

Extending the control tower at ShipitSmarter

Designing a tool to analyse carrier performance and perform what-if analyses

An IEM master thesis project carried out at ShipitSmarter

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Management Summary

This thesis project is carried out at ShipitSmarter, an independent IT service provider active in the supply chain and logistics sector. We formulated the following main research question:

MQ: How can ShipitSmarter extend the Control Tower proposition to provide support on all levels (operational, tactical and strategic) by incorporating business intelligence capabilities?

ShipitSmarter provides a control tower function for its customers and our analysis of control towers shows that ShipitSmarter has the operational functions in place. The main issue is the lack of tools for reporting and analysis to support the customers in making decisions on tactical and strategic levels.

The goal of this research is to design a tool for analysis of the performance of carriers, and to design a what-if analysis tool to simulate different scenarios. In order to reach this goal, we answered four research questions:

RQ1: What performance indicators should be included in the performance analysis tool of ShipitSmarter?

We reviewed literature on performance measurement in the logistics and transportation sector to obtain a list of performance indicators that are used in the sector of ShipitSmarter. We applied the stakeholder approach by analyzing the contracts and relations between carriers and customers. Based on this approach and the indicators from literature we selected the carrier performance indicators for the data analysis tool. These are presented in figure 1, and grouped under shipment cost, service quality, and throughput.

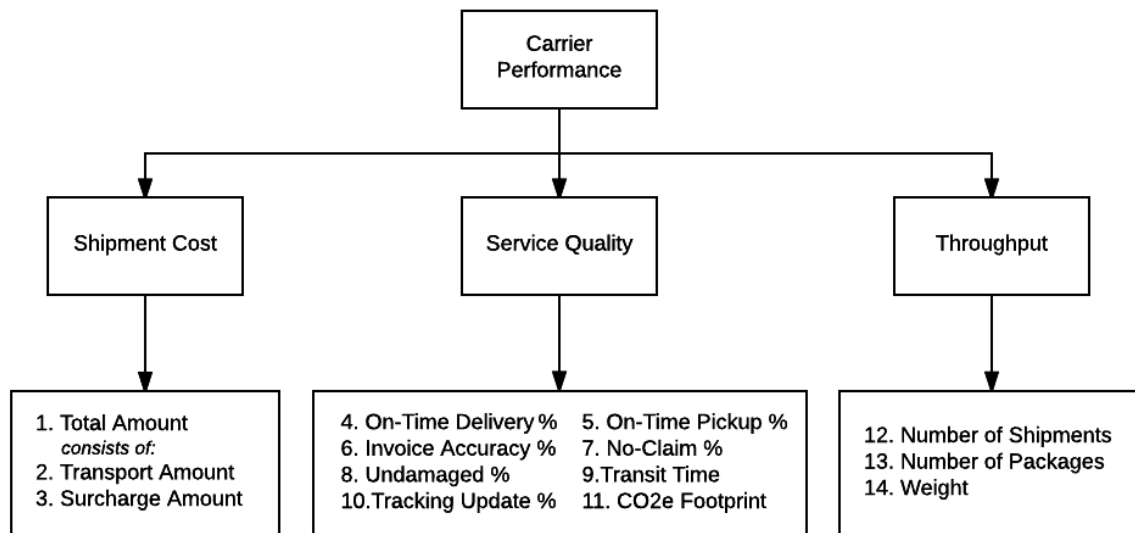


Figure 1 - The selected performance indicators for the data analysis tool

RQ 2: What is an effective what-if analysis model for ShipitSmarter?

We defined the objectives of the what-if analysis and described five types of scenarios that we want to simulate. Based on these objectives we defined the input and output variables of the model. The main

output variables are shipment cost and transit time. The main input variables are the carrier and service level used for the shipment, the warehouse location of the shipment, the available tariff sets, and the shipment data set that contains the shipment types that we simulate. We defined all shipment attributes required to perform the what-if analysis. Based on our understanding of the situation and the input and output variables, we proposed a conceptual model for the what-if analysis. Finally, we proposed three approaches to generate the shipment data set used as input for the simulation.

RQ 3: What is the quality of the required input data?

We analysed the availability and collectability of the data, analysed the available data based on twenty data quality dimensions and finally concluded whether the data was of sufficient quality for use. We conclude that the data are available and of good quality for the shipment cost and throughput indicators, but the input data for the service quality indicators is incomplete for 6 out of 8 indicators. For the on-time delivery rate, the input data is in some cases incomplete and unreliable. The input data for the what-if analysis are available and of quality.

RQ 4: What do the prototypes for the data analysis tools look like?

We created four reports in QlikSense for the prototype of the reporting tool in QlikSense. (See table 1)

Table 1 - Reports in the prototype of the reporting tool

1	Carrier Performance Scorecard This report gives an overview of all performance indicators for a carrier.
2	Spend Details This report shows the total spend per month in 2015 and 2016 for the selected shipments.
3	Warehouse Spend Overview This report gives an overview of spend per warehouse in 2015 and 2016, and shows the distribution of spend over carriers and service levels
4	On-time Delivery Overview This report gives an overview of on-time delivery rate of carriers in the selected period.

We created a prototype of the what-if analysis tool to provide a proof of concept and ran an example. This example illustrates the processes described in the conceptual model of the what-if analysis.

Based on our findings we recommend ShipitSmarter to take action on:

1. Create data generation/collection processes for the unavailable input data of selected performance indicators.
2. Review data generation/collection processes to ensure high quality input data for performance indicators.
3. Develop and implement the what-if analysis tool.
4. Develop and implement the data analysis tool.

Preface

This is my thesis to complete the Production and Logistics Management track of the master program Industrial Engineering and Management at the University of Twente. I wrote the thesis during my internship at ShipitSmarter, an independent IT service provider active in the supply chain and logistics sector.

In my internship I worked part-time on my thesis, and part-time on other projects at ShipitSmarter. Because of these shared responsibilities, the progress on the thesis wasn't always as good as I had hoped. In the final months of my internship the focus got back on the thesis and this allowed me to make progress much faster, finally leading to this report.

My thanks go out to ShipitSmarter and all its employees for providing me an opportunity to do my internship and thesis. I want to thank my company supervisors Pieter Nijman and Peter Lakenman who helped me understand some difficult situations in my thesis, and helped me to find the solutions. I also want to thank my University supervisors Fons Wijnhoven and Peter Schuur, who provided valuable feedback during our progress meetings that allowed me to improve my thesis. Finally, I want to thank my parents, sister and friends for their ongoing support and believe in me.

Lars Rozema

Hilversum, July 2016

Table of Contents

Management Summary	ii
Preface	iv
Chapter 1 - Introduction	1
1.1 ShipitSmarter	1
1.2 Control Towers.....	6
1.3 Problem Identification	8
1.4 Research Goals.....	9
1.5 Research Questions	10
1.6 Thesis Structure	11
Chapter 2 – Theory and Methods.....	13
2.1 Performance Measurement.....	13
2.1.1 Theory	13
2.1.2 Methods.....	16
2.1.3 Method Selection.....	18
2.2 What-if Analysis	19
2.2.1 Theory	19
2.2.2 Methods.....	21
2.2.3 Method Selection.....	23
2.3 Data Quality Analysis	24
2.3.1 Theory	24
2.3.2 Method	25
2.4 Prototype Creation.....	25
2.5 Conclusion on Research Approach	26
Chapter 3 - Performance Indicator Selection	27
3.1 Indicators in literature	27
3.2 Selecting Performance Indicators	29
3.3 Definition of the Performance Indicators	30
3.3.1 Shipment Cost Performance Indicators	30
3.3.2 Service Quality Performance Indicators	32
3.3.3 Throughput Performance Indicators.....	34
3.4 Conclusion.....	34

Chapter 4 – What-If Analysis Design.....	35
4.1 Understanding the Situation.....	35
4.2 Objectives.....	38
4.3 Inputs and Outputs	39
4.4 Model Content.....	41
4.4.1 Model Processes	41
4.4.2 Shipment Attributes.....	43
4.5 Generating Shipment Data Sets.....	44
4.6 Conclusion.....	46
Chapter 5 – Data Quality Analysis.....	47
5.1 Performance Indicator Input Data Analysis	47
5.1.1 Shipment Cost Performance Indicators	47
5.1.2 Service Quality Performance Indicators	48
5.1.3 Throughput Performance Indicators.....	50
5.2 What-if Analysis Input Data Analysis	51
5.3 Conclusion.....	52
Chapter 6 – Prototype Creation.....	53
6.1 Reporting Tool Prototype	53
6.2 What-if Analysis Tool Prototype	58
6.3 Conclusion.....	64
Chapter 7 - Conclusions and Recommendations	65
7.1 Conclusions	65
7.2 Recommendations	67
7.3 Lessons Learned.....	68
7.4 Further Research.....	68
Bibliography	69

Chapter 1 - Introduction

In this chapter, we give an introduction to the thesis. In section 1.1, we introduce ShipitSmarter and its processes. In section 1.2, we review the definition and functions of a control tower. In section 1.3, we identify the problems ShipitSmarter faces, which leads to the research goals in section 1.4. In section 1.5, we define the research questions, and we end the chapter in section 1.6 where we give an overview of the thesis structure.

1.1 ShipitSmarter

The company ShipitSmarter is an independent IT service provider active in the supply chains of well-known national and international shippers and logistics service providers. The service of ShipitSmarter is provided via a SaaS (Software as a Service) model. Founded in 1999, ShipitSmarter has grown considerably over the years. Their specialty is finding smarter ways to ship packages, pallets and containers with their self-developed shipment management system. This system forms the core of the modular services it provides. Through the system, services like shipment management, spend management, multi-leg-, inbound- and reverse logistics are provided. This gives a control tower view on the customer's worldwide supply chain and provides excellent supply chain visibility (ShipitSmarter, 2016).

In the network of ShipitSmarter, three main types of actors are identified (see figure 1.1):

1. **ShipitSmarter:** Provides the shipment management service to the customer.
2. **Customer:** The customer of ShipitSmarter who uses the shipment management service. (e.g. 3M, Beckman Coulter)
1. **Carrier:** Provides transportation services for the customer (e.g. DHL, UPS, TNT)

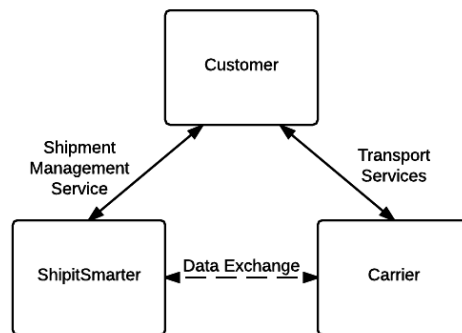


Figure 1.1 – Three types of actors involved in the network of ShipitSmarter

Relations between these types of actors are described as follows:

ShipitSmarter – Customer: ShipitSmarter provides the shipment management service as a SaaS solution. The customer has a contract with ShipitSmarter and pays an implementation price and a price per shipment sent with ShipitSmarter. ShipitSmarter maintains the service and provides support to the customer whenever required. The customer sends the tariff contracts they have with carriers to ShipitSmarter to be uploaded in the shipment management service.

Customer – Carrier: The carrier provides transportation services for the customer. The customer and carrier have a tariff contract which specifies all prices for sending shipments depending on sender

location, receiver location, number of packages, weight, service level, surcharges and many other variables. The customer requests and negotiates these contracts themselves and usually have contracts with several different carriers. The customer 3M for example, uses over 30 different carriers for their transport all throughout Europe.

ShipitSmarter – Carrier: ShipitSmarter exchanges information with the carrier regarding the customer. This includes transit times, shipment pickup requests, tracking updates, delivery information, electronic invoices, and more. Because ShipitSmarter needs a connection with every carrier their customers use, it has connections with over 600 different carriers. It is important to note that ShipitSmarter itself doesn't have contracts with the carriers, but only acts as a trusted third party between the customer and carrier.

There are many different customers and carriers, which leads to a gigantic network with many connections. Two simplified networks with three customers and four carriers are presented in figure 1.2.

The left graph in the figure displays the network without ShipitSmarter, where every customer and carrier have their own connections. Customer A has three carrier connections, and customer B and C have four carrier connections.

In the right graph ShipitSmarter has entered the network. ShipitSmarter has a connection with every carrier, and shares it with all of its customers. This means that each carrier and customer only requires one connection with ShipitSmarter. This leads to a network with a much lower number of connections.

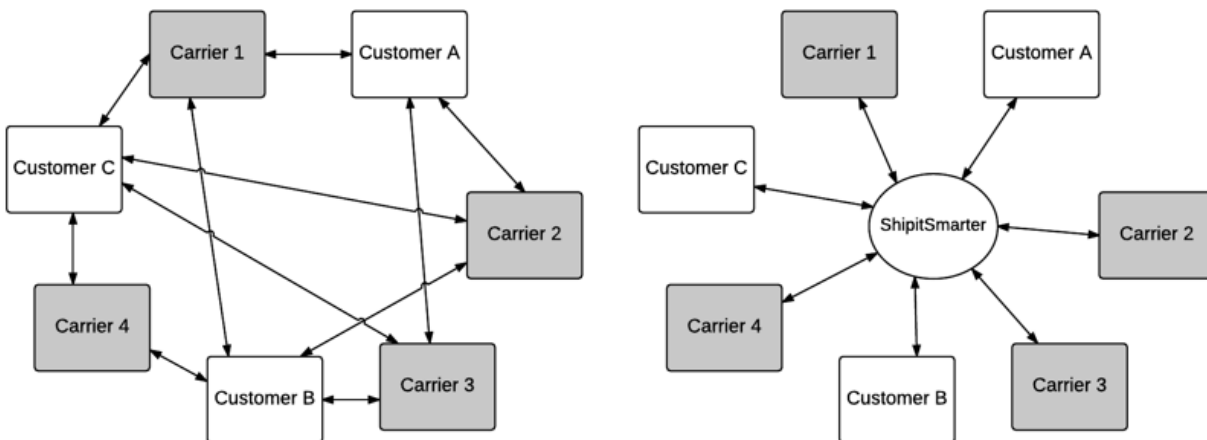


Figure 1.2 - Simplified customer-carrier network without ShipitSmarter (left graph) and with ShipitSmarter (right graph)

The shipment management service of ShipitSmarter revolves around the three-way matching principle (see figure 1.3). The purpose of this principle is to avoid paying incorrect invoices. The three-ways refer to the three documents that have to be matched before an invoice should be processed for payment:

Purchase order – States the details and price at which the customer agrees to buy the service.

Goods receipt – States the service that is delivered.

Invoice – The price the carrier requests to be paid for the service.

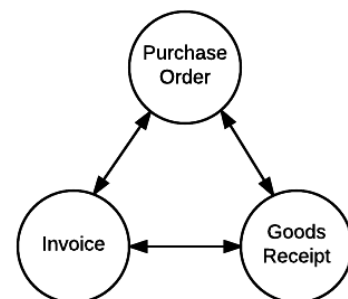


Figure 1.3 - Three-way matching

For transportation services, matching refers to the comparison of the price and the details like service level, quantity and shipment weight. If these values match on all documents then the invoice is assumed to be correct and can be safely processed for payment.

ShipitSmarter handles three-way matching through the following processes: (see figure 1.4)

- Customer receives an order in their order management system and uses ShipitSmarter to book shipments at their available carriers, either parcel, express, road, air, or ocean. Based on the entered data, the rate engine calculates the available service levels and prices from the carrier contracts. The customer then books the shipment at the carrier of choice and prints the label. The purchase order is created when a shipment is booked in ShipitSmarter.
- The carrier performs the requested service, delivers the goods, and sends the track and trace updates with the information of delivery to ShipitSmarter. This is the goods receipt.
- The carrier sends an invoice to the customer, and an e-invoice to ShipitSmarter through an EDI connection.

ShipitSmarter now has the three documents that are required for three-way matching. The documents are matched in the system and the customer is informed in case of any deviations. This system enables the customer’s freight payment specialists to only have to deal with exceptions. The customer performs the audit and exports the information to their financial management system for further processing.

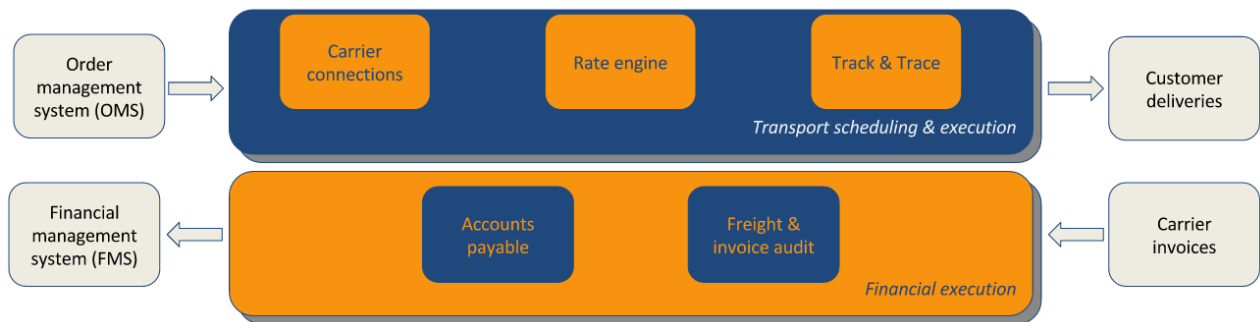


Figure 1.4 - Processes around the three-way matching principle

We now give an example of how a shipment can be manually booked in ShipitSmarter to explain how the system works.

Example:

Customer Beckman Coulter wants to send two packages containing medical supplies from their warehouse in Nyon, Switzerland to a hospital in Groningen, the Netherlands.

In order to do this, the five steps of figure 1.5 have to be performed:

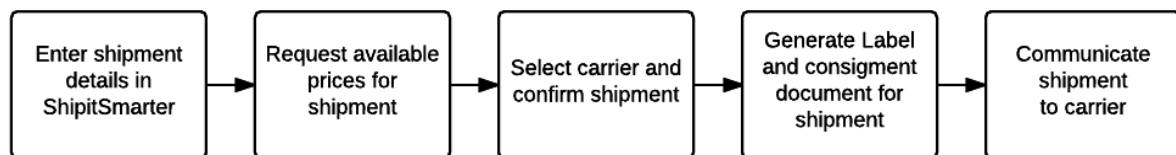


Figure 1.5 – Steps required for booking a shipment

Enter shipment details in ShipitSmarter

The customer populates the shipment information in ShipitSmarter. This includes names, addresses, package weight and dimensions, etc. (see figure 1.6):

From									
From	Beckman - Nyon			Address					
	Hide/Unhide								
	Rue Juste-Olivier		22						
				State/Province					
	1260		NYON						
				Switzerland			Save Address		
Destination									
To	UNIVERSITAIR MEDISCH CENTRUM GRONINGEN			Address					
Address line 1	JEVERWEG 3								
Address line 2				State/Province					
Zipcode / City	9723JE		GRONINGEN						
Country	Netherlands			Save Address					
Contact name									
Phone									
Email									
Duties & Taxes address									
	Hide/Unhide								
Third party address									
	Hide/Unhide								
Packages									
#	Pieces	Package	kg	Description	length	width	height	Weight	
1	2	Box 1	9	medical supplies	37	31	23	cm = 18	kg
2								cm =	kg
		BOX 1			52762		cm3	18	kg
Description									
Carrier instruction									
Special Remarks									
Dropoff id									
Pick-up date	<input checked="" type="checkbox"/>	1	March	2016	15:22				
Requested delivery date	<input type="checkbox"/>	1	March	2016					
Dangerous goods	No dangerous goods								
DG Packing instruction	No Lithium Batteries included UN3480 Lithium ion batteries 965 (section II & IB) UN3481 Lithium ion batteries packed with equipment 966 (section II)								
Scanned POD requested	No								
Declared value	EUR								
			Calculate prices + Print label		Calculate prices		Add		Print label

Figure 1.6 - Entering shipment details in ShipitSmarter

Request available prices for shipment

The customer presses the “Calculate prices” button. ShipitSmarter’s rate engine searches through the customer’s tariff contracts which are loaded in the database to calculate the available prices and service levels for each carrier, and shows them to the customer. Availability of a tariff is based on sender and receiver addresses, shipment weight and size, and many other variables. Additional information on fuel surcharges or other surcharges are displayed in this screen as well. (See figure 1.7)

	Carrier	Price	Delivery date	Service	Transit time
<input type="radio"/>	UPS Express	EUR 21.80	04-Mar-2016	UPS, mstandard,packages Incl. 3.900% fuel surcharge Rate converted from CHF to EUR with factor 0.902	Online: 3 day(s) 23:30
<input type="radio"/>	DHL Express	EUR 39.60	03-Mar-2016	DHL, economy,packages Incl. 5.250% fuel surcharge Rate converted from CHF to EUR with factor 0.902	Online: 2 day(s) 23:59
<input type="radio"/>	UPS Express	EUR 44.26	02-Mar-2016	UPS, saver,packages Incl. 8.300% fuel surcharge Rate converted from CHF to EUR with factor 0.902	Online: 1 day(s) 23:30
<input type="radio"/>	UPS Express	EUR 47.63	02-Mar-2016	UPS, express,packages Incl. 8.300% fuel surcharge Rate converted from CHF to EUR with factor 0.902	Online: 1 day(s) 12:00
<input type="radio"/>	DHL Express	EUR 61.23	02-Mar-2016	Express Incl. 9.375% fuel surcharge Rate converted from CHF to EUR with factor 0.902	Online: 1 day(s) 23:59
<input type="radio"/>	TNT Express	EUR 77.39	02-Mar-2016	Express Packages Incl. 6.000% fuel surcharge Customs Clearance, CHF 10.00 + 6.000% fuel surcharge (=9.56). Rate converted from CHF to EUR with factor 0.902	Online: 1 day(s) 18:00
<input type="radio"/>	TNT Express	EUR 92.04	03-Mar-2016	Economy Packages Incl. 3.750% fuel surcharge Customs Clearance, CHF 10.00 + 3.750% fuel surcharge (=9.36). Rate converted from CHF to EUR with factor 0.902	Online: 2 day(s) 18:00
<input type="radio"/>	UPS Express	EUR 439.37	10-Apr-2016	UPS, plus,packages Incl. 8.300% fuel surcharge Rate converted from CHF to EUR with factor 0.902	No online transit time found, this service might not be available
<input type="radio"/>	<input type="text" value="DHL Express"/>	EUR <input type="text"/>	<input type="text" value="Today"/>	<input type="text" value="EXPRESS"/>	

Choose one of the above shipment services and click :

All prices are excluding VAT / BTW / MWS

The calculation is based on a shipment from CH/1260 to NL/9723JE, 74 x 31 x 23 cm, 18.00 KG, DD-DDP-PP

Figure 1.7 – Available shipment prices selection screen in ShipitSmarter

Select carrier

The customer selects the option based on his preferences. In case he wants the lowest price he will select the option on top: UPS Express mstandard packages for €21,80 with a 3-day transit time. In case he needs the shipment to arrive as quickly as possible, he can choose UPS Express packages for €47,63 with a 1-day transit time and before 12:00 (noon) delivery. If the shipment has to arrive within 2 days, then the DHL Express economy packages for €39,60 with a 2-day transit time is a good option. Once an option is selected the screen will return to the shipment overview.

Generate label and consignment document for shipment

Once the customer selected his preferred carrier and service level, he can press the “Print label” button. ShipitSmarter uses the shipment information to generate an airwaybill, the label, and consignment document for the selected carrier. The customer then prints these documents and attaches them to the physical shipment in their warehouse.

Communicate shipment to carrier

At the same time ShipitSmarter sends the generated airwaybill, containing all the required shipment information, to the selected carrier. The carrier then picks up the shipment and delivers it on the specified date.

These are the steps required for manually booking a shipment. For customers like 3M who book 3 million shipments per year this would be impossible to do. So in practice most shipments are booked automatically from the customer’s ERP system using EDI and XML messages that contain rules on which actions to take. For example: select the cheapest option, or select TNT Express 1200.

These shipments generate a lot of data which is stored in ShipitSmarter's database. During transport the tracking information is shared with ShipitSmarter and when the shipment is delivered the IOD (information of delivery) is sent to ShipitSmarter as well. An electronic invoice is sent to ShipitSmarter in order to allow for invoice auditing.

ShipitSmarter considers its services to provide a control tower view that helps its customers manage parts of their supply chains. But what does the term control tower actually mean? In the next section we discuss the definition, the goals, and the functions of control towers, and how it is currently present at ShipitSmarter.

1.2 Control Towers

Capgemini Consulting (2011) describes the Supply Chain Control Tower as: "A supply chain control tower is a central hub with the required technology, organization and processes to capture and use supply chain data to provide enhanced visibility for short and long term decision making that is aligned with strategic objectives."

The term control tower is taken from airports, where the control tower uses flight information to keep an overview of all airplanes. From this central position, decisions are made to operate the airport according to schedule and to make important decisions in case of unplanned events. A plane has to be boarded by a certain time, then taxi to the runway, and finally take off. This can be compared to products in a supply chain which have to be picked up by a certain time, be transported and finally delivered. Both examples work with a time schedule and require resources - runways and trucks - to reach the end state.

The main goal of a control tower is to provide visibility to support decision making (Capgemini Consulting, 2011). The definitions in literature relate visibility to information sharing, but also mention the properties of the shared information. It should be relevant and meaningful (McCrea, 2005), and accurate, trustworthy, timely and useable (Caridi, Moretto, Perego, & Tumino, 2014). Other sources view visibility as taking action and decision making on the implications of data (Francis, 2008). The primary purpose of visibility is to allow for better-informed decisions in order to improve company performance (Caridi, Moretto, Perego, & Tumino, 2014).

Why is increased visibility suddenly required for supply chains? Traditional enterprise systems like ERP, MRP and DRP were invented when most companies were vertically integrated. Nowadays, logistics functions are often outsourced in order for companies to focus on their core competencies. This leads to lower prices for customers because of the increased specialization, but this also leads to increased complexity in the supply chain. Complexity refers to a system having many parts that all interact with each other in multiple ways, and gets harder to understand as more parts are connected. Increased visibility makes it easier to access and understand the interactions between these connected parts, leading to better-informed business decisions.

Supply chain visibility has gained much interest from both researchers and practitioners (Yu & Goh, 2014). Around 79% of large companies surveyed globally mentioned the lack of visibility as their top concern (Enslow, 2006). Heaney (2013) mentions that the top business pressures are the impact of increasing supply chain complexity and rising supply chain management costs.

One Network Enterprises (2014) states that the complexity of today's supply chains is overwhelming the ability to manage them. One of their recent surveys found that 85% of respondents felt that supply chain complexity is a significant and growing challenge for their operations.

Control towers offer a solution to this increasing complexity by combining people, systems and processes in order to provide visibility in the supply chain network. This enables three levels of management control (Capgemini Consulting, 2011):

- Strategic: control over the design of the supply chain network.
- Tactical: enables proactive planning of procurement, operations and distribution.
- Operational – real time functionalities including transportation management and exception management.

Capgemini Consulting (2011) mentions leading principles that are used in order to achieve supply chain visibility, these enable an end-to-end view of operations. These can most effectively be achieved with an integrated Control Tower solution that includes having the right people chosen and trained to act upon the data provided. These leading principles include:

- Create an information hub
- Track landed costs along the chain
- Manage trading partners with scorecards

ShipitSmarter provides the central information hub by integrating information from the customers, like order and shipment information from internal ERP, WMS and TMS systems, and by exchanging data with the carriers. The total cost including transport costs and surcharge costs are tracked for each shipment. The costs are stored in the system, and can be downloaded in detailed reports on shipment level. This is useful when detailed information is required on shipments, but when analysis has to be done on higher levels these reports do not give sufficient information.

The trading partners, in this case the carriers, should also be managed with scorecards. Lately customers have been requesting analysis on performance of carriers for carrier contract management. This is a function that ShipitSmarter wants to research and possibly add to its services.

Capgemini (2011) listed five functions that a control tower should include:

- **Planning and Routing:**
Planning, booking and tracking are functions that are included in ShipitSmarter.
- **Event Management:**
ShipitSmarter provides event management in the stages within the supply chain network related to shipping, such as shipment management, billing and invoicing.
- **Auditing and Reporting:**
Invoice auditing can be done easily in ShipitSmarter by comparing the data in ShipitSmarter with the received invoice of the carrier. Correct invoices are approved automatically and exceptions are manually reviewed by the customer. Shipment and invoice reports can be downloaded to assist with the auditing process.

- **Forecasting:**
Making predictions at the operational level about ETAs or forecasting supply chain costs and demand. This function is currently not present and ShipitSmarter wants to research the possibilities to extend this and add it to its services.

- **Decision Making Support:**
Currently there is no centralized accountability and responsibility for cost, quality and performance in ShipitSmarter. A platform to display this information for tactical and strategic decision making is a function that ShipitSmarter wants to add to its services.

These control tower functions are assigned to the three levels of management control as displayed in table 1.1:

Table 1.1 - Control tower functions assigned to three levels of management control

Function	Operational	Tactical	Strategic
Planning and Routing	X	X	
Event Management	X		
Auditing and Reporting	X		
Forecasting		missing	
Decision Making Support		missing	

The functions *Planning and Routing*, *Event Management* and *Auditing and Reporting* are present in ShipitSmarter and are on the operational level. Planning can be considered to be on the tactical level as well. The functions *Forecasting* and *Decision Making Support* are currently not present within ShipitSmarter. These functions are missing on all levels of management control.

In the next section, we identify the problems that ShipitSmarter has in providing the complete control tower function.

1.3 Problem Identification

Based on the previous section we conclude that ShipitSmarter has the infrastructure for a control tower in place. On the operational level the functions are present and this allows for the continuation of the day-to-day business. The main issue is the lack of tools for reporting and analysis to support the customers in making decisions on tactical and strategic levels. An example is the following situation:

The customer Beckman Coulter sends thousands of shipments from their warehouse in Nyon to different locations in the Netherlands. Their logistics manager wants to see an overview of the carriers used for these shipments, their delivery performance, and the costs that occurred. With this overview he can see where improvements can be made. Currently, only reports on shipment level are available in ShipitSmarter, resulting in a large excel files with thousands of lines of shipments and their details. This large amount of data takes a lot of effort to analyse by the manager, and he decides that it is not worth his time. However, it would be great if this analysed data is quickly available in ShipitSmarter.

Based on such situations, customers have recently requested for a service to analyse the data in ShipitSmarter to get insight in the performance of carriers on a tactical and strategic level. The analysis can be used to find areas on which the carriers perform worse than expected. This information can be used to improve the processes in these areas, leading to better performance results. This information

can also be used when new contracts have to be negotiated. It would be of value to the customer’s position in the negotiations to have an overview of the carrier’s performance over the last period. ShipitSmarter wants to investigate which information is of value to the customer in a performance analysis tool, and wants to extend their control tower function by including this service.

Besides the performance analysis tool, ShipitSmarter wants to investigate if it is possible to make forecasts in the form of what-if analyses. These analyses should show the impact on costs when changing variables in a scenario. Examples for scenarios are switching carriers or using a different service level for a set of shipments. The customer can use these what-if analyses for decision making on topics such as carrier selection and routing. We choose not to include forecasts based on extrapolation of historical data, to narrow the scope of the research

Figure 1.8 displays an overview of the functions and processes in ShipitSmarter. These include the processes around the three-way matching principle as seen in figure 1.4, and the area of “Reporting & Analysis”, which include reporting and event handling. These processes represent the first three functions of the control tower as listed in table 1.1. The functions that are currently lacking and that ShipitSmarter wants to add to its services are circled in red. The what-if & scenario analysis provides forecasting and decision-making support, and the performance and spend analysis provides decision-making support.

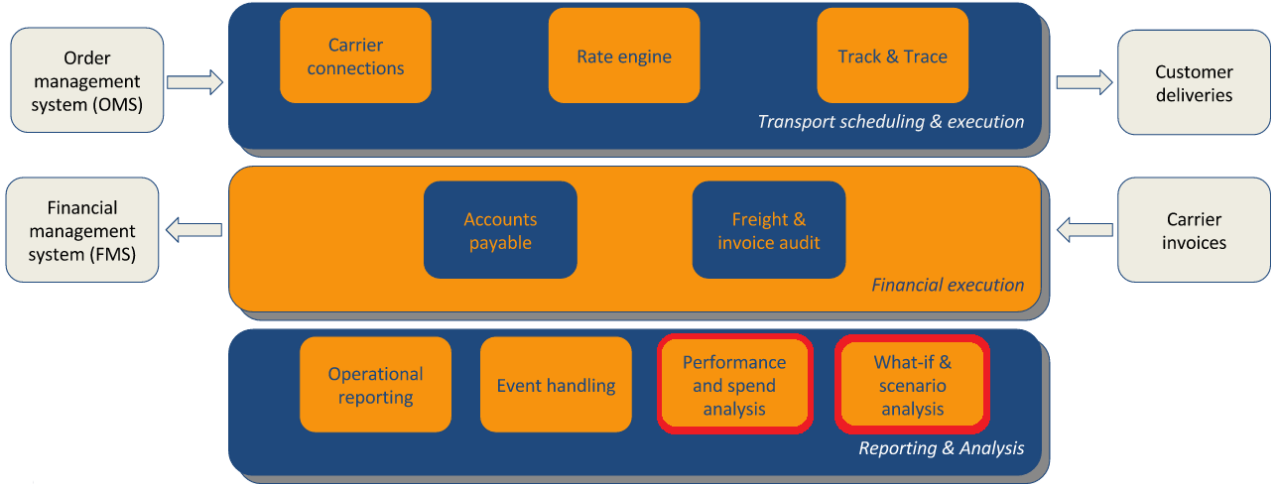


Figure 1.8 - Functions in ShipitSmarter

In the next section, we discuss the goals of this research.

1.4 Research Goals

The goal of this thesis is to provide ShipitSmarter with a data analysis tool for its customers to get an overview of carrier performance and spend, and a tool to perform what-if analyses related to the processes within ShipitSmarter. This will add important functions to ShipitSmarter’s service and will bring it closer to the complete control tower package that it wants to provide. ShipitSmarter has access to a business intelligence software called QlikSense, and wants to use this as their reporting and analysis tool.

We split up the goal in the following sub-goals:

- Provide ShipitSmarter with a list of performance indicators to measure carrier performance for its customers.
- Design a conceptual model of a what-if analysis tool.
- Analyse the quality of data that is required as input for the data analysis tools.
- Create a prototype of the data analysis tools.

In the next section, we discuss the research questions that are required to reach these goals.

1.5 Research Questions

ShipitSmarter wants to improve their control tower proposition and asks the following main question:

MQ: How can ShipitSmarter extend the Control Tower proposition to provide support on all levels (operational, tactical and strategic) by incorporating business intelligence capabilities?

In order to answer this question, we defined the term control tower and compared it to the situation of ShipitSmarter in the previous sections. We identified the problems in achieving a complete control tower function and concluded that ShipitSmarter wants to focus on two topics to solve this.

The first topic is to provide a reporting and analysis tool for customers that can be used to analyse their data. The goal is to create a prototype with a set of reports to analyse the performance of carriers, including detailed cost reports for spend management.

In order to reach this goal, we first research what performance measurement is, and what methods are available to find performance indicators. We also want to research what performance indicators are used by organizations in the same sector as ShipitSmarter. Based on the knowledge we obtained by answering these questions, we select a method to find the performance indicators for ShipitSmarter. Therefore, we formulate the first research question:

RQ 1: What performance indicators should be included in the performance analysis tool of ShipitSmarter?

The second topic is to design a tool to perform what-if analyses, used to analyse the effects on performance indicators when variables are changed in different scenarios. We formulate research question 2 to design the what-if analysis model for ShipitSmarter. We first review literature on what-if analyses and simulation, and then select a method to design the model.

RQ 2: What is an effective what-if analysis model for ShipitSmarter?

Once the performance indicators and the concept of the what-if analysis model have been determined, the required input data has to be analysed on quality. It is important to analyse the quality of the data so users can trust the results of the performance analysis and what-if analysis. We formulate research question 3 to analyse the quality of the data.

RQ 3: What is the quality of the required input data?

The next step is to create a prototype for the performance analysis tool and the what-if analysis tool. ShipitSmarter has access to a business intelligence software called QlikSense that will be used to create a prototype of the reports required for analysis. The goal of the prototype for the what-if analysis model

is to provide a proof of concept with an example. We define research question 4 in order to design the prototypes.

RQ 4: What do the prototypes for the data analysis tools look like?

With these research questions we want to achieve the research goals and answer the main question. In the next section we discuss the structure of the thesis.

1.6 Thesis Structure

In Chapter 2, we discuss the theory and methods used in this thesis. The goal of this chapter is to discuss theories and concepts that are relevant and provide a basis in literature for the selected research methods. We research methods to answer the research questions and select the methods that we use in this thesis to solve the research questions.

In Chapter 3, we first do a literature review to find performance indicators in the logistics and transportation sector. Then we answer RQ 1 by applying the method selected in Chapter 2 to select the performance indicators for the performance analysis tool.

In Chapter 4, we answer RQ 2 by designing the conceptual model of the what-if analysis. We do this by applying the method selected in Chapter 2.

In Chapter 5, we answer RQ 3 by analyzing the required input data for the performance indicators and the what-if analysis. We do this by applying the method selected in Chapter 2.

In Chapter 6, we create the prototypes of the analysis tools to answer RQ 4. We do this by applying the method selected in Chapter 2.

In Chapter 7, we present the conclusions of the research and do recommendations for ShipitSmarter.

Chapter 2 – Theory and Methods

In this chapter, we discuss the theory and methods that we use in this thesis. In every section, we discuss theory related to a research question, and select the method that we apply to answer the research question. In section 2.1, we discuss performance measurement. In section 2.2, we discuss what-if analyses. In section 2.3, we discuss data quality analysis. In section 2.4, we discuss the prototypes. In section 2.5, we conclude on the chapter and provide an overview of the research approach.

2.1 Performance Measurement

In this section, we discuss theory on performance measurement and select a method to answer RQ 1:

RQ 1: What performance indicators should be included in the performance analysis tool of ShipitSmarter?

2.1.1 Theory

Performance measurement can be defined as the process of quantifying the efficiency and effectiveness of action. Effectiveness refers to the extent to which customer requirements are met, while efficiency is a measure of how economically resources are utilized. A performance measure can be defined as a metric used to quantify the efficiency and/or effectiveness of an action (Neely, Gregory, & Platts, 1995). Ultimately, these measures should be combined into a performance measurement system. Neely, Adams, & Kennerley (2002) define a performance measurement system as a balanced and dynamic system that enables support of decision-making processes by gathering, elaborating and analyzing information. It can be examined at three different levels as shown in figure 2.1:

1. The individual performance measures.
2. The set of performance measures – the performance measurement system as an entity.
3. The relationship between the performance measurement system and the environment in which it operates.

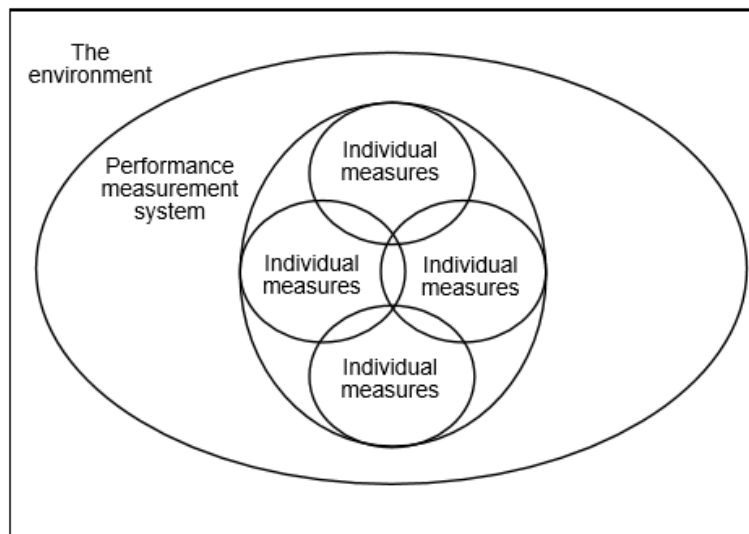


Figure 2.1 - A framework for performance measurement system design (Neely, Gregory, & Platts, 1995)

Objectives for indicators should be defined according to a set of criteria. A method for setting goals is the SMART method first introduced by Doran (1981). This acronym stands for specific, measurable, attainable, relevant and time bound. Specific goals make clear what exactly should be achieved and by making it measurable through quantification it is possible to track the progress. The goal must not be impossible to achieve, so should be attainable. It should be clear why this goal is pursued, and if it is relevant to the vision and strategy of the organization. Finally, the goal should be time bound by setting a time frame in which it should be achieved. In certain situations, involving abstract objectives it is not realistic to attempt quantification. It is the combination of the objective and its action plan that is really important.

Parmenter (2015, p. 1) defines three types of performance measures:

1. Key results indicators (KRIs) tell you how you have done in a perspective
2. Performance indicators (PIs) tell you what to do
3. Key performance indicators (KPIs) tell you what to do to increase performance dramatically

KRIs should give a clear picture of whether you are travelling in the right direction. They do not, however, tell you what you need to do to improve these results. Thus, KRIs provide information that is ideal for the board and typically cover a longer period of time than KPIs. In between KRIs and the true KPIs are numerous performance indicators which complement the KPIs (Parmenter, 2015).

“KPIs represent a set of measures focusing on those aspects of organizational performance that are the most critical for the current and future success of the organization” (Parmenter, 2015, p. 3).

Based on extensive analysis and discussions with over 1,500 participants in KPI workshops, Parmenter (2015) defines seven KPI characteristics:

1. Nonfinancial measures
2. Measured frequently
3. Acted on by the management team
4. Understanding of the measure and the corrective action required by all staff
5. Ties responsibility to the individual or team
6. Significant impact (e.g. affects most of the core critical success factors [CSF's] and more than one BSC perspective)
7. Positive impact (e.g. affects all other performance measures in a positive way)

Besides these characteristics, there are four common levels in any organization on which measures can be assigned (Barr, 2010):

Level 1: Success and sustainability measures

This level monitors the success and sustainability results for the business that are implied by the vision, mission and ultimate outcomes for the stakeholders. These measures show the success of the business and its likelihood to sustain it into the future.

Level 2: Strategic measures

These measures monitor the strategic objectives or goals and track the results implied by the business' current strategic direction. They describe how the organization does for the next two to five years.

Level 3: Tactical (or process output) measures

These measures are derived from the core, end-to-end processes. These processes have significant impact on the organizations ability to achieve its success, sustainability and strategic results. The strategic objectives and goals provide the focus of what these processes should achieve. Examples of tactical measures are customer satisfaction or on-time delivery.

Level 4: Operational measures

Operational performance measures usually track the root causes of tactical performance results. They are drivers of whole-process results and are where resources are allocated to improve process performance and ultimately improve organizational success and sustainability.

Some companies concentrate on financial performance measures, and others on operational measures. This inequality does not lead to a good picture of the company's performance. Financial performance measurements are important for strategic decisions and external reporting. Day to day control of operations is often better handled with non-financial indicators. Performance measurement systems based primarily on financial performance measures lack the focus and robustness needed for internal management and control (Atkinson, Waterhouse, & Wells, 1997).

Companies realize the importance of both financial and non-financial performance measures, however they fail to use them in a balanced framework. An example of a method for designing a performance measurement system which applies this balanced approach is the Balanced Scorecard (BSC) by Kaplan and Norton. Parmenter (2015) recommends using the Balanced Scorecard to find these indicators. The BSC will be discussed in more detail in section 2.1.2.

The number of KPIs is important as well. Companies often have a large number of performance measures. They fail to realize that performance assessment can be better addressed using only a few measures which measure areas most critical to success (Gunasekaran, Patel, & McGaughey, 2004).

In their literature review on performance measurement, Neely, Gregory, & Platts (1995) mention guidelines and principles for performance measurement design:

- Performance measures must be chosen from the company's strategy and objectives.
- The purpose of each performance measure must be clear.
- Data collection and methods of calculating the performance measures must be clearly defined.
- Non-financial measures should be adopted.
- Ratio-based performance measures are preferred to absolute numbers.
- Performance measures should be under control of the evaluated organizational unit.
- Performance measures should be selected through discussions with the people involved.
- Objective performance measures are preferable to subjective ones.
- The measures should provide fast feedback.

In the next sections we discuss methods to select performance indicators, and explain which approach we take in this thesis.

2.1.2 Methods

The goal of this section is to review two performance measurement methods and formulate the method that we use in this thesis. We perform a literature search to identify which methods are available and will now briefly explain why we selected these methods.

Taticchi, Tonelli, & Cagnazzo (2010) performed an analysis of citations data, in which they analysed the frequency of citations for individual pieces of work on performance measurement methods. The Balanced Scorecard (BSC) by Kaplan and Norton (1992) dominates the rankings, receiving much more attention than any other method. Therefore, we start with reviewing the Balanced Scorecard as a possible method in the research.

Second, we review the stakeholder approach by Atkinson, Waterhouse, & Wells (1997) which discusses several shortcomings of the BSC, and suggests improvements on these issues. This approach takes a look at the contracts and relations of the different stakeholders, which seems applicable for the network of ShipitSmarter.

After describing these methods, we compare them and discuss their applicability based on the situation of ShipitSmarter. We then formulate an appropriate method to find the performance indicators.

The Balanced Scorecard

The widely used Balanced Scorecard by Kaplan and Norton (1992) gives the ability to link an organization's long-term strategy with its short-term actions. It emphasizes that financial and non-financial measures must be a part of the information system for employees at all levels of the organization. Operational employees should understand the financial consequences of their actions and senior executives should understand the drivers of long-term success. The BSC should translate the organization's mission and strategy into tangible objectives and measures. The measures represent a balance between external measures and internal measures, and between outcome measures of past efforts, and measures that drive future performance. They are grouped into four perspectives (Kaplan & Norton, 1996):

- **Financial perspective**
Financial performance measures indicate whether a company's strategy, implementation, and execution are contributing to bottom-line improvement. Financial objectives typically relate to profitability.
- **Customer perspective**
In the customer perspective managers identify the customer and market segments in which they will compete and the measures of performance in these targeted segments. The core outcome measures include customer satisfaction, customer retention and customer profitability, but also factors which are critical for specific customers. Examples are lead times and on-time delivery.
- **Internal Business Process perspective**
In this perspective critical business processes are identified in which the organization must excel. These processes enable the business to deliver the value propositions that attract and retain customers, and satisfy shareholder expectations of excellent financial returns.

- **Learning and Growth perspective**

The learning and growth perspective identifies the infrastructure that the organization must build to create long-term growth and improvement. Learning and growth come from three principal sources: people, systems and organizational procedures. Businesses will have to invest in training employees, improving information technology and systems, and aligning organizational procedures and routines.

To apply the BSC method, Kaplan & Norton (1995) mention three key questions to ask:

- If we succeed with our vision and strategy, how will we look different to our shareholders and customers, in terms of our internal processes, and in terms of our ability to innovate and grow?
- What are the critical success factors in each of the four scorecard perspectives?
- What are the key measurements that will tell us whether we are addressing those success factors as planned?

Altogether, the BSC leads to a set of objectives and measures across the four perspectives based on the vision and strategy of the organization. It should have an appropriate mix of outcome measures and performance drivers (Kaplan & Norton, 1996).

The Stakeholder Approach

Although Atkinson, Waterhouse, & Wells (1997) think the BSC is a good approach, they feel that it is incomplete because:

- It fails to adequately highlight the contributions that employees and suppliers make to help the company achieve its objectives,
- It fails to identify the role of the community in defining the environment within which the company works,
- It fails to identify performance measures as a two-way process, enabling management to assess stakeholders' contributions and enabling stakeholders to assess the organization's capabilities in fulfilling its obligations to them.

Therefore, they created an approach to performance measurement that focuses on the nature and scope of the contracts that it negotiates with its stakeholders. The results of this approach is a performance measurement system used to monitor those contractual relationships.

The stakeholder approach to strategic planning views the organization as a complex web of contracts that specifies relationships between the company and its stakeholders. A stakeholder is an individual or group that has a stake in or can influence the organization's performance. The purpose of strategic planning is to define the relationships and contracts between the company and its stakeholders. The nature of these contracts and relationships reflect how they individually and jointly contribute to achieving the company's primary objective, which is most often profit. They also specify or imply both what the company expects from each stakeholder, and what each stakeholder expects from the company in return for its cooperation. They also provide the focus for the company's performance measurement and control systems (Atkinson, Waterhouse, & Wells, 1997).

The stakeholder approach views performance on the organization's primary objectives as a result of the processes used to generate results, by understanding and evaluating the factors for success related to all stakeholders.

2.1.3 Method Selection

The BSC and the stakeholder approach view the main objective of an organization to be the financial results, where the other objectives are the means to achieve this goal. Both methods aim for a continuation of the business through positive financial results to satisfy shareholders, balanced with non-financial indicators to satisfy the other stakeholders.

A critique on the BSC is that it is outdated because it has a limited amount of stakeholder groups (Neely, Adams, & Crowe, 2001). The Stakeholder Approach doesn't have this problem because it first identifies all the important stakeholder groups of the organization. Based on Kaplan and Norton's (2004) work on strategic mapping, which also addresses this issue, Parmenter (2015) suggests to extend the BSC by adding the perspectives "Environment/Community" and "Employee Satisfaction" to provide a framework with a broader stakeholder scope. However, this still allows for certain stakeholder groups to be missed, or not be explicitly mentioned.

The BSC can be considered to have more of a strategic focus, since the BSC starts the process with identifying the organization's long term goals, described as vision, mission and strategy. It then works its way down to critical success factors related to the strategy and finally assigns measures to these CSFs. A downside of this approach is that an attempt to formulate KPIs sometimes changes in an effort to improve business plans and strategy first (Kaplan & Norton, 1996).

The stakeholder approach can be considered to be more operationally focused, since the approach starts with identifying the goals and objectives for stakeholder groups by analyzing the underlying processes of the contracts and relations between the stakeholder groups. Analysis of these processes required to complete the goals and objectives of these stakeholder groups, finally lead to the measures for these processes.

The goal in this thesis is to obtain a list of performance indicators to measure carrier performance for the customers of ShipitSmarter. This means that we do not have to focus on the performance of a company as a whole, but only on the performance of the carriers that deliver the service to the customer. However, the performance indicators should contribute to the overall results of the company of the ShipitSmarter customer.

The BSC focusses on the four perspectives in order to get a complete view of the company. The idea is to apply the method in the company that requires the performance indicators. In our situation this isn't applicable, since we are not able to perform the BSC method for the entire customer company. However, we can still link the performance of the carrier to the overall strategic results of the different perspectives. There is a relation to a financial perspective in the form of costs made by the customer for the services, or to the customer perspective in the form of on-time delivery.

The stakeholder approach tries to encompass the entire company as well, but does this in a different way. In this method, different stakeholders and their relations and contracts are identified. The performance indicators required to monitor these relations and contracts are used in the performance measurement system. We can apply the concept of this method on our smaller situation, by using only two stakeholders: the customer and carrier. The relations and contracts between these stakeholders form a basis from which we can identify the processes and select the required performance indicators. Therefore, we choose to apply the stakeholder approach in this thesis.

Before we apply this approach, we also review literature and other sources in order to find performance indicators used by companies in the logistics and transportation sector.

We discuss the list of performance indicators obtained from this research, and use them as a reference when applying the method of analyzing the contracts between customer and carrier. Based on this discussion and analysis we select the performance indicators that ShipitSmarter can use.

After the performance indicators have been selected they will be operationalized in order to identify the required input data. In order to operationalize the performance indicators, the following details are described:

Indicator: Name of the indicator

Description: Description of the indicator

Output: The output of the formula

Formula: The formula required to calculate the output from the input

Input: The input of the formula

The target values of these performance indicators should be set by the customers themselves, therefore we do not define them.

The result of applying the method discussed in this section is an overview of the selected performance indicators and their operationalization, and this answers the first research question.

2.2 What-if Analysis

In this section, we discuss theory on what-if analyses and select a method to answer RQ 2:

RQ 2: What is an effective what-if analysis model for ShipitSmarter?

2.2.1 Theory

In order to be able to evaluate the impact on performance indicators of a strategic or tactical move, decision makers need reliable predictive systems such as what-if analyses. A what-if analysis can be described as a data intensive simulation whose goal is to inspect the behavior of a complex system under some given hypotheses, called scenarios. In particular, what-if analysis measures how changes in a set of independent variables impact on a set of dependent variables with reference to a given simulation model (Rizzi, 2009).

A difference with forecasting should be noted. Forecasting is carried out by extrapolating trends out of the historical information, while what-if analysis requires to simulate complex phenomena whose effects cannot be simply determined as a projection of past data. This requires to build a simulation model capable of reproducing the real behavior of the business (Golfarelli, 2006).

A what-if model is centered on a simulation model as can be seen in figure 2.2. The *simulation model* establishes a set of complex relationships between some *business variables* corresponding to significant entities. In order to simplify the specification of the simulation model and encourage its understanding by the users, we decompose it into *scenarios*, each describing a way to construct a *prediction* of interest for the user. The prediction typically takes the form of a multidimensional cube, meant as a set of cells of a given type, whose dimensions and measures correspond to business variables, to be explored by the user. A scenario is characterized by a subset of business variables, called *source variables*, and by a

set of additional parameters, called *scenario parameters*, whose value the user has to enter in order to execute the simulation model and obtain the prediction. It is important to distinguish the source variables among the business variables, since it enables the user to understand which are the “levers” that can be adjusted to drive the simulation (Rizzi, 2009).

A critical design issue for developing a reliable simulation model is to address the trade-off between precision and complexity. A very precise and fine-grained model could give rise to high simulation costs, while a lightweight simulation engine could be too simplistic to be reliable. A careful choice has to be made to meet both requirements on an acceptable degree (Golfarelli, 2006).

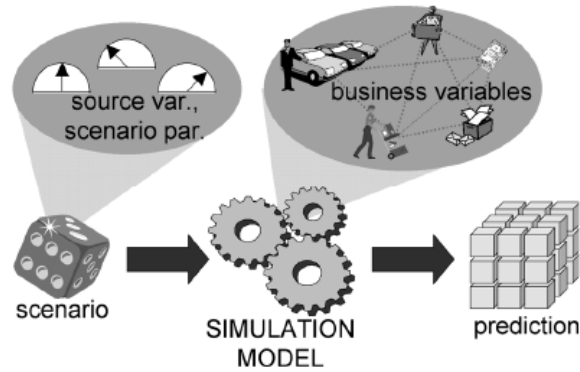


Figure 2.2 - What-if analysis at a glance (Golfarelli & Rizzi, 2009)

Because a what-if analysis is centered around a simulation model, we will briefly discuss the concept of simulation. Simulation is a technique used to imitate the operations of various kind of real-world facilities or processes. The facility or process at interest is often called a system. A system is defined to be a collection of entities that act and interact together toward the accomplishment of some logical end.

At some point there is a need to study a system and try to gain some insight into the relationships among various components, or to predict performance under some new conditions being considered. Figure 2.3 maps out different ways in which a system might be studied.

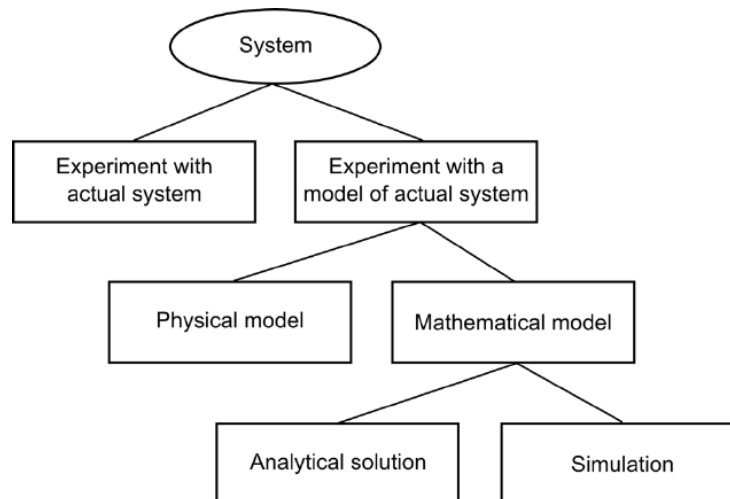


Figure 2.3 - Ways to study a system (Kelton & Law, 2000, p. 5)

If it is possible to alter the system physically and then let it operate under the new conditions, it is probably desirable to do so, because in this case there is no question about whether what we study is valid. However, this rarely feasible because such an experiment would be too costly or too disruptive to the system. For these reasons, it is usually necessary to build a model as a representation of the system and study it as a surrogate for the actual system. When using a model there always is the question of whether it's valid (Kelton & Law, 2000).

Physical models, like clay cars in wind tunnels, are usually not of interest in operations research and systems analysis. The majority of models built for such purposes are mathematical, representing a system in terms of logical and quantitative relationships that are then manipulated and changed to see how the model reacts, and thus how the system would react, if the model is a valid one.

Once a mathematical model is built, it must be examined to see how it can be used to answer the questions of interest about the system it is supposed to represent. If the model is simple enough, it may be possible to work with its relationships and quantities to get an exact analytical solution. If an analytical solution to a mathematical model is available and is computationally efficient, it is usually desirable to study the model in this way rather than via a simulation. However, many systems are highly complex, so that valid mathematical models of them are themselves complex, removing the possibility of an analytical solution. In this case, the model must be studied by means of simulation. Based on the classification of the system the correct way can be selected to create a model (Kelton & Law, 2000).

2.2.2 Methods

We now discuss two methods that can be used to design a what-if analysis. First, we discuss the structured approach proposed by Golfarelli (2006). Then we discuss the process of designing a simulation model by Robinson (2004).

The method proposed by Golfarelli (2006) consists of seven phases, as presented in figure 2.4:

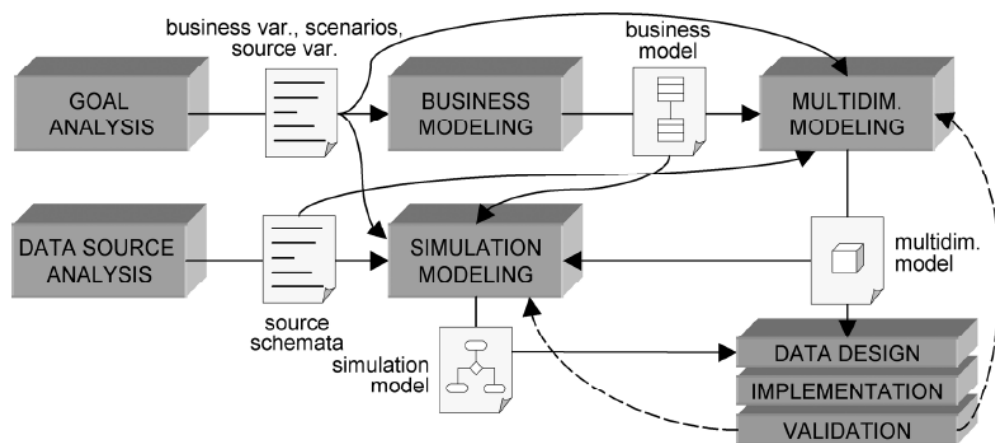


Figure 2.4 - A methodology for what-if analysis application design (Golfarelli & Rizzi, 2009)

1. **Goal analysis** – This phase is aimed at determining which business phenomena are to be simulated, and how they will be characterized. The goals of analysis are expressed by (i) identifying the set of business variables the user wants to monitor and their granularity; and (ii) defining the relevant classes of scenarios in terms of business variables the user wants to

control and other additional parameters.

2. **Business modeling** – A draft model of the application domain is built, to the extent suggested by the requirements expressed during the first phase. Generally, three submodels will be included: (i) one to statically represent the main entities involved and their associations; (ii) one to express how business variables are functionally derived on each other; and (iii) one to describe the dynamic interactions between the entities involved. This model helps to understand the business phenomenon as well as giving preliminary indications about which aspects can be either neglected or simplified for simulation. A set of standard UML diagrams can be used here.
3. **Data source analysis** – The relevant data sources are analysed, in order to understand what information is available to drive the simulation and how it is structured. Specific attention should be devoted to evaluate the quality of each data source, which significantly impacts on the actual applicability of the simulation model to be built.
4. **Multidimensional modeling** – The multidimensional schema describing the prediction is built, taking into account the static part of the business model produced at phase 2, and respecting the requirements expressed in phase 1.
5. **Simulation modeling** – The core phase of design. The goal is to build, based on the business model, the functional/dynamic model allowing the prediction to be constructed, for each given scenario, from the source data available. The most crucial issue the designer has to face during this phase is the achievement of a good compromise between the level of precision of the simulation model and its complexity.
6. **Data design and implementation** - The multidimensional schema of phase 4, and the simulation model of phase 5, are implemented on the chosen platform to create a prototype for testing.
7. **Validation** – During the last phase the designer evaluates, together with the users, how faithful the simulation model is to the real business model. The simplest approach is to run the simulation model on a past period and comparing the prediction with the actual values.

These are the seven phases in the structured approach proposed by Golfarelli (2006). We now review a method to perform a simulation study and compare the two methods in the next section.

The key processes of a simulation study according to Robinson (2004) are outlined in figure 2.5. These are the key stages in a study and represent the important deliverables.

- Conceptual model: a description of the model that is to be developed
- Computer model: the simulation model implemented on a computer
- Solutions and/or understanding: derived from the results of experimentation
- Improvement in the real world: obtained from implementing the solutions

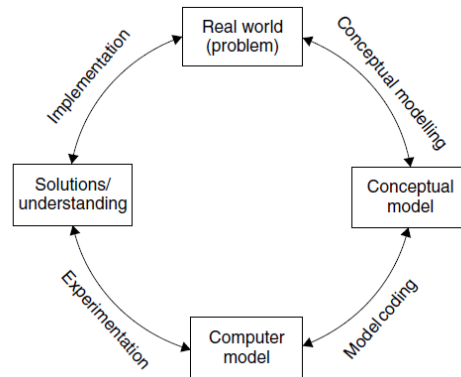


Figure 2.5 - Key processes of a simulation study (Robinson, 2004)

The goal of this thesis is to deliver a conceptual model of the what-if analysis to ShipitSmarter and provide a prototype with an example scenario. The implementation of the entire model is outside the scope of this research and will be performed by developers at ShipitSmarter at a later stage. ShipitSmarter only wants to provide the tool to perform the what-if analysis so the experimentation and the implementation of the results are done by the customers themselves.

Designing the conceptual model requires the following sub-processes (Robinson, 2004):

- Develop an understanding of the problem situation
- Determine the modelling objectives
- Design the conceptual model: inputs, outputs and model content
- Collect and analyse the data required to develop the model

Data collection and analysis is included as part of the conceptual modeling for two reasons. First it is necessary to obtain data in order to develop an understanding of the problem situation. Secondly, the detailed data required for the development of the computer model are identified by the conceptual model. Until the conceptual model is defined the data required for the computer model are not known. It therefore makes no sense to start a detailed data collection exercise. It is for this reason that data collection and analysis is placed last in the list of sub-processes above.

2.2.3 Method Selection

When comparing the methods of Golfarelli and Robinson, we observe many similarities. First the goals and objectives are defined by analyzing the situation. Robinson continues by designing the conceptual model. Golfarelli does the same, but splits it in multiple steps: business modeling, multidimensional modeling and simulation modeling.

A difference between the methods is that Golfarelli performs the data source analysis before completing the conceptual model, while Robinson does this after it is completed. Robinson argues that the conceptual model defines the data that is required, and that it makes no sense to do a detailed data analysis before that. Golfarelli's approach has the advantage that the available data and the quality of it is known before the design of the conceptual model is started. However, this can lead to analyzing data that is not ultimately not used in the model.

In our opinion, the best way to approach this, is in an iterative way by first analyzing the problem scenario and obtaining an idea of the data that is available. Then the conceptual model is designed in which the required data is defined, followed by the detailed data analysis. Finally, if the data analysis shows any issues with the required data, then the conceptual model can be revised.

The implementation in Golfarelli’s method compares to the coding of the computer model in Robinson’s method. The question whether the model is valid should be asked as well. However, there are no formal methods for validating a conceptual model (Robinson, 2004). The conceptual model should be circulated among those who have knowledge of the system to receive feedback whether the model is appropriate.

Both methods are comparable, but because the data analysis is done after the design of the conceptual model, we decide to apply the first three processes as defined by Robinson to design the conceptual model in this thesis:

- Develop an understanding of the problem situation
- Determine the modelling objectives
- Design the conceptual model: inputs, outputs and model content

The result of applying the method discussed in this section is the conceptual model of the what-if analysis, which answers the second research question.

2.3 Data Quality Analysis

In this section, we discuss theory on data quality analysis and select a method to answer RQ 3:

RQ 3: What is the quality of the required input data?

2.3.1 Theory

Wang & Strong (1996) define data quality (DQ) as “*data that are fit for use by data consumers*”. In addition, they define a “*data quality dimension*” as a set of data quality attributes that represent a single aspect or construct of data quality.

In their research, Wang & Strong (1996) developed a hierarchical framework that captures the aspects of data quality that are important to data consumers. Specifically, 118 data quality attributes collected from data consumers are consolidated into twenty dimensions, which in turn are grouped into four categories. The framework is displayed in table 2.1.

Table 2.1 - Conceptual Framework of Data Quality (Wang & Strong, 1996)

Data Quality Category	Data Quality Dimensions
Intrinsic DQ	Believability, Accuracy, Objectivity, Reputation
Contextual DQ	Value-added, Relevancy, Timeliness, Completeness, Appropriate amount of data
Representational DQ	Interpretability, Ease of understanding, Representational consistency, Concise representation
Accessibility DQ	Accessibility, Access security

Intrinsic DQ denotes that data have quality in their own right. Contextual DQ highlights the requirement that data quality must be considered within the context of the task at hand. Representational DQ and

accessibility DQ emphasize the importance of the role of systems. Based on these attributes the quality of data can be analysed. We discuss the method used for analyzing the input data in the next section.

2.3.2 Method

In this section, we formulate the method for analyzing the required input data. After identifying the data requirements of the performance indicators and what-if analysis, the data must first be obtained. Some data is immediately available and some data must be collected. Robinson (2004) describes three types of data, as presented in table 2.2. We first assign the input data to one of these categories.

Table 2.2 - Categories of Data Availability and Collectability (Robinson, 2004)

Category A	Available
Category B	Not available but collectible
Category C	Not available and not collectible

Category A data are available either because they are known or because they have been collected previously. With category A data it is important to ensure that the data are accurate and in the right format for the simulation model.

Category B data needs to be collected. The collection of this data might be a case of putting a data collection exercise in place, or might require interviews with experts on the subject. In collecting category B data, it is important to ensure that the data obtained is both accurate and in the right format.

Category C data is not available and cannot be collected. These occur because the real world system does not yet exist, or because the time frame does not allow to collect meaningful data. It is important to have some means for dealing with these data, as well as data that are available but are inaccurate.

The availability and collectability of the required data can be considered to cover the data quality dimension of accessibility. When this is done we analyse the available data based on the other quality attributes listed in table 2.1.

Based on the situation of the data quality, the decision is made whether the conceptual model of the what-if analysis has to be revised, and which data will be presented in the performance analysis reports.

The result of this analysis is an overview of the data quality, which answers the third research question.

2.4 Prototype Creation

This section describes the steps we take to create the prototype of the data analysis tool. This answers research question 4:

RQ 4: What do the prototypes for the data analysis tools look like?

A prototype lets the user interact with the system, and will enable ShipitSmarter to better understand the system before developing it completely. We create prototypes for the reporting tool, and for the what-if analysis tool.

The prototype of the reporting tool should contain the reports required for displaying the performance indicators. We create this prototype in the business intelligence software QlikSense.

The prototype of the what-if analysis tool should provide a proof of concept. It should be able to demonstrate the processes of the conceptual model that we designed. We provide an example to explain all the processes.

2.5 Conclusion on Research Approach

Based on the methods of the previous sections we formulate a research approach. This research approach, describes the steps taken in the remaining chapters of this thesis.

In Chapter 3, the performance indicators are selected which are included in the data analysis tool. We do this by first performing a review on literature and other sources to find performance indicators used in the sector of ShipitSmarter. With these indicators as reference, we apply the concept of the stakeholder approach to determine and operationalize the performance indicators for the performance analysis tool. The result of this chapter gives an answer to the first research question:

RQ 1: What performance indicators should be included in the performance analysis tool of ShipitSmarter?

In Chapter 4, we create the conceptual model of the what-if analysis model by developing an understanding of the problem situation, determining the modelling objectives, designing the conceptual model: inputs, outputs and model content. This answers research question 2:

RQ 2: What is an effective what-if analysis model for ShipitSmarter?

In Chapter 5, we analyse the required input data for the performance indicators and what-if analysis to see if they are available and of quality. This answers research question 3:

RQ 3: What is the quality of the required input data?

In Chapter 6, we create the prototypes of the reporting tool and the what-if analysis tool. This answers research question 4:

RQ 4: What do the prototypes for the data analysis tools look like?

In chapter 7, we present the conclusions of the research and do recommendations for ShipitSmarter.

Chapter 3 - Performance Indicator Selection

In this chapter, we select the performance indicators for the data analysis tool. In section 3.1 we review literature and other sources to obtain a list of performance indicators used in the sector of ShipitSmarter. In section 3.2 we select the performance indicators by performing the stakeholder approach. In section 3.3 we define the selected performance indicators by operationalizing them. Finally, we conclude on the chapter in section 3.4.

3.1 Indicators in literature

In this section we perform a literature research in order to obtain a reference list of performance indicators used by companies in the logistics and transportation sector.

Table 3.1 summarizes a logistics metric survey of metrics used by major US companies in the transportation sector. It shows the average ranking (on a scale of 1 to 7, with 1 indicating 'not important' and 7 indicating 'very important') for the 15 highest ranked metrics included in the survey (Kasilingam, 1998).

Table 3.1 – Ranked logistics metrics in the transportation function (Kasilingam, 1998)

Logistics Metric	Ranking
On-time delivery	6.83
Complete and damage-free delivery	6.83
Service level	6.50
Average transit time	6.40
Accurate freight bills	6.17
Timely response to inquiry and claims	6.00
Order accuracy and completeness	6.00
Customer communication	6.00
Order throughput cycle time	6.00
Total logistics costs as percentage of sales	6.00
Order cycle time	5.50
Inventory accuracy	5.00
Forecasting accuracy	5.00
Order selection	5.00
Replenishment cycle time	5.00

We see that on-time, complete, and damage-free delivery are considered to be the most important metrics. Third important is the service level, which is the availability of service. Followed by lead times and the accuracy of invoicing.

The bottom metrics are more related to other logistics functions rather than transportation, and are not relevant for ShipitSmarter. However, the cost metric is important for ShipitSmarter as well.

Table 3.1 provides a good list of indicators, but we want to consult some additional sources. By searching the internet for transportation metrics, we identified eight sources which listed metrics in transportation. We divide the metrics in three different groups: Shipment Cost, Service Quality, and Throughput. The total score of the metric is the number of sources a metric got mentioned in. The results are displayed in table 3.2 on the next page.

Table 3.2 – Amount of times transportation metrics are mentioned in 8 sources

Metric		Source							
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Shipment Cost	Score								
Freight cost per unit/SKU	7	1	1		1	1	1	1	1
Claims as % of freight cost (total, carrier)	7	1	1	1	1	1		1	1
Surcharge as % of freight costs	6	1	1	1		1		1	1
Spend per carrier / destination / origin	6			1	1	1	1	1	1
Spend per lane/service level/weight category	6			1	1	1	1	1	1
Freight cost per ton per km	3		1			1			1
Benchmarking rates	3			1		1		1	
Fuel cost per ton per km	2		1			1			
Service Quality									
% on-time delivery	8	1	1	1	1	1	1	1	1
% on-time pickup	8	1	1	1	1	1	1	1	1
Billing accuracy (% exceptions)	6	1	1	1	1			1	1
% no damage to goods	4		1				1	1	1
% acceptance rate on shipment requests	4			1	1	1		1	
Transit Time	3	1	1				1		
% shipments with status updates	3	1				1		1	
Mean Time to status update (EDI)	3			1		1		1	
Accuracy of status updates (EDI)	3			1		1		1	
% of truck capacity utilized	2	1				1			
Number of stops per trip	2		1				1		
Status update reason codes	2					1		1	
% orders correct delivery location	1		1						
% invoices with (unexpected) surcharges	1			1					
Time to process and pay invoices	1				1				
Data richness	1							1	
Emissions Greenhouse gas	1		1						
Throughput									
Number of carriers	2	1							1
Number of shipments	2		1						1
SKUs/weight per shipment	2		1						1

Sources:

(1): (Adam Robinson, 2014)

(3): (Merrill Douglas, 2015)

(5): (Shagawat, 2005)

(7): (Inbound Logistics, 2014)

(2): (SCM Wiki, 2012)

(4): (Ransom, 2015)

(6): (Transportation Insight, 2014)

(8): (Lynch, 2006)

While table 3.2 doesn't provide a definitive list of transportation metrics, because of the small number of sources, it gives some indication of how important a metric is. It also provides an additional reference for determining the performance indicators in the next section.

The metrics which are mentioned the most are the on-time delivery and on-time pickup percentages. Next up are the various metrics regarding costs, and the billing accuracy. These important metrics are in line with the results of the logistics metrics survey in the transportation function (Kasilingam, 1998).

3.2 Selecting Performance Indicators

In this section, we select the performance indicators by discussing the contracts and relations between customers and carriers, and by using the performance indicators we found in the previous section as a reference.

The contracts between customer and carrier consist of the service levels that the carrier offers. These service levels offer a transit time and delivery time for a type of shipment, for a certain price. Other relations the carrier has to the customer are sending the tracking updates and invoicing. Based on these contracts and relations we discuss the performance indicators listed in table 3.1 and table 3.2.

We select 14 performance indicators and divide those over three categories: shipment cost, service quality and throughput. Figure 3.1 shows an overview of the selected performance indicators.

The performance indicators in the category shipment cost provide information on the price of shipments. The service quality category provides mostly rates on operational performance, but also transit time and CO2e footprint. The throughput category contains performance indicators on the amount of shipments, packages or weight that is shipped in a certain period.

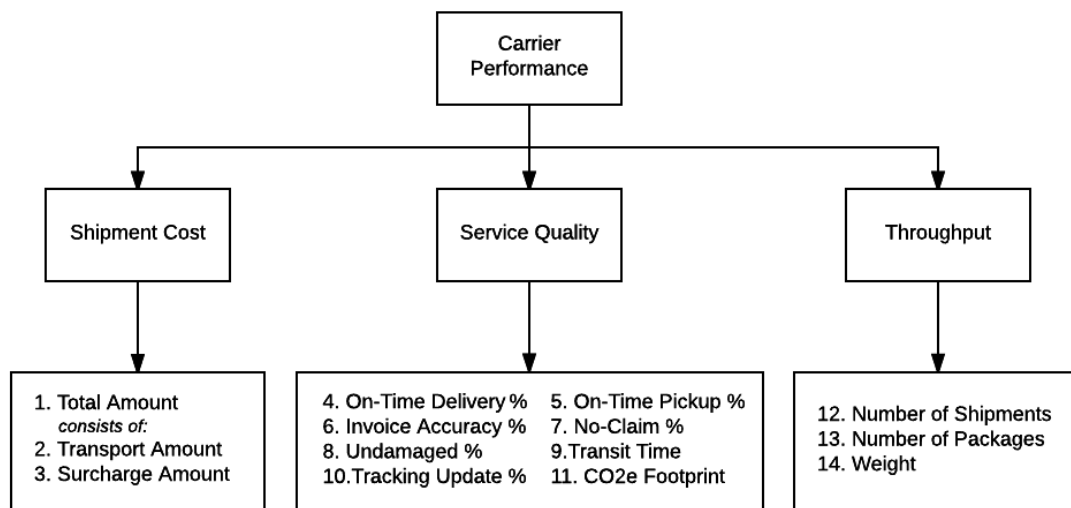


Figure 3.1 - The selected performance indicators

The category shipment cost contains the total amount of the shipment, which consists of the transport amount and the surcharge amount. The transport amount is the base price that the carrier uses for the shipment. Different surcharges are added, such as a fuel surcharge depending on the current fuel prices, or an oversize surcharge for shipments of large dimensions. The costs can be viewed over different time periods to detect trends, or to see a difference in costs per warehouse. These are important indicators

to provide an overview for cost analysis for the customer. We choose not to list all the cost measures mentioned in table 3.2, or any other cost measures we could think of, in order to keep the list manageable. The three selected indicators provide the tools we need to calculate any of these specific measures.

The category service quality contains the performance indicators to measure how the carrier performed its services. The most important performance indicator for service quality is the on-time delivery percentage of the shipments. This indicates whether the carrier has performed on the service level that the customer pays for. A similar indicator is the on-time pickup percentage.

Other important indicators are the invoice accuracy of the shipments and the percentage of invoices without claims. These claims for reimbursement can be made by a customer for loss or damage on a shipment, or when the shipment arrives late and can be considered on a lower service level. This is related to the indicator for the percentage of shipments without damage.

While on-time delivery is important to see if the booked service level was achieved, the actual transit time can give insight in the amount of time that shipments are in transport. The percentage of shipments that have tracking updates is an indicator that measures the level of communication of a carrier. Table 3.2 shows more measures related to communication but we decided to use only one. To measure the effects on the environment, we add the CO₂e footprint level of a shipment.

In the throughput category, we include the indicators for the numbers of shipments, the number of packages and the weight shipped. These can give an overview of how the number of shipments are divided over certain carriers, service levels or warehouses. They also can be used to derive cost statistics such as average cost per kg, or average cost per shipment.

3.3 Definition of the Performance Indicators

In this section, we define the performance indicators that have been selected to measure the carrier performance. Each indicator is listed with its description, the output, the formula, and the input. We start with defining the shipment cost performance indicators in section 3.3.1, then continue the service quality performance indicators in 3.3.2, and the throughput performance indicators in 3.3.3.

3.3.1 Shipment Cost Performance Indicators

In this section, we define the shipment cost performance indicators.

The costs indicators are used to get an overview of costs, or to compare the shipment costs for different selections. One of the main variables for these selections is time, which allows us to view costs per month or quarter. Other selections can be based on factors such as the carrier, service level or warehouse.

Since most customers work with the currency Euro, the operationalisation is done for the amounts in Euro. This also shows the most complex version of the formula because an exchange rate has to be applied. If necessary, the amount can be displayed in the original currency.

Table 3.3 shows the definition of the shipment cost performance indicators. We list all the required input values of the indicator with its own unique reference number.

Table 3.3 - Definition of shipment cost performance indicators

Indicator:	1	Total Amount ↓
Description:		The total amount of the shipment cost
Output:		Amount in Euros
Formula:	1.F	Total Amount in Euros = TA / rC
Input:	1.1	TA = Shipment total amount in currency C
	1.2	C = Currency of shipment amount
	1.3	rC = Exchange rate from Euro to currency C

Indicator:	2	Transport Amount ↓
Description:		Amount of the shipment transport cost
Output:		Amount in Euros
Formula:	2.F	Transport Amount in Euros = TrA / rC
Input:	2.1	TrA = Shipment transport amount in currency C
	2.2	C = Currency of shipment transport amount
	2.3	rC = Exchange rate from Euro to currency C

Name:	3	Surcharge Amount ↓
Description:		Costs of surcharges of the shipment. Individual surcharges and total surcharge amount
Output:		Amount in Euros
Formula:	3.F1	Individual Surcharge Amount CP in Euros = SA_{CP} / rC
	3.F2	Total Surcharge Amount = $\sum (SA_{CP} / rC) \forall CP$
Input:	3.1	CP = Code Price: description of the surcharge
	3.2	SA_{CP} = Surcharge amount of surcharge CP in currency C
	3.3	C = Currency of shipment amount
	3.4	rC = Exchange rate from Euro to currency C

3.3.2 Service Quality Performance Indicators

In tables 3.4a and 3.4b, we define the service quality performance indicators.

Table 3.4a - Definition of service quality performance indicators

Name:	4	On-time Delivery % ↑
Description:		Percentage of shipments that are delivered on or before the expected delivery date and time.
Output:		Percentage
Formula:	4.F	On-time Delivery = $\frac{\sum \text{shipments with } ADT \leq PDT}{\text{Total number of shipments}} * 100\%$
Input:	4.1	ADT = actual delivery date/time
	4.2	PDT = planned delivery date/time

Name:	5	On-time pickup % ↑
Description:		Percentage of shipments that are picked up on or before the planned pickup time.
Output:		Percentage
Formula:	5.F	On-time pickup = $\frac{\sum \text{shipments with } APT \leq PPT}{\text{Total number of shipments}} * 100\%$
Input:	5,1	APT = actual pickup date/time
	5,2	PPT = planned pickup date/time

Name:	6	Invoice accuracy % ↑
Description:		Percentage of shipments that have invoiced amounts that are in the accepted range of the booked amount in ShipitSmarter
Output:		Percentage
Formula	6.F1	Accurate Invoice = $\begin{matrix} Y & \text{if } SiSA * (1 - x) < InvA < SiSA * (1 + x) \\ N & \text{if else} \end{matrix}$
	6.F2	Invoice accuracy = $\frac{\sum \text{shipments with Accurate Invoice} = Y}{\text{Total number of shipments}} * 100\%$
Input:	6,1	SiSA = Amount in ShipitSmarter
	6,2	InvA = Amount invoiced by carrier
	6,3	x = Accepted fraction for error range

Table 3.4b - Definition of service quality performance indicators

Name:	7	No Claims % ↑
Description:		Percentage of invoices without claims
Output:		Percentage
Formula:	7.F	$\text{No Claims \%} = \frac{\sum \text{shipments with CI} = N}{\text{Total number of shipments}} * 100\%$
Input:	7,1	CI = Indicator of claim on an invoice (Y/N)

Name:	8	Undamaged % ↑
Description:		Percentage of shipments that are undamaged
Output:		Percentage
Formula:	8.F	$\text{Undamaged Shipments} = \frac{\sum \text{shipments with DMG} = N}{\text{Total number of shipments}} * 100\%$
Input:	8,1	DMG = Indicator of damage on shipment (Y/N)

Name:	9	Transit Time ↓
Description:		Transit time of a shipment
Output:		Transit time in hours
Formula:	9.F	Transit time = ADT - APT
Input:	9.1	APT = actual pickup date/time
	9.2	ADT = actual delivery date/time

Name:	10	Tracking Update % ↑
Description:		Percentage of shipments that have tracking updates
Output:		Percentage
Formula:	10.F	$\text{Tracking Updates} = \frac{\sum \text{shipments with TU} = Y}{\text{Total number of shipments}} * 100\%$
Input:	10,1	TU = Indicator of tracking updates on shipment (Y/N)

Name:	11	CO2e Footprint ↓
Description:		The total CO2e (Carbon Dioxide Equivalent) greenhouse emission value of shipments
Output:		CO2e in grams
Formula:	11.F	$\text{CO2e Footprint} = \sum \text{CO2e}$
Input:	11,1	CO2e = CO2e greenhouse emission value in grams

3.3.3 Throughput Performance Indicators

In table 3.5, we define the throughput performance indicators.

Table 3.5 - Definition of throughput performance indicators

Name:	12	Number of Shipments
Description:		The number of shipments in the selection criteria.
Output:		Integer number
Formula:	12.F	Count the number of shipments in the selection criteria
Input:	12.1	Shipments within the selection criteria

Name:	13	Number of Packages
Description:		The number of packages indicator gives the sum of the packages in the shipments
Output:		Integer number
Formula:	13.F	Number of packages = $\sum Packages$
Input:	13.1	Packages = Number of packages in a shipment

Name:	14	Weight
Description:		The total weight of the shipments
Output:		Real number in KG
Formula:	14.F	Weight = $\sum Weight$
Input:	14.1	Weight = Weight of shipment in KG

3.4 Conclusion

In this chapter, we reviewed literature and sources which list performance indicator. After that, we selected 14 performance indicators and divided them in three groups: shipment cost, service quality and throughput. We defined each of these indicators by listing the description, the output, the formula and the input.

In the next chapter, we design the conceptual model of the what-if analysis.

Chapter 4 – What-If Analysis Design

In this chapter, we design the conceptual model for the what-if analysis. Robinson (2004) describes an outline of a framework for conceptual modelling, to provide the modeler with an understanding of how to develop a conceptual model. Figure 4.1 shows this framework:

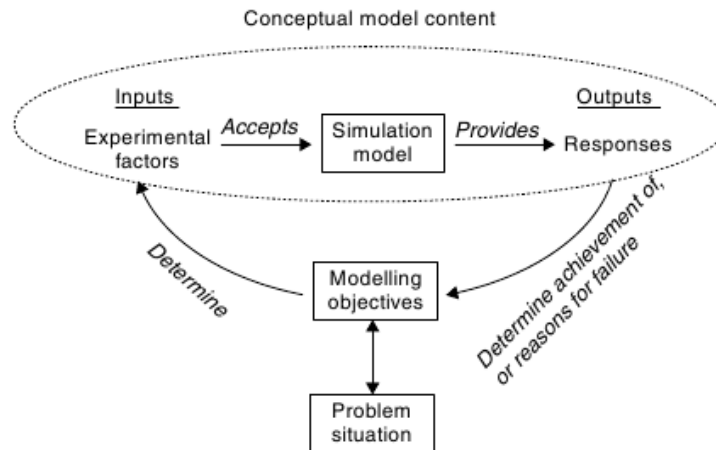


Figure 4.1 - A framework for conceptual modelling (Robinson, 2004)

The framework consists of four key elements:

- Develop an understanding of the problem situation
- Determine the modelling objectives
- Design the conceptual model: inputs and outputs
- Design the conceptual model: model content

These elements are the guideline of this chapter and are handled in the succeeding sections.

4.1 Understanding the Situation

In this section we develop an understanding of the situation by reviewing the related processes.

Carriers have contracts with their customers and provide a document containing the prices for the services they provide. This document includes the prices for every service level and the locations to which the customer can send their shipments to. This information is loaded into the system of ShipitSmarter in order to calculate the price for a shipment.

Every service level has a sheet with information on the prices, and a sheet with information on the zones. We define these as the Tariff Sheet (C,SL) and the Zone Sheet (C,SL):

Tariff Sheet (C,SL) = Sheet with information on prices for service level SL of carrier C.

Zone Sheet (C,SL) = Sheet with information on zones for service level SL of carrier C.

We define the set of all available tariff sheets and zone sheets for a customer as the Tariff Set of a customer.

Figure 4.2 displays the tariff set for a customer who has contracts with two carriers with each four service levels. This set contains a total of 8 tariff sheets and 8 zone sheets. In practice these tariff sets are much larger.

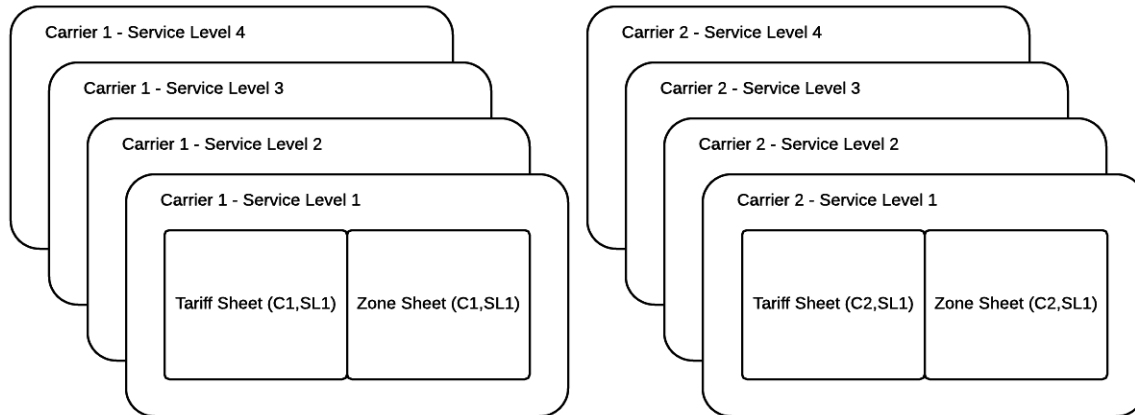


Figure 4.2 – Example of a Tariff Set

Now we'll explain how the tariff sheet and zone sheets work.

Tariff Sheet (C,SL) lists the transport- and surcharge prices and transit times for service level SL of carrier C. The price depends on the weight of the shipment and the zone it is shipped to, because transporting a heavy package over a long distance is more expensive than transporting a light package to a destination close by. The transit time only depends on the service level and the zone. Based on the shipment data the correct tariff line is selected from the list to determine the price and transit time. Figure 4.3 shows a simplified example of a tariff sheet.

Most carriers apply surcharges for instance when a shipment is oversized or overweight, or when goods are transported that require dry ice packaging. When a shipment satisfies the condition for a surcharge, the surcharge is added on top of the provided price for transport.

Tariff Sheet (Carrier,Service Level)					
	Zone 1	Zone 2	Zone 3	Zone 4	Surcharge 1
	Transit Time	Transit Time	Transit Time	Transit Time	
Weight Class 1	Price	Price	Price	Price	Surcharge Price
Weight Class 2	Price	Price	Price	Price	Surcharge Price
Weight Class 3	Price	Price	Price	Price	Surcharge Price

Figure 4.3 - Example of a Tariff Sheet

The zones for the service level SL of carrier C are defined in Zone Sheet (C,SL). A zone consists of all combinations of locations which use the same price. By combining the 'location from' and the 'location to' of a shipment, the correct zone can be identified in order to select a price from the tariff sheet. These locations are identified by the country code and zip code ranges. While the country code is mandatory, many carriers use country to country tariffs which don't use zip code ranges.

Figure 4.4 shows an example zone sheet for a customer in the Netherlands who ships to various countries in Europe. We see that shipping from any location in the Netherlands to a location in the

Benelux uses the tariffs of zone 1. Italy applies zip code ranges to divide the country in a northern area which is part of zone 3, and a southern area which is part of zone 4. In this way the price and transit time can be determined for every location in the carrier contract.

Location From		Location To		Zone
Country	Zipcodes	Country	Zipcodes	
NL		NL		1
NL		BE		1
NL		DE		2
NL		LU		1
NL		FR	00000-24999	2
NL		FR	25000-99999	3
NL		ES		4
NL		IT	00000-66999	3
NL		IT	67000-99999	4
NL		CH		3

Figure 4.4 - Example of a Zone Sheet

To briefly summarize the process of selecting the price and transit time for a shipment: First the *Carrier* and *Service Level* are used to select the tariff sheet. Then the *Location From* and the *Location To* are used to select the corresponding zone in the zone sheet. The zone and the *weight* of the shipment are then used to select the transport price and transit time from the tariff sheet. We conclude that these attributes are required in a shipment to select a price and transit time. These attributes are listed in table 4.1. If we want to add more detail to the model we can add additional shipment attributes, which we will discuss later.

Table 4.1 - Required shipment attributes for selecting a price and transit time

Shipment Attribute	Description
Carrier	Carrier, must be one of available carriers
Service Level	Service Level, must be one of available service levels
Country From	Country of which the shipment is sent from
Zip Code From	Zip Code of which the shipment is sent from
Country To	Country of which the shipment is sent to
Zip Code To	Zip Code of which the shipment is sent to
Weight	Weight of the shipment in KG

4.2 Objectives

The objective of the what-if analysis is to see how costs and transit times of a set of shipments behave in different scenarios. We describe five different scenarios that ShipitSmarter wants to analyse and list them in table 4.2.

The first scenario should simulate the costs and transit times when a selection of shipments is shipped with a different carrier, while the service level remains the same. This is used in decision making when a warehouse manager has to select the best carrier to use for shipments to a country.

The second scenario should simulate the costs and transit times when a different service level is used. When most shipments are shipped by using an EXPRESS service level, which generally have a transit time of one day, it is interesting to know what the effects on costs are when a service level like ECONOMY is used which usually take a day longer to deliver. The customer can then make a decision whether the increased transit time is worth the reduction of costs.

The third scenario should simulate the costs and transit times when a different warehouse location is used. This can be used to see the effects on costs of closing a warehouse, and sending its shipments from another warehouse, or opening a warehouse on a new location.

The fourth scenario should give a simulation of the costs and transit times when a different tariff structure is used for a carrier. It is possible for customers to buy off surcharges on tariffs, which lead to higher base prices. A simulation of this scenario would give an indication if such an action is viable.

The fifth scenario should simulate the costs and transit times when a different set of shipments is used. A set of shipments describes distribution of the type of shipments which are simulated. The main variables are the destination, the weight of the shipments, and the number of times they occur. But other shipment attributes can be changed as well. This can be applied when a customer acquires a new customer, and wants to simulate the expected shipments that are added.

Table 4.2 - Scenarios for the what-if analysis

#	Scenario	Description
1	Carrier Change	Effect on costs and lead times when changing the carrier used for a set of shipments.
2	Service Level Change	Effect on costs and lead times when changing a service level for a set of shipments.
3	Warehouse Change	Effect on costs and lead times when a different warehouse location is used for a set of shipments.
4	Tariff Change	Effect on costs and lead times when using a different set of tariffs for a set of shipments.
5	Shipment Data Set Change	Effect on costs and lead times when using a different set of shipments.

4.3 Inputs and Outputs

In this section we identify the input and output variables of the model. The output variables are the output of the simulation and are the measures we are interested in. Their values depend on the input variables which are entered in the simulation.

As we described in the scenarios, ShipitSmarter is interested in the effects on shipment costs and transit time, therefore we define costs and transit time as the output variables. Like the similar performance indicator that we defined in Chapter 3, the shipment cost variable consists of total amount, transport amount and surcharge amount. The output variables for the what-if analysis are listed in table 4.3.

Table 4.3 - Output variables for the what-if analysis

#	Output variables	Description	Data Range
1	Costs	Cost of the shipment	
1.1	Total amount	Total amount in Euro	Amount ≥ 0
1.2	Transport amount	Transport amount Euro	Amount ≥ 0
1.3	Surcharge amount	Surcharge amount in Euro	Amount ≥ 0
2	Transit Time	Expected Transit Time of the shipment in days	Integer ≥ 0

In the formulated scenarios, we see which variables are able to affect the output variables. These input variables are the carrier, the service level, the warehouse, the tariff sets and the shipment data set:

1. **Carrier** - The carrier variable is the carrier that is used to calculate the output of the shipments. It can only take the values of the carriers that have tariff sheets loaded into the system.
2. **Service Level** - The service level variable is the service level that is used to calculate the output of the shipments. It can only take the values of the service levels that have tariff sheets loaded in the system.
3. **Warehouse** - The warehouse variable is the location of which the shipment is sent from. This variable can be split in multiple attributes: the country, the zip code and the city of which the shipment is sent from. The city name is generally used as the warehouse name.
4. **Tariff Set** - The tariff set variable contains all the available tariffs that are loaded into the system. The scenario for changing a tariff can be interpreted as changing the service level, but with a tariff that didn't exist before. One of the first steps should then be to load additional tariffs, because they provide the possible ranges on the carriers and service levels.
5. **Shipment Data Set** - The shipment data set variable consists of all the types of shipments that we want to run through the simulation. These shipments are described with attributes that allow the rate engine to calculate the correct price and transit time.

The input variables for the what-if analysis are displayed in table 4.4:

When we define a scenario for the what-if analysis, all input variables have to be either inserted as input, or set as a variable. The unique combination of input variables is what defines the scenario, and are all required to calculate the output variables.

Table 4.4 - Input variables for the what-if analysis

#	Input variable	Description	Data Range
1	Carrier	The carrier used for the shipment	Carrier ∈ Tariff Set
2	Service Level	The service level used for the shipment	Service Level ∈ Tariff Set
3	Warehouse	The warehouse location of which the shipment is sent from	Warehouse location or new location
3.1	country from	Country of which the shipment is sent from	ISO2 country code
3.2	zip code from	Zip code of which the shipment is sent from	Zip code format
3.3	city from	City of which the shipment is sent from	String
4	Tariff Set	The tariff sets available in the system. Consisting of all tariff sheets for the service levels of carriers.	Tariff Sheet Format
5	Shipment Data Set	The data set of shipments used for the simulation	
5.1	Shipment ID	Unique identifier for the type of the shipment	Unique ID
5.2	Frequency	Number of times the shipment type is shipped	Integer ≥ 0
5.3	Carrier	The carrier used for the shipment	Carrier ∈ Tariff Set
5.4	Service Level	The service level used for the shipment	Service Level ∈ Tariff Set
5.5	Location From	Location of which the shipment is sent from	Any location
5.5.1	country from	Country of which the shipment is sent from	ISO2 country code
5.5.2	zip code from	Zip code of which the shipment is sent from	Zip code format
5.5.3	city from	City of which the shipment is sent from	String
5.6	Location To	Location which the shipment is sent to	Any location
5.6.1	country to	Country which the shipment is sent to	ISO2 country code
5.6.2	zip code to	Zip code which the shipment is sent to	Zip code format
5.6.3	city to	City which the shipment is sent to	String
5.7	Weight	Weight of the shipment in kg	Weight > 0
5.8	Package Type	Package type of the shipment	Pallet, Box, Document or Envelope
5.9	Dangerous Goods	Indicator for dangerous goods	Y/N
5.10	Length	Length of the shipment in cm	Length > 0
5.11	Width	Width of the shipment in cm	Width > 0
5.12	Height	Height of the shipment in cm	Height > 0

We now discuss the data entry methods for the input variables, and list them in table 4.5.

The input variables carrier, service level and warehouse are inserted in the menu of the what-if analysis, because they require no preparation of data.

The input variable tariff set is changed by loading a tariff sheet. This should be done before the what-if analysis is started. The process of loading a tariff is too complex to add it to the what-if analysis menu itself, and users of ShipitSmarter are already familiar with loading tariff sheets in their own environment.

The shipment data set contains all the shipments that are simulated. This data set has to be generated and prepared before it can be inserted in the what-if analysis. We discuss this process in section 4.5. We decide to create this data set as a spreadsheet that contains all the attributes of the shipments. It is loaded in the what-if analysis menu.

Table 4.5 - Data entry methods for the input variables

#	Input variable	Data Entry Method
1	Carrier	Insert values in what-if analysis menu
2	Service Level	Insert values in what-if analysis menu
3	Warehouse	Insert values in what-if analysis menu
4	Tariff Set	Insert loadsheet before starting what-if analysis
5	Shipment Data Set	Insert spreadsheet in what-if analysis menu

4.4 Model Content

In this section we describe the content of the model for the what-if analysis.

The model that we create has to be suitable for the system we want to analyse. Kelton & Law (2000) mention that if it is possible to alter the system physically and then let it operate under the new conditions, it is probably desirable to do so, because in this case there is no question about whether what we study is valid. However, the question is whether such an experiment would be too costly or too disruptive to the system.

ShipitSmarter uses the rate engine in order to calculate prices for shipments. The rate engine does this based on the rules we described in section 4.1. Because the system is based on software and data we can easily replicate it and run it on a different server, without affecting the performance of the real system. By doing this we obtain a result as if we used the real system, leaving no question whether the simulation is valid. The costs can be considered to be insignificant as well when replicating a system based on software and data. Because the system of ShipitSmarter isn't very complex, we decide to use a replication of the rate engine to simulate the shipment prices in the what-if analysis. We refer to the calculation of shipments by the rate engine as the simulation process.

4.4.1 Model Processes

When the user has identified the scenario he wants to simulate, he can start the what-if analysis. Based on the goals, input variables and output variables we propose the conceptual model as displayed in figure 4.5. The model consists of six processes that the user should perform:

1. **Insert Tariff**

A tariff sheet for a new or changed service level is loaded into the system. This is only required if the scenario for a tariff change is simulated or when old tariffs are updated with new rates. The result of this step is a complete and updated tariff set for the what-if analysis.

2. **Generate Shipment Data Set**

After the tariff set is ready, the spreadsheet with the shipment data set is created. Section 4.5 discusses this process in more detail. The result of this step is a shipment data set spreadsheet that is ready to be inserted into the system.

3. **Insert Shipment Data Set**

The shipment data set spreadsheet is loaded into the system. In this process a name, a description, and a unique identifier are assigned to the shipment data set. The result of this step is a defined shipment data set in the system that is ready for use.

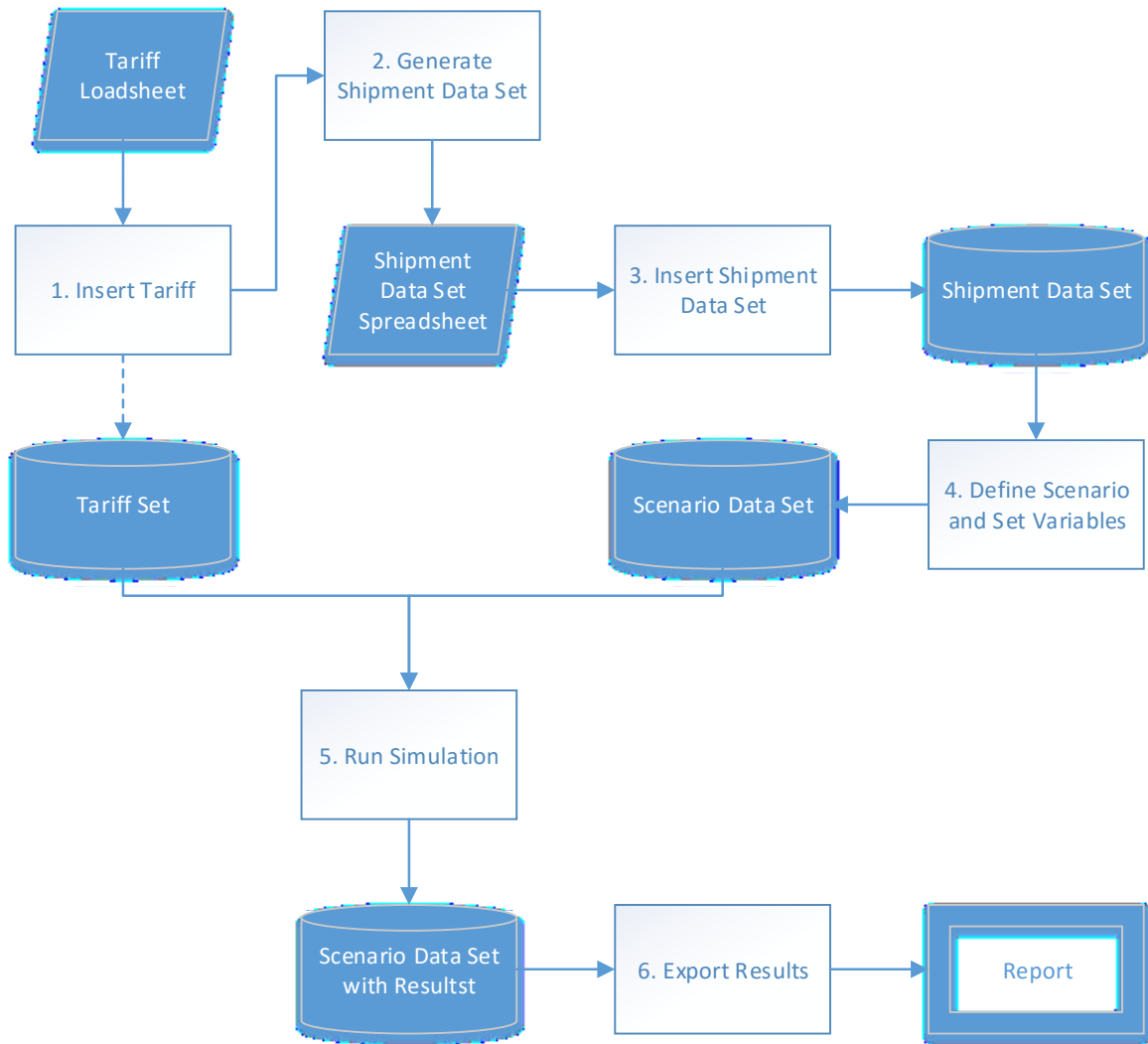


Figure 4.5 – Conceptual model of the what-if analysis

4. Define Scenario and Set Variables

The scenario that has to be simulated is defined. The required shipment data set is selected, and a scenario name, description and unique scenario ID are entered. Depending on the type of scenario, the carrier, service level and/or warehouse variables are set. When the user confirms the scenario, the shipment data set is copied and used to generate a scenario data set in which the scenario ID and the changed input variables are updated. The result of this step is a scenario data set that is ready for simulation.

5. Run Simulation

The scenario data set is simulated by the rate engine. The shipments are picked up by the rate engine one by one, and based on the attributes of the shipment the price and transit times are calculated. The system then updates the costs, transit time and tariff code for the shipment in the scenario data set. The simulation is complete when the system has updated every shipment in the scenario data set. The scenario data set with results is then ready to for analysis.

6. Export Results

The scenario data sets with results are exported to the data analysis tool in QlikSense where the user can view the results in the available reports. We design these reports in chapter 7.

When a scenario is simulated not all six processes are necessarily required, or have to be performed in the same order. The tariffs most often exist in the system already, unless new tariffs are tested. Inserted shipment data sets are saved and can be re-used for different scenarios. It is also possible to first simulate several scenarios before exporting them to the data analysis tool in QlikSense.

4.4.2 Shipment Attributes

Values are assigned to the simulated shipments that aren't included in the shipment data set spreadsheet used as input. These values include the unique identifiers for the shipment data set and the scenario data set, the attributes for the output variables, and the tariff code. Table 4.6 lists all shipment attributes that we use in the system with their descriptions and value types.

Table 4.6 - Shipment Attributes in the what-if analysis

#	Shipment Attribute	Description	Value Type
1	Shipment Data Set ID	Unique identifier for the Shipment Data Set	Integer
2	Scenario ID	Unique identifier for the scenario of the shipment	Integer
3	Shipment ID	Unique identifier for the type of the shipment	Integer
4	Frequency	Number of times the shipment type is shipped	Integer
5	Carrier	The carrier used for the shipment	String
6	Service Level	The service level used for the shipment	String
8	Country from	Country of which the shipment is sent from	String
9	Zip code from	Zip code of which the shipment is sent from	String
10	City from	City of which the shipment is sent from	String
12	Country to	Country which the shipment is sent to	String
13	Zip code to	Zip code which the shipment is sent to	String
14	City to	City which the shipment is sent to	String
15	Weight	Weight of the shipment in kg	Float
16	Package Type	Package type of the shipment	String
17	Dangerous Goods	Indicator for dangerous goods (Y/N)	Binary
18	Length	Length of the shipment in cm	Float
19	Width	Width of the shipment in cm	Float
20	Height	Height of the shipment in cm	Float
21	Total Amount	Total amount of shipment cost	Float
22	Transport Amount	Transport amount of shipment cost	Float
23	Surcharge Amount	Surcharge amount of shipment cost	Float
24	Transit Time	Expected transit time of shipment in days	Integer
25	Tariff Code	Unique identifier of the tariff line that is used	String

4.5 Generating Shipment Data Sets

The most interesting input variable in the what-if analysis is the shipment data set, because it allows the most variation. The other input variables such as carrier and service level are defined by the available tariff set, and the warehouse location is just an address. The shipment data set consists of different attributes, which gives many possibilities to change the scenario.

We define three approaches to generate a shipment data set.

Approach 1: Exact copy of historical shipments

In this approach we export the shipment attributes of a selection of historical shipments. We use this when we want to obtain the exact result of changing variables in a historical situation. For example, we select all shipments sent from warehouse X, in January 2016, that were sent to Croatia, and choose to simulate these with another carrier. Because every single shipment is copied this can result in a large shipment data set that can take a long time to simulate. To solve this problem, we suggest the second approach:

Approach 2: Group shipments based on a frequency distribution of historical shipments

In this approach we group the selection of historical shipments based on weight and the location they are sent to. By counting the shipments in these groups we obtain a frequency distribution of the type of shipments based on weight, for every location they are sent to. The weight classes are based on the weight classes that are often used in the tariff contracts of the carriers. Figure 4.6 shows an example of a frequency distribution for 334 shipments that are sent to Croatia with carrier TNT and service level EXPRESS in January 2016.

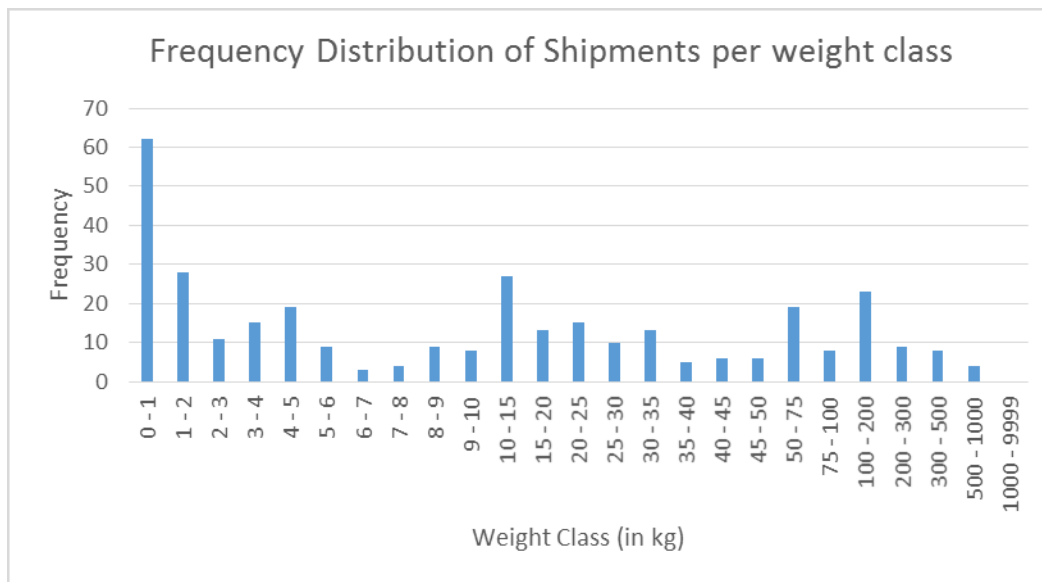


Figure 4.6 - Example frequency distribution of shipments in weight classes

In the example of figure 4.6 we see that there are 62 shipments in the weight class of 0 – 1 kg. If we calculate the cost for a shipment in this weight class once, and multiply it by 62, we obtain an approximation of the total cost of those 62 shipments. We apply this to the spreadsheet that is used to

load the shipment data set by adding the attributes of this type of shipment, and giving it a frequency of 62. We use the average weight of the 62 shipments as the weight for the shipment.

The first four lines of the spreadsheet for this example are displayed in table 4.7. Only a few attributes are displayed in this example to illustrate the concept, the complete spreadsheet should contain all attributes as listed in table 4.4 under Shipment Data Set.

Table 4.7 - Example Shipment Data Set Spreadsheet

Shipment ID	Frequency	Carrier	Service Level	Country From	Country To	Weight	Other Attributes
1	62	TNT	EXPRESS	CZ	HR	1	...
2	28	TNT	EXPRESS	CZ	HR	2	...
3	11	TNT	EXPRESS	CZ	HR	3	...
4	15	TNT	EXPRESS	CZ	HR	3.85	...

The grouping of the 334 shipments over the 25 weight classes reduces the number of shipments that have to be simulated to 25 shipment types per destination. This is a big reduction of the required simulation time, but results in a less accurate solution than the exact one we obtain with approach 1.

We also have to make a tradeoff between the amount of different location groups, the accuracy of the output of the simulation, and the simulation time. When a carrier has the same tariffs for all locations in a country, we don't have to group them based on zip codes. However, a carrier can split the country in 10 zones based on zip code ranges, each with different prices. In order to obtain an accurate result in this situation, we should split the shipment data set based on those zip code ranges as well.

Approach 3: Group shipments based on frequency distribution provided by the customer

The third approach uses a similar frequency distribution as the second approach. The difference is that this frequency distribution isn't necessarily based on historical shipments, but can be based on a forecast or scenario provided by the customer.

When a customer forecasts a certain amount of shipments, he can generate a shipment frequency distribution based on this forecast. This frequency distribution can be based on the weight classes provided in the previous approach, but this is not required. The customer can use any number of weight classes or locations, as long as he provides all the required attributes.

There is no best option among these approaches, because each one has its own advantages and disadvantages. Depending on the situation, the correct approach should be chosen.

- Approach 1 is used for a detailed what-if analysis of historical shipments, at the cost of extra simulation time, and is best used for a smaller amount of shipments.
- Approach 2 reduces the amount of shipments that have to be simulated by grouping similar historical shipments at the cost of less accurate results. This approach is best used when simulating a large number of shipments.
- Approach 3 is the most versatile one, because it allows the user to create his own shipment data set. It can be based on a set of historical shipments with some changes or additions, or it can be built from scratch based on a forecast of the user. The user can choose to use many detailed shipments, or to group them together. The downside of this approach is that the user has to spend time to create the shipment data set.

4.6 Conclusion

In this chapter we designed the conceptual model of the what-if analysis. We first developed an understanding of the situation by analyzing the tariff structure. Then we defined the objectives of the what-if analysis and described five types of scenarios that we want to simulate.

Based on these objectives we defined the input and output variables of the model. The main output variables are shipment cost and transit time. The main input variables are the carrier, service level and warehouse location of the shipment, the tariff sets available to calculate the prices, and the shipment data set that contains the shipment types that we simulate.

Then we discussed the processes of the what-if analysis model, and defined all the attributes of the simulated shipments. Finally, we discussed three approaches to generate the shipment data set used as input for the simulation.

In the next chapter we discuss analyse the required input data for the performance indicators and the what-if analysis.

Chapter 5 – Data Quality Analysis

In this chapter we analyse the required input data for the performance indicators and the what-if analysis. First, we assign the required input data in a category of data availability and collectability, as displayed in table 5.1. If we can locate the data in the database we assign it to category A, and write down the location. If the data is unavailable we discuss whether we can collect it in order to assign it to category B or C.

Table 5.1 - Categories of Data Availability and Collectability (Robinson, 2004)

Category A	Available
Category B	Not available but collectible
Category C	Not available and not collectible

By categorizing the data on availability and collectability, we analyse the data in the accessibility dimension of data quality. We then continue the analysis by discussing whether the available data scores high enough in the remaining data quality dimensions listed in table 5.2. The data quality is then marked OK or NOT OK. The most important dimensions are accuracy and completeness, which indicate whether the data is correct and usable for all shipments in the database.

Table 5.2 – Conceptual framework of Data Quality (Wang & Strong, 1996)

Data Quality Category	Data Quality Dimensions
Intrinsic DQ	Believability, Accuracy, Objectivity, Reputation
Contextual DQ	Value-added, Relevancy, Timeliness, Completeness, Appropriate amount of data
Representational DQ	Interpretability, Ease of understanding, Representational consistency, Concise representation
Accessibility DQ	Accessibility, Access security

After the input data is analysed based on these categories and dimensions, we discuss the data that isn't available or of not of quality. We propose a method to collect this data, or to improve its quality.

We start with the analysis and discussion of the input data of the performance indicators in section 5.1, followed by the what-if analysis in section 5.2.

5.1 Performance Indicator Input Data Analysis

In this section we analyse and discuss the input data of the performance indicators. We start with the shipment cost indicators, followed by the service quality indicators, and finally end with the throughput indicators.

5.1.1 Shipment Cost Performance Indicators

The results of the data analysis of the shipment cost performance indicators is shown in table 5.3.

Table 5.3 - Data analysis for shipment cost performance indicators

#	Description	Location	Category	Quality
1	Total Amount			
1.1	TA = Shipment total amount in currency C	shipment.price	A	OK
1.2	C = Currency of shipment amount	shipment.code_currency	A	OK
1.3	rC = Exchange rate from Euro to currency C	shipment.rate_eur	A	OK
2	Transport Amount			
2.1	TrA = Shipment transport amount in currency C	shipment_price.price <i>where code_price = TRANSPORT</i>	A	OK
2.2	C = Currency of shipment transport amount	shipment_price.code_currency	A	OK
2.3	rC = Exchange rate from Euro to currency C	shipment.rate_eur	A	OK
3	Surcharge Amount			
3.1	CP = Code Price: description of the surcharge	shipment_price.code_price	A	OK
3.2	SACP = Surcharge amount of surcharge CP in currency C	shipment_price.price	A	OK
3.3	C = Currency of shipment amount	shipment_price.code_currency	A	OK
3.4	rC = Exchange rate from Euro to currency C	shipment.rate_eur	A	OK

From this analysis we can conclude that all input data is available and that the quality is sufficient for these indicators. These results are expected because booking shipments for the correct price is the daily business of ShipitSmarter.

5.1.2 Service Quality Performance Indicators

The results of the data analysis of the service quality performance indicators are shown in table 5.4a to 5.4h. We will discuss these indicators individually now.

Table 5.4a – Input Data Analysis of Service Quality Performance Indicators

#	Description	Location	Available	Quality
4	On-time Delivery %			
4.1	ADT = actual delivery date/time	shipment.date_delivery shipment.time_delivery	A A	OK OK
4.2	PDT = planned delivery date/time	shipment.date_delivery_plan shipment.time_delivery_plan	A A	OK NOT OK

On-time delivery % can be considered to be the most important indicator to measure carrier performance. To provide a reliable performance report for the customers, it is important that the input data for this indicator is available and accurate for every shipment.

We discovered that the planned delivery time is sometimes missing, incorrect or inconsistent. When a shipment should be delivered before 09:00, the field is either empty, contains values 0000 or has a version of 0900 or 09:00. The planned delivery time is only relevant for service levels that strive to deliver before a certain time, such as 0900 or 1200 service levels. Other service levels only use the delivery date to measure on-time delivery.

In order to improve the quality of the planned delivery time data we suggest the following:

- Use one data format for this field. (e.g. 0900)

- Review processes that populate *shipment.time_delivery_plan* to make sure that it is always populated with the correct planned delivery time when the service level requires that.

Table 5.4b - Input Data Analysis of Service Quality Performance Indicators

#	Description	Location	Available	Quality
5	On-time pickup %			
5,1	APT = actual pickup date/time	shipment.date_pickup	A	OK
		shipment.time_pickup	A	OK
5,2	PPT = planned pickup date/time	N/A	B	NOT OK
		N/A	B	NOT OK

Currently there is no planned pickup date or time for a shipment. Two extra attributes can be added to the shipment table: *date_pickup_plan* and *time_pickup_plan*. The collection/generation processes to populate these fields should also be created.

Table 5.4c - Input Data Analysis of Service Quality Performance Indicators

#	Description	Location	Available	Quality
6	Invoice accuracy %			
6.1	SiSA = Amount in ShipitSmarter	shipment.price	A	OK
6.2	InvA = Amount invoiced by carrier	invoice_in.amount_total	A	OK
6.3	x = Accepted error range percentage	Customer parameter: INVOICE-ACCEPT-PERC	A	OK

A shipment is considered to be correctly invoiced when the invoiced amount is within the accepted error range of the booked amount in ShipitSmarter. Both amounts are available in ShipitSmarter and the accepted error range percentage can be found in the parameters of the customer.

Table 5.4d - Input Data Analysis of Service Quality Performance Indicators

#	Description	Location	Available	Quality
7	No Claims %			
7,1	CI = Indicator of claim on an invoice (Y/N)	N/A	B	NOT OK

In order to measure the percentage of shipments without a claim, we need an indicator which shows whether a claim has been made on an invoice. This indicator can be provided by the customer when they decide to file a claim on the invoice.

Table 5.4e- Input Data Analysis of Service Quality Performance Indicators

#	Description	Location	Available	Quality
8	Undamaged %			
8,1	DMG = Indicator of damage on shipment (Y/N)	N/A	B	NOT OK

Currently there is no information available whether a shipment is damaged. We can collect this data by requesting the carrier to include this information in the tracking updates, or the customer to update this information in the system if they notice damage on delivery.

Table 5.4f - Input Data Analysis of Service Quality Performance Indicators

#	Description	Location	Available Quality	
10	Tracking Update %			
10	TU = Indicator of tracking updates on shipment (Y/N)	N/A	B	NOT OK

The transit time of a shipment can be obtained by calculating the time between the moment of pickup and the moment of delivery. This data is available and of quality for the delivered shipments.

Table 5.4g - Input Data Analysis of Service Quality Performance Indicators

#	Description	Location	Available Quality	
10	Tracking Update %			
10	TU = Indicator of tracking updates on shipment (Y/N)	N/A	B	N/A

An indicator whether a shipment has tracking updates is currently not available, but this can be created. We recommend to create an attribute *ind_tracked* for the shipment, which is set to Y when a tracking update is received for that shipment.

Table 5.4h - Input Data Analysis of Service Quality Performance Indicators

#	Description	Location	Available Quality	
11	CO2e Footprint			
11,1	CO2e = CO2e greenhouse emission value in grams	N/A	B	NOT OK

The value for a CO2e Footprint is currently not available. Carriers such as DHL and TNT provide reports on CO2 emissions to track and analyse the CO2 emissions. These carriers can be requested to send this data for the customer's shipments.

5.1.3 Throughput Performance Indicators

The results of the data analysis of the service quality performance indicators are shown in table 5.5.

Table 5.5- Data analysis for throughput performance indicators

#	Description	Location	Available Quality	
12	Number of Shipments			
12.1	Shipments within the selection criteria	shipment table	A	OK
13	Number of Packages			
13.1	Packages = Number of packages in a shipment	shipment.pieces	A	OK
14	Weight			
14.1	weight = Weight of shipment in KG	shipment.weight	A	OK

From this analysis we can conclude that all input data is available and that the quality is sufficient for these indicators. These results are expected because the number of packages and weight are required to be entered by the customer when booking a shipment.

In the next section we analyse the input data for the what-if analysis.

5.2 What-if Analysis Input Data Analysis

In this section we analyse and discuss the input data of the what-if analysis.

Many of the input variables don't have to be based on existing data in order to describe a scenario. The analysis that we perform here is based on the assumption that we want to obtain the data from the existing system.

The result of the data analysis is shown in table 5.6.

Table 5.6 - Data analysis of input variables of the what-if analysis

#	Description	Location	Category	Quality
1	Carrier	Carrier ∈ Tariff Set	A	OK
2	Service Level	Service Level ∈ Tariff Set	A	OK
3	Warehouse			
3.1	country from	Customer Address Info	A	OK
3.2	zip code from	Customer Address Info	A	OK
3.3	city from	Customer Address Info	A	OK
4	Tariff Set	Existing Tariff Set	A	OK
5	Shipment Data Set			
5.1	Shipment ID	shipment.code_shipment	A	OK
5.2	Frequency	count shipment types	A	OK
5.3	Carrier	shipment.courier2	A	OK
5.4	Service Level	shipment.service_level	A	OK
5.5	Location From			
5.5.1	country from	shipment.code_country_from	A	OK
5.5.2	zip code from	shipment.postcode	A	OK
5.5.3	city from	shipment.address4	A	OK
5.6	Location To			
5.6.1	country to	shipment.code_country_to	A	OK
5.6.2	zip code to	shipment.postcode_delivery	A	OK
5.6.3	city to	shipment.address14	A	OK
5.7	Weight	shipment.weight	A	OK
5.8	Package Type	shipment.package	A	OK
5.9	Dangerous Goods	shipment.ind_dangerous	A	OK
5.10	Length	shipment.length	A	OK
5.11	Width	shipment.height	A	OK
5.12	Height	shipment.width	A	OK

Based on this analysis we can conclude that all required input data is available and of quality. This was expected because these variables are necessary to book shipments in ShipitSmarter.

In the next section we conclude on the quality analysis of input data.

5.3 Conclusion

We first analysed the availability of this data by locating it the system of ShipitSmarter, and if the data was unavailable we discussed whether we could obtain it. Then we analysed the available data based on twenty data quality dimensions and concluded whether the data was of sufficient quality for use.

The results of this analysis show that the data required for the shipment cost indicators and the throughput indicators are available and of good quality. This was expected because these are required for of the daily operations of ShipitSmarter. The input data for the service quality indicators is of worse quality. The input data isn't completely available for 6 out of 8 indicators, and the data quality of data required to measure the on-time delivery is found to be incomplete and unreliable in some cases. These results are summarized in table 5.7.

Table 5.7 - Summary of the quality of the input data for performance indicators

#	Description	Available	Collectable	Quality
Shipment Cost				
1	Total Amount	Y	-	OK
2	Transport Amount	Y	-	OK
3	Surcharge Amount	Y	-	OK
Service Quality				
4	On-time Delivery %	Y	-	NOT OK
5	On-time pickup %	N	Y	NOT OK
6	Invoice accuracy %	N	Y	NOT OK
7	No Claims %	N	Y	NOT OK
8	Undamaged %	N	Y	NOT OK
9	Transit Time	Y	-	OK
10	Tracking Update %	N	Y	NOT OK
11	CO2e Footprint	N	Y	NOT OK
Volume				
12	Number of Shipments	Y	-	OK
13	Number of Packages	Y	-	OK
14	Weight	Y	-	OK

We made suggestions on how to collect the unavailable data and how to improve the quality of the data for the on-time delivery %. The performance indicators that have data that is currently unavailable will not be used in the design of the prototypes. The on-time delivery % is unreliable in some cases, but will be used in the prototype for the reports to give an illustration of how it is applied.

The input data for the what-if analysis consists of shipment attributes of historical shipments. These attributes are necessary to book shipments in ShipitSmarter, meaning they are all available and of quality. Therefore, we can use this data to generate a shipment set for the prototype.

In the next chapter we create the prototypes for the reporting tool and the what-if analysis tool.

Chapter 6 – Prototype Creation

In this chapter we create the prototypes of the reporting tool and the what-if analysis tool. First we discuss the prototype of the reporting tool in section 6.1. Then we discuss the prototype of the what-if analysis tool in section 6.2.

6.1 Reporting Tool Prototype

In this section we create the prototype of the reporting tool.

We define four reports for the prototype:

1. Carrier Performance Scorecard
2. Spend Details
3. Warehouse Spend Overview
4. On-time Delivery Overview

For every report we define the details on the charts included, the measures and dimensions used, and the filtering options available to change the selection. We present a screenshot of the report in QlikSense, with an example selection to provide additional clarification of the report.

These reports are presented on the next pages.

Report 1: Carrier Performance Scorecard

Description:	
This report gives an overview of carrier performance in a selected period. This report contains all performance indicators in the selected period. Selections can be made per year and month, and per carrier, service level, warehouse and country to.	
Performance Indicators:	
1. Total Amount 2. Transport Amount 3. Surcharge Amount 4. On-time Delivery % 5. On-time Pickup % (not available yet)	6. Invoice Accuracy % 7. No-Claim % (not available yet) 8. Undamaged % (not available yet) 10. Tracking Update % 11. CO2e Footprint (not available yet)
Filter Selection:	
Time (Year, Month), Carrier, Service Level, Warehouse, Country To	

Figure 6.1 shows a screenshot of the carrier performance scorecard. The selection is set on carrier DHL in the first three months of 2016. This report shows an overview of the shipment cost-, the service quality-, and the throughput performance indicators for the shipments in the selection.

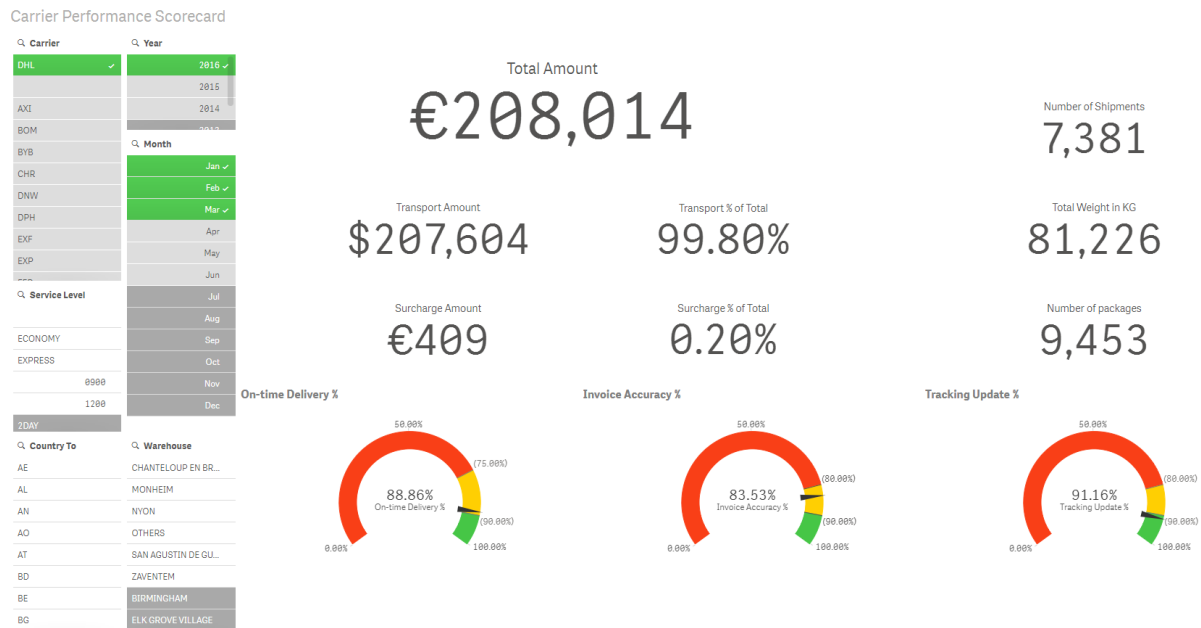


Figure 6.1– Screenshot of report 1: Carrier Performance Scorecard

Report 2: Spend Details (2015-2016)

Description:	
This report shows the total spend per month in 2015 and 2016. Selections can be made per carrier, service level, warehouse and country to.	
Graph 1, Bar Chart: Total shipment costs per month (2015-2016)	
Measures (y-axis)	Dimensions (x-axis)
1. Total Amount in 2016 1. Total Amount in 2015	Time (Month)
Filter Selection:	
Carrier Name, Warehouse, Service Level, Country To	

Figure 6.2 shows a screenshot of the Spend Details (2015-2016) report. This example report gives a clear overview of the total amount spend for shipments sent with carrier DHL to Germany.

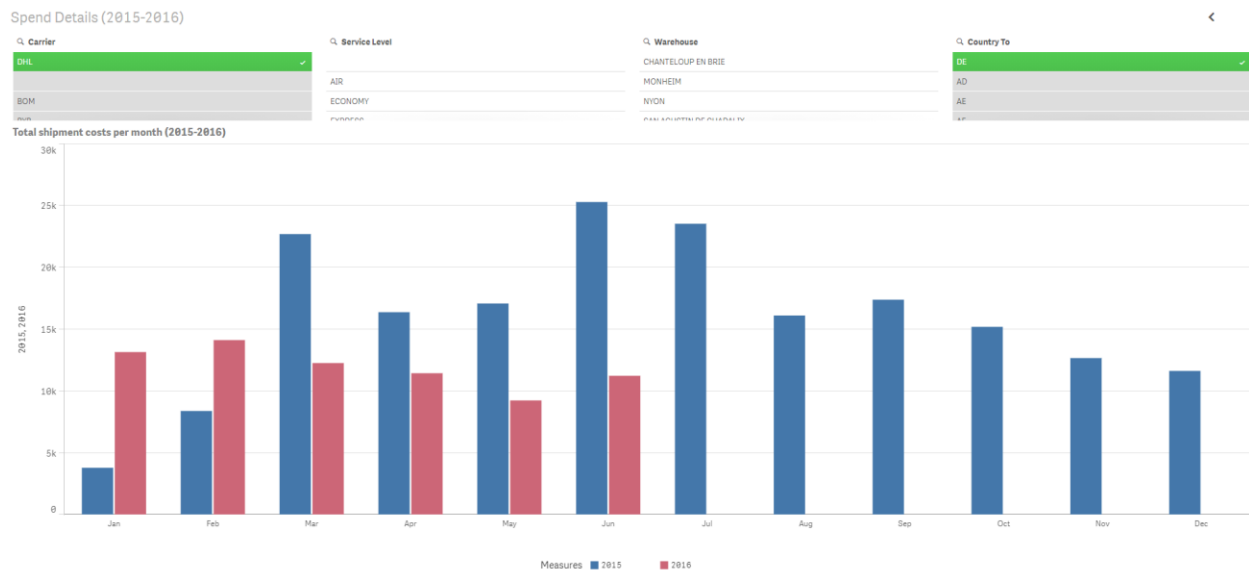


Figure 6.2 – Screenshot of report 2: Spend Details (2015-2016)

Report 3: Warehouse Spend Overview (2015-2016)

Description:	
This report gives an overview of spend per warehouse. The two pie charts show the percentage of spend per warehouse, carrier or service level for 2015 and 2016. The bar chart shows the total amount spend per carrier or service level for 2015 and 2016.	
Graph 1, Pie Chart: Percentage of total spend in 2016	
Measures	Dimensions
1. Total Amount in 2016	Warehouse, Carrier, Service Level
Graph 2, Pie Chart: Percentage of total spend in 2015	
Measures	Dimensions
1. Total Amount in 2015	Warehouse, Carrier, Service Level
Graph 1, Bar Chart: Total shipment costs per month (2015-2016)	
Measures (x-axis)	Dimensions (y-axis)
1. Total Amount in 2016 1. Total Amount in 2015	Warehouse, Carrier, Service Level
Filter Selection:	
Time (Month), Warehouse	

Figure 6.3 shows a screenshot of the Warehouse Spend Overview report. We selected the months January and February for the warehouse in Birmingham. We see how spend is divided over the different carriers and that the customer uses a new carrier PRL in 2016, which resulted in less business for TNT. When a carrier is selected in a chart, the charts will show the spend per service level instead.

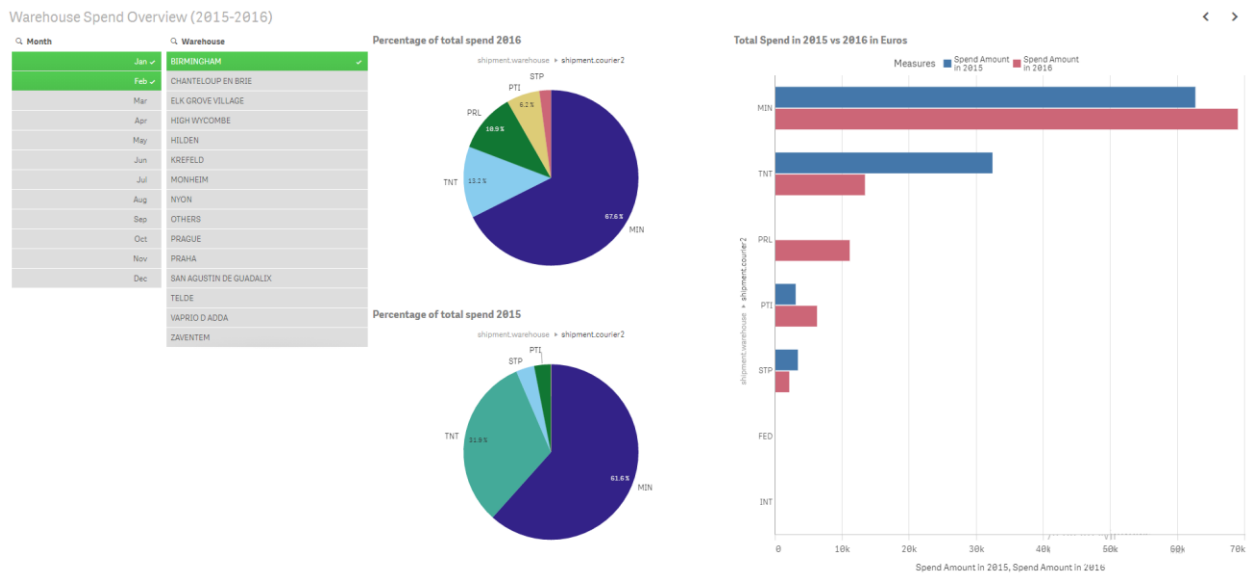


Figure 6.3 - Screenshot of report 3: Warehouse Spend Overview (2015-2016)

Report 4: On-time Delivery Overview

Description:	
This report gives an overview of on-time delivery rate. The first graph sorts the carriers on the number of shipments, and displays their on-time delivery rate for the selected year, warehouse or service level. Carrier columns can be selected to view their monthly on-time delivery rate in the second chart. The second graph displays the on-time delivery rate per month for the selection.	
Graph 1, Combo Chart: On-time Delivery % and Number of Shipments per Carrier	
Measures (y-axis)	Dimensions (x-axis)
4. On-time Delivery % (Bars) 12. Number of shipments (Line)	Carrier
Graph 2, Line Chart:	
Measures (y-axis)	Dimensions (x-axis)
4. On-time Delivery %	Time (Month)
Filter Selection:	
Time (Year, Month), Warehouse, Service Level	

Figure 6.4 shows a screenshot of the On-time Delivery Overview report. We selected the year 2015 for the warehouse in Birmingham. We see that most of our shipments are sent with carrier TNT and that TNT has an on-time delivery rate of 94% during 2015. We select the TNT column in order to view the on-time delivery rates per month in the bottom chart.

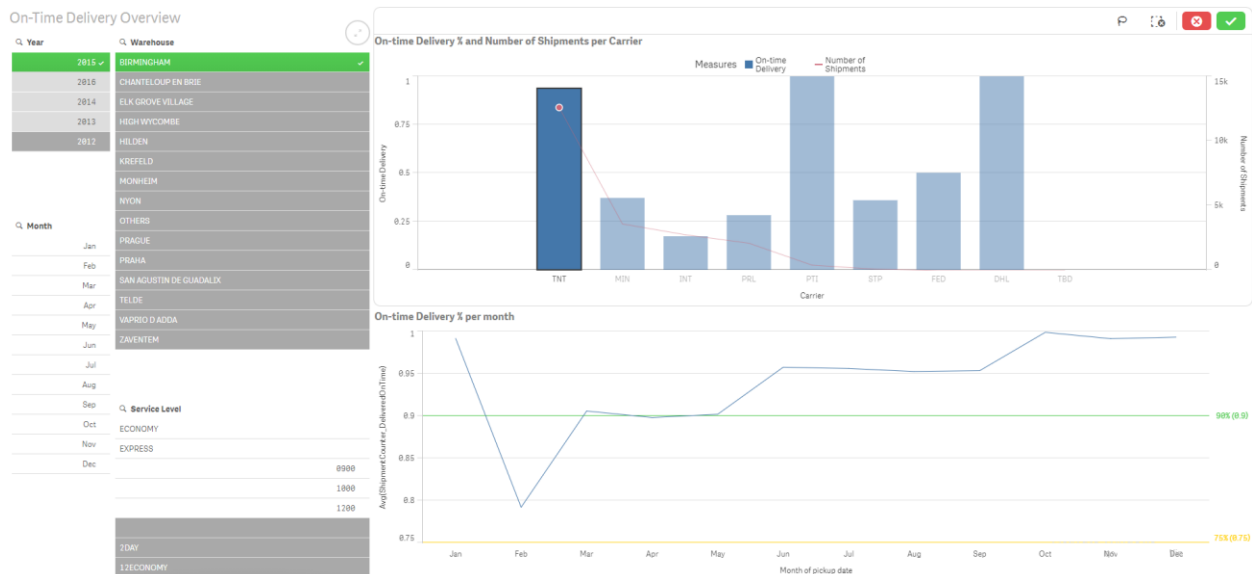


Figure 6.4 - Screenshot of report 4: On-time Delivery Overview

6.2 What-if Analysis Tool Prototype

In this section we create the prototype of the what-if analysis tool. The goal of this prototype is to provide a proof of concept of the what-if analysis. We do this by providing an example situation and run it through the six processes of the what-if analysis.

We define the following example situation:

The manager at Beckman Coulter's warehouse in Prague wants to analyse the shipments sent to Czech Republic, Croatia and Poland that were shipped with carrier TNT in January 2016. He wants to perform a what-if analysis to see what the effects are of doing these shipments with Fed Ex.

The menu of the what-if analysis is displayed in figure 6.5, and lists the steps required to perform the what-if analysis. We go through each step to show and discuss how it is performed.

What-If Analysis Menu

Step 1: Load all required tariffs into the system first.
If the tariff set is complete, continue to step 2.

Step 2: Create shipment data set
Select one of the options:

Approach 1: Generate a shipment data set based on a selection of historical shipments.

1. Generate Shipment Data Set

Approach 2: Create your own shipment data set spreadsheet. Download a template for the spreadsheet and populate it with your own shipments or shipment frequency distribution.

2. Download Template for Shipment Data Set

When your spreadsheet is ready, continue to step 3.

Step 3: **Insert Shipment Data Set**

When Shipment Data Set is inserted, continue to step 4.

Step 4: **Define Scenario and Set Variables**

Define all scenarios before continuing to step 5.

Step 5: **Run Simulation**

Select the scenarios for simulation, then continue to step 6.

Step 6: **Export Results**

Select the scenarios for export to QlikSense

Figure 6.5 - What-if Analysis Prototype Menu

Step 1: Insert Tariff

In step 1 the tariffs are inserted in the system, so we can work with a complete tariff set. The tariffs of TNT and Fed Ex are present in the system already, so we don't have to load any new tariffs and can continue to step 2.

The process of inserting new tariffs in ShipitSmarter is a complex activity that is understood by the users, but we believe that it doesn't add much value to the example in this thesis. Therefore, we decide not to explain this process in detail.

Step 2: Create Shipment Data Set

In step 2 the shipment data set spreadsheet is created. In section 4.5 we discussed three approaches to do this. In this example we use the approach that generates a frequency distribution of similar shipments based on weight classes and the country of destination. Therefore, we click the "1. Generate Shipment Data Set" button in the menu of figure 6.5.

Figure 6.6 shows the screen to generate the shipment data set spreadsheet. In this screen the user selects the shipments he wants to use in the what-if analysis.

Generate Shipment Data Set Spreadsheet

Select Shipments

Date range	<input checked="" type="checkbox"/> 1 ▾ January ▾ 2016 ▾	Specify the date range for the selection
to	<input checked="" type="checkbox"/> 1 ▾ February ▾ 2016 ▾	
Weight range	0 <input type="text"/> kg	Specify the weight range for the selection
to	9999 <input type="text"/> kg	
Carrier	<div style="border: 1px solid #ccc; padding: 2px;">All DHL TNT FED</div>	Select one or more carriers for the selection
Service Level	<div style="border: 1px solid #ccc; padding: 2px;">All EXPRESS ECONOMY 0900</div>	Select one or more service levels for the selection
Warehouse	<div style="border: 1px solid #ccc; padding: 2px;">All Birmingham Monheim Prague</div>	Select one or more warehouses for the selection
Destination Country	<div style="border: 1px solid #ccc; padding: 2px;">All BE CZ HR</div>	Select one or more destination countries for the selection
Generate frequency distribution based on weight classes	<input checked="" type="checkbox"/>	Select to group shipments per weight class. Clear selection to generate each individual shipment

Figure 6.6 - What-if Analysis: Generate Shipment Data Set Spreadsheet menu

We select the shipments from 1-jan-2016 to 1-feb-2016, from 0 to 9999 kg, that are shipped by TNT, with any service level, from the warehouse in Prague, to locations in the Czech Republic, Croatia and Poland.

We select the option to generate the frequency distribution based on weight classes to group similar shipments together in order to reduce the size of the spreadsheet. If this option is not selected each individual shipment is listed in the shipment data set spreadsheet with a frequency of one.

We click the “Generate” button and the system generates the loadsheet of the shipment data set.

This selection contains 1137 shipments of which 378, 334 and 425 are sent to respectively Czech Republic, Croatia and Poland. These shipments are divided over 25 weight classes for each destination country as displayed in figure 6.7. Because some heavier weight class don't have any shipments, this leads to a total of 71 shipment types in the shipment data set spreadsheet.

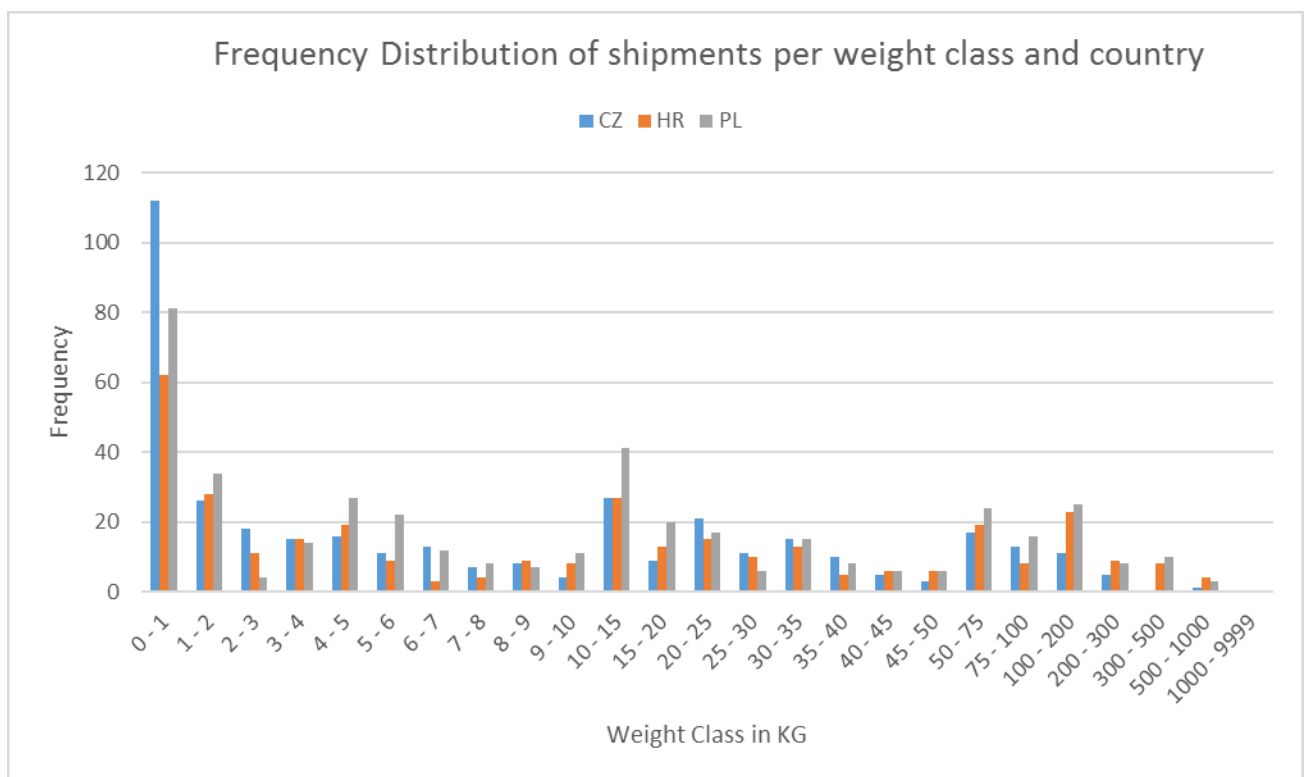


Figure 6.7 - Frequency distribution of the shipments per weight class and country

Table 6.1 shows the first 10 lines of the loadsheet of the example. We see that there are 112 shipments to Czech Republic in the 0-1 kg weight class with an average weight of 1.0 kg, and 8 shipments to Czech Republic in the 8-9 kg weight class with an average weight of 8.9 kg. The destination zip code and city name are undefined because the tariffs are only based on the destination country. The user can make changes to the spreadsheet or insert it with the original values.

Another option is to create this spreadsheet from scratch by downloading the template and populating it with the required shipment types.

Table 6.1 - The first ten lines of the Shipment Data Set Spreadsheet

Shipment ID	Frequency	Carrier	Service Level	Country From	Zipcode From	City From	Country To	Zipcode To	City To	Weight	Package Type	Dangerous Goods	Length	Width	Height
1	112	TNT	EXPRESS	CZ	10200	Prague	CZ	0	Unknown	1.0	BOX	N	1	1	1
2	26	TNT	EXPRESS	CZ	10200	Prague	CZ	0	Unknown	2.0	BOX	N	1	1	1
3	18	TNT	EXPRESS	CZ	10200	Prague	CZ	0	Unknown	3.0	BOX	N	1	1	1
4	15	TNT	EXPRESS	CZ	10200	Prague	CZ	0	Unknown	4.0	BOX	N	1	1	1
5	16	TNT	EXPRESS	CZ	10200	Prague	CZ	0	Unknown	5.0	BOX	N	1	1	1
6	11	TNT	EXPRESS	CZ	10200	Prague	CZ	0	Unknown	6.0	BOX	N	1	1	1
7	13	TNT	EXPRESS	CZ	10200	Prague	CZ	0	Unknown	7.0	BOX	N	1	1	1
8	7	TNT	EXPRESS	CZ	10200	Prague	CZ	0	Unknown	8.0	BOX	N	1	1	1
9	8	TNT	EXPRESS	CZ	10200	Prague	CZ	0	Unknown	8.9	BOX	N	1	1	1
10	4	TNT	EXPRESS	CZ	10200	Prague	CZ	0	Unknown	10.0	BOX	N	1	1	1

Step 3: Insert Shipment Data Set

In step 3 the shipment data set is inserted into the system. We click the “Insert Shipment Data Set” button in the menu in figure 6.5, which brings us to the screen displayed in figure 6.8. In this screen we select the spreadsheet file that we want to insert, assign it a name, and provide a description. We then click the “Insert” button to upload it into the system. Now we continue to step 4 to create scenarios with this data set.

Insert Shipment Data Set

Select Shipment Data Set Spreadsheet to upload:

Shipment Data Set Name:

Shipment Data Set Description:

Jan 2016 TNT shipments from Prague to CZ, HR and PL

Figure 6.8 - What-if Analysis: Insert Shipment Data Set screen

Step 4: Define Scenario and Set Variables

In step 4 we define the scenario we want to simulate and set the variables. By clicking the “Define Scenario and Set Variables” button in the menu of figure 6.5 and arrive in the screen displayed in figure 6.9. We select the shipment data set we want to use from the available data sets and define the scenario by assigning a scenario name and description. Then we set the carrier, service level and warehouse variables that we want to simulate.

In our example we create a scenario for both carriers TNT and Fed Ex, leading to a total of two scenarios. Figure 6.9 shows the settings for the Fed Ex scenario, where we set the carrier to FED and the service level and warehouse variables to the values provided by the shipment data set.

We save both scenarios and continue to step 5 in order to simulate the scenarios.

Define Scenario and Set Variables

Define Scenario

Shipment Data Set Select the shipment data set for the scenario.

PragueJan16toCZHRPL

Scenario Name Assign scenario name and description.

PragueJan16toCZHRPL_FED

Scenario Description

Jan 2016 shipments from Prague to CZ, HR and PL, shipped by FED

Set Variables

Carrier Set carriers that will be used for the simulation.

Shipment Data Set Values
 All
 TNT
FED

Service Level Set service levels that will be used for the simulation.

Shipment Data Set Values
 All
 EXPRESS
 ECONOMY

Warehouse Set warehouse that will be used for the simulation.

Shipment Data Set Values
 Birmingham
 Monheim
 Prague

Figure 6.9 - What-if Analysis: Define Scenario and Set Variables screen

Step 5: Run Simulation

In step 5 we run the simulation. We click the “Run Simulation” button in the menu of figure 6.5 and arrive in the screen displayed in figure 6.10. Here we see the scenarios that we saved in the previous step. We select the scenarios we want to simulate and click the “Run Simulation” button to start the simulation. The simulation can take a while depending on the size of the scenarios. The rate engine calculates approximately one shipment per second, which means each scenario consisting of 71 shipment types takes a little over a minute to simulate. After completing the simulation, we can continue to step 6.

Run Simulation

Select scenarios for simulation Select the scenarios that should be simulated

PragueJan16toCZHRPL_TNT
 PragueJan16toCZHRPL_FED

Figure 6.10 - What-if Analysis: Run Simulation screen

Step 6: Export Results

In step 6, we export the simulated scenarios to QlikSense so they can be analysed. By clicking the “Export Results” button in the menu of figure 6.5, we arrive in screen displayed in figure 6.11. Here we select the simulated scenarios that we want to export to QlikSense and click the “Export Results” button.

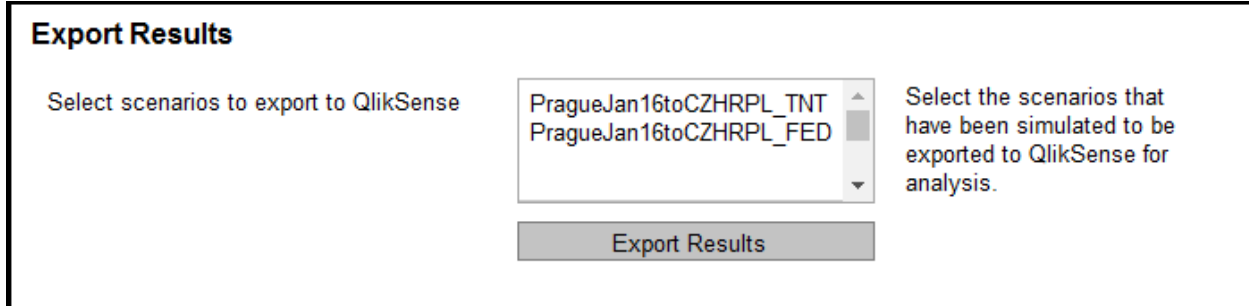


Figure 6.11 - What-if Analysis: Export Results screen

In QlikSense the results can be viewed in a report and the result of our example is displayed in figure 6.12. In this report we see scenario ID's 1 and 2 which represent the scenarios for TNT and Fed Ex. We see a graph of the total amount, the total amount per destination, and the total amount per weight class for each scenario.

We see that the total amount of scenario 1 is €37.812 and the total amount of scenario 2 is €37.528, which is pretty similar. We can see that TNT is cheaper when shipping to Czech Republic and Poland, but more expensive when shipping to Croatia. This indicates that the manager should use Fed Ex for shipments to Croatia, and keep TNT for shipments to Czech Republic and Poland.

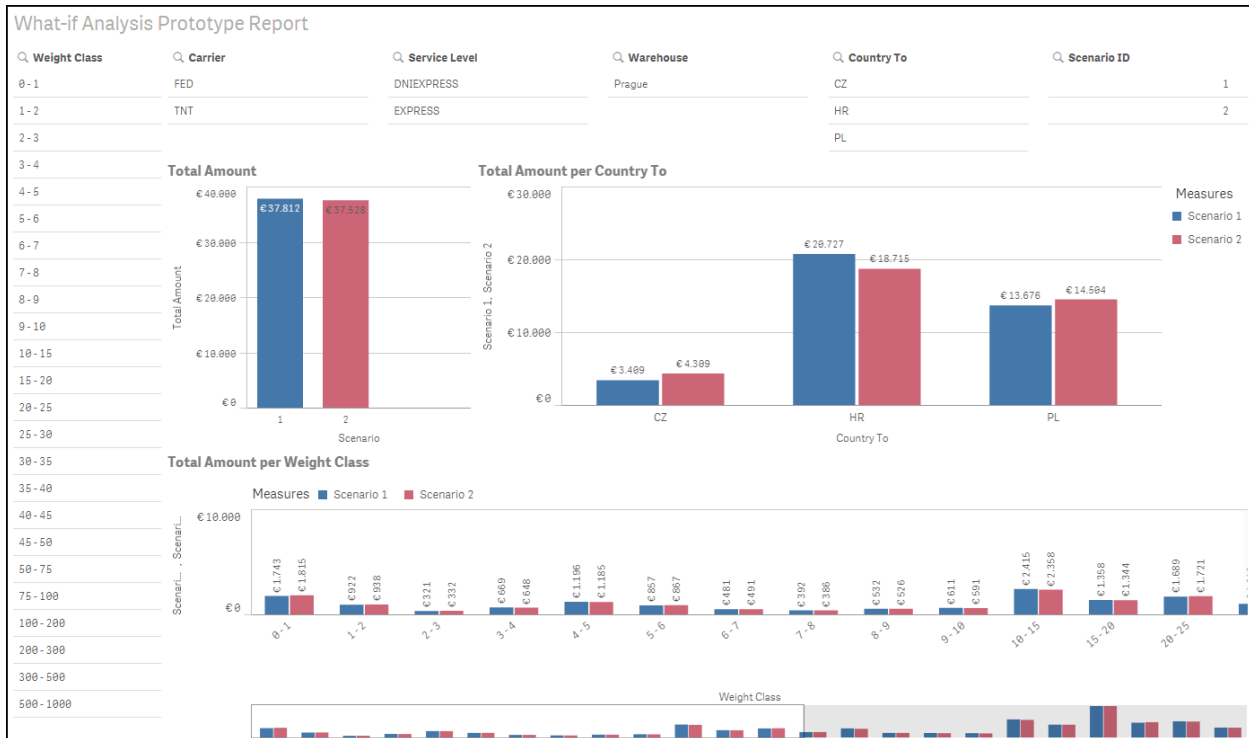


Figure 6.12 - QlikSense Report of the what-if analysis

The reports are interactive and can be used to analyse the data in more detail. By filtering on country or weight class we can easily obtain more detailed information on these selections. A selection on the weight classes over 50 kg and destination country Croatia is displayed in figure 6.13.



Figure 6.13 - QlikSense Report of the what-if analysis with filters

This example situation we ran with this prototype showed the concept of the what-if analysis. Implementing the what-if analysis will provide the customer with a tool to assist him in decision making on the tactical and strategic levels.

6.3 Conclusion

In this chapter we created the prototypes for the data analysis tool and the what-if analysis tool. In section 6.1 we created four reports in QlikSense. In section 6.2 we defined an example situation to go through the process steps of the what-if analysis. This prototype provided a proof of concept on the what-if analysis model, and can be used as a starting point when developing the real system.

Chapter 7 - Conclusions and Recommendations

In this chapter we describe the conclusions and recommendations of this research. In section 7.1 we discuss the conclusions on the goals and the research questions of this thesis. In section 7.2 we give recommendations for ShipitSmarter to implement the findings of the research. In section 7.3 we discuss the lessons learned in the research. In section 7.4 we discuss possibilities for further research.

7.1 Conclusions

In Chapter 1 we described ShipitSmarter and their current situation related to the control tower framework. Based on the analysis we identified the problems and formulated the following main question for the thesis:

MQ: How can ShipitSmarter extend the Control Tower proposition to provide support on all levels (operational, tactical and strategic) by incorporating business intelligence capabilities?

The goal of this thesis is to provide ShipitSmarter with a data analysis tool for its customers to get an overview of carrier performance and costs, and to perform what-if analyses related to processes within ShipitSmarter.

In order to complete this goal, we formulated four research questions. We now present the results and conclusions per research question.

RQ 1: What performance indicators should be included in the performance analysis tool of ShipitSmarter?

We answered this question in Chapter 3. First we reviewed literature on performance indicators in the logistics and transportation sector which resulted in a list of performance indicators that we could use in our next step. That step consisted of selecting performance indicators based on analyzing the contracts and relations between customers and carriers. We selected 14 performance indicators and assigned them to three groups: shipment cost, service quality and throughput. Each indicator is operationalized to obtain a detailed definition and identify the required input data. The selected performance indicators that we selected for the performance analysis tool are displayed in figure 7.1.

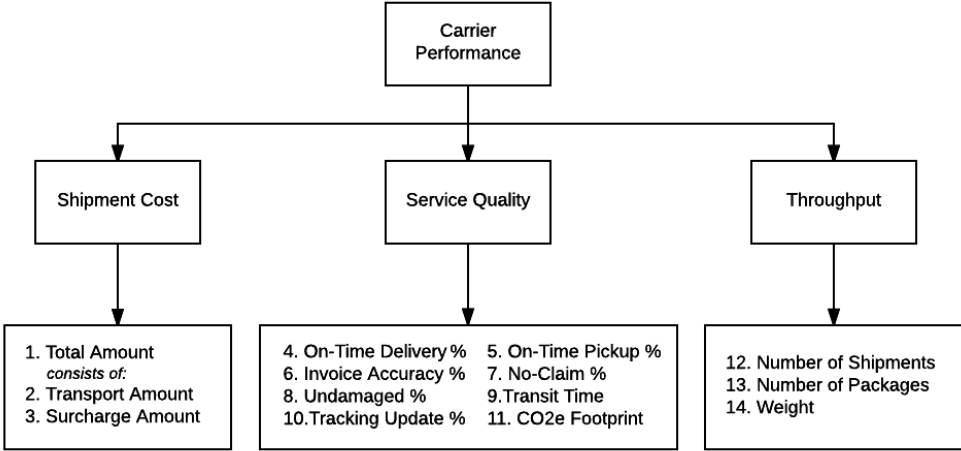


Figure 7.1 - The selected performance indicators

RQ 2: What is an effective what-if analysis model for ShipitSmarter?

We answered this question in Chapter 4. We first developed an understanding of the situation by analyzing the tariff structure. Then we defined the objectives of the what-if analysis and described five types of scenarios that we want to simulate. Based on these objectives we defined the input and output variables of the model. The main output variables are shipment cost and transit time. The main input variables are the carrier and service level used for the shipment, the warehouse location of the shipment, the available tariff sets, and the shipment data set that contains the shipments types that we simulate. We proposed a model for the what-if analysis and discussed its processes, and we defined all attributes the shipments require to perform the what-if analysis. Finally, we discussed three approaches to generate the shipment data set used as input for the simulation. With approach 1 we use an exact copy of historical shipments. Approach 2 uses a frequency distribution of shipment types of historical shipments based on weight classes and destination locations. Approach 3 uses a shipment data set created by the customer himself, based on his forecasts or a scenario he wants to simulate. The conceptual model of the what-if analysis is shown in figure 7.2:

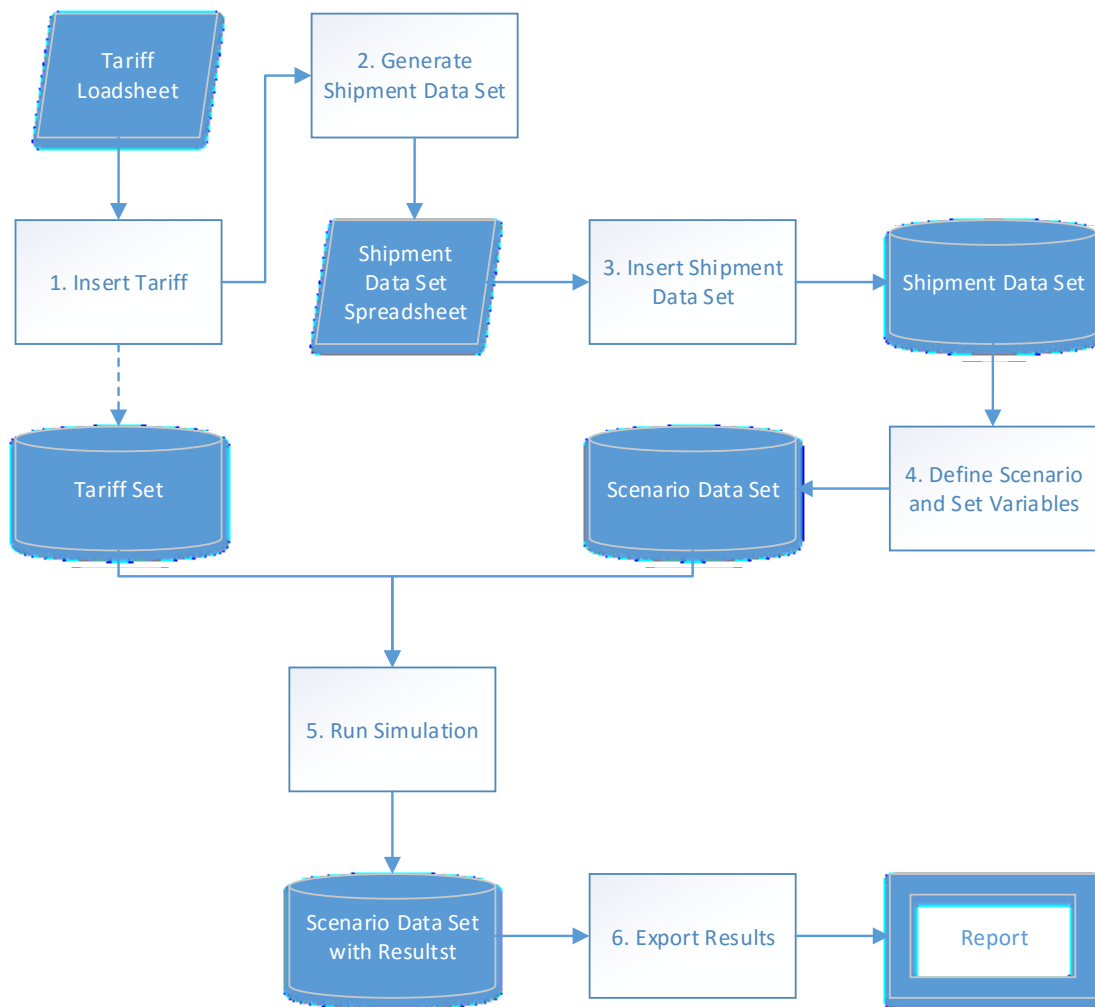


Figure 7.2 - Conceptual Model of the What-if Analysis

RQ 3: What is the quality of the required input data?

This question was answered in Chapter 5. We analysed the required input data that we defined for the performance indicators in Chapter 3, and for the what-if analysis in Chapter 4.

We first analysed the availability of this data by locating it the system of ShipitSmarter, and if the data was unavailable we discussed whether we could obtain it. Then we analysed the available data based on twenty data quality dimensions and concluded whether the data was of sufficient quality for use.

The results of this analysis show that the data required for the shipment cost indicators and the throughput indicators are available and of good quality. This was expected because these are required for of the daily operations of ShipitSmarter. The input data for the service quality indicators is of worse quality. The input data isn't completely available for 6 out of 8 indicators, and the data quality of data required to measure the on-time delivery rate is found to be incomplete and unreliable in some cases. The input data for the what-if analysis consists of shipment attributes of historical shipments and these are available and of good quality.

RQ 4: What do the prototypes for the data analysis tools look like?

We answered this question in Chapter 6. We first created the prototype for the reporting tool for which we created the four reports listed in table 7.1. These reports allow the user to analyse the performance of the carriers and obtain a good overview of how their transport costs are divided.

Table 7.1 - Reports in the prototype of the reporting tool

1 Carrier Performance Scorecard	This report gives an overview of all performance indicators for a carrier.
2 Spend Details	This report shows the total spend per month in 2015 and 2016 for the selected shipments.
3 Warehouse Spend Overview	This report gives an overview of spend per warehouse in 2015 and 2016, and shows the distribution of spend over carriers and service levels
4 On-time Delivery Overview	This report gives an overview of on-time delivery rate of carriers in the selected period.

For the prototype of the what-if analysis we defined an example situation to go through the process steps. This prototype provided a proof of concept on the what-if analysis model, and can be used as a starting point when developing the real system.

7.2 Recommendations

In this section, we recommend ShipitSmarter to follow up on the findings of this research.

- 1. Create data generation/collection processes for the unavailable input data of selected performance indicators.**

In Chapter 5, we concluded that for 6 out of the 8 service quality performance indicators the input data wasn't directly available. The processes that are required to generate or collect this input data should be identified and based on the costs to implement these processes, and the importance of the related performance indicators, ShipitSmarter should decide whether to implement the processes or not.

2. Review data generation/collection processes to ensure high quality input data for performance indicators.

In Chapter 5, we concluded that the quality of the input data for the on-time delivery rate was not of sufficient quality. To provide a reliable performance report for the customers, it is important that the input data for this indicator is available and accurate for every shipment. We therefore recommend reviewing the processes that generate or collect this input data, and make sure these are accurate so reliable reports are provided to the customer. The on-time delivery rate is the most important carrier performance indicator. Therefore, we highly recommend reviewing these processes because the data analysis tool will not be used when the customer doesn't trust the results.

3. Develop and implement the what-if analysis tool in ShipitSmarter.

In Chapter 4, we designed the conceptual model for the what-if analysis, and in Chapter 6 we created a prototype and ran an example situation to provide a proof of concept. ShipitSmarter should make a planning for the development and implementation of the what-if analysis tool.

4. Develop and implement the data analysis tool in QlikSense.

In Chapter 7, we created four reports for the prototype of the reporting tool. ShipitSmarter should make a planning for the development and implementation of the reporting tool. Once implemented, user feedback can be used to improve or add reports. While a set of general reports is useful, some customers might want to use specific information that is currently not available in the reports.

7.3 Lessons Learned

In this thesis we researched different theories and methods to answer the question of ShipitSmarter. We applied the method of combining a literature research and the stakeholder approach to determine the performance indicators. We designed a conceptual model for a what-if analysis for ShipitSmarter, based on a method for designing a simulation study. Finally, we analysed the data quality of the required input data.

The generalisability of the research is limited because it is very specific for the situation and processes at ShipitSmarter. By applying the methods to this specific problem, we can say that the contribution to practice is great for ShipitSmarter. However, the scientific contribution to the field and the general applicability in practice is limited.

7.4 Further Research

We limited our research on the topic of forecasting to the what-if analysis to narrow the scope of the research. Further research can be done on extrapolation of historical data to provide additional forecasting functions to the customer.

The what-if analysis prototype should be further researched. The next step would be to create a functional prototype that can be tested by users at ShipitSmarter or customers. Based on feedback from users the tool can be further developed.

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