B2B APPROACH ON SHIPMENT CONSOLIDATION AND DISPATCHING PROBLEMS WITH SEMI SOFT TIME WINDOWS

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This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

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ABSTRACT

B2B APPROACH ON SHIPMENT CONSOLIDATION AND DISPATCHING PROBLEMS WITH SEMI SOFT TIME WINDOWS

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The research herein explores how the timeliness of delivery affects cost and service structure and how penalties vary in case of late delivery for both business buyers and service providers. For this aim, mixed technique that comprises qualitative and quantitative method is used. Hence, this thesis can be evaluated as two interrelated studies in a comprehensive way.

Research outputs and managerial implications of this thesis comprise of objective function improvements, decreasing number of scheduled vehicles, and decreasing total penalty and total cost for service providers. In this respect, it has achieved better results in terms of cost and service level when it is compared to the Sinem Tokcaer (ST) model which is previously used for solving single-objective cost minimization problem.

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Keywords: transportation planning, shipment consolidation, multiple-criteria decision making, business to business approach

ÖZET

YARI ESNEK ZAMANLI YÜK BİRLEŞTİRME VE SEVKİYAT PLANLAMASI PROBLEMLERİNE İŞLETMELER ARASI YAKLAŞIM

Lafcı, Seda

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Bu çalışmada teslimat zamanının maliyet ve hizmet yapısını nasıl etkilediğini ve geç teslimat durumunda cezaların hem servis sağlayıcılar hem iş alıcıları için nasıl değiştiği araştırılmaktadır. Çalışmada araştırma metodu olarak nitel ve nicel metodu içeren karışık teknik yöntemi kullanıldığından bu çalışma birbirini etkileyen iki farklı çalışma olarak değerlendirilebilir.

Bu tezin araştırma çıktıları ve yönetimsel sonuçları, amaç fonksiyonunda sağlanan iyileştirmeleri, planlanan araç sayısının azaltılmasını, hizmet sağlayıcılarının toplam ceza ve toplam maliyetinin düşürülmesini içermektedir. Bu bağlamda, daha önce tek amaçlı olan maliyet en küçükleme problemini çözmek için kullanılan Sinem Tokcaer (ST) modeline kıyasla maliyet ve hizmet seviyesi açısından daha iyi sonuçlar elde edilmiştir.

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Anahtar sözcükler: ulaşım planlaması, yük birleştirme, çok ölçütlü karar verme, işletmeler arası yaklaşım

To my family

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CHAPTER 1

INTRODUCTION

1.1 Background

Today's highly competitive marketplace brings about substantial shifts to the function of supply chains. Combining demand and supply with optimal cost and service level alone do not satisfy expectations from supply chains. Creating competitive advantage has become a 'one-step ahead' criterion for most of the companies. Similarly, numerous firms have realized the potential of fully integrated supply chains to get competitive advantage; the importance of responsiveness, speed to market, delivery quality and sustainability come into prominence for them.

Regarding speed to market delivery, as one of five supply chain processes, has a role in performance of supply chains. It demonstrates how successful the supply chain is in terms of providing products and services to customer (Lockamy and McCormack, 2004). In addition, timeliness of delivery and time management are fundamental aspects of overall supply chain success to establish competitive advantage for many organizations within the supply production - distribution chain. In this regard, the focus of partners of integrated supply chains, whose primary objective is to facilitate basic activities related to production, distribution and delivery, is on improving service level performance by reducing delivery time. Similarly, industrial supply chains aim to achieve superior delivery performance due to the complexity of the supply chain processes.

In this context, delivery performance is acknowledged as a strategic level performance measure for excellence of supply chains and customer service levels. In addition, it is strongly related with other supply chain operations, such as selection of third party logistics providers and other suppliers, globalization of sales, investments and production planning and control systems (Golini and Kalchschmidt, 2010).

There are several performance measures connected to delivery, such as on-time delivery (Katayama & Bennett, 1999; Li & O'Brein, 1999; Stock&Lambert, 2001 ;Garg et al., 2004), delivery reliability (Stock&Lambert, 2001 ;Garg et al., 2003; Rupp & Ristic, 2004; Michael & McCathie, 2005), faster delivery times (Bowersox et al., 1999), reduction in lead times (Stewart , 1995), delivery service, delivery frequencies (Katayama & Bennett, 1999), delivery synchronization (Lee & Whang, 2001), delivery speed (Mason et al., 2003), order fulfillment lead time (Tannock et al., 2007), supplier's delivery performance (Morgan & Dewhurst, 2008), inventory service level (Novich, 1990; Stock&Lambert, 2001), process stability (Meier et al. 2013), sustainable delivery (Litman, T, 2016). The importance of these measures vary across organizations, and thus organizations decide which of these measures should be used.

When it comes to the importance of delivery performance measures, on-time delivery is generally considered as the most important performance variable (Gunasekaran et al., 2004). As timeliness of delivery has a direct effect on customer satisfaction, improving the performance of the delivery process is seen as a key concern by supply chain and logistics managers. Thus, companies have created time windows to provide on time delivery and time efficiency for both themselves and satisfaction of their customers.

A design and manufacturing company, **Analog Devices,** defined time window as two weeks early to zero days late in order to determine what percentage of shipment is made in an acceptable window around the factory commit date (Schneiderman, 1996). **Cemex**, a Mexican multinational cement manufacturer and distributor created an operational system for short delivery windows, and decreased delivery windows by 20 minutes.

In an example from the food sector, on time delivery and product quality were selected as key KPIs for supplier performance measurement, and delivery windows were created from 30 minutes early to 30 minutes late. In one of the cases of **Wal-Mart**, suppliers who are consistently early or late in delivering goods, and who miss the window could face a penalty just because of this, they were obliged to deliver within 4-day period (Reuters, 2010).

From the information technology sector, **Hewlett-Packard's** window, which is three days early to zero days late, was used for measuring delivery performance. Another example came from **chemical sector**; a group decided to encourage its logistics team to reduce delivery times to two days from three in order to increase service level.

Nowadays, because customers are demanding faster and cheaper deliveries, delivery windows are shrinking and expressed in hours. For example, **FedEx** reduced delivery window to 2 hours for package deliveries with a payment of $40 per year for premium perks. Similarly, **Amazon Prime** use very narrow windows, especially in pharmaceuticals and food deliveries, based on the idea that "by the time the order comes in, it has to be processed and ready to go."

As it can be seen from the examples, companies attempt to reduce delivery time and give importance to on-time delivery. They set different time windows, based on the industry and they measure delivery performance based on the compatibility provided by specified time windows. Looking at cases, it can be said that when time intervals are not met, customers are dissatisfied. Companies aware of the importance of customer satisfaction avoid being out of the specified time window, and they define some obligations and penalties.

1.2 Delivery Time Windows and Penalties

A delivery window is defined as the difference between the earliest and the latest acceptable delivery date. When an order is placed, the customer is typically notified with a fixed promised date. Under the concept of delivery windows, business buyers give an earliest allowable delivery date and a latest allowable delivery date (Guiffrida and Nagi, 2006a). Delivery windows are proposed to provide timely delivery of the products within the tolerance.

When the delivery occurs within the window, the buyer accepts delivery, and does not impose any penalties. However, deliveries before or after delivery window are penalized due to undesirable consequences for both sides. For example, early deliveries lead to excess inventory holding, and late deliveries bring about production stoppage costs, lost sales and loss of goodwill. An early application of a delivery window model that financially penalizes a supplier for early and late delivery in a two stage (supplier–buyer) supply chain is found in Guiffrida et al.

(1990). Guiffrida and Nagi (2006a) characterized these penalties as “penalty costs” incurred in addition to the normal operating costs of the supply chain.

Depending on the business problems, time windows can be classified as hard, soft or semi soft. In hard time windows, each load must be delivered within the time window of the respective customer. In this type of the problem, a release time is defined, and a hard time window is created with earliest and latest time for the pickup and delivery services. On the other hand, a hard time window requires that vehicles wait until the time window begins before a delivery or must not arrive until the time window begins. When the time window finishes, the delivery cannot be made. In other words, violations are not allowed (McKinnon et al., 2010).

In soft time windows, which is also considered as relaxed time windows, trucks are allowed to serve customers before and after the earliest and latest time windows, but costs are introduced depending on the service time of a customer in order to penalize early and late arrivals that are feasible but undesirable. (Glover and Kochenberger, 2003)

In semi-soft time windows, penalties are considered for late arrivals (Setak et al., 2016). However, waiting on early arrival is allowed without cost as distinct from soft time windows. Because late deliveries are going to be allowed with a cost and early deliveries are not subjected to a cost, the current thesis can be assessable as semi soft time window problem. In this regard, it is not required that the delivery begins with the given time windows, as the “hard time delivery window” does, but rather, it is required that the solution is penalized whenever the time window is missed.

1.3 Research Objectives & Significance of the Study

The objectives of this research are as follows:

1. Evaluate delivery performance and service quality criteria based on the perception of service providers and buyers,
2. Determine the importance level of the on-time delivery concept for both sides,
3. Understand tolerance level of customers against deferred and delayed deliveries,

4. Explore measures against late deliveries will be examined in order to prevent penalty costs and corrective actions to be taken after late deliveries,
5. Reveal delivery windows for late delivery based on the tolerance of the customers, and express them as constraints in mathematical model,
6. Classify penalties in case of late deliveries in a hierarchical manner,
7. Model penalties by associating them with customer service level while providing cost efficiency.

Because this thesis comprises both qualitative and quantitative data, it differs from other studies. In most of the penalty cost based studies, techniques employed are generally one-sided. However, in this thesis, a mixed technique is used to create a more comprehensive study.

On the qualitative side, we aim to create delivery performance and service quality categories. Also, the importance of timely delivery, one of the most important indicators of delivery performance, will be investigated. Regarding delivery cycle time, upper and lower bound of tolerance level will be defined, and customer tolerances for these bounds will be revealed within the context of delivery window. Herein, customers' reactions to deferred and delayed customer shipments will be specified, and penalties considering different delay situations are classified accordingly. Measures against late deliveries will be examined in order to prevent penalty costs.

On the quantitative side, delivery windows for late delivery, based on customer tolerance, will be revealed and expressed as constraints in mathematical model, and then late deliveries outside of these delivery windows will be subject to penalty. Also, penalties will be classified by means of creating a hierarchical structure, and modeled accordingly. These penalty costs as a result of late delivery will be examined under the heading of finance and time for both buyers and service providers. These costs will be associated with customer service level and relative importance of cost and customer satisfaction will be found.

These two studies will be done from the viewpoint of business buyer and service provider taking a dyadic view. The reason for investigating delivery performance as KPI is that customers, in other words, business buyers, expect on time deliveries and

shipments. For this reason, it is in the service provider's best interest to ensure that on time delivery is as high as possible, so that the supply chain runs smoothly, and satisfaction remains high. Especially in the B2B world, a late delivery can have a major influence on the business buyers waiting for the finalized product, and penalties are much more severe. Also, because late delivery is strongly related with customer service, this could be disastrous for service providers as well. For these important reasons, we focus on working on B2B, believing that it will bring more comprehensive results for late deliveries in terms of penalties.

The research reported herein also contributes a methodology for determining the optimal delivery window which minimizes the penalty cost of late delivery. In this methodology, measures for late delivery will be set by both buyers and service providers.

In addition to the main contribution, the importance of on time delivery herein is associated with combined dimensions, such as planning, sale, productivity and penalty, in contrast to the existing literature, which investigates delivery performance and production planning (Lane& Szwejczewski, 2000), delivery performance and supplier selection (Ernst et al., 2007), globalization of sales, investments in supply chains and delivery performance (Golini&Kalchschmidt, 2010).

CHAPTER 2

LITERATURE REVIEW

The chapter is organized as follows. In the first section, the supply chain delivery window literature is reviewed, and the importance of on time delivery is examined. In second section, the models are classified for evaluating delivery performance which uses delivery windows.

2.1. On-Time Delivery

Several studies have documented the importance of on-time delivery in supply chain operations (**Table 1**). Neely et al. (1994) investigated small and medium-sized UK firms, which seek a way to realize their manufacturing strategies through their performance measurement systems. Based on their questionnaire, on-time delivery was identified as the most important order winning criterion. Vonderembse and Tracey (1999) searched for the most important supplier selection criteria enhancing supplier and manufacturer performance. They design a model and develop a five-point Likert scale for improving supplier and manufacturing performance, and found that supplier performance is strongly related with manufacturer performance regarding on-time delivery to final customer. Tan et al. (2002) searched for a specific description of supply chain practices, and examined how the practices impact company performance. Under examined supplier evaluation practices, respondents were asked to indicate how they evaluate their supplier's performance. Through utilizing a designed questionnaire and statistical analysis, they found that practices receiving the highest mean scores are: on time delivery and reducing response time. Kumar and Antony (2008) conducted a comparative study on quality management practices and measured the impact of Six Sigma practices on firm performance. In this study, manufacturing quality, product reliability, and on-time delivery were

found as the three most important factors in winning customer loyalty and capturing customer voice, irrespective of the size of the firm. Anderson et al. (2011) identified factors that are important in a logistics service provider selection. They used discrete choice analysis to model the choices of key decision makers. Among different logistics service attributes, the majority of customers considered reliable performance linking with consistent "on time" delivery as the most critical factors for choosing of a 3PL provider. Blome et al. (2013) assessed the influence of supply chain agility on operational performance. Through the survey which was constituted by means of tailored design method, they defined operational performance as a firm's competitive position in terms of service level performance (on-time-in-full deliveries). Jena and Seith (2016) identified various significant elements of logistics cost for the Indian steel sector, and observed its relationship with cost of transportation, warehousing and administration. Among these, route mapping and on time delivery were seen as important elements which have an effect on these costs.

Table. 1. Summary of Empirical Studies on the Importance of On Time Delivery

Study	Method	Sample	Finding
Neely et al. (1994)	Total Design Survey Method	800 small and medium-sized UK manufacturing firms	Firms perceive delivery on time as their most important performance measure.
Vonderembse and Tracey (1999)	Design a model and develop a scale for performance	268 purchasing managers	Supplier performance is highly correlated with manufacturing performance with regard to on-time delivery to final customer.
Tan et al. (2002)	Survey and Statistical Analysis	1500 senior US senior managers of manufacturing firms	On time delivery is reported as the most important (out of 24) supply chain performance practices.
Kumar and Antony (2008)	A survey-based approach	500 UK manufacturing enterprises	On-time delivery of the final product is one of the most important criteria to win customer orders and important for capturing customer voice.
Anderson et al. (2011)	Discrete Choice Analysis and Latent Class Segmentation	309 Asia Pacific customers of large multinational 3PL providers	Reliability performance regarding on time delivery plays an important role in the selection of third party logistics providers.

Study	Method	Sample	Finding
Blome et al. (2013)	The Tailored Design Method	121 supply chain management professionals	Operational performance shows that on time delivery and supply chain agility are interrelated.
Jena and Seith (2016)	Probability Sampling Method	12 senior managers and senior logistics professionals	Route mapping and on time delivery of shipments have an effect on logistics cost.

2.1.1 Supply Chain Delivery Window

Delivery windows were firstly seen as time window constraint in production scheduling and vehicle routing models, and later appeared in supply chain delivery models. An early example of time window constrained in scheduling and routing problems was found in Solomon and Desrosiers (1988). In the recent literature, time windows act as integral component in models for **project scheduling** (Cesta et al., 2002; Hurink et al., 2011), **machine scheduling** (Brucker and Kravchenko, 2008; Huang and Yang, 2008 ; Ullrich, 2013), **vehicle routing** (Dondo and Cerda, 2007; Benjamin and Beasley, 2010; Ullrich, 2013), and **supply chain scheduling** (Yeung et al., 2010; Yeung et al., 2011).

Immediately after the first application of a delivery window model (Guiffrida et al., 1990), the attractiveness of delivery windows was further advanced by Corbett (1992), who emphasized that delivery windows offer an ability to improve on-time delivery performance or dependability in manufacturing sector. In that case study, the manufacturer was supplying office furniture to firms which installed it. Early and late start dates for the installation task were defining delivery window. Kumar and Shaman (1992) discussed competitive advantages of suppliers who decrease the delivery time window from four hours to one hour. Johnson and Davis (1998) defined delivery windows in order to track the performance of the delivery process

by measuring the percentage of orders delivered within the customer's delivery target. According to these metrics, delivery reliability was disclosed as one of the important aspects of delivery process. Boyer et al. (2009) searched the relative change between efficiency and cost as delivery windows were lengthened.

2.2 Classification of Supply Chain Delivery Performance Models

Models utilizing delivery windows in order to evaluate delivery performance within supply chains can be divided into two groups: index based models and penalty cost based models. In both categories, delivery timeliness is analyzed pertaining to the customer's specification of on-time delivery window.

2.2.1 Index Based Models

Index based models translate untimely delivery (early and late delivery) into a "delivery capability index" measure, similar to the family of process capability indexes traditionally used in manufacturing (Bushuev and Guiffrida, 2012). **Table 2** summarizes index based models which utilize Six Sigma statistical tools, such as process capability indices, tolerance and control charts, to provide cost-based metrics for evaluating delivery performance.

Narahari et al. (2000) introduced a notion called six sigma supply chains to describe and quantify supply chains with timely deliveries. They used upper and lower specification limits as process capability indices to achieve a high level of delivery performance in supply chains. Garg et al. (2006) solved specific problem, which compute allowable variability in lead-time for individual stages of the supply chain, so that specified levels of delivery sharpness and delivery probability are achieved in a cost-effective way. They defined delivery sharpness, which was later used with delivery probability as classical performance index. They also suggested an efficient heuristic approach for solving the problem. Wang and Du (2007) investigated supply chain performance based on the capability index, which establishes the relationship between customer specification and actual process performance by providing an exact measure of process yield. They designed an objective to achieve a high success rate for delivering finished products to customers in a pre-specified delivery time

window. Hsu et al. (2013) used lead-time, delivery window and delivery performance chart (DPC) to measure delivery performance of every stage in a serial supply chain. They considered uncertainty of estimated process capability indices caused by sampling data, and also plotted lower confidence bounds (LCBs) to measure minimum delivery capability of each stage in the supply chain. Ngniatedema et al. (2016) measured delivery performance using a cost-based analytical model which evaluates expected cost for early and late delivery. They presented set of propositions that define the effect of changes to the parameters of the delivery time distribution on the expected penalty cost for untimely delivery in the case that a supplier uses an optimally positioned delivery window to minimize the expected cost of untimely delivery.

Table.2. Index Based Supply Chain Delivery Performance Models

Author	Method	Remark
Narahari et al. (2000)	Six Sigma Approaches by applying Statistical Tolerance Technique	Achieving outstanding delivery performance and customer service levels in a supply chain by guaranteeing high probability of delivery within the promised delivery window.
Garg et al. (2006)	Six-Sigma based delivery capability index and Heuristic Approach	Attaining delivery probability and delivery sharpness for a given end-to-end lead-time delivery window in a cost effective way.
Wang and Du (2007)	A capability index to model continuous improvement	Achieving high success rate for delivering finished products to customers in a pre specified delivery time window.
Hsu et al. (2013)	Delivery Performance Chart	Using lead-time, delivery window and delivery performance chart (DPC) to measure the delivery performance.
Ngniatedema et al. (2016)	Cost-Based Analytical Model	Developing a framework to improve delivery performance of a supplier.

2.2.2 Penalty Cost Based Models

Penalty cost based models translate untimely delivery into an expected cost measure. Hence, these models help to measure delivery performance in financial terms (Gunasekaran et al., 2001). This model are relevant to our problem, and will be reviewed in detail. This is because, based on the result of interviews about late delivery, penalties will be defined and added to the objective function of the mathematical model as an expected penalty cost measure, by associating it with customer satisfaction.

Penalty cost based models are indicated in **Table 3.** These models introduce penalty cost functions associated with an untimely delivery (early and late) for both pickup and delivery. Grout (1998) proposed delivery windows as a means of achieving timely delivery of the products. Also, he found that selecting a delivery window alone does not assure desired on-time delivery performance; the buyer can also use penalties to manage delivery timeliness. As it stands, optimal proportion of on-time deliveries could be increased by raising late penalty costs. In this regard, linear and hyperbolic variance cost functions were explored, and per-time period penalty for late delivery was defined. Guiffrida and Nagi (2006a) addressed some strategies for improving delivery performance in a serial supply chain when delivery performance is evaluated with respect to a delivery window. They presented some propositions to provide an analytical analysis of the expected penalty cost model as a function of the following: the width of the on-time portion of the delivery window, the mean and the variance of the delivery time distribution. They developed an expected penalty cost model for assessing financial investment required to improve delivery performance. Chan et al. (2012) addressed the scheduling problem of delivery where it is expected that the products ship from suppliers to customers within time window. To generate online delivery scheduling for the distribution network, they found a solutions aiming to minimize inventory, transportation and penalty cost. They used a soft time penalty window that issues penalty for both early and late deliveries, by using both cross docking network model and generic algorithm. Bhattacharyya and Guiffrida (2015) illustrated how improving supplier delivery performance leads to better

supplier management. They introduced a framework model, which shows the true present worth of penalty costs to a buyer due to future untimely deliveries from a supplier. Through greedy algorithm, total penalty cost was increased for untimely deliveries. Setak et.al (2016) discussed a variant of supply chain networks, including simultaneous pickup and delivery through semi-soft time windows. They used a model that minimizes total cost including penalty cost, and determines whether or not the service start times of customers are in their corresponding penalty interval. The variant of time windows increased the upper bound of time windows intervals and considered penalties on late arrival.

Table.3. Penalty Costs Based Supply Chain Delivery Performance Models

Study	Method	Remark
Grout (1998)	Linear and Hyperbolic Variance Cost Function were used and per-time period penalty for late delivery was defined.	Demonstrating how delivery windows and penalties were used as a tool for reducing late deliveries.
Guiffrida& Nagi (2006a)	Cost-Based Measure Model was used for assessing financial investment in relation to late delivery.	Defining penalties for (1) the width of the on-time portion of the delivery window, (2) the mean of the delivery time distribution, and (3) the variance of the delivery time distribution.
Chan et al. (2012)	Penalties for deliveries and pick up were defined through Cross Docking Network Model and Generic Algorithm.	Deciding the execution of deliveries from suppliers within defined time horizon.
Bhattacharyya & Guiffrida (2015)	Expected penalty cost associated with untimely delivery and penalty cost incurred over N deliveries with Greedy Algorithm.	Designing an optimization model including penalty costs for untimely delivery of multiple products through multiple cross-dock doors.
Setak et.al (2016)	Node-Based Mixed Integer Linear Programming, Genetic and Simulated Annealing Algorithm were used.	Node-based mixed integer linear programming is developed for pickup and delivery with semi soft time windows constraints considering penalties on late

		arrival.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Research Design

Within the context of this research, **qualitative method** was used to examine a variety of topics, including the perceptions of business buyers and service providers in case of late deliveries, importance of delivery on time, determination of delivery performance and service quality metrics and penalty approaches of parties and measurements against late deliveries. Regarding the perceptions of parties, qualitative research enables interviewees to "speak in their own voice and express their own perceptions and feelings" (Berg, 2007: 96). It also helps researchers to understand how and why people undertake particular behaviors within specific contexts (Rubin & Rubin, 2005). Associating with importance of delivery on time, qualitative research enables a deeper examination of what is important to customers, since it relies on the use of the customer's own voice and language. In terms of metric determination, use of qualitative research as a foundation for a quantitative method makes it easier to select metrics effectively matching customer interests (Vault, 2017). This type of research can provide insights for improvements and develop parameters (i.e., relevant questions, range of responses) for a quantitative study.

Quantitative method is also used in order to classify variables emerging from qualitative method and explain what is observed. These methods emphasize objective measurements and the statistical, mathematical, or numerical analysis of data

collected through polls, questionnaires and surveys (Babbie, 2010). In this type of research, certain statistical methods are applied on the data to obtain results for analysis, and to propose explanation for the relationship among variables. In this thesis, we aim to create multi-objective mathematical model, and measure the relative importance of these objectives which are defined as service quality and cost for both parties. Also, it is important to reveal tolerances of parties numerically for late deliveries through using lower and upper bounds in order to examine the effect of late deliveries on objective function. This method means that, results will be more generalizable and testable. Since both qualitative and quantitative methods are used interactively in this thesis, these two approaches will provide a more complete understanding of a research problem compared to a single method.

3.2 Sample

As one of the non-probability sampling techniques, purposive sampling method has been used to develop the sample of the research. In purposeful sampling, sample members are selected on the basis of their knowledge, relationships and expertise regarding a research subject (Freedman et al., 2007). Purposive sample sizes are often determined on the basis of theoretical saturation (the point in data collection process when new data no longer bring additional insights to the research questions). In this thesis, companies are selected from different sectors to address the late delivery problem in a more comprehensive way. Half of the sample members selected as business buyers have sufficient and relevant work experience in fields of production and purchasing, and the other half have experience in logistics and transportation as service providers. Within this context, the participants of this study are representatives of 14 well-known production and logistics companies located in Turkey and specifically in Izmir. For the interview, only face-to-face communication is used. After we experience the same results and reach theoretical saturation, our sample size was considered sufficient.

Data was collected in July and August of 2017 with the representatives of the related companies mentioned above. The interviews lasted between 40 and 60 minutes. Interviews were audio recorded in order to analyze the gathered data easily. Due to

confidentiality, companies' names are shown as "M" referring manufacturing firms, and "P" service providers.

Table.4. Sample of the study

Company	Position	Duration/min	Company operations
M1	Purchasing Engineer	48	Commercial and military vehicle manufacturer
M2	Customer and Production Coordinator	50	Fashion and textile manufacturer
M3	Order Management Specialist	40	Wheel Manufacturer
M4	Logistics Manager	31	Manufacturer of food products
M5	Logistics Specialist	35	Construction equipment manufacturer
M6	Logistics Specialist	45	Supplier of heating, ventilation, air-conditioning, and refrigeration (HVAC&R) systems and solutions
M7	Logistics Specialist	46	Mining company
P1	Izmir Overland Freight Manager	42	Global logistics solutions company
P2	Road Operation Specialist	51	Integrated logistics service provider
P3	Sales Manager	38	Transportation company
P4	Freight Operations Officer	60	International cargo
P5	Logistics Manager	62	Logistics solutions
P6	Sales Department	43	Transportation company

P7	Land Freight Manager	50	Logistics Services, Supply Chain Solutions and Supply Chain Consulting Services

3.3 Data Collection

Semi-structured interview is a more flexible version of the structured interview as "it allows depth to be achieved by providing the opportunity on the part of the interviewer to probe and expand the interviewee's responses" (Rubin & Rubin, 2005). When doing such interviews, researchers recommend using a basic protocol to help covering all relevant areas (i.e. research questions). The advantage of such a checklist is that it "allows for in-depth probing while permitting the interviewer to keep the interview within the parameters traced out by the aim of the study." (Berg, 2007)

For the purposes of this research, this type of interview is selected as it would allow covering various issues related with late deliveries. In this regard, some certain themes are prepared to guide the interview, and then additional themes are accrued during the interview in order to reveal more criteria. These themes are designed separately for both service providers and customers in order to gain more comprehensive insight into late deliveries. Some sample themes that were included in the semi-structured interview were the following:

- Delivery performance of service providers
- Elements of service quality
- Notion of delivery cycle time
- Penalties for late deliveries
- Difference between deferred and delayed shipments
- Prevention of delays
- Corrective actions after late deliveries
- Detrimental consequences of late delivery
- Relative importance of cost and quality

3.4 Data Analysis

3.4.1 Theming

Theming is the drawing together of codes from transcripts, presents the findings of qualitative research in a coherent and meaningful way (Sutton and Austin, 2015). The importance of this process is that, it is possible to present the data from the interviews using quotations from the individual transcripts to illustrate source of the researchers' interpretations. Thus, when the findings are organized for presentation, each theme can become the heading of a section in the report or presentation. Underneath each theme will be the codes, examples from the transcripts, and the researcher's own interpretation of what the themes mean.

3.4.2 Grounded Theory Approach

Grounded theory methodology was developed by American sociologists Glaser and Strauss in 1967 to describe a qualitative research method they introduced in their "Awareness of Dying" research in 1965. In this study, they adopted an investigative research method which avoids a judgmental hypothesis, and they frequently used comparative analysis of data. They believe that the theory obtained by this method is truly grounded in the data, and therefore named the methodology "grounded theory" (Glaser & Strauss, 1967).

Because we investigate a real word problem in the real world and analyze the data with no preconceived ideas or hypothesis, we use grounded theory. We expect that theory will emerge inductively from the data.

Grounded theory data analysis involves searching out the concepts behind the actualities by looking for codes, then concepts, and finally, categories. Coding means using words and concepts that highlight an issue of importance or interest to the research; they are noted and described in a short phrase. If mentioned again in the

same or similar words, the issue is again noted. This process is called coding, and the short descriptor phrase is a code (Allan, 2003).

While engaging in a grounded theory analysis, we used 3 types of coding; open, axial and selective. Regarding open coding, data from the company interviews were read line by line several times, and tentative labels created accordingly, which summarize the information extracted from the data. Then relationships among the open codes were identified via a combination of inductive and deductive thinking through axial coding. Then, we identified the core variable that includes all of the data with selective coding, which involved integration of the categories in the axial coding model. Axial codes and selective code based on the open codes were demonstrated below for this study in relation to the research objectives of this study:

Research Objective (RO 1): Evaluate delivery performance and service quality criteria and Research Objective (RO 2): Determine the importance level of on-time delivery concept

Table.5. Open, Axial and Selective Codes

Open Codes	Axial codes	Selective Codes
Ensuring customer satisfaction, strengthen brand image, expectation of sales increments	The place of reliability	Delivery performance of service providers
Providing definite stance for customers, ensuring customer satisfaction	The place of certainty	
Prominence in terms of planning, satisfying customer expectation, efficiency in operations, sales expectations	On delivery time	
Classifying subcontractors based on their performances, rewarding or breaking up with them, keeping score card	Subcontractors performance	

Special requests from customers	Flexibility	Importance of service quality of service providers
Being available at any time	Accessibility	
Consideration of estimated arrival date, force majors and customer relations	Consistency	
Information sharing, using subcontractors, peer to peer communication	Extra services	
Having chance to follow customer loads	Traceability	

Research Objective (RO 3): Display tolerance level of customers against deferred and delayed deliveries,

Research Objective (RO 4): Explore measures against late deliveries will be examined in order to prevent penalty costs and corrective actions to be taken after late deliveries,

Research Objective (RO 5): Reveal delivery windows for late delivery based on the tolerance of the customers and express them as constraints in mathematical model

Open Codes	**Axial codes**	**Selective Codes**
Tolerance change based on business and product group, in case of force major or special days, based on ongoing relationships, affect of honesty, flexibility of customers' customer, determination of lower and upper bounds	Tolerance rate	Delivery cycle time
Profit consideration, working	Customer priority level	

potential of customers		
Effect of product group, consolidation strategies, contract and routing	Consolidation plan	
Losing customer, suspension of payment, withdrawing of load, court solution, time for calling customers, exposure to different customer behavior, difficult requests, calling customer's customer	Customer reactions	Delayed and deferred orders
Avoiding certain deadlines, assistance of subcontractors, alteration of route , vehicle and transportation mode, getting double drivers, route planning, ordering of shipments, creating new document, relocation of addresses, using more operators, on time custom clearance, additional navigation, information sharing	Proactive behavior	Prevention of penalties

Split delivery, maturity extension, vehicle addition, order alteration, intermediate shipping, communication power	Recovery of late delivery	Corrective actions
Information sharing, working with reservation	Shorten waiting period	
Discount, invoice return, maturity extension	Offering promotions	

Research Objective (RO 6): Classify penalties in case of late deliveries in a hierarchical manner

Open Codes	**Axial codes**	**Selective Codes**
Late delivery, based on contract, based on customer relationship and effect of subcontractors	Penalty situations	Penalty classification
Breaking up, exposure to band stopping cost and fast shuttle cost, rejection of load, request for recovery, reflection of overtime fee, complaints, free freight, turning to	Types of penalties	

competitors, putting into black list, vehicle retention, bad reputation		
Based on customer categories, operations of customer and sector of product	Hierarchical penalties	

Research Objective (RO 7): Model penalties by associating them with customer service level while providing cost efficiency

Open Codes	**Axial codes**	**Selective Codes**
Rejection of goods, cost of the operators, paying difference, cost of changing transportation mode, losing of turnover free freight, cost of unsold goods, cost of discount	Monetary cost	Costs after late deliveries
Rework of operators, extra customer dialogues, customer recovery, missing the entrance to the harbor, waiting for the vehicle to be empty	Time cost	

3.4.3 Validity-Reliability

Validity and reliability must be addressed in all studies. In qualitative research, it is common to encounter the terms quality, rigor or trustworthiness instead of validity and dependability instead of reliability (Davies & Dodd, 2002).

Regarding validity, a pilot preliminary test was done in order to the ensure clarity and accuracy of the questions before the interviews with the company representatives, and incomprehensible questions were revealed and edited accordingly. Besides preliminary testing, I also applied to triangulation method by asking the similar research questions to service providers and business buyers and collecting data from different sources. The concept of data saturation is also applied; process of gathering and analyzing data lasted until the point where no new insights were observed. After repeatedly observing data similarity and confident that the categories are saturated, I stopped sampling data and rounded off the analysis.

In terms of reliability, I made meticulous record keeping, demonstrating a clear decision trail and ensuring interpretations of data were consistent and transparent. After analyses were complete, I used a common approach; cross-checking method. I asked my thesis supervisors to read through the data analysis part of my thesis so as to be sure that I and my supervisors' view if the data there consistent. I also requested their suggestion about the interpretation of some conceptions and ideas. This process provided me an opportunity to correct errors of interpretation.

3.5 Findings

After coding which is one of the grounded theory data analysis concept is used, themes and main categories are created accordingly. Table 6 shows how our research questions form the main themes of the study and how themes are used for categorizing analyzed data.

Table.6. Themes and main categories

Themes	**Main categories**
Elements of service quality	Flexibility Consistency Accessibility Company services

	Traceability
Themes	**Main categories**
Notion of delivery cycle time	Tolerance limit Customer priority level
Penalties for late deliveries	Sanction situations Sanction types Hierarchical penalties
Difference between deferred and delayed shipments	Expectation of customers Reactions for delayed and deferred deliveries
Prevention of late delivery	Prevention of delay Prevention of penalties
Corrective actions after late deliveries	Recovery of late delivery Shortening customer waiting period
Detrimental consequences of late delivery	Monetary cost Time cost Spiritual cost
Relative importance of cost and quality	Acceptable cost for quality

With respect to **RO 1** including evaluation of delivery performance and service quality criteria based on the expression of service providers and business buyers and

RO 2 which determines the importance level of the on-time delivery concept for both parties, findings are represented as below;

3.5.1 Delivery Performance

In the light of findings, it can be said that **reliability** is one of the indicators of delivery performance for both business buyers and service providers in terms of customer satisfaction. It is sometimes the only reason for business buyers to make business call, because at the end of business, there is a possibility of customer disappointment. Related to this, one of the representative of a manufacturing company says:

"Losing customer is something even more important than cost. Even the firm is very convenient for the others, if you do not have confidence from the beginning, you do not prefer to work anyway."

From the point of service providers, being reliable is also important for satisfying their customers and increasing profit. Also, they are aware that they are chosen because of the trust in field of delivery performance. As it is known to all, there are so many alternatives in the sector, and this factor is very decisive for service providers.

"Sometimes the only reason of being preferred by our clients is that we have confirmed to him that the loads will definitely be specified place and time."

"In terms of customer credibility, the right delivery time is crucial for us because there are so many alternative service providers in the sector."

"Confidence is lost when you deliver late. Trust is very important for companies especially for the countries where we work. If the trust is lost, it is very hard to get a load again."

Reliability of service provider is also important consideration for the brand image of business buyers. If service providers do not meet the promised transit times, their image in their clients' eyes will be affected negatively. Viewed from a broad perspective, it can damage the position of business buyer in the sector. Accurate statements about delivery time are also crucial for service providers' presence in the market. Hence, business buyers expect providers to perform as well as they do

because they are in a sense representatives of their brand. Two representatives pointed out that:

"Some forwarders offer minimum cost and time to get the job. However what happens is totally different, which is of course very damaging to our credibility."

"I prefer to lose money instead of losing confidence as in the case of Bosch. Once you get a bad reputation; your brand image is affected."

"False statement about transit time can go to the point where it can even threaten the company's commercial presence. Until this day I only experienced this with only one company and we detected the continuity of their false statements."

Regarding reliability, consideration of brand image is significant for service providers, as well. They attach importance to this factor, because when they do not honor their promises, their awareness in the market will be adversely affected and their brand image will be tarnished. Expressions of a few service providers are as follows:

"The industry is so small and so many people know each other. Hence, you have to keep going without damaging your brand with late delivery."

"If your client says to other firms that you do not bring the load on time, it's the worst ad for you, and you automatically lose your future load."

Certainty is another indicator of delivery performance from the point of business buyers. In order to be sure that transit times are met, business buyers sign a contract with service providers from the beginning. Here is the comment of one of the business buyer;

"While working with big companies like us, they sign very big contracts. If they give us 9 days transit time, they have to comply with this argument. Not early or late than this certain time period."

From the perspective of the service providers, certainty is crucial for reliability, and can be achieved by providing a definite stance for customers.

"Our express transit times are always 5 days, and double express are 4 days. These are standardized and known by all our customers."

"We have a 'following week' delivery condition for example when you give us instructions on Friday to send the goods; we certainly deliver them until next Friday. We work with many contracted customers on these terms."

Delivery on time is also an important element of delivery performance for business buyers and service providers in terms of planning.

"If you are in a manufacturing company, it is very important to deliver the goods on time, because production is planned so many weeks in advance." ***(Business buyer)***

"Orders usually come on Monday or Wednesday. It is important to know what we do if the customer gives us a different date or time. We re-evaluate the process from the beginning. This completely influences our delivery performance." ***(Service provider)***

On time delivery is also a very effective factor in terms of sales and productivity of the business buyers and providers.

"In the construction sector, we do not make only one residency or one hotel. Being late for a single job means that you will not have the offer for the other jobs." ***(Business buyer)***

"To avoid interruption of production plans and provide higher productivity rate, product must arrive on time." ***(Business buyer)***

"..So, on time delivery significantly impacts our sales performance for the upcoming period." ***(Service provider)***

"We have to deliver the loads on time to unload the other loads because other loads also have a deadline." ***(Service provider)***

As distinct from sales and productivity, delivery on time is also important in terms of ensuring customer satisfaction.

"Creating a low-cost route is actually a positive thing for both the transportation company and the customer. When the routes are shorter, loads are delivered faster." ***(Service provider)***

On time delivery is one of the factors that service providers pay attention to avoid penalties by their own customers, and it is essential for determining safety stock levels.

"..For example, in free zone areas, there are some procedures about the entry and exit of the vehicles. If service providers arrive late and miss the time period, I will be punished by my customers."

"Delivery time is also important because safety stocks are determined accordingly."

While **performance record** of service provider is another delivery performance indicator for business buyers, subcontractors' performance is important for service providers.

"Both our company and the central company in Germany keep score cards about service providers. The criteria include the transit time, sustainability etc." ***(Business buyer)***

For service providers, sub-contractors are classified, rewarded or penalized based on delivery performances. Moreover, scorecard records are kept to improve delivery performance.

"There are some sub-contractors that we work on minivan loads, for example, even if the price is higher, we prefer to continue with them because they always keep to their deadlines, they always deliver on the date they stated."

"If similar customers experience the same lateness problems, contracts which are made with the sub-suppliers are terminated."

"Delivery performance of subcontractors is crucial factor in our score card and it has biggest percentage among other factors."

3.5.2 Service Quality

Concerning service quality flexibility, accessibility, consistency and extra customer services are seen as key indicators for both business buyers and service providers. On behalf of **flexibility,** business buyers expect service providers to perform special tasks, and service providers try to fulfill these requests in this direction.

"We say to the logistics company that if they want to work with us they should keep stock in their intermediate warehouses abroad and send the load from there immediately in case of late delivery." ***(Business buyer)***

"Business buyers send out regulations about how loads should be handed over and they want forwarders to take photo of the loads." ***(Service provider)***

Accessibility is another concern for both parties and is important for a good service quality.

"References of service providers are considered because sometimes we cannot reach them for hours and we call thousands of people from the firm." ***(Business buyer)***

*"Business buyers complain about companies. They say that they cannot find any respondent and cannot get info about their product in case of late delivery."****(Service provider)***

Consistency of service is seen as important indicator of service quality for business buyers. It also matters for service providers, but for them being successful depends on several issues at once for them such as force majors, estimated arrival date, ongoing customer relations.

"Most of service providers are certain in terms of transit time. However, their consistency is so important. In order to be consistent, they need to be serving in certain standards." ***(Business buyer)***

"I can say that we have 99% of our performance in fulfilling the promises we make. % 1 is caused by force major situations such as gateways, traffic accidents, etc." ***(Service provider)***

Extra company services play an essential role with regard to service quality. While for business buyers important components are information sharing, sending delivery reports and being a solution partner are considered as important components of service quality; for service providers, important factors are using sub-contractors and peer to peer communication.

"There are important things like sending a daily report on delivery situations. This is a nice advantage of receiving a good service." ***(Business buyer)***

"Our network is wide and we reach other customers more quickly when we use subcontractors instead of using only our own vehicles. It is totally for satisfaction of our customers..." ***(Service provider)***

For a favorable service quality, **traceability** is necessary for both service providers and business buyers, because the customers of both parties wish to see vehicle status from the system to have a control over the process.

"We prefer trucks and companies with GPS. We want to be valued and we expect better follow-up." ***(Business buyer)***

"We update the vehicle locations every day and share the info in the company. Almost everyone in there see where the vehicles are." ***(Service provider)***

Regarding **(RO 3)** which aims to display tolerance level of customers against deferred and delayed deliveries findings are as follows;

3.5.3 Deferred and Delayed Shipments

If shipments are deferred by service providers, it is found that customers turn to spot offers, and plan to end the relationship with them. If the service providers are too late (more than a week), business buyers start to use a bad language and compare service providers with their competitors. If this delay causes extra cost for business buyers, they reflect a difference payment to service providers.

"Let's say the carrier did not show up on time to take my loads, you would turn to alternative firms to get spot offers."
"Our industry cannot be postponed because we go to the production band. If they defer our load then we just say 'goodbye'."
"We reprimand service providers by questioning how they can work with a subcontractor that has such an inappropriate performance."

From the point of service providers, when they postpone customer shipments they face undesirable customer behavior, because business buyers have also customers. In

this regard, service providers sometimes attempt to communicate the customers of the business buyers, so as to compensate late delivery. Service providers immediately attempt to provide the next vehicle and call other customers to take their load in order to complete the truck, which only includes deferred loads.

In case request of business buyers is not fulfilled, they suspend the payment process and withdraw their loads. The worst-case scenario for service providers is losing the customer and going to court.

"When you delay more than you promise, business buyers stop paying you."
"When the load is delayed, customer may withdraw his load by intermediate shipping and decide to give the load to another firm."
"When the car breaks down, customer says that this is your problem and demands us to send the load with another truck immediately."

3.5.4 Prevention of Delays and Penalties

Due to the fact that late delivery causes business buyers difficulties, they take action to prevent this (**RO 4**). The most common action is creating buffer day by putting an additional period of one week. They divide days as acceptance and shipment day in order to speed up the operations and they sometimes request vehicles to be ready early at their factories. To avoid delay, they receive letter of guarantee from service providers, and preset 'what if' plans to be certain. In this sense, they work with different companies. Business buyers also requests from their customers to stockpile.

If they foresee the delay, they get orders in advance and make early and over delivery. They create a merge team in order to be ready to take action. If the border gates are too busy, they change preferred border gates accordingly, and contact customs to accelerate the process. To prevent delay, they chose service providers based on their experience. Hence, they expect them to change transportation mode or

hire full truckload, as needed. They prefer service providers with specific properties. For example, the product groups carried are important. If they have their own warehouses and offer jockey transportation, or they specialize on certain fields, these are the reasons for working them.

"There is a thing called jockey transportation. Forwarder takes measure against risks and gets support for providing plate for drivers in case of urgency."
"So we have already divided the days that we accept and ship the load for both our warehouse workers and forwarders so as not to make them wait and cause a delay."
"If there are adversities about weather conditions that may cause late delivery problems, we try to get orders in advance to prevent late delivery."
"We have a merge team in Turkey. They inform us whether the orders will be late or not and based on this info we let service providers to take action quickly."
"We deal with our clients to keep safety stock to avoid being out of time window. It doesn't matter how it can be done. It can be VMI or CMI."
"I collect materials from all the suppliers in Europe and keep them in the warehouse of the service provider. Also, if it is necessary I want Kuehne Nagel to assign a full truck for me."
"In general, there may be situations such as when we can turn the ship to road, or road to air to prevent late delivery..."
"If we send the loads within 8 days to Germany, we change the route in winter and we increase it to 10 days so as not to get caught up with the land conditions."
"Now, one of the most important measures we take against late delivery risk is that we send the products two days in advance instead of one to some points."
"The entire destiny should not be left on the hands of the logistics company. I should think what I should do if Seda Logistics does not carry the load under the commitment."
"If it is clear that the next load will be delayed because of some reasons, you offer to send more loads in advance."

Because late delivery is detrimental for service providers, they also have a number of different measures. For instance, they avoid certain deadlines in order not to disappoint customers. They give importance to on time custom clearance and border

gate control before planning operations. They also take into account the time taken by each driver's to avoid any driver-related problems.
If they predict that the load will be delayed, they reject that load from the beginning. To avoid lateness, they request support from their subcontractors, besides using their own vehicles. Moreover, they use multiple operators to speed up the operation. They also pay attention to vehicle maintenance because they are aware of that some business buyers work with service providers with robust vehicles.

If late delivery is anticipated, service providers use double drivers in order to be faster. They may prioritize loads or change the vehicle, route, and transportation mode. They attempt to take advantage of additional navigations set by the private sector. If the load is urgent, they create affirmative document to internal customs in order to pass customs without any problem.

"..We need to be foreseeable in this regard as a matter of business, we always put an option like 'if there is no setback related with weather conditions, your load will arrive.'"

"We do not give a definite term to customers especially on partial deliveries; we share deadline information as optional +-2 days."

"If we cannot raise the load of the customer, we request contracted subcontractors to transport it."

"For example when we have problems in Kapikule, we can direct the vehicles to the Hamzabeyli door or Ipsala door so that we can change the route of the vehicles."

"When there is a possibility of late delivery, another vehicle is immediately supplied and double drivers are arranged to avoid late delivery."

"for example after their first transportation to Munih, both drivers and vehicles have the right to be on road for 8 hours If you planned to take load that is 400 km away from Munih, you exceed the 8 hour- time condition so it causes late delivery."

"Loading position is very important. When you load goods with reverse position, it causes you to be late. Hence load sequence should be considered based on the cities that you will stop by."

"We transfer loads to frigo vehicles if there is a queue on border gates. Since frigo vehicles have priority, they do not wait and pass directly."

"When there is a queue at customs or there is a walking ban, we change the route from road to sea way transportation. For example it seems more logical to go from Hungary to Romania by road but we ship the load through Trieste port in those cases."

"..When the vehicle could not exit the port, we risk ourselves as a forwarder, we create an affirmative document and we leave the load to our depot somewhere in Europe."

"When vehicle cannot exit the doors, then you need to organize an affirmative document to internal customs in order to pass customs."

"If there is a delay and if delayed product is in the second or third unloading address, then the address is also changed. We deliver this load first and then deliver the other loads."

"Normally I have 100 customer files per week to be handled, I need 3 staffs, but if I reduce this to 2 staff this time, it is possible that ı will not manage the process. If we have a lot of people, we will have the time to operate the other operations and we prevent lateness, too."

3.5.5 Solutions and Corrective Actions

After late deliveries, solutions and corrective actions are also so essential for both service providers and business buyers.

From the business buyers' point of view, they require timely information and quick action from the service providers. In this process, communication power of the service provider plays a great role. They sometimes expect service providers to make intermediate shipping, or split delivery to compensate for their mistakes. They also expect them to provide extra services and gestures, such as offering extra warehousing service or gesturing in load calculations.

In terms of service providers, taking action starts from the moment when the delay begins. They attempt to shorten waiting period of business buyers within this period, increase the frequency of information provision, and attempt to work with reservation for the upcoming shipments.

3.5.6 Delivery Cycle Time

When tolerance level of customers **(RO 5)** is examined, it is found that tolerance of business buyers depends on **the tender and nature of contract**. If contract and tender terms are clear, there be no tolerance for service providers.

"If there is a tender sale, the delivery dates are certain. If he says you will go there on July 13th, you have to go; otherwise you pay penalties for every late day."

In addition, tolerance is strongly related with the **business** in which the business buyers engage. If the business is very costly, and the sector is very fast or urgent, tolerance is very low.

"Because of we are a fashion company, we race against time. There is no tolerance for late deliveries." ***(Business buyer)***

"There may be no tolerance if buyers' production band works as just on time not even just in time." ***(Service provider)***

The **stock level of the customers'** of business buyers has also an essential influence on tolerances.

*"Tolerance depends on the stock level of the destination point where we work with, if the warehouse management belongs to you and if you manage the stock there, you have influences over your customer."****(Business buyer)***

Both business buyers and service providers agree that **product group** affects tolerances positively or negatively.

"Our tolerances are low because we send the loads that are light in weight but heavy in value." ***(Business buyer)***

"Tolerance varies depending on the product groups. If it is food sector it is different, otherwise different." ***(Service provider)***

From the point of both parties, tolerances can be relaxed based on the **mutual relationship**.

"The relationship, communication, and the organic link between with your customer and you are more important than the commitment. If you convince them in case of late delivery, there is no problem." ***(Business buyer)***

"If we know the customer beforehand, we can ask a favor of waiting more for their load and tell the reason of delay in detail. The customer will give us that support in this regard because he knows us." ***(Service provider)***

In case of **special days and force majors**, tolerances are also relaxed between parties.

"Orders accumulate on special occasions. So, sometimes the length of the stay of the products reaches up to 7 or 8 days at our factory, and customers accept this situation." ***(Business buyer)***

"Except natural disasters, floods etc. suppliers do not accept excuses like vehicle malfunction." ***(Service provider)***

In addition to these situations, flexibility of business buyers' customers and the role of being honest to business buyers are also defined as important parameters by service providers.

"Tolerances for late delivery are related to the degree of the buyer's pressure on our customers."

"It's really important to be honest in case of late delivery. When you are honest, the customer understands 3 days or 5 days delay because he trusts on you."

When it comes to the **lower and upper bounds of tolerances** for late delivery, it is found that lower bound is 1 day, and upper bound is 2 days for business buyers.

"Our tolerance is maximum 2 days considering all special days."

"The vehicle may not come on time. We can extend the arrival of order for 1-2 days by calling our sales staff."

It can be said that bounds for tolerances are slightly different from the service providers' point of view. For providers, lower bound is 1 day and upper bound is 4 days. However, this lower and upper limit varies depending on: the sector in which the company is involved, the product group worked with, the nature of contract, the sales volume of the company, pre-information capabilities of the providers, frequency of late deliveries and the customer potential. According to the information obtained from the interview, customers penalize service providers materially and morally after 4 days of delay.

"Usually the delays between 2 and 3 days are not too big if you do not bring about a band stopping situation. Delays over 4 days become difficult."

"You will tell one day delay in a certain way, but the fourth day the problem must be solved because customer cannot wait us anymore."

Apart from tolerance rates, **customer priority level** plays a fundamental role from the stand point of both business buyers and service providers. Profitability of customer is also taken into account when delivery cycle times are considered.

"..I think customer contribution is important. Pareto Analysis can be done. It is important to know what percentage of the sales belongs to which customer? Delivery cycle times are affected by this factor." ***(Business buyer)***

*"According to the circulation, we sort customers. Their sales volume is important."****(Service provider)***

At this juncture, service providers also reveal that delivery cycle times are affected by **consolidation plans,** which are created based on the product groups, consolidation strategies, agreed contracts, and routes. These are some examples:

"I can give a firm-based example, for example, we do Egem Ambalaj's uploads as follows: we deliver the load 'next week' absolutely, whether the vehicle is full or not."

"Of course first customer that gives us his load will have priority because especially for partial delivery when you fill the vehicle completely, you take road. There is always possibility that some loads may remain uncovered."

"We classify product groups such as flammable, textiles group, packaging materials etc."

3.5.7 Penalty Classifications

As stated previously in **RO 6, service** providers are subjected to penalties in case of late deliveries. However, these penalties vary by the consequences of delay. When the views of both sides are taken into consideration, it can be clearly seen that if the delay causes great material or moral loss for the company, business buyers dissolve the partnership with service providers or put them into black list.

*"There were companies that stopped working with us because we could not deliver on time." (**Service provider**)*
*"We terminated our contract with a company because of improper and late deliveries." (**Business buyer**)*
*"Customers punish providers by putting them into their black list." (**Service provider**)*
*"Because they represent us, some companies are prohibited to work with due to late delivery experience." (**Business buyer**)*

If service providers cause a band-stopping situation, business buyers expose band-stopping cost to service providers as it is. If they use fast shuttle to handle late delivery situation, or if the workers of business buyers have to take extra work, then service providers also have to cover fast shuttle and overtime fee costs.

*"If the shipping company cannot provide the goods on time to my customer,and if it is such a line stoppage punishment that may come to me, I will reflect it to the shipping company." (**Business buyer**)*
*"We have our fast services as a company, I will give an example from this week; our agency did not take the load from customs but the load should have been in Izmir the next day. We made the load almost fly. We brought it in 2 days as we promise. It caused a cost to us and this was our punishment." (**Service provider**)*

*"If late delivery is a chronic problem and if I leave a lot of people to work overtime because of my provider, and if I pay more than the normal, I make the service provider to pay the price for it." (**Business buyer**)*

Even if service providers try to compensate this situation, business buyers have the right to reject to late shipment that did not arrive when needed.

*"If you send the load after 3 days with delay, the customer may say I reject the load because it is no longer necessary for me." (**Service provider**)*

Business buyers may also demand to be exempt from transportation charges (free freight). They expect this action to be taken by the service provider side.

*"If my transit time is 6 days and I send the load in 8 or 10 days, I do not request freight cost from customer." (**Service provider**)*
*"We do not pay the freight as a punitive sanction when products return to us due to the lateness of service provider." (**Business buyer**)*

If service providers are continuous partners of business buyers, they are likely to request recovery from service providers. However, if they do not have a very close business relationship, they make their complaints known publicly and pave the way for bad reputation of service providers.

*"We prepare a DÖF (Düzenleyici Önleyici Faaliyet) form after late deliveries. Then providers has to develop a project and redeem themselves." (**Business buyer**)*
*"Sometimes they complain to your lateness, and this reaches to other customer's ears." (**Service provider**)*
*"At once we came to the point where we would ask our customers not to work with some providers because of their false statement about transit times." (**Business buyer**)*

In addition to these penalties, business buyers also introduce penalty per day practices. It is an application that greatly influences the costs of service providers. For this reason, it is important to include this in our problem.

"If you have made a contract with a company in the private sector, you are charged a penalty of 1000 TL per day for late delivery."

"We usually set a penalty on a daily basis. We have penalties of 100 -150 euros per day."

Business buyers keep scorecard records to evaluate the performance of service providers, which they use as a punishment function. As late delivery is one of their performance indicators, they use this measure to reduce their companies' scores based on this measure.

"Providers get a lower score on their score card because of late delivery. They are evaluated by such categories..."

"Their low score card record will result in material and moral loss. It is very obvious that providers are being marked."

They can also reduce the business volume as a punishment method. They start to give less freight to their usual service provider companies, and move some business to other carriers in order to penalize their frequently used companies.

"The number of jobs we plan to make with them decrease after late delivery. Therefore, they lose turnover because we do not give them work."

"We lowered the amount of load that we used to give to ABC Cargo. We were giving 350 tons of cargo monthly but it fell by 70-80 tons currently."

Moreover, if the subcontractors of service providers cause the delay situation, business buyers use their influence to force service providers to work with their chosen carriers.

"Our sanction right is generally high in big companies. If subcontractors cause delay, we have the right to eliminate ones who we don't want to work with again."

Business buyers also keep late arrival vehicles waiting and reconsider the use of service providers to punish the delay. The greatest material and moral loss is orientation of the customers to the competitive firm.

*"If our trucks do not go to Porsche's gate on time, they make us wait because they give a term to other vehicles, too." (**Service provider**)*

*"If you are constantly late, following the end of the contract, customer says that he will try another firm and punish us this way." (**Business buyer**)*

3.5.8 Hierarchical Penalties

The degree of the penalties is not the same for all companies or sectors. There is a hierarchy. In business buyer's point of view, degree of penalties vary based on volume and sector of service providers. If the customers' volume of business buyers is high, the lateness of service providers will have a major impact on customers, and business buyer's punishments will increase accordingly. The sector is also important; if it is a risky sector, the nature of penalties will change accordingly. In late delivery cases, customers generally reflect penalties to business buyers, and then business buyers will hand over this responsibility to service providers as a result.

"We also have low-cost shipments up to 50 kg. The good is not risky in terms of late delivery and the customer that purchases this amount is not a big customer. So, bigger customer means bigger penalties."

"After late deliveries, there are cases where the costs are very high, even if you explain the reason of being late, it will return to your desk tomorrow as a claim especially when you work with automotive sector."

From the provider's point of view, hierarchical penalties vary based on customer categories. If the customer has a significant share in sales, it is generally considered as key customer, and late delivery will have major effects on them. Hence, customer categories are important in determining the degree of penalties.

"For me Porsche and Tetrapak are the most important customers, when they turn to me and say, 'You caused band to stop and I punish you by paying the cost of result. If

we earn 10 times more of money from this customer on an annual basis, we say, ßlease fine us, we made this mistake, and we can face such penalty."

"Smaller firms are more flexible, larger firms are more rigid and more punitive."

Besides customer categories, customers' operations are also essential in terms of determining the degree of punishment. In this regard, the workforce and working principles of the company are the main factors.

*"The punishment for late delivery is based on human power that buyers use and also the material that they produce. When a brand is a real well-known brand, they also have costs accordingly and they reflect it." (**Service provider**)*

*"The working principles of large firms are generally just in time, so their penalty terms for delay are more." (**Service provider**)*

In addition, the sector of the product affects the level of punishment. If the late material is used during the production process or goes to the production band, the penalty coefficient grows accordingly.

*"If the product goes directly to the production band or goes to after-market or if it is used as spare part… in all cases penalties vary." (**Business buyer**)*

3.5.9 Cost after Late Deliveries

Regarding **(RQ 7),** costs after late deliveries are formed as monetary and time cost. Monetary costs for service providers are difference due to late delivery, cost of changing transportation mode to not be late anymore, losing turnover due to decreasing number of shipments, free freight as a penalty. Monetary costs for business buyers are as follows: changes in pricing strategy for specified company by lowering the price to compensate late delivery, airway and intermediate carriage cost to catching delivery window, inventory cost when the goods are not taken on time from the business buyers' warehouse, missing payment plan due to late arrival of carriers to the factory, hiring full truck to compensate late delivery, line stoppage costs for manufacturing companies.

Rejection of goods, cost of operators who work overtime to meet the time deficit, cost of discount which is set for recovery of late delivery and cost of unsold goods caused by delay are seen as monetary costs for both business buyers and service providers.

"..As I said before, cost of late delivery is caused by return of goods by our clients, they may not accept..." ***(Business buyer)***

"We have an agreement with Bim. If we do not send the goods until specified date, then they do not accept them as a penalty." ***(Service provider)***

"In case of late delivery, both our band and workers stop working. We have to make overtime for compensate the situation." ***(Business buyer)***

"I have an agent and staff. In case of late delivery they all have a cost." ***(Service provider)***

"When carriers are late it means that the products are not going to take place in the stores. This is not allowable. This is a serious money loss because customers may turn to other firms if the shelves are empty." ***(Business buyer)***

"BIM says that if we do not raise the goods to their warehouse on time specified by us, they will bill us as much as the price of these goods." ***(Service provider)***

Time cost for both business buyers and service providers are rework of the operators by repeating work, preparing DÖF document for process improvement of service providers, extending loading periods because of the late arrival of carriers, exposing them to unnecessary customer dialogues and e-mailing process, delayed harbor operations because of missing entry and exit periods of vehicles, the process regaining of their customers' favor after losing prestige.

"..When we want another vehicle to be allocated, this time the operators do the same job again, dispatch notes are created again and this means waste of time for everyone." ***(Business buyer)***

"The time loss is that my operators do the job a second time." ***(Service provider)***

"There are situations where we constantly have to follow the vehicle. We mail or make phone calls 30 times in a day to learn where the vehicle is exactly." ***(Business buyer)***

"I had 12 phone calls! Also customer relations department worked for the same task." ***(Service provider)***

"Late delivery has a spiritual dimension, too. We may pay the money and get rid of it, but there will also be a question mark in the head of our clients that do we do the same mistake again?" ***(Business buyer)***

"..When you lose the customer, the process for win the customers back and the time to win a new customer takes a long time." ***(Service provider)***

CHAPTER 4

MATHEMATICAL MODEL

In this section, we state the problem; use Sinem Tokcaer's mathematical model (Tokcaer, S., 2018) as a base; develop the mathematical model for the quantitative side of our research objectives; and reformulate later based on the data gathered through interviews.

Based on the real life problem, we define the problem with the following assumptions;

- Information on orders, such as dimensions, destination, release date and deadline, are deterministic and initially known.
- The orders can be delivered either on wheels or by using a transshipment terminal. Each transshipment decision implies a cost proportional to the size of the order.
- Routes are previously defined, and possible stopping points on each route are known.
- The costs of routes are fixed, defined with respect to the farthest destination along the route.
- Fixed costs of routes includes a limited number of stops, and after that number, each additional stop incurs an extra cost of stopping up to maximum number of stops that cannot be exceeded.
- The number of stops for a vehicle is limited; hence, the delivery duration is not affected by the number of stops.

The difference of our mathematical model from ST Model is time constraint. In ST Model delivery realized within the delivery time intervals and late delivery condition was not allowed. In our model, we allow delivery to occur outside of time intervals

to provide cost efficiency because each late delivery returned to the firm as cost advantage. While performing this practice, each delivery is subjected to a penalty in order to keep customer service level high at the same time. In this direction, our model considers two objective simultaneously to achieve better outcomes for both service providers and business buyers. Thus, the subject of this thesis is regarded as one of the multiple decision-making problems.

Considering the data on the qualitative part of the research, timely delivery has been identified as the most important performance criterion for both the customer and the service provider. In this context, the number of days which can be endured by customers in case delivery window is determined between 1 and 4 days. Customers can not tolerate delays of more than 4 days and start to impose penalties.

Indices and Sets

K Set of orders, $k \in K$

I Transshipment Terminals, $i \in I$

J Destinations, $j \in J$

T Days in planning horizon, $t \in T$

N Homogeneous trucks, $n \in N$

R Set of routes, $r \in R$

A_r Possible stopping points along route r, $A_r \subset J$, $\forall r$

B_r Transshipment terminal points along route r, $B_r \subset I$, $\forall r$

H^t_r Set of orders that may depart on day t by direct delivery to its destination j on route r, where $H^t_r \subset K \ \forall r, t$

G^t_{ir} Set of orders that may depart on day t, by delivering from transshipment terminal i on route r, where $G^t_{ir} \subset K \ \forall$i, r, t

Parameters

Details of orders, $\forall k$;

v_k Total volume

w_k Total weight

l_k Total length

r_k Release day

d_k Deadline

p_k Destination, where $p_k \in J$

Vehicle capacities;

v volume capacity

w weight capacity

l length capacity

τ_{jr} Transit time to destination j on route r, $\forall j, r$

λ_{ri} Transit time to transshipment terminal i on route r, $\forall i,$

ρ_{ij} Transit time from transshipment terminal i to destination j, $\forall i,j$

μ Limit on additional number of stops

φ Number of stops included in the fixed cost, where $1 \leq \varphi \leq \mu$

f_r Fixed cost of route r, $\forall r$

c_{ik} Cost of transshipping order k from transshipment terminal i $\forall i, k$

α Additional cost of each stop after φ stops

M Very big number

Decision Variables:

$$x_{kir}^{tn} = \begin{cases} 1, \text{if order } k \text{ is assigned to CD } i \text{ on vehicle } n \text{ departing on route } r \text{ on day } t \\ 0, \text{otherwise} \end{cases}$$

$$y_{kr}^{tn} = \begin{cases} 1, \text{if order } k \text{ is assigned to destination on vehicle } n \text{ departing on route } r \text{ on day } t \\ 0, \text{otherwise} \end{cases}$$

$$\theta_{ir}^{tn} = \begin{cases} 1, \text{if vehicle } n \text{ departing on route } r \text{ on day } t \text{ stops at CD } i \\ 0, \text{otherwise} \end{cases}$$

$$\kappa_{jr}^{tn} = \begin{cases} 1, \text{if vehicle } n \text{ departing on route } r \text{ on day } t \text{ stops at destination } j \\ 0, \text{otherwise} \end{cases}$$

$$s_{r}^{tn} = \begin{cases} 1, \text{if vehicle } n \text{ departs on route } r \text{ on day } t \\ 0, \text{otherwise} \end{cases}$$

$$u_{r}^{tn} = \text{number of stops on vehicle } n \text{ departing on route } r \text{ on day } t$$

In addition to the mathematical model used in ST model, three additional parameters and four new decision variables are defined. These are;

Additional Parameters

δ *:* Upper limit of delay

p *:* Penalty for each day exceeding upper limit of delay

m *:* Penalty for each day exceeding due date

Additional Decision Variables

dl_k: Receipt order date by customer

tr_k : The number of late days,

er_k : Number of early days,

pt_k : Penalties for δ day and after

The on-time delivery limitation in the previous model was completely removed, so the model was made flexible for late delivery to the customer. A fixed penalty cost (m = 0.10) was determined for each late day here (þ = late after: 1, 2, 3, 4, 5, 6, 7). Also, if the number of late days is greater than the 4 days which are identified in the qualitative part of the study, penalties are calculated for each p value (p = 0, 50, 100, 150, 200).

Thus, equations and constraints have been updated as follows;

Min $$\sum_{r\in R}\sum_{t\in T}\sum_{n\in N}\left[f_r s_r^{tn} + \alpha u_r^{tn} + \sum_{i\in I}\sum_{k\in K} c_{ik}\, x_{kir}^{tn}\right] \quad (1)$$

Min $$\sum_{k\in K}[ppt_k + mtr_k\ ]$$

Subject to;

$$\sum_{i\in B_r}\sum_{k;r_k\le t} x_{kir}^{tn} v_k + \sum_{j\in A_r}\sum_{k;r_k\le t} y_{kr}^{tn} v_k \le v\ s_r^{tn} \quad \forall r,t,n \quad (2)$$

$$\sum_{i\in B_r}\sum_{k;r_k\le t} x_{kir}^{tn} w_k + \sum_{j\in A_r}\sum_{k;r_k\le t} y_{kr}^{tn} w_k \le w s_r^{tn} \quad \forall r,t,n \quad (3)$$

$$\sum_{i\in B_r}\sum_{k;r_k\le t} x_{kir}^{tn} l_k + \sum_{j\in A_r}\sum_{k;r_k\le t} y_{kr}^{tn} l_k \le l s_r^{tn} \quad \forall r,t,n \quad (4)$$

$$\sum_{i\in B_r}\sum_{r\in R}\sum_{n\in N}\sum_{k;r_k\le t} x_{kir}^{tn} + \sum_{j\in A_r}\sum_{r\in R}\sum_{n\in N}\sum_{k;r_k\le t} y_{kr}^{tn} = 1 \quad \forall k \quad (5)$$

$$\sum_{k;\, p_k\in B_r}\sum_{k;r_k\le t} x_{kir}^{tn} \le M\theta_{ir}^{tn} \quad \forall r,t,i,n \quad (6)$$

$$\sum_{k;\, p_k\in B_r}\sum_{k;r_k\le t} y_{kr}^{tn} \le M\kappa_{jr}^{tn} \quad \forall r,t,j,n \quad (7)$$

$$\kappa_{jr}^{tn} \le s_r^{tn} \quad \forall r,t,j,n \quad (8)$$

$$\theta_{ir}^{tn} \le s_r^{tn} \quad \forall r,t,i,n \quad (9)$$

$$\sum_{i\in B_r}\theta_{ir}^{tn} + \sum_{j\in A_r}\kappa_{jr}^{tn} \le \varphi + u_r^{tn} \quad \forall r,t,n \quad (10)$$

$$u_r^{tn} \le \mu \quad \forall r,t,n \quad (11)$$

$$x_{kir}^{rtn}, y_{kr}^{tn}, s_r^{tn}, \kappa_{jr}^{tn}, \theta_{ir}^{tn} \in \{0, 1\} \quad \forall k,i,j,r,t,n \quad (12)$$

$$tr_k\ , er_{k\,}, u_r^{tn} \ge 0 \quad \forall r,t,n \quad (13)$$

The objective function (1) minimizes the total cost of shipping all orders, including fixed costs of routes and additional stops; the cost of transshipping orders from cross-docks; and penalty for each day exceeding due date and upper limit of delay. Equation (2), (3) and (4) ensures that the total volume, weight and loading meter of orders, which are loaded on the vehicle $n \in N$ with route $r \in R$, departing on day $t \in T$, cannot exceed the capacity of that vehicle.

The equations also ensure that the destination of order k is a stop along route$r$, and due date is satisfied **without** respecting to release date and transit time required to deliver that order. Equation (5) ensures that each order $k \in K$is shipped and delivered either on wheels or via cross-docks. Equation (6) ensures that the cross-dock $i \in I$is assigned to vehicle $n \in N$ with route $r \in R$, departed on day $t \in T$ only if any order k in that vehicle is shipped via cross-dock i. Equation (7) ensures that the destination $j \in J$is assigned to vehicle $n \in N$ with route $r \in R$, departed on day $t \in T$ only if any order k in that vehicle is delivered directly. Equation (8) ensures that the destination $j \in J$is assigned to the vehicle $n \in N$ with route $r \in R$, departed on day $t \in T$. Equations (10) and (11) guarantee that the limit on number of stops is not exceeded. Equation (12) states that decision variables $x_{ki}^{rtn}, y_{k}^{rtn}, \theta_{ir}^{tn}, \kappa_{jr}^{tn}$ and s_{r}^{tn} are binary variables, and equation (13) guarantees that u_{r}^{tn} , tr_k , er_k is a positive variable.

$$\sum_{j\in A_r}\sum_{r\in R}\sum_{n\in N}\sum_{t+\tau_{jr}}(t+\tau_{jr})y_{kr}^{tn} + \sum_{i\in B_r}\sum_{r\in R}\sum_{n\in N}\sum_{t+\lambda_{ri}+\rho_{ir}}(t+\lambda_{ri}+\rho_{ir})x_{kir}^{tn} = dl_k \quad (14)$$

$$dl_k\text{-}d_k = tr_{k-}\, er_k \quad (15)$$

$$pt_k \geq tr_k - \delta \quad (16)$$

In equation (14), the time constraint on the previous model is completely removed, so that the model is stretched to make late delivery possible and delivery day is represented by dl_k. Equation (15) shows how late the shipment is realized to the customer. Equation (16) shows the number of shipments with 4 days delay.

CHAPTER 5

NUMERICAL EXPERIMENTS

The two-pronged mathematical model proposed above was compiled with the GAMS 22.9 solver and solved using the Intel® Core ™ i5-6600 3.31 8 GB RAM GHz with Windows 10 on the experimental set. The solution time was limited to 3600 seconds, the process was terminated when no solution was found for the specified time, and the difference between the best solution found so far and the lower limit value obtained by the solution was reported. The following table shows penalties for late shipments in order of 1, 2, 3, 4, 5, 6, 7 days for both orders of 10 and 20, respectively. The results are calculated for 5 different penalties as 0, 50, 100, 150 and 200 in the same way. (Table 7) Here, the number of both orders is examined within two scenarios. In the first scenario, the daily penalty cost was kept constant, the number of late days was continuously increased from 1 to 7, and as the number of days delayed increased, the penalties were predicted to decrease. The reason for this is that as the number of late days increases, punishments are also increase rapidly at same rate, and delivery time becomes important for service providers. In the second scenario, the number of days was kept constant but a change was made in the daily penalty cost. It is envisaged that the amount of penalty applied here has an effect on both objective function and the total cost of penalty. It is also estimated that there is a negative relationship between them. From these scenarios, the examples have been solved in two stages. A total of 220 experiments were conducted with samples with 10 and 20 orders.

Table.7. Parameter Values that Control Sample Pattern

	Level						
Parameter	1	2	3	4	5	6	7
I	10	20					
δ	1	2	3	4	5	6	7

p	0	50	100	150	200

Table.8. The solution of the sample with 10 orders (p=100)

δ	Solved in 1 hour	Average CPU (sec)	Average optR (%)	Total Penalty	Total Cost
1	10	302	4.76	561	13388
2	10	710	4.74	341	13126
3	7	1617	5.50	141	12908
4	5	1999	5.85	51	12841
5	6	2108	7.25	21	12772
6	4	2325	7.78	2	12728
7	5	2002	7.53	2	12698
Average		**1581**	**6.07**	**160**	**12923**

Table.9. Examples of late delivery allowed up to 4 days for 10 orders (δ=4)

Penalty Amount (Euro)	Solved in 1 hour	Average CPU (sec)	Average optR(%)	Total Penalty	Total Cost
0	4	2283	7.46	2	12698
50	6	1646	5.40	72	12821
100	5	1999	6.27	51	12841
150	7	2151	5.45	76	12833
200	7	1928	4.69	101	12858
Average		**2001**	**5.85**	**60**	**12810**

It is seen in Table 8 that the highest penalty is observed when the penalty is applied every 1 day late. For this reason, the objective function calculated after this day gets the highest value. For every late 2 days and after, there is no change in the number of vehicles coming out (average number of cars); however, the difference percentage (Average optR) which is determined as 0.05% between the effective solution, and the solution obtained increases and reaches a maximum of 7.78 %. In here, the difference increases depending on the number of late days. This is because the

problem is made more flexible by permitting late delivery up to 1 week, and the solution cluster is enlarged, as well. Thus, as the solution set increases, the solution of the problem becomes more difficult, and moves away from the effective solution. Again, all of the 10 samples reached the solution within the specified time interval; but as the number of late days increases, the duration of the process increases. When the penalty costs are examined in detail, it can be seen that penalty is gradually reduced when it is applied for 2 days and later instead of implementing penalties after each late day, and the total value of the objective function decreases accordingly.

Considering the technical report data, it is seen that the customers do not apply any penalty except 100 TL for late deliveries up to 4 days, but the penalties change after 4 days. In Table 9, the difference percentage of shipments subjected to the same penalty cost for 4 days and after also moves away from the effective solution. The number of vehicles and the number of solved samples remain constant, despite the increasing cost of penalty imposed on late deliveries. As the cost of penalties increase, average Optr and Average CPU decrease, and the value of the objective function increases steadily with the total cost of penalty.

Table.10. The solution of the sample with 20 orders (p=100)

δ	Solved in 1 hour	Average CPU(sec)	Average optR (%)	Total Penalty	Total Cost
1	13	2981	6.47	9520	21591
2	12	3036	7.95	3220	20634
3	12	3248	9.51	1324	20581
4	13	2889	8.66	1037	20273
5	13	2744	8.43	136	20059
6	12	2968	8.55	141	20212
7	13	2792	8.78	38	20034
Average		**2951**	**8.45**	**2532**	**22412**

Table.11. Examples of late delivery allowed up to 4 days for 20 orders (δ=4)

Penalty Amount	Solved in 1 hour	Average CPU (sec)	Average optR (%)	Total Penalty	Total Cost
0	12	2942	8.74	54	20007
50	13	2922	8.48	982	20166
100	13	2889	8.54	1037	20273
150	13	2940	8.62	931	20287
200	12	2999	8.89	1834	20286
Average		**2938**	**8.66**	**968**	**20203**

As in the previous sample with 10 orders, it can also be seen the highest penalty for the sample with 20 orders when the penalty is applied after 1 day delay (Table 10). There is no change in the number of vehicles coming out (average number of vehicles) up to 4 days; but Average optR between the effective solution and the solution obtained generally increases and reaches a maximum of 8.89 %.(Table 11) Here, as the solution set increases, the solution of the problem becomes more difficult, and the increase in the process time is more than the sample with 10 orders. Regarding the total cost of penalty for each day, as in the case of 10 cases, the total cost of penalty and the objective function are also reduced in parallel.

As can be seen from these two tables, if the fixed costs are applied, the longer delay in days, the greater the effective distance to the solution, and the longer the duration of the process. When the penalty cost is increased, the effective solution of the problem is reached in a shorter time. Fixed costs lead to a reduction in the total cost of penalties, which lead to reduced costs in the objective function. However, when the increasing penalty costs are applied, the total penalty cost increases and this causes the increase of the objective function.

Here, the main reason for the increase in penalty costs after 4 days is to take into account the level of customer service. When penalties continue at a fixed cost, service providers are able to deliver customer deliveries later and they are more

flexible. In this way, they have the opportunity to lower costs, customer satisfaction take second place. When the penalty costs increase, the problem maximizes the effectiveness of the solution, and the highest penalty and objective function costs are summed up because of the high penalty costs for customer satisfaction and not exceeding the tolerable limit of 4 days.

In Table 12, the objective function of the orders (10, 20) is calculated for each penalty value (p: 0, p: 50, p: 100, p: 150, p: 200) and for 4 days late shipments which is indicated as (la: 4). In addition, every late day penalty cost (p = 100) is kept constant and the changes in the objective function are monitored as a percentage. In table 13, ST model and developed model are compared based on the vehicle numbers for the orders of 10 and 20 respectively, and improvements are indicated as percentages.

Table. 12. Percentage improvements in objective function

Sample with 10 orders

la:4 | p: 0	la:4 | p: 50	la:4 | p: 100	la:4 | p: 150	la:4 | p: 200	la: 1 | p:100	la: 2 | p:100	la: 3 | p:100	la: 5 | p:100	la: 6 | p:100	la: 7 | p:100
57.8	54.05	53.83	53.83	54.28	49.40	50.73	52.95	54.27	53.83	54.71
42.40	42.40	42.40	42.40	42.40	41.93	41.93	41.93	42.40	42.40	42.40
49.77	49.13	48.92	48.71	48.50	45.52	46.79	48.07	49.35	49.77	49.77
38.34	38.30	38.30	38.30	38.30	36.21	37.46	38.30	38.30	38.34	38.34
26.86	26.86	26.86	26.86	26.86	25.93	26.40	26.86	26.86	26.86	26.86
43.08	43.08	43.08	43.08	43.08	40.14	41.73	42.59	43.08	43.08	43.08
29.43	28.74	28.51	28.05	27.58	25.72	26.65	27.58	29.45	29.45	29.45
47.81	47.39	47.81	47.81	47.81	46.57	47.40	47.81	47.81	47.81	47.81
48.94	48.09	47.67	47.67	47.67	44.72	46.83	47.67	48.09	48.9	48.94
52.95	50.83	50.61	51.62	50.74	47.64	49.41	51.18	51.46	52.50	52.94

Sample with 20 orders

la:4 | p: 0	la:4 | p: 50	la:4 | p: 100	la:4 | p: 150	la:4 | p: 200	la: 1 | p:100	la: 2 | p:100	la: 3 | p:100	la: 5 | p:100	la: 6 | p:100	la: 7 | p:100
39.89	39.25	39.04	39.32	39.85	37.24	38.02	38.06	39.65	39.97	39.97
39.50	39.4	39.51	39.01	39.17	37.29	38.71	38.84	39.60	39.50	39.51
41.12	40.20	40.04	39.77	39.77	35.44	37.77	32.98	40.58	40.85	41.12
43.70	42.20	42.50	41.11	41.90	35.62	41.01	43.40	44.00	39.26	43.70
41.79	40.97	40.36	41.80	41.80	38.75	40.17	40.42	41.80	41.52	41.09
31.22	31.24	31.24	31.24	30.91	27.96	29.60	30.91	31.26	31.24	31.57
41.47	41.48	41.48	41.48	41.48	38.73	40.38	40.38	41.48	40.92	41.48
35.23	34.93	34.63	34.94	34.63	32.33	34.34	34.94	34.63	35.54	34.63
40.78	40.27	37.99	38.06	36.61	23.61	36.39	38.70	40.09	40.05	40.91
41.23	41.24	40.96	40.69	40.96	39.58	40.41	40.69	41.24	40.96	41.23

Sample	**ST Model**	**Developed model**	**Improvement (%)**		**ST Model**	**Developed model**	**Improvement (%)**
1	7	3	57.14		10	6	40.00
2	7	4	42.86		10	6	40.00
3	8	4	50.00		12	7	41.67
4	8	5	37.50		11	6	45.45
5	7	5	28.57		11	6	45.45
6	7	4	42.86		10	7	30.00
7	7	5	28.57		12	7	41.67
8	8	4	50.00		11	7	36.36
9	8	4	50.00		9	5	44.44
10	7	3	57.14		12	7	41.67
	Average		**44.46**		**Average**		**40.67**

Table.13. Percentage improvements in number of vehicles

CHAPTER 6

CONCLUSION

In this thesis, the importance of on time delivery is examined in detail by considering both business buyers and service providers' view. Within the scope of research questions, delivery performance and service criteria of both parties are addressed. In this regard, there is an examination of the importance level of on time delivery concept is examined, and also the tolerance level of parties against deferred and delayed deliveries. Based on the interviews with 14 companies from logistics and production sector, penalties are classified hierarchically in case of late deliveries. The study reveals the cases in which customers impose penalties, and how these are applied. The study also examines measures taken by both business buyers and customers to deal with late deliveries. From the service provider side, it was found that, most of the business buyers tend to impose penalties from the first day as per-day based and also the amount of penalties increases after 4 day delay. In this thesis, the aim is to measure the impact of penalties respectively applied as per day and after 4 late days on objective function. In this regard, cost and customer service level are taken into consideration while finding the value of objective function.

After experimentation with two orders set, it is found that highest penalty is observed when per-day penalty is applied. Also, for each data set, the difference percentage (Average optR) between the effective solution and the obtained solution and CPU time increase as lateness increases. Regarding percentage improvements in objective function, it can be clearly seen that by imposing per-day penalty, business buyers bring considerable percentage improvements in objective function (Table 12). Moreover, imposing penalties after 4 days delay, it is observed that the percentage of objective function improvement is decreased in each set of order.

In terms of percentage improvements in number of vehicles, our model brings improvements of over 40 percent (Table 13). It can be observed that the number of

vehicles is reduced by half in each instance in a set. Because the reduction in the number of vehicles is a factor influencing the cost level deeply, it can be said that reduction here is provided by considering both cost and customer service level.

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APPENDIX

A. Semi-Structured Questionnaire for Service Providers

Service Quality - Delivery performance

• The importance of delivery quality on service quality
• Difficulties / process inaccuracies in accordance with delivery and deadlines
• Consistency in delivered time and delivery time
• Late delivery risk and countermeasures against this risk

Planning Process

• Situations where the load can not be released due to planning and the solution part
• Implementation of the "first come, first served" basis / other methods
• Cost and customer satisfaction
• Classification of customers before delivery
• The role of the customer's priority level in the planning process (flexible customers, etc.)
• When carrying out a freight consolidation, the existence of other goals besides customer satisfaction, cost and customer satisfaction
• Time tolerance of your customers
• Classification of working subcontractors according to delivery performances

Sanctions / Penalties / Customer Perception

• Customer reactions to delayed and deferred deliveries
• Change in the customer's sanctions, indicated by the upper and lower limits

of time violations

- Sanctions from customers after late delivery
- Penalties vary by company size / brand strength / product value
- Trust in late delivery to the company and its impact on brand image
- The impact of live delays on overall performance

Solutions and Corrective Actions

- Communication with customers about late deliveries
- Initiatives to shorten the waiting times of customers
- Separate delivery of deliveries on behalf of customer satisfaction
- incentives or discounts applied to losing customers for late deliveries
- Post-delivery complaints return and solution support
- Cost and customer satisfaction
- Time and money-based costs after late delivery

B. Semi-Structured Questionnaire for Business Buyers

Service Quality - Delivery performance

• The importance of delivery quality in service quality

• Problems / process inaccuracies in respect of compliance with delivery and deadlines

• Concepts of consistency in delivering and delivering on time

• Late delivery risk and countermeasures against this risk

Planning Process

• If the load is ready but the carrier does not release it at that time - your reactions - your preferences for how to approach

• Tolerance against time violations

• Classification of companies according to delivery performances - Scorecard records

Sanctions / Penalties / Customer Perception

• Responses to delayed and deferred postings

• The change in the bottom and upper limits of time violations in your sanctions

• Your sanctions against companies after late delivery

• Penalties vary by company size / brand strength / product value

• Trust in the brand image of the late delivering company / company

• The effect of delayed outlook on the outlook on the company

Solutions and Corrective Actions

• Communication with you about late deliveries

• The effect of initiatives to shorten your waiting times

• incentives or discounts applied to losing you for late deliveries

• Your complaint about late delivery and your thoughts on how to evaluate your proposals

Preferences and Costs

• Are you going to a competitor for your next request instead of a late delivering company?

• Choice of cost and service quality

• Time and money-based costs for you after late delivery