (\frac{Toll\ costs}{HWAY9 \times VOT})$$

Equation 2-4 (David McNamara, 2013)

With parameters:

Parameter code	Parameter	Value
$\boldsymbol{HWAY1}$	Distance (7-8 AM)	1.180
$\boldsymbol{HWAY2}$	Distance (8-9 AM)	2.150
$\boldsymbol{HWAY3}$	Distance (9-10 AM)	3.425
$\boldsymbol{HWAY4}$	Travel time (7-8 AM)	1.000
$\boldsymbol{HWAY5}$	Travel time (8-9 AM)	1.000
$\boldsymbol{HWAY6}$	Travel time (9-10 AM)	1.000
$\boldsymbol{HWAY7}$	Toll calibration (7-8 AM)	1.232
$\boldsymbol{HWAY8}$	Toll calibration (8-9 AM)	2.409
$\boldsymbol{HWAY9}$	Toll calibration (9-10 AM)	0.863
$\boldsymbol{VOT}$	Value of time for commuters	-

Table 2-4 parameters PCTS, cited from: (David McNamara, 2013).

The post-PCTS costs are calculated using the pre-PCTS travel costs equations (mentioned above) and adding the costs of CO_2.

$$Post\ costs = Pre\ costs + PCO_2$$

Equation 2-5 (David McNamara, 2013)

Like Iwaniuk's model, the Personal Trading Scheme (PCTS) considers both distance (fuel costs) and salary costs. Additionally, the Personal Trading Scheme (PCTS) includes the costs resulting from CO_2 emissions. All parameters are universally applicable; hence the business case offers valuable parameters that can be utilized in the post-calculation process of Nijhof-Wassink.

2.3 Post-calculation in customized bus services

Along the same lines, Li (2021) investigated the pricing of customized bus services and ridesharing. A customised bus (CB) service is a demand-responsive transit system that provides transportation by aggregating similar travel demands of passengers using online information platforms.

Similarly, ridesharing (RS) matches transport supply and demand by integrating real-time traffic, vehicle, and passenger information. As shown in table 2-5, Li's model integrates environment parameters, random variables, intermediate variables, decision variables and other variables in his model.

Symbol	Name
Environment parameters	
$\boldsymbol{c^{CB}}$, $\boldsymbol{c^{RS}}$	The fixed costs of each scheduled CB and each ride of RS
$\boldsymbol{\lambda}$	The parameter of the Poisson process of passenger arrivals
$\boldsymbol{\sigma}$	The parameter of the Rayleigh distribution of passengers' travel distance
$\boldsymbol{X}$	The passenger's travel distance
$\boldsymbol{\alpha}$	The commission rate of the platform
$\boldsymbol{\gamma}$	The proportion of platform-owned RS vehicles
$\boldsymbol{h}$	The departure headway of CB
$\boldsymbol{H}$	The total service time of CB
$\boldsymbol{I_i}$	The ith billing intervals of CB, $i = 1, \dots n-1$
$\boldsymbol{\hat{p}_i}$	The median of the expected price of transport of passengers in billing interval i
$\boldsymbol{\beta}$	The monetary valuation of waiting time of a passenger
Random variables	
$\boldsymbol{T}$	The waiting time of a passenger for choosing CB
$\boldsymbol{X}$	The travel distance of a passenger

$\boldsymbol{\delta_i^{CB}}$, $\boldsymbol{\delta_i^{SR}}$	The demand rates of passengers choosing CB or RS in billing interval i
$\boldsymbol{\epsilon_i^{CB}}$, $\boldsymbol{\epsilon_i^{SR}}$	The churn rates of passengers choosing CB or RS in billing interval i
Intermediate variables	
$\boldsymbol{Q}$	The total number of passengers arriving in the planning horizon
$\boldsymbol{p_i^{CB}}$, $\boldsymbol{p_i^{SR}}$	The pricing for passengers who choose CB or RS in billing interval i
$\boldsymbol{q_i^{CB}}$, $\boldsymbol{q_i^{SR}}$	The quantities of passengers who choose CB or RS in billing interval i
$\boldsymbol{\widehat{U}_i^{CB}}$, $\boldsymbol{\widehat{U}_i^{SR}}$	The disutility's of passengers for choosing CB or RS in billing interval i
$\boldsymbol{\Pi^{CB}}$, $\boldsymbol{\Pi^{RS}}$	The total profits of transport mode CB and RS
Decision variables	
$\boldsymbol{u_i}$	The price of CB in billing interval i
$\boldsymbol{w_i}$	The expected price of RS in billing interval i
$\boldsymbol{f}$	The fixed factor of the price of RS
$\boldsymbol{v}$	The variable coefficient of the price of RS
Others	
$\boldsymbol{n_i}$, $\boldsymbol{\varphi_i}$	Notations used for convenience in the deduction process, calculated from d_i

Table 2-5 notations Li's model, cited from: (Yanan Li, 2021).

The equations for the expectations of profits are:

$$\begin{cases} \max \Pi^{CB} = -\dfrac{\lambda H}{\beta h}\displaystyle\sum_i \frac{\hat{p}_i n_i u_i (u_i - w_i)}{\hat{p}_i + u_i} - \frac{c^{CB} H}{h} \\ \max \Pi^{RS} = -\dfrac{\lambda H}{\beta h}\displaystyle\sum_i \frac{\hat{p}_i n_i (u_i - w_i + \beta h)}{\hat{p}_i + w_i} [(\alpha + \gamma - \alpha\gamma) w_i - \gamma c^{RS}] \end{cases}$$

Equation 2-6 (Yanan Li, 2021)

As the company establishes its process after the trip execution, the statistical distributions applied in Li's model and any parameters related to uncertain demand are unnecessary. However, the model considers other general applicable parameters:

- Direct costs; salary costs (H), fuel expenses (X), and other direct costs (α)
- The goods transported (q_i^{CB}, q_i^{SR}, Q)
- The fixed costs of a trip (c^{CB}, c^{RS})

2.4 Conclusion

Note that a variety of definitions are used to refer to the proposed solution, however, the majority of literature utilizes the term “model”. Consequently, the term “model” is used throughout this thesis to refer to the uniform solution.

Analysing and integrating insights from the previously examined case studies yields the following answer to the research question *“How do companies execute the post-calculation process?”*:

The examined research employs numerous shared parameters to calculate the overall costs for the executed trip. Combining these parameters delineate a scheme with general applicable parameters, as shown in table 2-6.

Symbol	Name
Direct costs	
$\boldsymbol{time}$	Travel time (h)
$\boldsymbol{labour}$	Labour rate per man hour ($/h)
$\boldsymbol{distance}$	Distance between the start and end of the journey (km)
$\boldsymbol{fuel}$	Price of fuel ($/litre)
Transported goods	
$\boldsymbol{Q}$	Quantity transported goods
Fixed costs	
$\boldsymbol{Prc_{vehicle}}$	Vehicle value ($)
$\boldsymbol{f_{costs}}$	Other fixed costs ($)
Efficiency	
$\boldsymbol{VoT}$	Value of time
Company specific parameters	

Table 2-6 scheme of general applicable parameters.

Integrating the parameters in an entity relationship diagram results in a general applicable model, as shown in figure 2-1. An Entity Relationship Diagram (ERD) depicts data in terms of the entities and relationships described by the data (Qing Li, 2009). The diagram helps visualizing and comprehending the organization of data in a system. On the left side of the diagram, costs incurred during the trip are represented, while the right side of the model provides space for efficiency parameters and company-specific parameters.

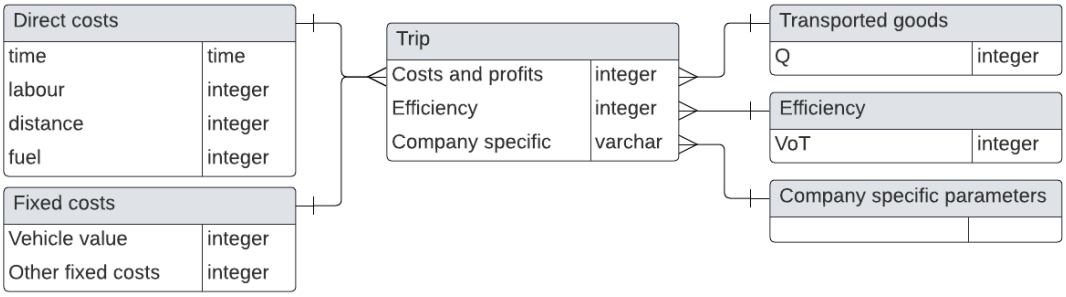

Figure 2-1 uniform model resulting from general applicable parameters.

The majority of parameters derived from this conclusion are also included in the firm's current post-calculation output. Nevertheless, the value of time and fixed costs as the vehicle value are not considered in the current output. However, the fixed costs are considered in a separate step during the invoice generation. Consequently, including the vehicle value in the post-calculation process is unnecessary.

3. Existing post-calculation process

The following section of this thesis moves on to describe in greater detail the origin, definition, and output of the post calculation process.

3.1 Process post-calculation

In Chemicals Logistics and Wemmers transport, each truck has its own board computer in which the trip is documented, in addition, the board computer shows the trip planned by the planning department. Firstly, the driver picks up the truck from the start location and drives it to the first location. The driver documents the time of departure and arrival. Next, the truck is either loaded or unloaded, depending on whether the truck is full or empty at the starting point. After the truck is (un)loaded, the driver again documents the activities in the board computer. Depending on the previous action, the truck is either cleaned (when the truck was previously unloaded) or unloaded (when the truck was previously loaded). After each step within the process, data on the arriving time, departure time and (un)loaded weight is documented. This process is repeated for each location visited. At the end of the trip, the truck is driven back to the starting point where the arrival time is documented again, this process is described in appendix 3.[1]

Figure 3-1 visualization of transport of BU's Chemicals and Wemmers (own drawing).

Figure 3-2 visualization of the trip of BU Feed (own drawing).

Contrary to Chemical Logistics and Wemmers Transport, Feed Logistics does involve intermediate stops. The trailer consists of smaller compartments, the bulk products within the compartments have different destinations. As shown in appendix figure 4, this results in a different process flow compared to Chemical Logistics. Firstly, the departure time is documented by the driver, after which he drives to the first destination. After the arrival time is documented, one or more compartments of the truck are either loaded or unloaded. Then, data on the (un)loaded products and departure time is documented. When the driver arrives at the next destination, the same process is repeated. The compartments on the truck are cleaned before they are reloaded.

[1] The information is based on unstructured interviews with two employees of the hour-check department. Additionally, information was gathered while accompanying a driver of Chemical Logistics during a trip.

The first event of a trip is the receival of an order. After the order approval, the trip is scheduled by the planning department. The assignment is sent to the driver's board computer. During the trip, the driver documents information on the trip and load in the board computer as shown in table 3-1. Furthermore, the board computer saves information on the driver, locations and travelled distance.

Event	Data documented by driver
Departure starting point	Approval vehicle check, departure time, break time
Arrival location	Arrival time
(Un)loading	Start time (un)loading, (un)loaded weight, end time (un)loading
Departure location	Departure time, break time
Cleaning	Start time, cleaning certificate, break time, end time

Table 3-1 information documented by the driver.

The data is uploaded to the Greencom database, which contains real-time data on the trip. After the completion of the trip, the data is uploaded to the Greencom database. The data of the Greenlog database is assessed by the hour check department. The department assesses and adjusts the data to correct mistakes made by the driver, aiming to find the hours made which are paid to the driver. The data of the business units Nijhof-Wassink Chemicals Logistics and Nijhof-Wassink Feed Logistics is assessed in the application Greencom, the data of Wemmers Transport is assessed in the application Fleethours. Finally, the data ends in Qlik

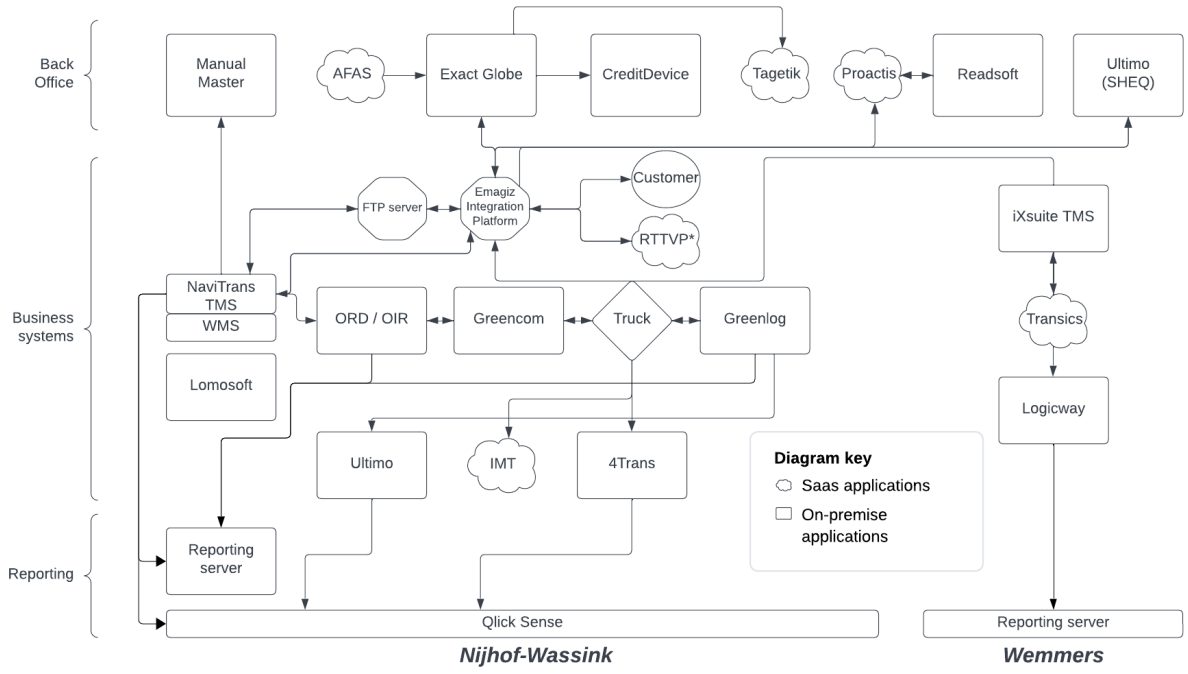

Figure 3-3 conceptual model describing the connections between the technical systems of the business units (own drawing).

Sense and the Reporting server, where the data is processed in the post-calculation process and integrated in dashboards. The conceptual model in figure 3-3 illustrates the connections between the several systems involved in the post-calculation process. A conceptual model (CM) can be defined as "an abstract representation of something generalized from particular instances" (Junjie Liu, 2011).

3.2 Defining post-calculation

The term post-calculation will be used throughout the thesis to refer to the process of calculating the actual costs and margins of a trip executed by the company. As the post-calculation process is the most important concept within this research, it is highly important to define which company operations are included in the post-calculation process.

The purpose of the post-calculation process is to create insight in the financial performance and efficiency and facilitate generating invoices. Therefore, it is assumed that the post-calculation process consists of all operations solely aimed at generating invoices and creating insight. The operations differ for each of the business units.

3.2.1 Defining the post-calculation of Nijhof-Wassink Chemical Logistics

The business unit invoices its clients according to pre-established rates, meaning it doesn't rely on the results of the post-calculation process for invoice generation. Nevertheless, the outcome of the post-calculation process plays a vital role in evaluating the business unit's performance. In the case of NW Chemical logistics, the post-calculation process is executed within NaviTrans, a Transport Management System (TMS) which offers planning tools, driver apps, and executes the post-calculation process. The results are then exported from NaviTrans to the Reporting Server and Qlik Sense. After that, the total costs are computed, and the Application Management department conducts a final output check. The output generated from the post-calculation process is illustrated in an Entity Relationship diagram in appendix 9.[2] Additionally, figure 3-3 shows the relationship between the different applications in a conceptual model.[3]

3.2.2 Defining the post-calculation of Nijhof-Wassink Feed Logistics

In contrast to Chemical Logistics, Feed Logistics does use the outcome of the post-calculation to generate invoices. The data generated during the executed trip is assessed by the Hour Check department, to calculate the hours made by the drivers. The data undergoes a secondary check by the Feed Support department. The data required for the invoice generation is assessed, eliminating possible data errors, using Microsoft Excel. After that, the data is integrated in the Reporting server and Qlik Sense. The output generated from the post-calculation process is illustrated in an Entity Relationship diagram in appendix 10.[4]

[2] The ERD-diagram is based on the output of the post-calculation process of Chemical Logistics provided by the company.
[3] The information was obtained through an unstructured interview with an employee of the application management department and an application landscape provided by the company.
[4] The ERD-diagram is based on the output of the post-calculation process of Feed Logistics provided by the company.

Furthermore, figure 3-3 shows the relationship between the different applications in a conceptual model.

3.2.3 Defining the post-calculation of Wemmers Transport

Since the business unit has recently been incorporated into the company, the post-calculation process is still under development. Currently, data is imported from Fleethours, followed by manual processing in Microsoft Excel. The output generated from the post-calculation process is illustrated in an Entity Relationship diagram in appendix 11.[5] Furthermore, figure 3-3 shows the relationship between the different applications in a conceptual model.[6]

3.3 Conclusion

Starting from the initial event, which is the placement of an order, until the completion of the service, data is collected. The majority of the data is gathered during the trip by the board computer installed in the truck. All data gathered before and during the trip forms the input for the post-calculation process. The output resulting from the post-calculation process is used for gaining insight in the performance of the business units and generating invoices for Nijhof-Wassink Feed Logistics. Therefore, the post-calculation is defined as all processes that are executed aimed at gaining insight in the performance and/or generating invoices. Currently, the post-calculation process encompasses a significant amount of data, as illustrated in the ERD-diagrams in figures 3-4, 3-5, 3-6.

[5] The ERD-diagram is based on the output of the post-calculation process of Wemmers Transport provided by the company.

4. Designing the uniform model

The section below reviews the interviews conducted among several stakeholders involved in the post-calculation process, aimed at gaining insight in the main problems of the current situation. Moreover, the section maps out the requirements for a uniform post-calculation process which are then aligned, and compared to the general model in chapter 2, resulting in a uniform model.

4.1 Uniform model resulting from literature research

In chapter 2, several case studies in the transportation industry were analysed. The post-calculation processes of a Small Air Transport System, commuters, customized bus services and ride sharing were compared, resulting in a general applicable model. As depicted in figure 4-1, the parameters are classified in direct costs, fixed costs, transported good-parameters, efficiency parameters, and company-specific parameters.

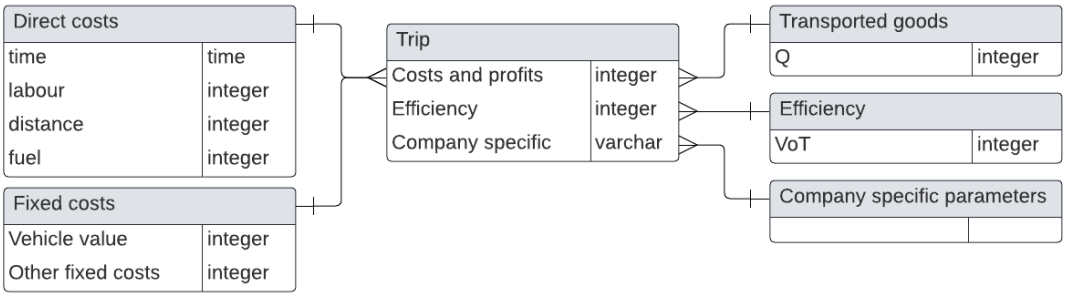

Figure 4-1 general model established in chapter 2.

In the subsequent sections, the general model is supplemented and evaluated using information obtained from conducted interviews. Consequently, the general model serves as the groundwork for the uniform model. In chapter 3, post-calculation is defined as “all operations solely aimed at generating invoices and creating insight”. The definition forms the basis for determining which parameters to include and exclude from the current post-calculation process as defined in chapter 3.

4.2 Current problems according to the stakeholders

Semi-structured interviews were conducted among 3 stakeholders, aiming to gain insight in the current post-calculation processes, perceived problems, and requirements for a uniform post-calculation process. The interview is separated into two segments: one describing the current situation, while the other segment involves questions aimed at gaining insight in the desired situation. The first segment begins with one open-ended question asking the participant for their opinion on the current post-calculation process, followed by a second question in which the interviewee is asked to identify possible points of improvement within the current process. The next two questions elicited information on the time spend on analysing and executing the post-calculation process and time spend on designing a post-

calculation process for new business units. All questions asked during the interview are listed in appendix 5, the interviews were conducted according to the rules and regulations proposed by the Ethics committee, therefore all participants signed the consent form in appendix 6.

4.2.1 Nijhof-Wassink Chemical Logistics

In order to obtain an understanding of the current situation and duration of the process, the interviewee was questioned regarding the time required for the post-calculation process. As illustrated in table 4-1, exporting the data from NaviTrans consumes 1 hour, subsequently importing the data into the Reporting server and Qlik Sense, requires 4 hours. After that, the data undergoes assessment and cleaning, a task requiring 2 to 3 hours. Subsequently, the costs are calculated, taking up to 30 minutes. Finally, the application management department conducts a final data check, which lasts 15 minutes. All actions mentioned above are executed once every month.

Process	Duration in current situation
Exporting from NaviTrans	1 hour
Importing in Reporting server and Qlik Sense	4 hours
Assessing and cleaning data	2 to 3 hours
Calculating costs	30 minutes
Check executed by application management department	15 minutes

Table 4-1 Duration of post-calculation process Chemical logistics.

When asked about the main issues, the manager of Chemical logistics indicated that Fuel, a division of Chemicals, does not have a post-calculation process. Consequently, there is no insight in the division's performance. Additionally, there is a lack of information concerning the intermodal aspect of the transportation. Furthermore, the interviewee argued that the post-calculation processes vary among the three business units, resulting in time-consuming efforts to harmonize the output.

4.2.2 Nijhof-Wassink Feed Logistics

Accordingly, the manager of Feed was questioned regarding the time required for the post-calculation process. As illustrated in table 4-2, the data is assessed and cleaned, this process is executed by the Feed support department. The assessment and cleaning of the data requires between 38 and 57 hours a week.

Process	Duration in current situation
Assessing and cleaning data	1 to 1,5 FTE (full-time equivalent)

Table 4-2 duration of the post-calculation process of Feed Logistics.

Addressing the challenges encountered in the current post-calculation process, the interviewee highlighted the significant time consumption involved in assessing and cleaning the data. Furthermore, they noted that the data assessment and cleaning is executed in Excel, leading to multiple versions of the document, making it difficult to trace changes.

4.2.3 Wemmers Transport

When asked about the time required for executing the post-calculation process, the manager of Wemmers Transport commented that the post-calculation process of the business unit is currently executed manually in Excel. Since the business unit is recently added to the company, a semi-automatic post-calculation process is still under development. The interviewee indicated that adding the data requires approximately 3 hours. Assessing the data and executing the calculations takes up to 3 hours.

Process	Duration in current situation
Adding data	3 hours
Assessing data and executing calculations	2 to 3 hours

Table 4-3 duration of the post-calculation process of Wemmers Transport.

4.3 Requirements for a uniform model

The second segment of the interview is conducted aimed at gaining insight in the desired situation. Starting with one open-ended question asking the participant for their requirements for a new post-calculation process, followed by a question asking the perceived benefits of a uniform model. The next two questions elicited information on the essential and additional indicators.

4.3.1 Nijhof-Wassink Chemical Logistics

A distinction can be made between essential and supplementary data. Concerning the essential data, the indicator TripId holds a significant importance. The code serves as a key linked to the trip, enabling tracing back information on the executed trip through all systems within the company. Additionally, the kilometres travelled during the trip and the duration of the trip serve as crucial information when assessing the performance of the business unit. Moreover, supplementary data such as a parameter indicating the proportion of time the truck was loaded or empty offers valuable insight in the efficiency of the trip. Currently, the post-calculation lacks information on the company's environmental performance. Looking ahead, the interviewee emphasized the importance of accommodating innovations that provide insights into the fuel usage and CO_2 emissions.[7]

[7]The information is obtained through one semi-structured interview with the manager of Nijhof-Wassink Chemical Logistics.

4.3.2 Nijhof-Wassink Feed Logistics

Contrary to Chemical Logistics, the parameter indicating the proportion of the travelled distance that the trailer is loaded or empty serves as essential data for gaining insight in the business unit's performance. Accompanied by the TripID, duration and distance travelled. Moreover, the interviewee emphasized the importance of supplementary data on fuel consumption and CO_2 emission.[8]

Feed Logistics invoices are based upon the outcome of the post-calculation. As the post-calculation process is defined as *"all operations solely aimed at generating invoices and creating insight",* it is necessary to incorporate the data required for generating invoices in the uniform model. According to the interviewee, an employee of Feed Logistics, invoices are generated based on various factors, with some being generated based on pre-established rates, while others are based on the duration of the trip, distance travelled, or unloaded weight.

When generating invoices based on the trip duration, it is necessary to include the trip's duration, loading and unloading times, a counter for the night included in the trip, and the weekend hours worked. All indicators are crucial, because the business unit works with different agreements with the customers regarding the costs associated with the time factors.

As the business unit invoices based on pre-established rates, it is important to differentiate which trip is executed. Therefore, the loading and unloading locations must be included in the post-calculation output.

Since the company often invoices based on the unloaded weight, it is important to include the indicator.

To calculate the overall profit, it is important to distinguish the trips between trips executed by the company and those executed by a charter. The cost centre is used to identify whether a charter was used, while the trailer number is used to identify which charter executed the trip.

The interviewee also mentioned the importance of including the indicators "other time" and "reference number". "Other time" refers to the duration of a trip during which the executed activity is unknown. A high amount of "other time" suggests potential gaps in the activities documented by the driver during the trip, resulting in errors in the data. Considering that the hour check department and Feed Support assess the data based upon the amount of other time, it was decided to exclude this indicator from the uniform model.

The reference number is a customer-generated identifier used for their own internal administration. Since the number is not unique, multiple trips can have the same reference number. The number cannot be used to trace a trip across different applications. As the reference number serves no other purpose for the post-calculation process, it is not included in the uniform model.[9]

[8]The information is obtained through one semi-structured interview with the manager of Nijhof-Wassink Feed Logistics.

[9] All information mentioned in this section is obtained through one unstructured interview with the employee of Nijhof-Wassink Business Support specialized in Feed Logistics

4.3.3 Wemmers Transport

Similar to Nijhof-Wassink Chemical Logistics and Nijhof-Wassink Feed Logistics, essential data for the business unit includes the trip duration, the distance travelled, and the TripId. However, the interviewee suggested that incorporating fuel usage and CO_2 emissions into the model could also be beneficial for the company, making these indicators a valuable addition to the current model.[10]

4.4 Alignment requirements

To gain insight into the company's performance, the managers of the business units propose similar requirements, as shown in figure 4-4. However, the significance of these requirements varies. Although the managers noted that supplementary data is not essential but highly valuable, all suggested indicators are incorporated into the model.

Furthermore, the inclusion of the supplementary data is supported by the findings of the literature review. The review highlighted the significance of indicators related to fuel consumption and emissions. Additionally, the concept of Value of Time (VoT) is covered, defined as the costs of the time a passenger spends on the journey (Mirjam Galetzka, 2018). The VoT parameter essentially is an indicator of the efficiency of the trip, as is the parameter indicating whether the trailer is loaded.

However, the literature review addresses the importance of factors such as labour rates and fixed costs (including vehicle value and other fixed expenses). These elements are currently not included in the post-calculation output. The factors are considered separately during the invoice generation. Given that one of the research goals is to reduce the duration of the post-calculation process, adding more indicators is not feasible.

Nijhof-Wassink Chemicals Logistics	Nijhof-Wassink Feed Logistics	Wemmers Transport
Essential data for performance		
Duration of the trip	Duration of the trip	Duration of the trip
TripId	TripId	TripId
Distance travelled	Distance travelled	Distance travelled
	Indicator for full/empty trailer	
Supplementary data for performance		
Fuel consumption	Fuel consumption	Fuel consumption
$\boldsymbol{CO_2}$emission	CO_2emission	CO_2emission
Parameter indicator a full or empty trailer		Parameter indicator a full or empty truck

Table 4-4 requirements according to the managers of the business units.

[10]The information is obtained through one semi-structured interview with the manager of Wemmers Transport.

4.5 Uniform model

For Feed Logistics, the post-calculation output serves more functions compared to the other two business units. Consequently, two separate models were designed.

The first model, depicted in figure 4-1, focusses solely on gaining insight into the performance of the business unit. The model fulfils the requirements of the business units Chemical Logistics and Wemmers Transport. However, for Feed Logistics, the model does not facilitate invoice generation.

The second model serves the dual purpose of gaining insight into the business unit's performance and generating invoices. The left side of the model is dedicated to providing insight, while the right side adds the necessary output for invoice generation.

It is important to note that various diagram types were explored to identify the optimal diagram to represent the data. Since the relationships and connections between the indicators are significant, an entity-relationship diagram was chosen.

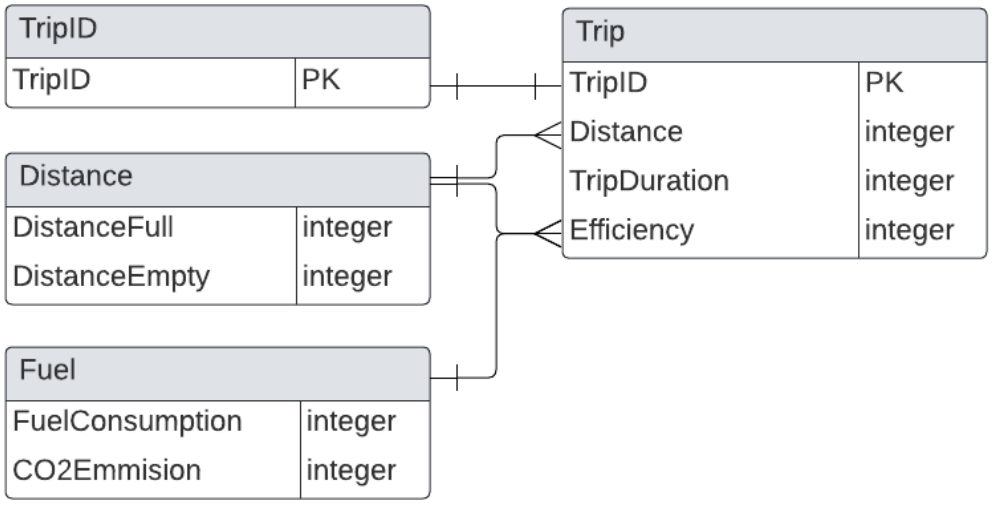

Figure 4-3 ERD-model showing the relationships between the entities used for gaining insight in the business units' performance.

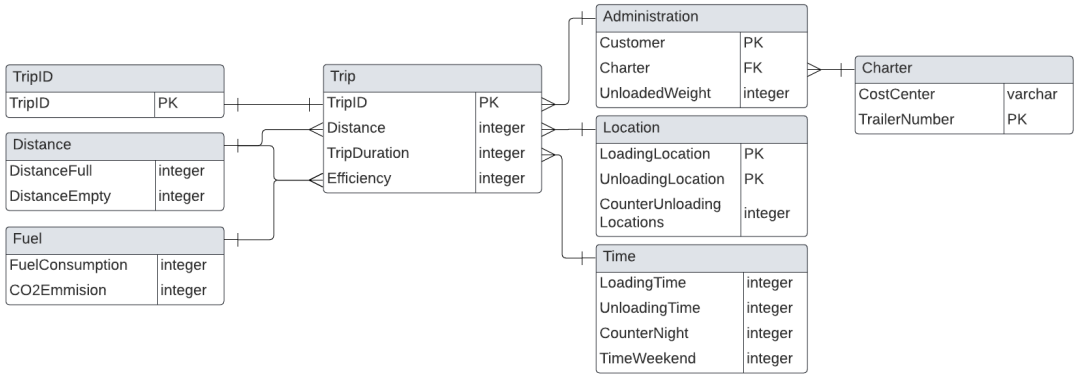

Figure 4-2 ERD-model showing the relationship between the entities used for gaining insight in the business unit's performance and invoicing.

4.6 Conclusion

In this section, the research question *"How can the new model be designed?"* is answered by answering the two sub-questions *"What are the main problems within the current post-calculation process according to the stakeholders?"* and *"What are the requirements for a uniform post-calculation model?".*

The conducted interviews revealed numerous issues, with one of the most significant being the time-consuming process of assessing and cleaning of the output of the post-calculation process. Additionally, one interviewee indicated that Fuel, a department within Chemical Logistics, is currently not taken into account in the post-calculation process. Furthermore, it was discovered that the intermodal aspect of the trip is not traceable and therefore not included in the post-calculation.

A distinction is made between the requirements for gaining insight and the requirements facilitating invoice generation. All requirements proposed by the interviewees, as depicted in table 4-4, are compared with the outcome of the literature search, resulting in the ERD-models 4-2 and 4-3.

5. Implementation and validation

The following part of this paper moves on in greater detail to describe how the model can be implemented and validated.

5.1 Implementation

The model functions as a filter selecting the data required for the execution of the post-calculation process, while eliminating any irrelevant data. As depicted in figure 5-2, the model is positioned before the Reporting Server and Qlik Sense. Once the data is filtered according to the model, the data is integrated in the Reporting Server and Qlik Sense.

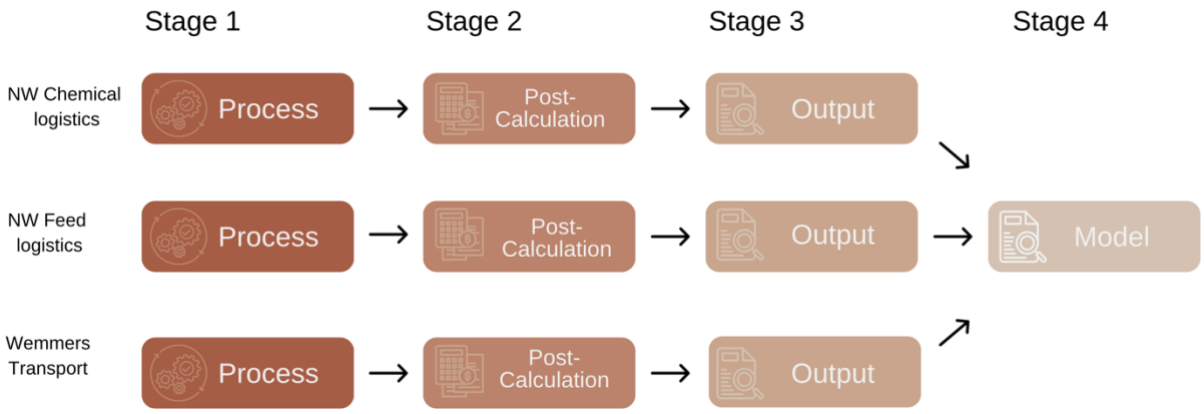

Figure 5-1 Stages of the post-calculation process with the new implemented model (own drawing).

The designed model is positioned in the final stage of the post-calculation process. It is crucial to consider the model's impact on the previous stages in the process. Implementing the model provides the opportunity to reassess the calculation models in stage 2. Given that all calculations result in the same uniform model, there may be potential to convert the three calculation models into one calculation model. Additionally, the model provides an opportunity to evaluate the data gathered during stage 1 of the process. Given that the process results in the same model, the data gathered during the trip can be reduced and streamlined.

Due to variations in indicator definitions across the company, all indicators used in the model are defined below. The definitions are based on the guidelines as suggested by part 4: Formulation of data definitions of the Metadata registries (ISO/IEC, 2004).

Business terms	Definition	Synonym(s)	Data source
Fleet	A collection of transportation vehicles and associated equipment, such as trucks, trailers or hoses, owned by or leased to an organization for transporting goods.	Vehicles, trucks	FMS/FMC
Customer		Client, klant	Exact
Trip	The process of transporting a trailer from one point to another, starting when the trailer is loaded until the trailer is loaded again.		-
Trailer	A towable non-motorized vehicle designed to carry goods either directly or by transporting containers. [11]	Oplegger, Chassis	-
Loading	The process of filling the trailer with goods, starting when the driver documents the start of the loading until the driver documents the completion of the loading.		-
LoadingLocation	The location of loading, including the postcode, address, and house number.	Loading address, location	NaviTrans
Unloading	The process of emptying the trailer with goods, starting when the driver documents the start of the unloading until the driver documents the completion of the unloading.		-
UnloadingLocation	The location of unloading, including the postcode, address, and house number.	Unloading address	NaviTrans
Night	The time between 21:00 and 5:00.[12]		-
Weekend	The time from Saturday 00:00 until Monday 00:00. [13]		-

[11] Definition as defined by Nijhof-Wassink
[12] As defined in the collective labour agreement (FNV vervoer, 2024).
[13] As defined in the collective labour agreement (FNV vervoer, 2024).

Good	Substance that transported in the trailer commissioned for the customer.	Product, loading (noun)	-
TripID	A unique code assigned to each trip.		-
TrailerNumber	A unique alphanumeric identifier assigned to a specific trailer within the fleet, as displayed on the trailer itself.	Chassisnummer, oplegger nummer, charter	Ultimo
CostCentre	A code referring to the department that executed the trip.	Department	Exact

Table 5-1 business terms used in the uniform model and their definitions.

Measures	Description
TripDuration	The total duration of a trip in hours.
LoadingTime	The duration of the loading process in hh:mm:ss.
UnloadingTime	The duration of the unloading process in hh:mm:ss.
CounterNight	A counter indicating the number of nights within the trip, calculated based on the time between 21:00 and 5:00.
TimeWeekend	The hours of the trip that occur during the weekend, calculated from Saturday 00:00 till Monday 00:00.
DistanceFull	The distance travelled during the trip while the trailer was loaded.
DistanceEmpty	The distance travelled during the trip while the trailer was empty.
FuelConsumption	The amount of fuel consumed during the trip, measured in litres.
$\mathbf{CO^2}$ emission	The amount of CO^2emitted during the trip, measured in kilograms.
UnloadedWeight	The weight of the goods unloaded from the trailer, measured in tons.
Distance	The total number of kilometres travelled during the trip.
CounterUnloadingLocations	The number of unloading locations during the trip.

Table 5-2 measures used in the uniform model and their definitions.

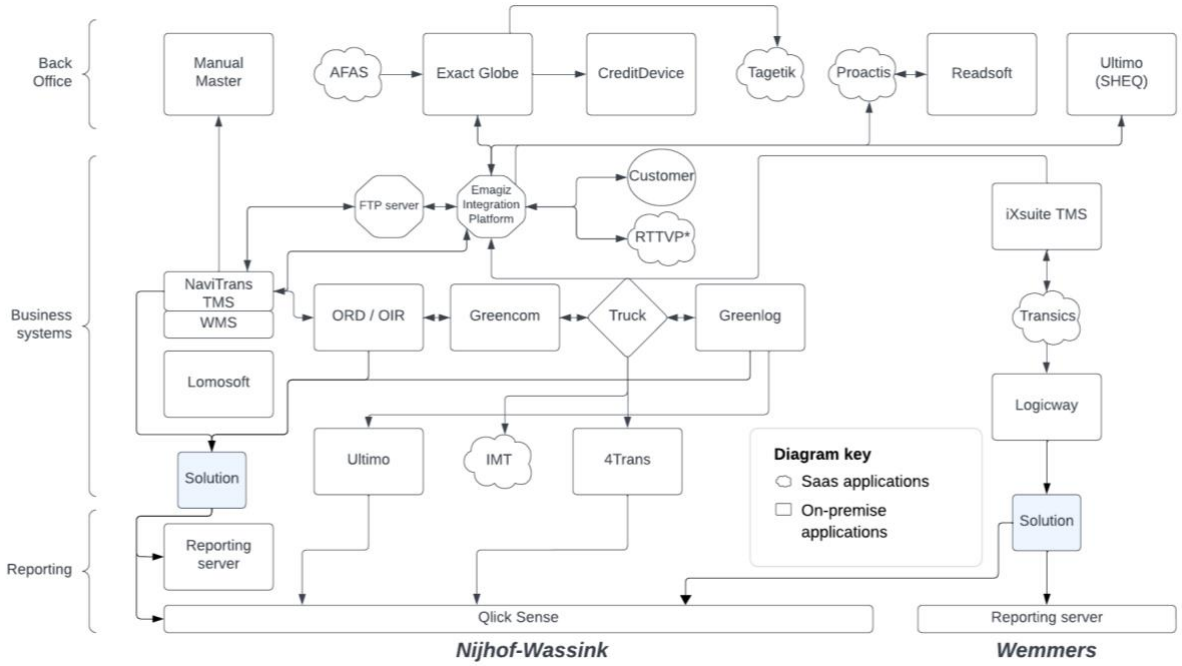

Figure 5-2 Conceptual model showing the relationships between the applications and the position of the designed model (own drawing).

5.2 Validation

The uniform model, illustrated in figure 4-1, reduces the data required for the importation into the Reporting server and Qlik Sense. Consequently, the duration of the importation, assessing, and cleaning decreases. An estimate provided by the application department suggests that the importation process will decrease to 3 hours in the case of Chemical Logistics. Moreover, an estimate provided by the manager of Chemical Logistics suggests that the assessing and cleaning of the data will decrease to 1 hour.

Process	Duration in current situation	Duration in new situation
Exporting from NaviTrans	*1 hour*	*1 hour*
Importing in Reporting server and Qlik Sense	*4 hours*	*3 hours*
Assessing and cleaning data	*2-3 hours*	*1 hours*
Calculating costs	*30 minutes*	*30 minutes*
Check executed by application	*15 minutes*	*15 minutes*

Table 5-3 the duration of the current post-calculation process compared to the estimated duration resulting from the implemented model.

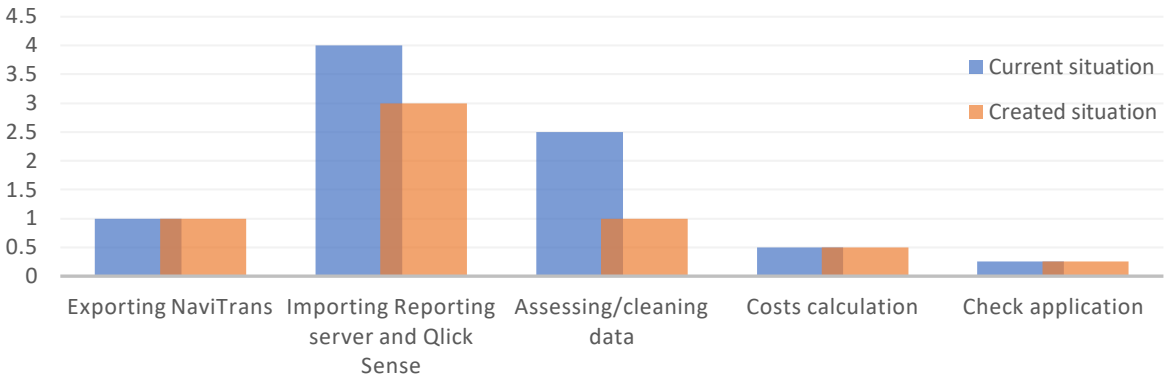

Figure 5-3 graphic representation of the duration of the current post-calculation process compared to the estimated duration resulting from the implemented model.

Since the post-calculation process of Wemmers Transport is still under construction, the model is not validated by comparing it to the current post-calculation process of this business unit. However, the uniform model was presented to the manager of the business unit. The manager indicated that the uniform model contains the data necessary for executing the post-calculation process and that it is a significant improvement.

Regarding Feed Logistics, the manager emphasized the importance of including the number of unloading locations in the model, since this is used during the invoice generation. Additionally, the interviewee proposed defining the loading and unloading locations as primary keys in uniform model. The manager expressed that with these suggested changes, which are now integrated in the final model, it would encompass the data necessary for executing the post-calculation process. Furthermore, the interviewee noted that, after the invoice procedure is changed, the Entity Relationship diagram in 4-1 would be sufficient for executing the business unit's post-calculation process.

5.3 Conclusion

This chapter, the research question: *"How can the model be implemented and validated?"* is answered. The uniform model functions like a filter, eliminating any irrelevant data from the post-calculation process. Implementing the model provides opportunities to further streamline the post-calculation process. As depicted in figure 5-2, the model is placed before the Reporting Server and Qlik Sense. Due to variations in the definitions across the company, the indicators are defined according to the guidelines suggested by ISO in table 5-1 and table 5-2. Interviews conducted among stakeholders indicated that the model is sufficient for the executing the post-calculation process. It is estimated that the duration of the post-calculation process decreases with 2 to 3 hours due to the uniform model.

6. Conclusions and recommendations

A summary of the main findings, together with the recommendations resulting from the research, is provided in the next chapter.

6.1 Conclusions

This project was undertaken for Nijhof-Wassink, the company specializes in bulk transport via road, rail, and water, offering transport services and logistic coordination. Nijhof-Wassink invoices based on the costs incurred upon the completion of the service of product. This way of invoicing accommodates personalization for each order; therefore, it is used in the mass customization service industry. Nijhof-Wassink cleans and assesses the data obtained from the trips for the purpose of invoicing and gaining insight in the company's performance. This process is referred to as the post-calculation process.

The current post-calculation process is time-consuming, with the execution time ranging from 9 hours per month up to 60 hours per week. The high execution times originate from the lack of uniform output for the three business units.

Therefore, the objective of this study is to design a standardized post-calculation model. Three models are proposed; a general model applicable across all companies that invoice based on the costs incurred upon completion, and two variations of the initial model tailored to the distinct business units within the company.

The research objective results in the following research question:

"How can a uniform model be designed to make the execution and evaluation of the post-calculation process less time-consuming?"

Chapter 2 presents several case studies on the post-calculation processes executed in different segments in the transportation industry, including Iwaniuk's model. His model is proposed for the costs calculation of personalized trips executed by small aircrafts. It relies on 10 parameters covering the direct expenses, another set of 5 parameters provides details on transported goods, incorporating information such as weight/quantity. Furthermore, two parameters offer insights into operational efficiency, while three parameters represent the overall vehicle value (fixed costs). Additionally, 8 parameters are specific for aircraft transport. Apart from aircraft-specific parameters, all other parameters are generally applicable and therefore can be utilized in the uniform post-calculation model for Nijhof-Wassink.

The Personal Trading Scheme (PCTS) is a case study executed for calculating the cost of commuters travelling with several modes of transport. The model considers both distance (fuel costs) and salary costs. Additionally, the Personal Trading Scheme (PCTS) includes the costs resulting from CO_2 emissions. All parameters are universally applicable; hence the business case offers valuable parameters that can be utilized in the post-calculation process of Nijhof-Wassink.

Li's model is designed for the cost-calculation of personalized transport by busses. The model considers several general applicable parameters; Direct costs (salary costs / fuel expenses / other direct costs), the goods transported and the fixed costs of a trip.

Comparing and evaluating the different models resulted in a uniform model, as shown in figure 2-1, answering the sub research question: *"How do customization companies execute the post-calculation process?".*

Furthermore, the internal research was conducted to address the questions: *"What are the main problems within the current post-calculation process according to the stakeholders?"* and *"What are the requirements for a uniform post-calculation model?".* This investigation uncovered several issues, with one of the most significant being the time-consuming process of assessing and cleaning the input of the post-calculation process.

Furthermore, the examination of the requirements distinguished the essential indicators from additional indicators, resulting in two variations of the initial model, tailored to the requirements of the business units, depicted in figure 4-1 and figure 4-2. The diagram in figure 4-1 encompasses all indicators necessary for gaining insight in the business unit's performance, while the diagram in figure 4-2 also facilitates generating invoices for Feed Logistics.

Chapter 5 answers the research question: *"How can the model be implemented and validated?"*. The uniform model functions like a filter, eliminating any irrelevant data from the post-calculation process. Implementing the model provides opportunities to further streamline the post-calculation process. As depicted in figure 5-2, the model is placed before the Reporting Server and Qlik Sense. Due to variations in the definitions across the company, the indicators are defined according to the guidelines suggested by ISO in table 5-1 and table 5-2. Interviews conducted among stakeholders indicated that the model is sufficient for the executing the post-calculation process. As depicted in figure 6-1, it is estimated that the duration of the post-calculation process of Chemical Logistics decreases with 2 to 3 hours due to the uniform model.

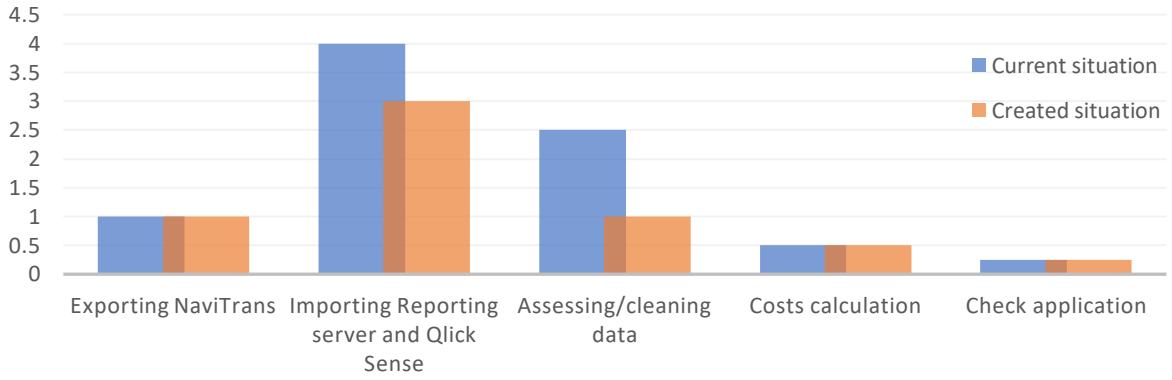

Figure 6-1 graphic representation of the duration of the current post-calculation process compared to the estimated duration resulting from the implemented model.

6.2 Limitations

A limitation of a study design or instrument is the systematic bias that the researcher did not or could not control and which could inappropriately affect the results (James H. Price, 2004).

One limitation of the model is the uncertainty regarding whether the user can accurately calculate and asses the input values. Furthermore, data related to the intermodal part of the trip is unavailable, leading to its exclusion from the post-calculation process and resulting in a bias in the output.

Moreover, note that the emission indicators included in the uniform model are not currently included in the post-calculation. The company is working on a method to gather data for these indicators. To facilitate the innovation, the indicators are already included in the uniform model.

Furthermore, the diagram depicted in figure 4-2 encompasses the data necessary for invoice generation. The Feed department is in the process of establishing a standardized procedure for the invoice generation, leading to a decrease of indicators required for invoice generation. Consequently, the model aligns with the current invoicing process, but may not fully accommodate the upcoming changes in the invoicing procedure.

6.3 Recommendations

As the way of invoicing accommodates personalization for each order, the findings of the research will be of interest of the mass customization service industry. Therefore, one general recommendation is proposed, followed by company specific recommendations.

This research followed a top-down approach, beginning with the output of the post-calculation process. Re-evaluating the post-calculation process form a bottom-up perspective could uncover more inefficient steps in the process, enabling further streamlining of the entire process. Therefore, the study should be repeated using the bottom-up perspective.

The model (figure 4-2) can be further streamlined. The Feed department applies various invoicing procedures tailored to the individual customers. Consequently, numerous indicators are required to accommodate for the various procedures. However, if the business unit adopts a unified invoicing approach, many indicators can be eliminated, reducing both the duration of the post-calculation process and the overall invoicing process. Currently, the department dedicates 1,5 FTE to assess the invoicing data. Implementing a standardized invoicing protocol will minimize the data and therefore shorten the duration of the assessment.

Furthermore, there exists a multitude of various definitions for indications and parameters across the company. In this study, the definitions within the uniform post-calculation model have been outlined. Establishing additional definitions within the company will reduce confusion and discrepancies in the data.

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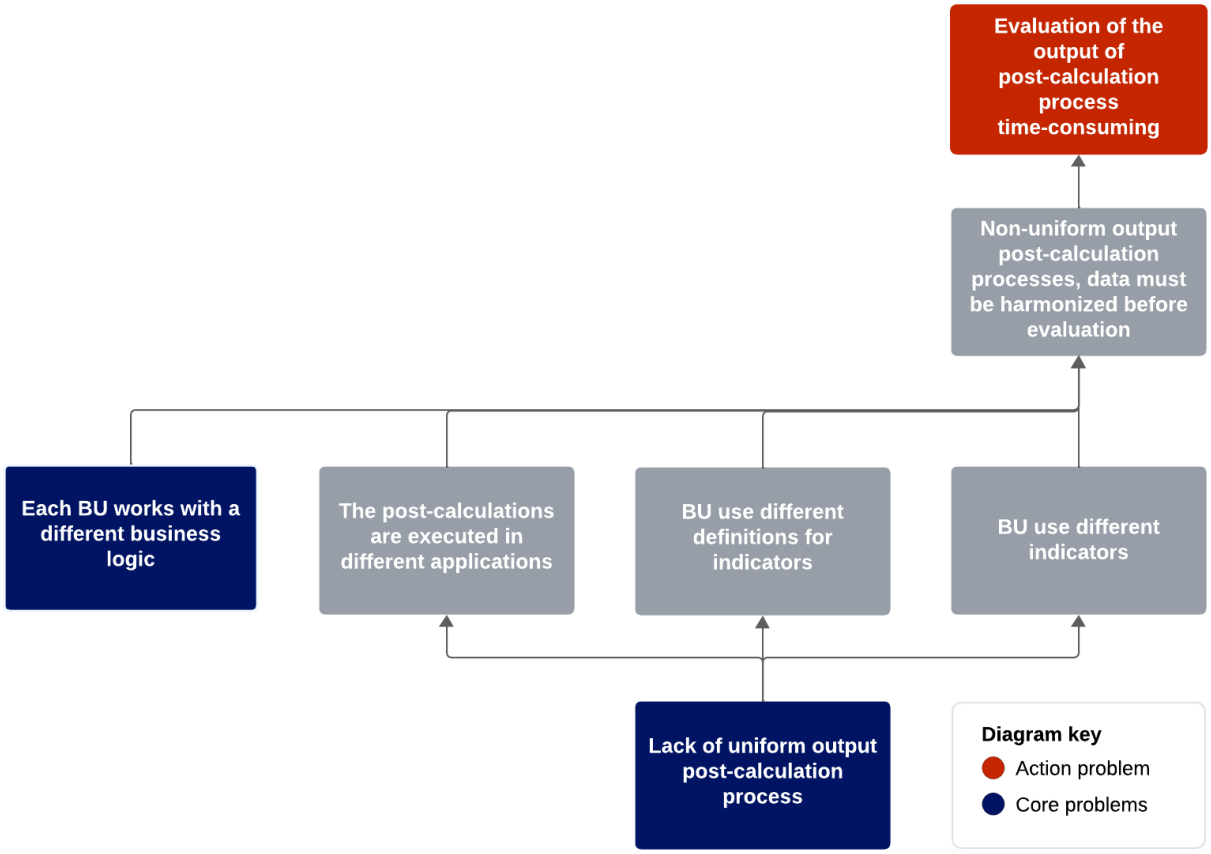
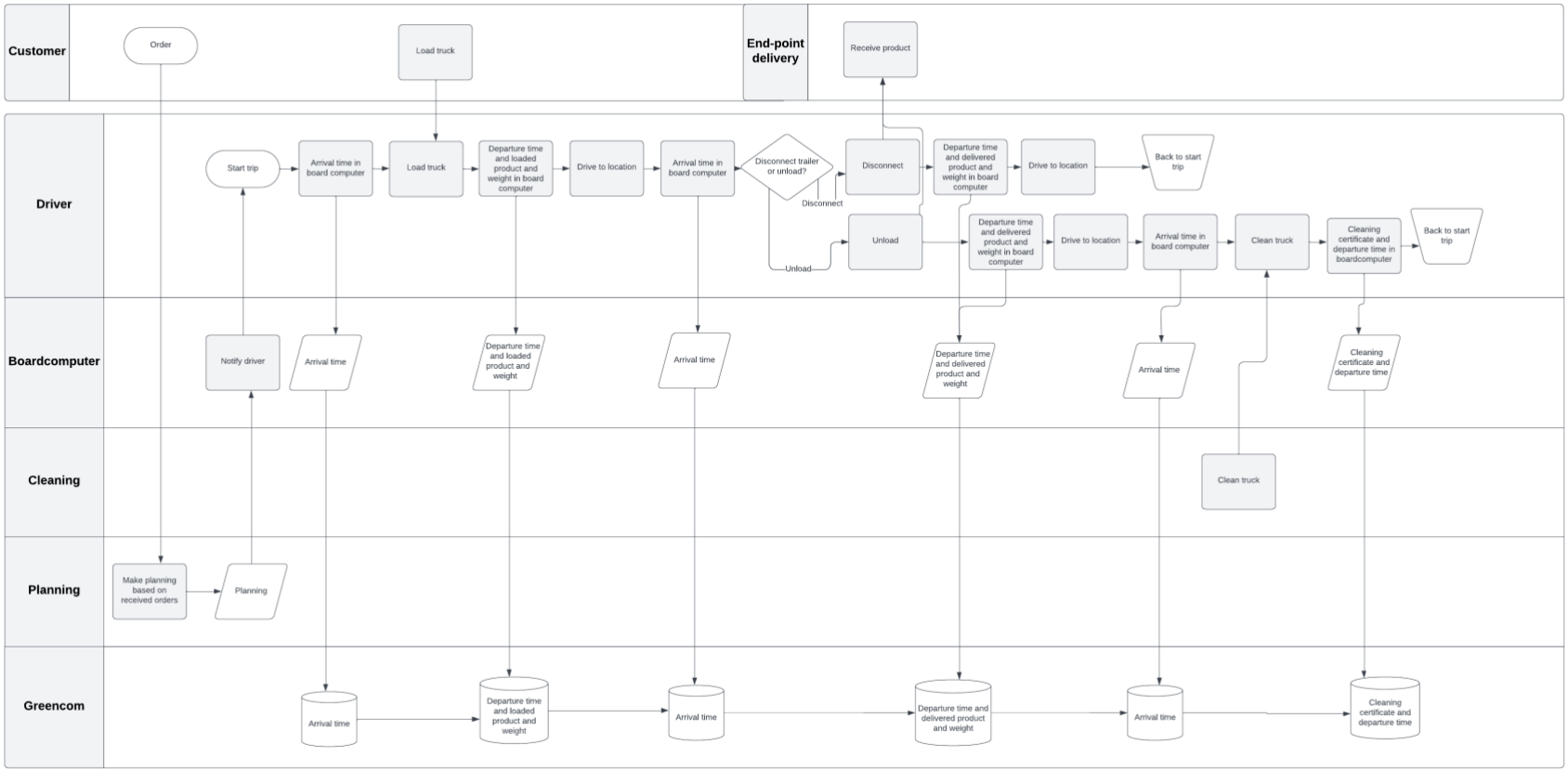
Appendix

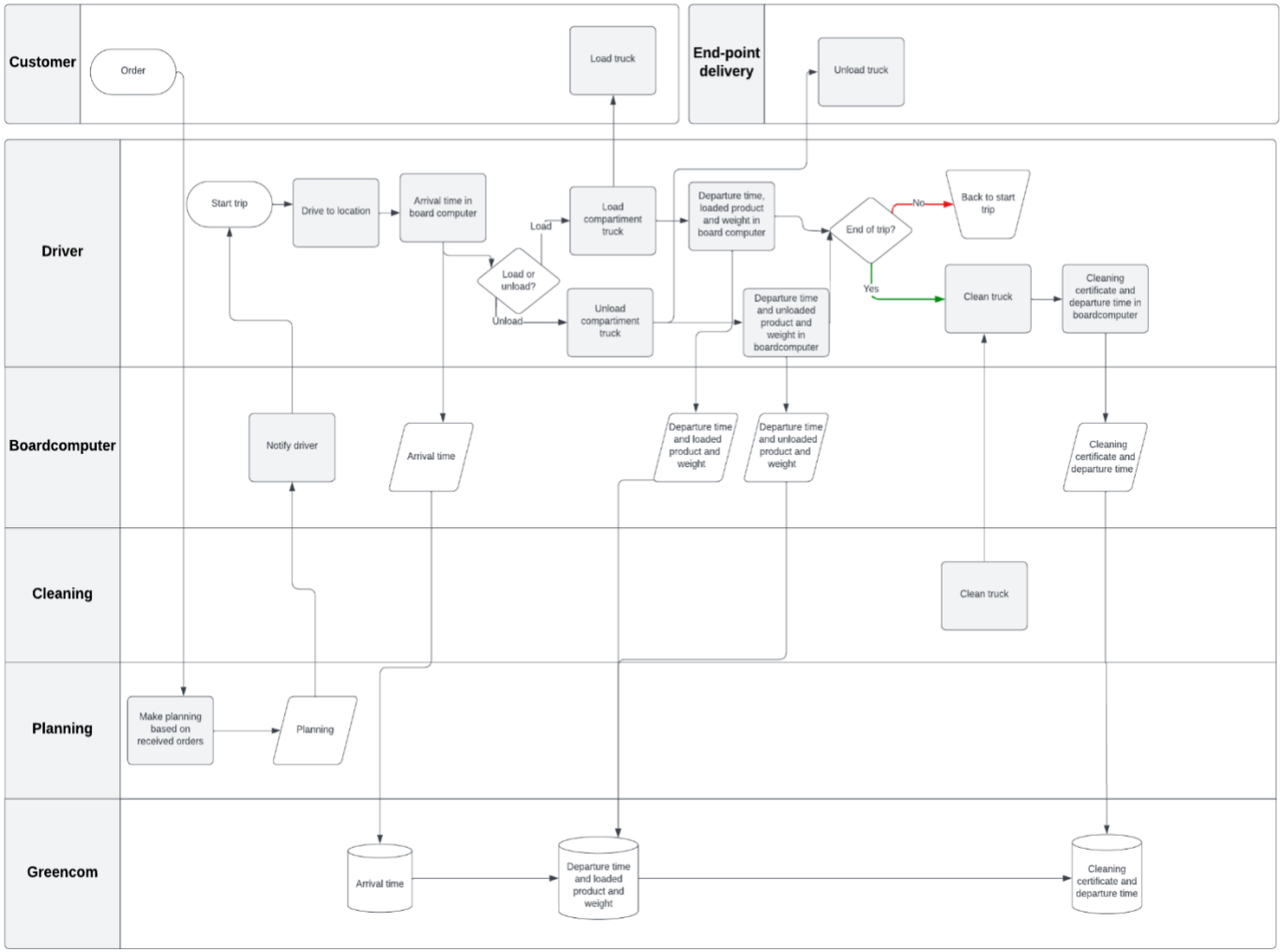
A.1 Problem cluster



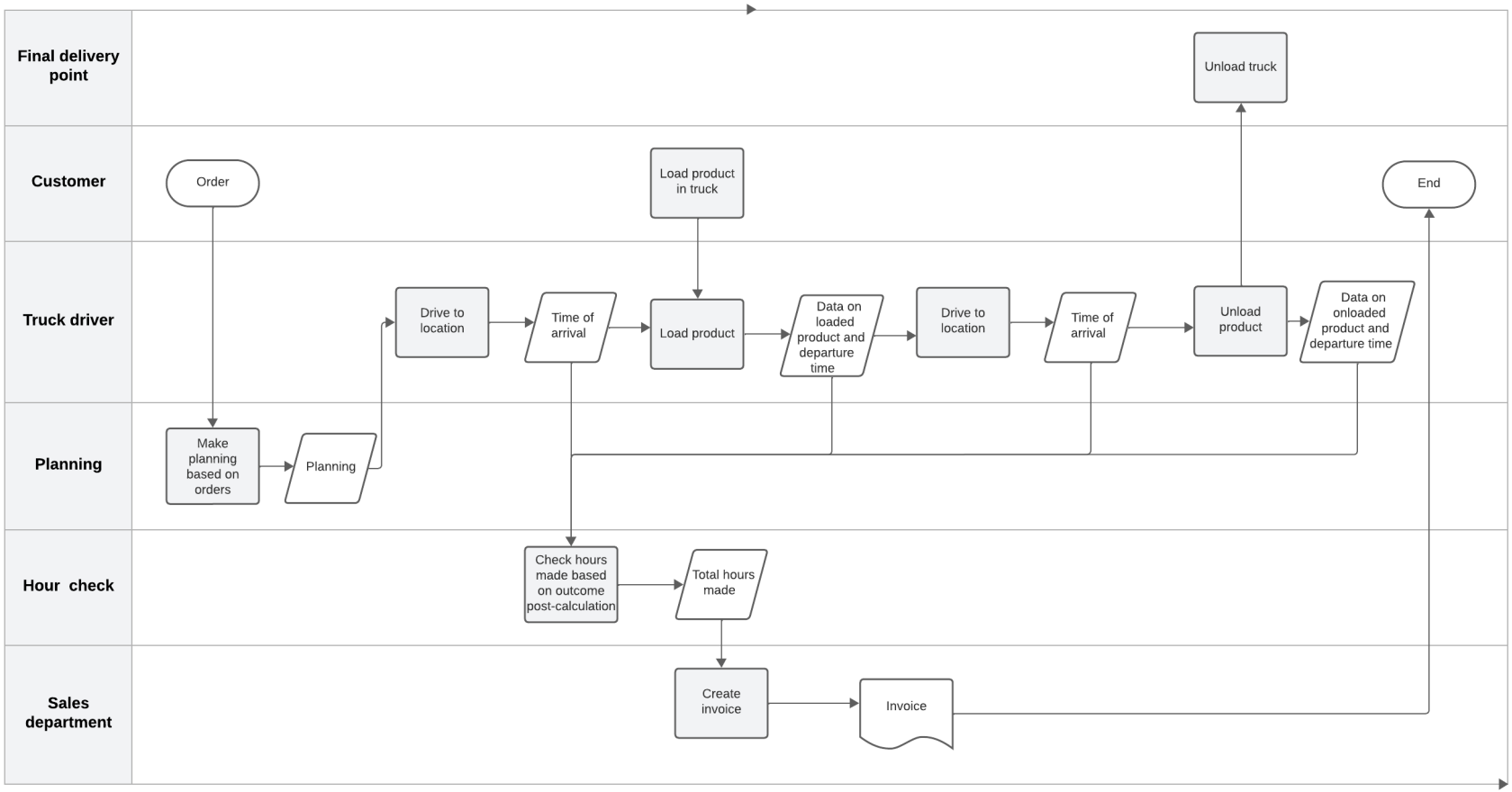
A.2 Process flowchart Chemical Logistics and Wemmers Transport



A.3 Process flowchart Feed Logistics



A.4 Process flowchart



A.5 Interview questions

Doel van het onderzoek: Het ontwerpen van een uniform nacalculatie format toepasbaar op alle bedrijfsonderdelen.

Doel van het interview: Inzicht krijgen in de huidige nacalculatie en de wensen voor een nieuw nacalculatie proces in kaart brengen.

Soort vragen: open vragen

Volgorde van vragen: Vragen over de huidige situatie gevolgd door vragen over de gewenste situatie.

Huidige situatie:

Vraag 1: Wat vind je van de huidige nacalculatie van het bedrijfsonderdeel?

Vraag 2: Waar liggen mogelijke verbeterpunten?

Vraag 3: Hoeveel tijd kost het uitvoeren en analyseren van de nacalculatie nu?

Vraag 4: Hoeveel tijd kost het nu om een nieuw bedrijfsonderdeel aan te sluiten?
200 uur

Gewenste situatie:

Vraag 5: Wat zijn de vereisten voor een nieuw nacalculatie proces?

Vraag 6: Wat zou voor jullie de voordelen zijn van een uniform nacalculatie proces?

Vraag 7: Welke indicatoren zijn noodzakelijk voor de nacalculatie?

Vraag 8: Welke indicatoren zijn niet per se noodzakelijk (maar wel een goede aanvulling)?

Research objective: To design a uniform post-calculation format applicable to all business units involved.

Interview objective: Gain insight into the current post-calculation process and identify the requirement for the new post-calculation process.

Question type: open questions

Order of questions: Questions about the current situation followed by questions about the desired situation.

Current situation:

Question 1: What do you think of the current post-calculation process of your business unit?

Question 2: What are the possible points of improvement?

Question 3: How much time does it take to carry out and analyse the post-calculation process and output?

Question 4: How much time does it take to connect a new business unit?

Desired situation:

Question 5: What are the requirements for a post-calculation process?

Question 6: What would be the advantages for you when a uniform post-calculation process is implemented?

Question 7: Which indicators are necessary within the post-calculation process?

Question 8: Which indicators are not necessary (but would be a good addition)?

A.6 Transcript interviews

It is important to note that the interviews were originally conducted in Dutch, therefore the interviews are translated, resulting in edited transcripts

Transcript interview manager Wemmers Transport and Chemical Logistics
Introduction provided by the interviewee:
The post-calculation process results in a margin calculation and insight into the costs and profits of the business unit. For chemicals, there is fixed price which is contracted with the customer. For Wemmers Transport, the duration of the trip is charged to the customer. The data used in the post-calculation process originates from the TMS, the planning package and the board-computer. The aim is to coordinate these to that the journey can be followed in the three applications.
At Wemmers, the main task was to add a unique code to the journey, so that the trip can be traced in all applications.
The process of tracing the journey works well with silo, tank and Wemmers. However, it is not possible to trace the intermodal part of a trip.

Current situation:

Question 1: What do you think of the current post-calculation process of your business unit?
The current post-calculation process works quite well. Currently, there is a 95% reliability, which is good compared to other companies.

Question 2: What are the possible points of improvement?
The container cannot be traced in the intermodal part of a trip, this can be improved. Additionally, the fuel department (part of Chemical Logistics) is not part of the post-calculation process. The connection and completion of all departments ensure that the processes are under control.

Question 3: How much time does it take to carry out and analyse the post-calculation process and output?
Chemical Logistics: Exporting from NaviTrans takes 1 hour, importing the data into the Reporting server and Qlik Sense takes 4 hours for a month's worth of data, street work (assessing and cleaning the data) takes 2 to 3 hours. Calculating the costs takes 0.5 hours, then everything is checked by the Application department, which takes 15 minutes.
Wemmers Transport: Everything is executed manually, the execution of the process and assessing the data requires 2 to 3 hours. Adding data takes 3 hours.

Question 4: How much time does it take to connect a new business unit?
This differs per business unit, however adding the unique number (TripId) always takes up a lot of time.

Desired situation:

Question 5: What are the requirements for a post-calculation process?
A unique number for a trip, the TripId is required. This already exists in Wemmers Transport.

Question 6: What would be the advantages for you when a uniform post-calculation process is implemented?
The uniform post-calculation model accommodates an easy and quick connection of new business units, it provides simplicity.

Question 7: Which indicators are necessary within the post-calculation process?
The uniform key, the TripId is necessary. Moreover, the travelled distance and duration of the trip are required.

Question 8: Which indicators are not necessary (but would be a good addition)?
It would be nice to make room for the fuel consumption and CO2 emissions. Additionally, a parameter indicating whether a trailer is full or empty would be a good addition.
An inventory of what goes wrong, often the same things go wrong. It would be a good idea to write a manual with error codes and their solutions.

Transcript interview manager Feed Logistics
Current situation:

Question 1: What do you think of the current post-calculation process of your business unit?
In the current situation, there is a lot of manual labour. The data is assessed by the hour check department, the department checks the data on the hours that are paid to the driver. Then, the data is sent to Feed Support, where the data is analysed based on the requirements of generating an invoice. This process is executed in Excel, making it difficult to trace which changes have been made, by who and when. There is room for improvement.

Question 2: What are the possible points of improvement?
As discussed in question 1, the data assessing of Feed Support is not efficient, there is no system in it.

Question 3: How much time does it take to carry out and analyse the post-calculation process and output?
It takes 5 to 6 man-days per week to analyse one week worth of data by Feed Support.

Question 4: How much time does it take to connect a new business unit?
This is difficult to answer, the duration varies per situation and business unit.

Desired situation:

Question 5: What are the requirements for a post-calculation process?
The duration of a trip, full distance, empty distance, full consumption, loading time and unloading time are required.

Question 6: Which indicators are necessary within the post-calculation process?
It is difficult to remove indicators from the current post-calculation process since the data is also used as KPI's which are send to the customers. The most complex is to generate an invoice for the company Agrifirm.

Question 7: Which indicators are not necessary (but would be a good addition)?
To make the model future-proof, it is important to add the fuel consumption and CO2 emission.

Transcript interview employee Feed Logistics

Question: Which indicators are required for generating invoices?
Invoices are generated based upon three different categories: some invoices are generated based upon pre-agreed rates, other based on the duration of a trip wile others are charged based upon the transported weight.

This results in the following indicators:

1. Customer
2. The loading and unloading address, this is used to determine the travelled distance. Moreover, this shows which trip is executed, used in invoicing based upon pre-agreed rates.
3. Indicator showing whether the trip is executed in the weekend/evening, this is important to calculate the labour costs.
4. Loading time, unloading time, driving time, other time, waiting time. The loading, unloading, driving, and waiting time are important, because there are different agreements with customers about the costs charged for these times. Other time indicates whether an action in the trip is not justified right, and therefore provides insight in the quality of the data.
5. TripId, this is a unique Id used for tracing back the trip in different applications.
6. Trailer number, sometimes the trip is executed by a charter, the trailer number shows which trailer is used.
7. Truck number
8. Unloaded weight, some customers are charged based upon the unloaded weight.
9. The reference number
10. Cost center, this code shows whether a charter is used, it does not provide insight in which charter.

A.7 Consent form interview

Informatieblad voor onderzoek 'Optimalisatie nacalculatie proces'

Doel van het onderzoek
Dit onderzoek wordt geleid door Josefien Idzes.
Het doel van dit onderzoek is het ontwerpen van een uniform nacalculatie format

Hoe gaan we te werk?
U neemt deel aan een onderzoek waarbij we informatie zullen vergaren door: U te interviewen en uw antwoorden te noteren/op te nemen via een audio-opname/video- opname. Er zal ook een transcript worden uitgewerkt van het interview.

Potentiële risico's en ongemakken
Er zijn geen fysieke, juridische of economische risico's verbonden aan uw deelname aan deze studie. U hoeft geen vragen te beantwoorden die u niet wilt beantwoorden. Uw deelname is vrijwillig en u kunt uw deelname op elk gewenst moment stoppen.

Vergoeding
U ontvangt voor deelname aan dit onderzoek geen vergoeding.

Vertrouwelijkheid van gegevens
Wij doen er alles aan uw privacy zo goed mogelijk te beschermen. Er wordt op geen enkele wijze vertrouwelijke informatie of persoonsgegevens van of over u naar buiten gebracht, waardoor iemand u zal kunnen herkennen.
Voordat onze onderzoeksgegevens naar buiten gebracht worden, worden uw gegevens zoveel mogelijk geanonimiseerd, tenzij u in ons toestemmingsformulier expliciet toestemming heeft gegeven voor het vermelden van uw naam, bijvoorbeeld bij een quote.

In een publicatie zullen anonieme gegevens of pseudoniemen worden gebruikt. De audio-opnamen, formulieren en andere documenten die in het kader van deze studie worden gemaakt of verzameld, worden opgeslagen op een beveiligde locatie bij de Universiteit Twente en op de beveiligde (versleutelde) gegevensdragers van de onderzoekers.
De onderzoeksgegevens worden bewaard voor een periode van 10 jaar. Uiterlijk na het verstrijken van deze termijn zullen de gegevens worden verwijderd of worden geanonimiseerd zodat ze niet meer te herleiden zijn tot een persoon.
De onderzoeksgegevens worden indien nodig (bijvoorbeeld voor een controle op wetenschappelijke integriteit) en alleen in anonieme vorm ter beschikking gesteld aan personen buiten de onderzoeksgroep.

Tot slot is dit onderzoek beoordeeld en goedgekeurd door de ethische commissie van de faculteit BMS(domain Humanities & Social Sciences).

Vrijwilligheid
Deelname aan dit onderzoek is geheel vrijwillig. U kunt als deelnemer uw medewerking aan het onderzoek te allen tijde stoppen, of weigeren dat uw gegevens voor het onderzoek mogen

worden gebruikt, zonder opgaaf van redenen. Het stopzetten van deelname heeft geen nadelige gevolgen voor u of de eventueel reeds ontvangen vergoeding.
Als u tijdens het onderzoek besluit om uw medewerking te staken, zullen de gegevens die u reeds hebt verstrekt tot het moment van intrekking van de toestemming in het onderzoek gebruikt worden.
Wilt u stoppen met het onderzoek, of heeft u vragen en/of klachten? Neem dan contact op met de onderzoeksleider.

Josefien Idzes
Josefien.idzes@nijhofwassinkgroup.com

Voor bezwaren met betrekking tot de opzet en of uitvoering van het onderzoek kunt u zich ook wenden tot de Secretaris van de Ethische Commissie/ domein Humanities & Social Sciences van de faculteit Behavioural, Management and Social Sciences op de Universiteit Twente via ethicscommittee-hss@utwente.nl. Dit onderzoek wordt uitgevoerd vanuit de Universiteit Twente, faculteit Behavioural, Management and Social Sciences. Indien u specifieke vragen hebt over de omgang met persoonsgegevens kun u deze ook richten aan de Functionaris Gegevensbescherming van de UT door een mail te sturen naar dpo@utwente.nl.

Tot slot heeft u het recht een verzoek tot inzage, wijziging, verwijdering of aanpassing van uw gegevens te doen bij de Onderzoeksleider.

Door dit toestemmingsformulier te ondertekenen erken ik het volgende:

1. Ik ben voldoende geïnformeerd over het onderzoek door middel van een separaat informatieblad. Ik heb het informatieblad gelezen en heb daarna de mogelijkheid gehad vragen te kunnen stellen. Deze vragen zijn voldoende beantwoord.
2. Ik neem vrijwillig deel aan dit onderzoek. Er is geen expliciete of impliciete dwang voor mij om aan dit onderzoek deel te nemen. Het is mij duidelijk dat ik deelname aan het onderzoek op elk moment, zonder opgaaf van reden, kan beëindigen. Ik hoef een vraag niet te beantwoorden als ik dat niet wil.

Naast het bovenstaande is het hieronder mogelijk voor verschillende onderdelen van het onderzoek specifiek toestemming te geven. U kunt er per onderdeel voor kiezen wel of geen toestemming te geven. Indien u voor alles toestemming wil geven, is dat mogelijk via de aanvinkbox onderaan de stellingen.

3. Ik geef toestemming om de gegevens die gedurende het onderzoek bij mij worden verzameld te verwerken zoals is opgenomen in het bijgevoegde informatieblad.	JA □	NEE □
4. Ik geef toestemming om tijdens het interview opnames (geluid /beeld) te maken en mijn antwoorden uit te werken in een transcript.	□	□
Ik geef toestemming voor alles dat hierboven beschreven staat.	□	

Naam Deelnemer:

Naam Onderzoeker:
Josefien Emma Idzes

Handtekening:

Handtekening:

Datum:

Datum:

A.8 Systematic Literature Review

The (sub) research question: "How do other customization companies execute the post-calculation process?" is answered by conducting a systematic literature review. The research question might be perceived as too wide or broad, however, not much research is available on post-calculation processes in business.

Criteria

Inclusion	Motivation
The article must be retrieved from academic sources.	This ensures quality and reliability of the source.
The research field should relate to post-calculation or recalculation.	At least one of the key words should correspond with the source, otherwise the literature does not match with the research question. recalculation is frequently used as a synonym, for post-calculation.

Exclusion	Motivation
The article is outdated (written before 2000).	This ensures relevance and reliability of the source.
Reports from unknown languages (other than Dutch and English).	If the language is not understandable, the interpretation of the researcher might be wrong.
Full report is not accessible.	The researcher might miss important information because the article is not fully accessible.

Academic databases

The main databases used for this systematic literature review are Scopus and ScienceDirect, as all articles are fully accessible with a membership. Moreover, the use of Scopus and ScienceDirect is rather easy. Additionally, the database Web of Science might be used.

Search terms

Key concepts	Broader concepts	Related terms
Post-calculation	"Post-calculation*"	Costs, Costing
Uniform		Improved
Recalculation	"recalculation*"	
Transport	"Transportation"	Logistics
Business	"Business*"	

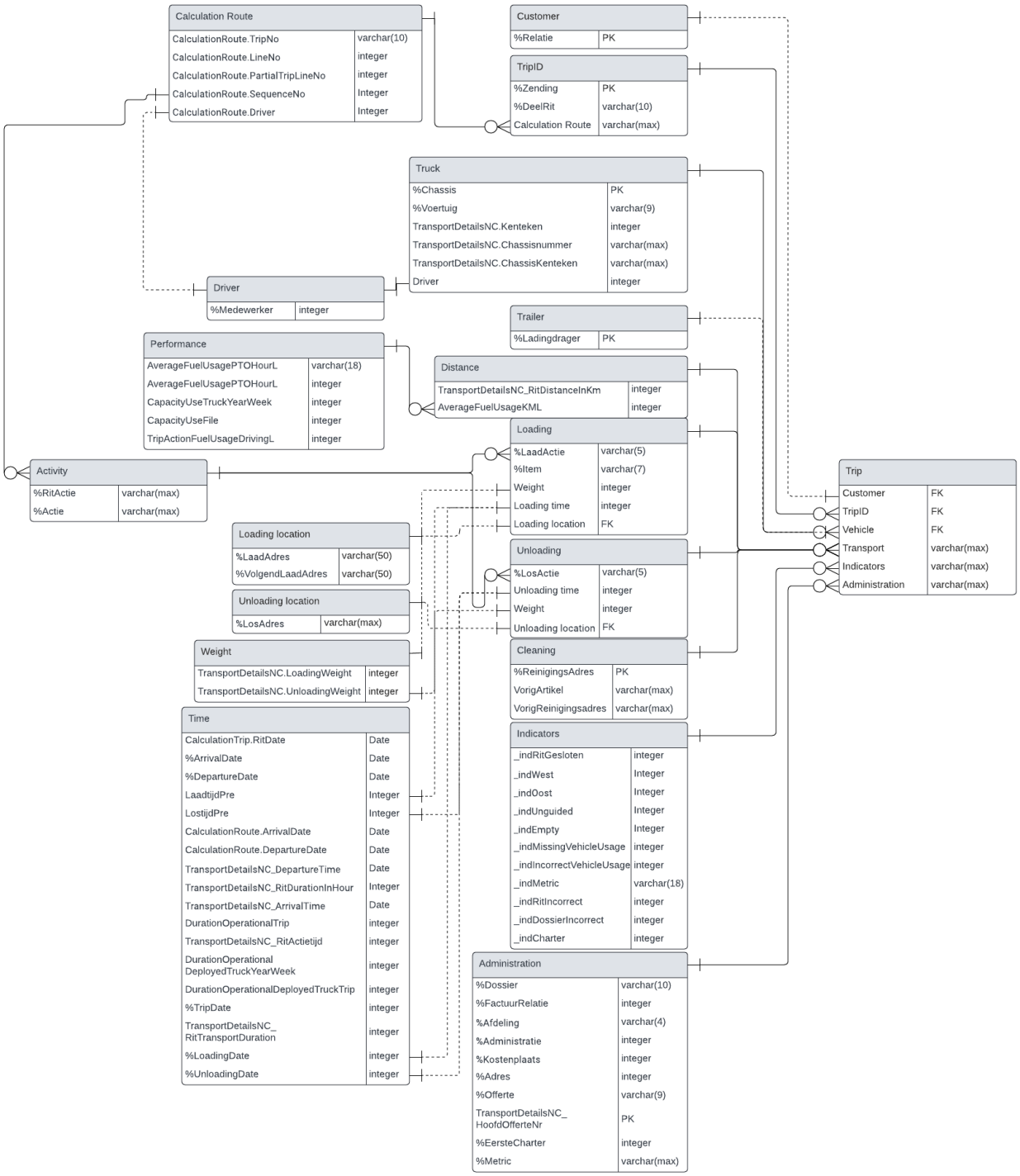
Results

Date	Database	Search string	Total articles	Notes
09-11	Scopus	TITLE-ABS-KEY (post-calculation OR "post-calculation*")	80	Right amount of articles, however result does not fit research question
09-11	Scopus	(TITLE-ABS-KEY (post-calculation OR "post-calculation*") AND KEY (logistics OR business))	0	Too narrow
09-11	Scopus	(TITLE-ABS-KEY (recalculation) AND TITLE-ABS-KEY (business))	47	Many relevant articles, but not specific enough to answer the research question
09-11	Scopus	(TITLE-ABS-KEY (recalculation) AND KEY (transport))	54	Many relevant sources, also targeting greenhouse effect
5-12	ScienceDirect	(TITLE-ABS-KEY (transportation) AND (emission) AND (cost calculation)	68	Contains several relevant sources

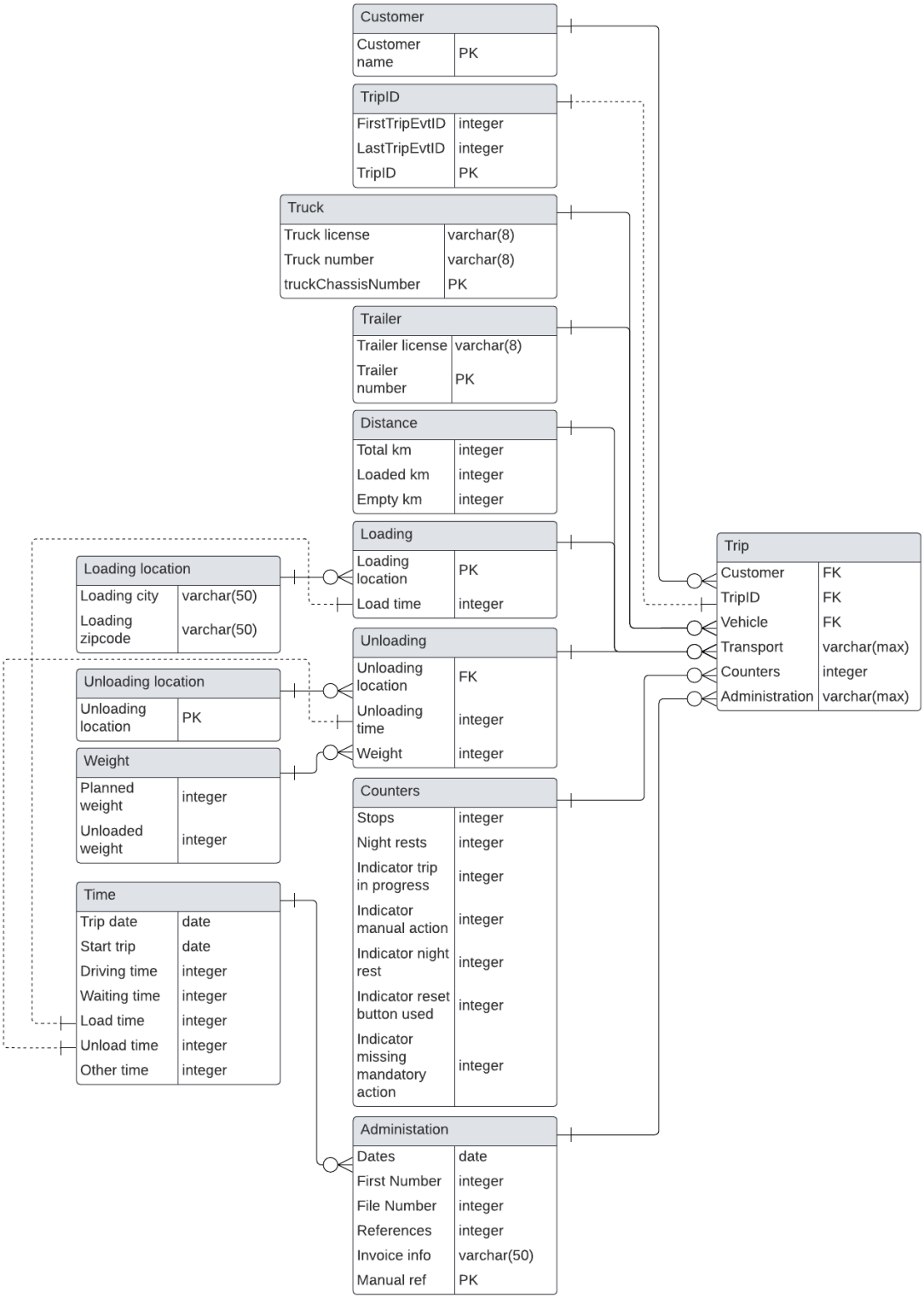
During the screening, many articles turned out to be irrelevant, written in an unknown language or not fully available. The number of useful articles turned out to be very limited.

Article & number of citations ↓ / concepts →	Post-calculation should contain direct costs, data on goods, efficiency indicators, fixed costs**,** and business specific parameters	The post-calculation should contain the distance, travel time and value of time	The effect on the environment should be accounted in the post-calculation process
(ANDRZEJ IWANIUK, 2018), 2 citations	X	X	X
(DAVID MCNAMARA, 2013), 27 citations		X	X
(JIN FAN, 2015), 48 citations	X	X	

A.9 ERD Chemical Logistics



A.10 ERD Feed Logistics



A.11 ERD Wemmers Transport