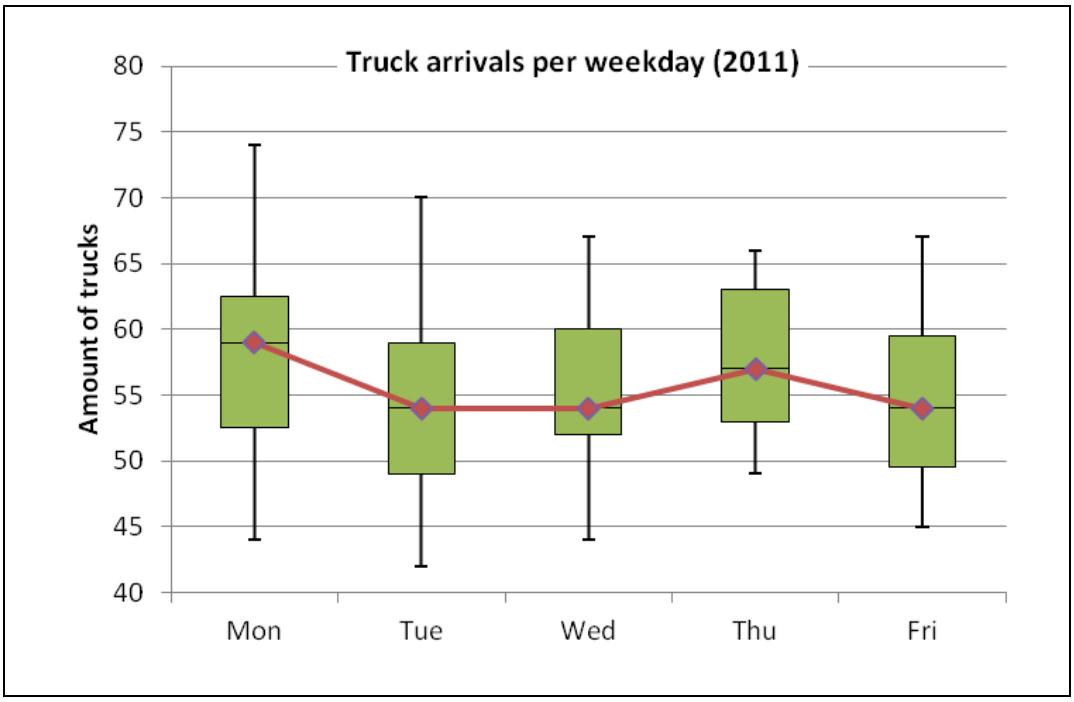

Evaluating Volvo Car Corporation's Central Distribution Center's Transport-Time Measure and Providing Practical Applications

Master of Science Thesis in Supply Chain Management

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CHALMERS UNIVERSITY OF TECHNOLOGY
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Cover:
Inbound goods volume variation summarized per weekday,
More information on page 2.

Chalmers reproservice
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Abstract

Volvo Cars’ Central Distribution Center (CDC) is Volvo Cars’ main spare parts hub in the world, which supplies local and regional warehouses with parts for all Volvo car models dating fifteen years back. The distribution center receives an average of 55 trucks per day with ordered goods from thousands of different suppliers all around the world.

Due to the vast inbound goods volume, controlling the number of arriving trucks per day is important for both economic and operational reasons. Two of the effects which follow from variation in inbound goods volume are first of all an inability to plan and optimize the goods receiving's manning-level, and secondly being forced to place goods outdoors; exposed to weather conditions which contribute to costs and also jeopardize the customer service. Today, the amount of inbound trucks average 55, but suffers a variation from 45 to 75 trucks per day.

Several factors contribute to this variation, and one of them is random variation in transport-time from the same geographical location. The purpose of this thesis is to find the actual reasons why trucks arrive in variations to Volvo Cars and evaluate CDC’s existing transport-time measuring, and find areas of practical applicability.

Findings conclude that random transport-time variation does not significantly contribute to inbound truck volume variation. However, the transport manifest data which the measure is based upon can be used to systematically level the number of inbound trucks over the weekdays. Furthermore, and perhaps the most important; it was concluded that monitoring the logistic provider’s performance on arrival-day is highly beneficial over monitoring and demanding transport-time.

Keywords: transport-time measure, goods volume variation, inbound logistics, leveling work load, goods reception, root cause analysis

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1. Introduction

In this chapter, the thesis background and problem definition is presented followed by its purpose. Further follows the scope and the limitations that were made by the assigner. Finally, the thesis outline will be presented.

Volvo Cars' Central Distribution Centre (CDC) receives an average of 55 trucks every day, accepting deliveries from their thousands' aftermarket suppliers all around the world. CDC is the central distribution center of spare-parts for Volvo cars, and keeps inventory for all car models up to 15 years of age. Due to the vast inbound goods volume, controlling the number of arriving trucks per day is important for both economic and operational reasons. Two of the effects which follow from variation in inbound goods volume, are first of all an inability to plan and optimize the goods receiving's manning-level, and secondly being forced to place goods outdoors; exposed to weather conditions which contribute to costs and jeopardize the customer service.

Today, the number of inbound trucks per day averages 55, but varies between 45 and 75 on a daily basis. One of the reasons for this variation is fluctuating transport-time between suppliers and CDC’s goods reception. If supplier shipments randomly arrive after different amount of time, the properties of the arrival statistic will remind white noise. Sometimes a truck arrives one day early and sometimes one day late; which results in that some days more trucks will arrive, and some days fewer trucks than planned.

CDC’s existing transport-time measures reveals that only 45% of all trucks arrive on the agreed transport-time. Volvo Logistics Corporate (VLC) however, which is the exclusive inbound logistics provider, claims that 96% of all goods arrive perfectly. Managers at CDC now wish to gain clarity and insight to the inbound truck volume issue. In essence, which are the causes to variation in transport-time, which in turn leads to variation in inbound truck-volume?

1.1. Background

The vision of Volvo Car Customer Service (VCCS) is to become world leading in customer satisfaction. Here CDC plays an important role, as the business unit responsible for timely delivery of spare parts to VCCS' service providers. Timely and accurate distribution of spare parts is critical for repair shops, since customers are waiting to use their cars until CDC delivers the right quantity. Apart from retailers and service providers, other customers are national, regional, and local distribution centers. These constitute the absolute majority of the customer base, where CDC is the middle-hand between suppliers and these smaller warehouses.

VLC is a 3PL forwarding firm, which coordinates all transportation between supplier sites and CDC. This exclusive partner answers for finding, evaluating, and using different carriers and haulers with the aim to satisfy CDC's inbound shipping needs. Thus, CDC's involvement in the transportation operation is limited to selecting arrival time-windows for certain carriers, and evaluating the savings which is made possible through VLC's consolidation expertise. A time-window is a time-slot of a few hours, in which different haulers are allowed to arrive. However, there is no active transport-time follow-up from either side. CDC relies on a supplier-based transport-time measure which is printed once a month, whereas VLC relies on carrier reported deviations which are e-mailed upon each occurrence. For example, if a truck gets stuck in traffic, or goods are left in a terminal, VLC administers a deviation report based on the carrier that is responsible for the handling. Consequently, there is a measure mismatch between the two companies. CDC measures transport-time per supplier, whereas VLC assumes perfect delivery and measures deviation from this per carrier.

1.2. Problem Definition

As stated in the introduction, the number of trucks arriving per day averages 55, but varies between 45 and 75. Figure 1illustrates the number of trucks which has arrived during each of the 120 first days of 2011. It is trivial to understand that several significant causes contribute to this effect, but which they are, which to focus on, and how to structure a contributive research proposal is not as trivial. This section argues for different points of departure upon the inbound goods variation which exaggerate the cost and jeopardize customer service, thus concludes that this thesis will focus on transport-time deviation.

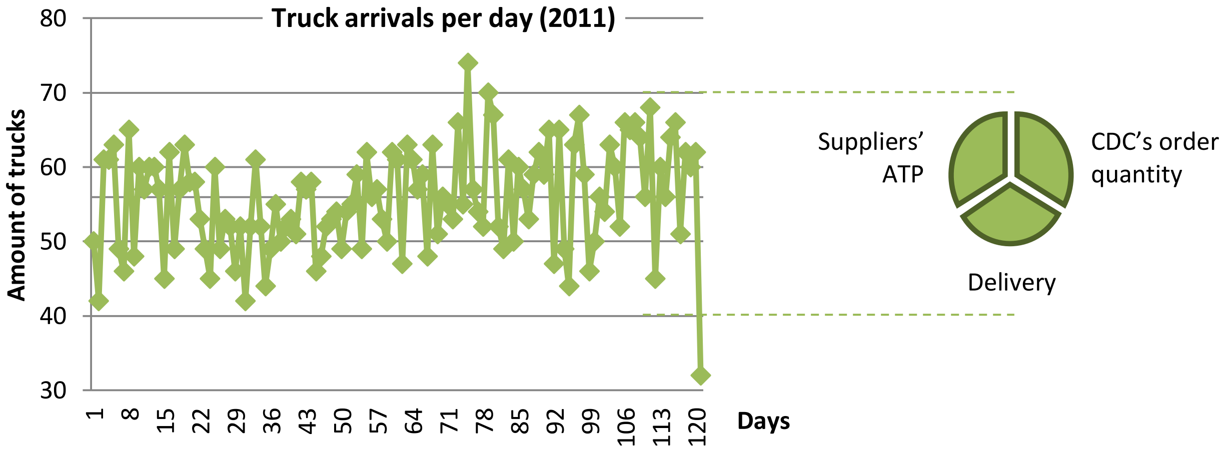


Figure 1. Daily variation in the number of inbound trucks arriving to CDC.

Three significant causes have been identified, which are CDC's order quantity, the suppliers' Available To Promise (ATP) probability, and random fluctuation in transport-time. The following three paragraphs define and argue for these three parameters, which is then followed by a discussion of alternative research approaches to the truck volume issue.

First of all, 'CDC's order quantity' is short for the total amount of goods which CDC has ordered from its supplier base. The inbound goods volume variation can never become lower than the order-quantity variation; if CDC would order from a perfectly leveled plan this cause is eliminated as no variation would arise. Fluctuation in the ordered goods quantity is expected to be the largest contributor to inbounds goods variation.

Secondly, supplier's ATP represents how many percent of the goods which suppliers were able to ship on time as planned. To illustrate this effect, consider the following example. Assume that a supplier receives weekly orders of 100 articles. If the supplier is only able to produce 80 articles one week, the supplier is expected to ship 120 articles the following week. Consequently, suppliers which cannot deliver on time, give rise to variation in the amount of inbound collies at the CDC.

Third and finally, transport-time deviation also causes inbound goods volume variation. With the purpose of balancing the daily work-load at CDC, managers use transport-time to decide on which days suppliers may ship goods. By assigning a week-day on which a certain supplier's goods should arrive, CDC can calculate the allowed outbound shipping day with the help of transport-time. Hence, the appropriate weekdays for goods pick-up are found. However, if carriers do not respect transport-time, then the planned daily goods balance is ruined and variation in the amount of inbound collies results. The current situation is shown in figure 2. The figure shows the minimum, maximum, median and first and third quartile of the truck variation. The boxes thus represent 50% of the total truck volume variation.

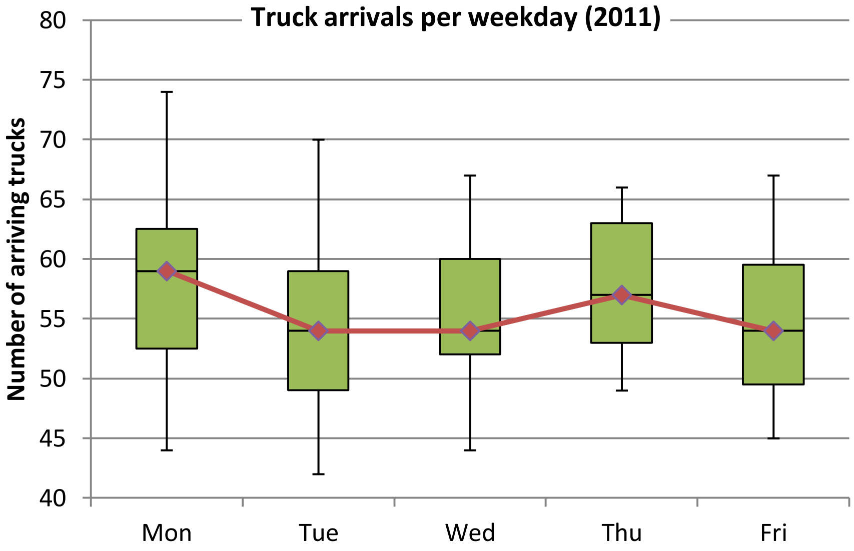


Figure 2. Inbound goods volume variation summarized per weekday.

Arguably, investigating other factors' contribution to truck volume variation and quantifying their relative importance, is a study of equal relevant importance as exploring any of these three. However, this thesis focuses on transport-time deviation for the following three reasons.

First, even though ultimately desirable, eliminating fluctuation in CDC's order quantity will most probably yield costly and time-consuming recommendations, which implementation may not be feasible within the next five year time-frame. Since CDC is one link in a chain of national, regional, and local warehouses, one may expect that the bullwhip effect is forcing CDC to order with quite some variation. Secondly, enforcing suppliers' on-time goods availability is a long-term process which responsibility has already been placed on procurement personnel. Through daily telephone contact and occasional live-meetings, CDC staff and suppliers continuously work on ensuring a high service-level. Third, the practical usefulness of investigating other possible factors contribution to inbound goods volume variation is questionable. First of all, other factors are most probably insignificant compared to the listed three. Secondly, the list of possible causes undoubtedly will be so long that practitioners will ask for a prioritization; which will reduce the list to only a few possibilities and then rendering all work useless.

Issues with transport-time are both theoretically and practically interesting for two key reasons. First of all, the existing transport-time measure shows that 55% of all trucks arrive on the wrong day. Thus, CDC seems to provide with an interesting case-study on how to practically improve transport-time reliability. Secondly, neither CDC nor VLC has formally addressed transport-related issues to date. Hence, it is likely that this path will give the opportunity to study and implement theoretical transport-time measure techniques.

1.3. Purpose

Variation in the number of inbound trucks is a problem at the CDC goods reception. Several causes gives rise to this variation, where transport-time is one of them. Transport-time is the time it takes for a truck to drive from a supplier to CDC's goods reception. Hence, transport-time variation can be exemplified with a supplier in e.g. Hamburg; sometimes it takes 2 days to ship the goods from Hamburg to Gothenburg, whereas sometimes it takes 3 days for the same journey. CDC and VLC have contradictory measures about the magnitude of variation in this value, which means that both companies have little insight to which potential issues actually exist in the transportation network.

Therefore, the purpose of this thesis is:

To find the actual reasons why trucks arrive in variations to Volvo Cars and provide an accurate interpretation of CDC's existing transport-time data, and scheme areas of practical applicability.

1.4. Scope

This thesis addresses only issues related to transport-time and how this is measured at CDC. Transport is defined as all activities which are performed from the moment when the supplier sends a pre-shipment advice to CDC via EDI, or the supplier prints the transport-documentation. The transport-time stops when the goods are registered as arrived at the CDC goods reception.

Disregarding whether goods arrive on the agreed date or not, the first challenge is to ensure that goods arrive on the same day. The authors have made the distinction between the notions 'correct day' and 'same day'. Correct day is if the goods arrive on right agreed date and same day is when the goods come repetitive on a day which is not agreed. Figure 3 illustrates the difference between the two concepts. It is important that goods arrive on the agreed date, but does not reveal any causes to the variation in transport-time. This thesis has only considered whether goods arrive on the same day or not, and has consequently not looked into transport agreements or figures in ERP systems.

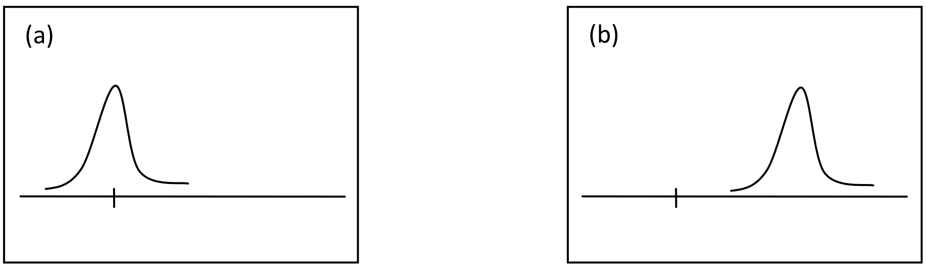


Figure 3. (a) correct day, and (b) same day here with exactly the same transport precision.

Furthermore, no exceptional cases of deviation in transport-time have been managed. Finding practical applications of the transport-time measure insight has been secondary, wherefore only major variation has been managed rather than outliers. For example, assume that one supplier has a transport-time variation where 80% lies between plus or minus one day, and one shipment was more than 10 days late. In those cases, only the plus or minus one day deviation has been concerned. The rationale from a practitioner's point of view is then that minimal effort then has the maximal impact.

1.5. Limitations

Implementation and execution of improvement programs is not covered by this thesis, but has been left at the stage of recommendation for managers. Hence, the case studies have been conducted in a rather general manner, and results are limited to a conceptual nature. However, this does not imply that the results are not valuable. General and conceptual problem areas are identified, but the solutions and exact specifications for each implementation have not been included.

1.6. Thesis Outline

First, a theoretical study of causes for transport-time variation was carried out in order to obtain a frame of reference when looking for root causes in CDC's case. Then, the method and analysis tools are presented, in which CDC's data which form the transport-time measure, was framed and used in new areas of application.

Then, the analysis section presents the data source and the current transport-time measure, and presents issues in the data when applying the method described in the method chapter. Finally, the analysis section concludes with testing method and analysis tools with the available data, though keeping the shortcomings in mind and the implications this may have on the case studies. The analysis is followed by results, which summarizes the findings relevant to CDC.

Finally follows conclusion and discussion, which aim at generalizing the findings and contributing to the practice of transport-time measuring and monitoring and controlling inbound logistics in general.

2. Frame of References

This thesis concerns transport-time. At least two areas of literature study are relevant to this field; the way transport-time is measured and real causes to transport-time disruption are of both practical and theoretical use.

2.1. Measuring Transport-Time

Literature review on smart traffic management, i.e. the use of technology to improve distribution performance, was the point of departure for this thesis. With knowledge about areas in which modern measure techniques has improved transport-time estimation, it is consequently possible to point out where flaws are likely in a traditional system. Stefansson and Lumsden (2009) have investigated the use of information technology to improve transport management. Three areas of potential improvement are listed; vehicle and driver management, goods management, and information management.

Vehicle and driver management includes but is not limited to driver identification, authority control, security, route recommendations, and maintenance. With a traditional system, some delays may be caused due to drivers' inexperience in route planning, congestion avoidance, and vehicle maintenance. Goods management includes but is not limited to goods location and control over which goods is loaded and unloaded. Without such control, it is possible that goods are unloaded at the wrong locations, as well as suppliers loading more goods than which capacity has been booked for. Information management includes paperless manifests and automated proof of delivery (POD) confirmations, and proof of collection (POC) control. Possibly, the measure of transport-time measures the time between POC and POD. Without an automated system, it is possible that such system is highly manual and therefore subject to administration errors and lost paper manifests.

2.2. Practical Applications of a Transport-Time Measure

All stakeholders which handle the goods are potential sources to disruption in transport-time. Hence, relevant stakeholders in a transport network includes the suppliers, haulers, forwarders, the receiving function at the end customer as well as all terminals between the goods' source and destination. Following the post-Fordism era, lean and just-in-time logistics has made it possible to reduce automotive manufacturing inventories from a few days to a few hours. However, such logistics system requires close monitoring and control of the material flow (Hesse and Rodrigue, 2004). Following the same logic, a transport network which lack close monitoring and control, is expected to suffer from disturbances in the flow of material.

Examples where congestion and delays are likely include the road network (which constitute 90% of goods transported in Europe), railroads which have not been upgraded to cope with high-speed trains, and terminals which are close to capacity limit (Schade et al, 2006; McKinnon, 1998; Hesse and Rodrigue, 2004).

Based upon a study on warehouses in UK within the fast moving consumer goods industry, McKinnon (1998) concluded that road congestions cause transport-time disturbance in the terminals if the warehouse is close to its capacity limit. However, a moderately utilized terminal is likely to cope with traffic disturbances within normal working hours. The author also concluded that the underlying problem to traffic congestion is not accidents, but rather the capacity of the road network. Thus, it is likely that rural areas, i.e. long distance transports, will not suffer heavily from transport-time deviation whereas traffic congestion may be likely to affect transport-time in urban areas.

Schadeet. al (2006), concludes in a study about the European union's competitiveness in goods transportation, that the main rail bottlenecks exists in France, Germany and Holland. Railways in France and Germany which have not been upgraded to handle high-speed trains, as well as connections from the Dutch to the German border are the current bottlenecks. Furthermore, the authors conclude that long distance trains are less reliable than short distance trains.

Kumar (2009) illustrates the effect of road congestion by looking at how the maximum possible speed is affected. The highest achievable speed on an empty road is only limited by the legal speed limit and possibly road conditions. This is referred to as V_f in figure 4. Then, with increasing cars per lane meter (congestion) the speed decreases due to presence of other cars and vehicles. This illustrates that the flow is rather constant until a certain point in trucks per hour, where speed drastically reduced.

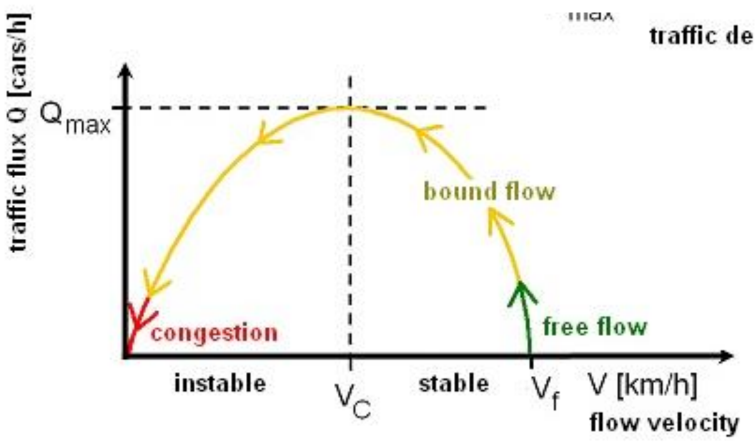


Figure 4. Traffic congestion and its effect on flow speed. Source: Kumar (2009).

2.3. Just In Time

Just In Time (JIT) is an approach that includes methods to deliver the right amount of items at the right time (Olhager, 2000). According PJO'Grady (1990) provides JIT ground for an effective and simple production through reduced lead times and inventories, improved delivery reliability and delivery performance and increased flexibility. JIT addresses the primary problems of waste elimination, strive for simplicity and to develop systems that detect problems. The primary problem is that such tackle bottlenecks by increasing capacity (use of multiple machines) or to outsource manufacturing through outsourcing and change bad suppliers. JIT principles are trying to integrate suppliers in production planning, resulting in capital costs, handling and storage advantages.

JIT transportation is something that is currently used by many companies. It is transports which consist of small quantities with high order frequency and short delivery time. It does not mean that it should be rapid or short deliveries but the deliveries should be made at a predetermined time or within a time window. By reducing the time for the product is in stock the company can reduce capital internally. If deliveries are in time then the company does not need to have large storage space and high tied up capital in raw material (Lumsden, 2006).

2.4. Relationships

Evaluation together with a supplier makes the supplier feel more comfortable and it helps to know each other better which leads to lower risk to collaborate with unreliable suppliers. According to Gadde and Håkansson (2001) the main point of a high involvement relationship is to establish consensual confidence. However if the company evaluate together with the supplier it will bring bigger confident and communicate it make suppliers not to feel uncomfortable. How big the company or supplier is have a vital function how to make a good relationship. Likewise suppliers should have good innovation skills, knowledge and be reliable. If the factory is too small customer for the supplier then the supplier would not put time to create a successful relationship. Nevertheless if it is in the other way that the company is bigger customer then suppliers will be forced to meet its demands. In the other hand it is better to allocate the total volume over few suppliers. Moreover the relationship has bigger probability to get successful when the suppliers are dependent of the company. The costs will furthermore be lower because the factory doesn't need to support many relationships. Another thing that is very important as now days when it is bad global economy it can be poor with raw material which makes it even more important to have good and close contacts. The suppliers then prioritize to supply those they are in long and good relationship with.

2.5. Contracts

A business should have an agreement or contract and it should be agreed and determined between the parties. If the business is of great importance it is vital to spend more time and money to create a good agreement. A contract may contain parts as which the parties are, their rights and responsibility during the contract, payment terms, other terms such as confidentiality and ownership, termination agreements, penalties for break of contract and so on. A contract cannot cover all necessary aspects of a successful business transaction. Rather, the key considerations must be identified and stated explicitly in the contract (Molin, 2002).

Skoog and Widlund (2001) argue that both parties in a negotiation have an interest that the contract is clear and leaves nothing open for interpretation. Additional appendices (such as shipping documentation) may be developed, for the customer to be able to identify and address problems. It is important for the supplier to document any assumptions and limitations in a client-provided contract, since verifying accuracy of the statements may be difficult at the time of the business agreement.

2.6. Delivery Precision

A freight should not be delivered too late or too early. Delivery precision is defined as the number of customer orders delivered on the promised delivery time in relation to the total number of customer orders. When a transport is delivered in timely way then both to transport planning are in good agreement and that customers can plan their activities. Product that have a high value or are bulky should not be in business to early due to frozen capital and space costs. Hence products that are delivered too late can stop its activities until they are delivered (Jonsson and Mattsson, 2005).

Delivery precision is defined as the number of customer orders delivered on the promised delivery time in relation to the total number of customer orders. Hence the promised delivery date should be specified as either a date or a time interval. By using time interval it accepts delivery any time in the given interval without that the delivery precision should be affected negatively. But if using delivery consists of a specific date, it will only be accepted on that date where both late and early deliveries are measured as negative time delivery (Jonsson and Mattsson, 2005).

2.7. Delivery Precision Measurement

The delivery precision is mostly calculated as a percentage which shows the amount of orders delivered on time. Delivery precision can be measured as promised/requested delivery date minus actual delivery date. If the result for the equation becomes equal to zero the delivery is on time. If it becomes a negative result it is delivered too late and positive number means that the delivery is early. It is very usual that the delivery date get changed by either the customer or by the production company. When it get changed by the customers it can be questioned if the date that it calculates its delivery performance also should be changed. Hence if the production changes the conditions of delivery should that date be used to calculate the delivery precision? It is not unusual that there are up to five or six different delivery dates to expect against a single order. This shows that the calculation of delivery precision is more complicated in practice than theory says (Slack and Lewis, 2002).

The work with measure a delivery performance is no easy task but the problem is to measure and how it should be measured. Hence the delivery precision has become a very important competitive advantage for companies where it is important to have good percentage of delivery performance. High delivery precision give the high costs while a low precision means that customers are dissatisfied and can seek for competitors (White, 1996).

Delivery precision measure the proportion of placed orders which are delivered at the right agreed time. Hence it has become increasingly important as measure since companies has gone to more order driven production. The delivery accuracy is affected by both the time delivery settings and how well it is kept with the operational control system. Many deliveries can be delayed due to wrong time settings rather than disturbance or insufficient planning (Mattsson and Jonsson, 2003).

According to Mattsson and Jonsson (2003) there are two different ways to measure delivery precision. The first is the number of actual deliveries in relation to the number of promised deliveries. The second is the number of late deliveries in relation to the total.

2.8. Performance Measurement Structure

The performance measures can be designed in several ways depending on what the company wants to measure. When the company has found a specific measure method then they should see how they will measure by looking at the source of data. Furthermore the source of the data that is getting collected can be both external and internal. The internal collection accounts historically data which is the most regular source. This is because the internal is easier to perform than the external. The external source mostly consists of customers and clients which have grown as more organizations are more customers driven. Further the external source can give information that the internal source is unable to provide as for instance the customers desires and needs. Hence many authors advise a combine of both external and internal measure (White, 1996).

Slack and Lewis (2002) talks about misunderstanding that can arise between supplier and customer which are internal versus external. One common misunderstanding is when the provider thinks that it performs in a specific way while the customer has another view of how the provider is performing. Hence only to measure internally can’t tell that the customer has the same picture of how it is getting performed. Furthermore the customer can desire other things from the supplier that they don’t know or the customer makes the wrong demands on the supplier. All this kind of misunderstanding can lead to strategic decisions are taken wrong because two parties are not on the same opinion. An example of this can be that the supplier focus on a certain performance that is irrelevant for the customer or that the supplier thinks it has better performance than they actually have. White (1996) concludes that it is important that the measured data get compared with a reference in order to strength that it is reliable. The data can be compared within the company where the new data get compared with the historically data. Another thing is that the competition is increasing and it is getting more relevant to also compare the data with competitors in order to compete on the market which is called benchmarking.

2.9. Collaboration for Transport Optimization

According to Mason et. al, (2007) says that supply chains are dynamic and it is common that the variance of the end users demand can be amplified due to it moves up in the supply chain. Furthermore there are factors that cause this as for instance time delays, order batching effects, rationing and gaming, duplication activities, larger inventory to reduce backlog and lack of coordination etc. This could be avoided through vertical and horizontal integration and collaboration which will optimize the transport management as well. It is stated that the transports can be defined as a physical link and integration that connects fixed points in a supply chain. Furthermore the transports are often used and managed as a commodity where the company focus on transactions rather than partnership which can be a fail factor in integrated transport management. It is concluded that “a collaborative supply chain simply mean that two or more independent companies work jointly to plan to execute supply chain operations with greater success than when acting in isolation”.

Mason et. al, (2007) argue that developments in information communication technologies (ICT) lead to renewed possibilities to share information, reduce inefficiencies, and build an understanding between suppliers and customers. For transportation, improved visibility allows companies to identify and specify problems with high resolution and thus easier find and follow reasons for failure. Hence, a logistics provider can improve the reliability of delivery service, with more shipments arriving on the agreed time.

According to Fugate et. al, (2009) the collaboration is a basis of supply chain management and companies can make a advantage through mutual respect, trust, information sharing, mutual ownership of decisions and a shared responsibility for good results between the participants. Furthermore it is unclear for the authors how one a collaborative relationship which is build on a strategic level with conclusions about allocation, sharing and management of resources are later facilitated on an operational level. In addition there are parallels how the strategic relationships affect the operational decisions and allocation of recourses in order to improve performance e.g. where companies focus on the operational activities between shippers and carriers that result from the strategic management decisions to collaborate and decide. Moreover the failure of collaboration comes from top management support, improbable expectations, authority imbalances and lack of shared aims.

Fugate et. al, (2009) say that few companies are self sufficient which make dependence on other organizations resources as for instance in the supply chain management there are third-party providers (transportation organizations) that are the link between parties. When parties engage to keep collaboration the success still depend on to get right amount of goods, right condition, at right place and at right time. The reliability of transportation have increased a lot and become very important. So the participants need to decide what and how much resources should be used in order to create a situation that is valuable for all participants.

One important thing that Fugate et. al, (2009) highlights which prevent that the driver from being on road is "waiting to unload and load material at the dock is one of the most time consuming". It is suggested that "the operational collaborative focus should be on dedicating resources and implementing processes to make the shipping and receiving dock exchange more efficient and to reduce the amount of time a driver waits at the dock door". Further to create an advantage the dock exchange need to be more efficient and effective in order to reduce the waiting time which the carriers are dependent on. There are stories that the trucks need to wait hours or even days at the shippers dock to be able to unload and load the goods. The shippers and the carriers need to put resources to improve the operational activities and processes at the dock exchange which would not be done just through collaboration but it is needed to allocate constraints, time, finances and to support strategic collaboration in order to get it done. Further to improve the dock exchange, the carries can train the transportation system planner to schedule in a way that reduces waiting time and slowdowns. The carries can invest in more standardized truck sizes and the shippers can improve the dock by building more floor space and building processes that allow more trucks per door or invest in yard tractors that remove trailers when they are finished and replace with trailers for next work. In addition the shippers operations at the dock can increase their shifts from two to three shifts and work six to seven days per week in order to be more accommodate for the carriers schedules. Another thing to improve is to place orders as early as possible to gain time for the carriers to allocate their equipment and trucks that are needed. All this are important to put effort on for strategic and operational collaboration between shipper, carrier and receiver to get better dock efficiency and to enhance the competitive advantage. Finally "the longer a truck waits at a dock door or in the facility yard to unload or to load, the greater the opportunity for stock outs and reduced customer satisfaction". So the key challenge to achieve high performance is to make a competitive advantage in implementation and operational issues with understanding of the implementation strategies.

2.10. Transport Uncertainties

According to Rodrigues et. al (2008), outsourcing can contribute to increasingly complexity of supply networks which can impact on important factors as for instance information visibility and communication between parties. The authors state that "insufficient fleet capacity can be a cause of disruption of transport operations, delaying the delivery process to customers". Other uncertainties can be lack of vehicle configuration, lack of drivers, defective vehicles and carrier flexibility or delivery frequency. Hence if the transportation is not managed in an integrated and collaborative way it can contribute to delivery delays and low capacity utilization. Furthermore lack of information according the truck location can reduce the visibility for the customer which can lead to delays in transportation process. Another uncertainty can come from the carriers scheduling and routing process where lack of flexibility of transports can cause operational problems at customer facilities and cause delays in the transport process. Likewise inefficient transport scheduling can result to more unpredictable arrival times and also damaging impact on the effectiveness at hubs.

Rodrigues et. al (2008) discuss the uncertainties from external sources such as variations in demand unpredictability and congestion. If congestions can be predicted then it can be planned but that is not often the case. Many congestions cause variability and less predictable transporting times which gives poor reliable service. Further the delays can lead to delivery refusals at depots or hubs and preferred routes are not always accessible. Other things as repairs, accidents, road and rail closures, missed shipping times make longer detours than planned there the external uncertainties which can't be affected or predicted can cause unavoidable disruptions and delays in the supply chain. Variations in demand should be managed through better demand forecasting techniques or to improve the visibility of information between the parties. On important thing that the authors conclude is that many causes of uncertainties can be linked to one particular member of the supply chain which is responsible for planning, organizing, procuring and managing the transport operation. This uncertainty from a specific member can be reduced through brilliant supply chain control mechanism and by sharing entire information within the supply chain. Therefore, uncertainties in transport performance and efficiency depend on which organization has the responsibility for transportation.

3. Method

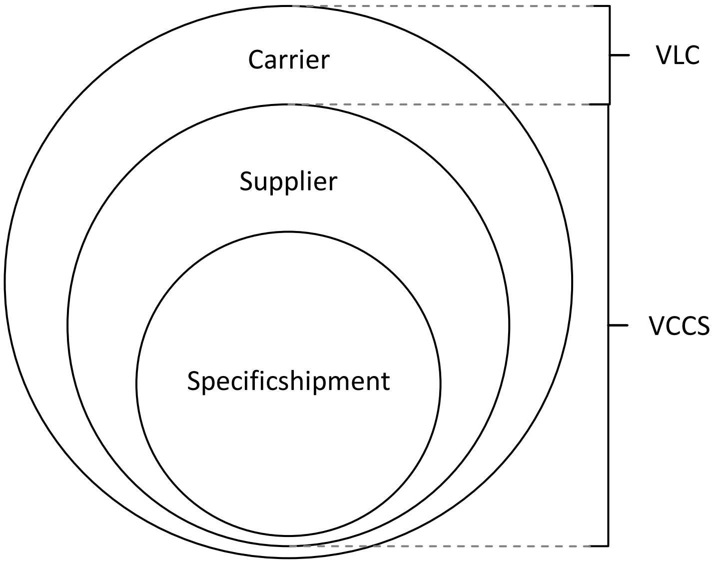
This section presents and explains the chosen approach to evaluating the transport-time measure at CDC, and the analysis tools which were used to test the practical applicability of the underlying data. Later it is written a description of the working method and how data collection was done. Furthermore describes the method of criticism which our own criticism raised against the method used.

Initially, an extensive amount of interviews with different staff at CDC resulted in familiarization of the subject. This was followed by gathering existing transport-time measure data, which had resulted in the 45% perceived transport-time precision. This data was collected from CDC's procurement ERP system (PULS); where the date on which goods has left the supplier and the date on which the goods arrived at CDC are recorded. The difference between the two dates is calculated as the transport-time. Finally, variation in transport time for the same supplier was cross-checked against VLC's carrier reported deviations to quantity the reliability of the data.

Following the consistency and reliability test of the transport-time measure, the next step is listing areas of practical applicability of the available data. Areas which are directly affected by transport-time are variation in arrival days for trucks from the same supplier. Indirectly, the data can be used to choose suppliers' allowed shipping days, and thereby balance the inbound goods flow per day to CDC.

3.1. Applying the Data to Variation in Inbound Truck Volume

CDC measures transport precision for each supplier. However, managing one supplier at the time overlooks the fact that one carrier may collect goods from several suppliers. Instead, summarizing several suppliers based on the existing transport network also takes e.g. milk-rounds and common transport hubs into account. Therefore, a natural first step is grouping and summarizing suppliers' transport-time variation on the carrier which was contracted for the geographical location of each supplier. Figure 5 illustrates this frame of reference, or analysis model, based on which the underlying data has been modeled.



Analysis model

Suppliers transport-time precision (data from CDC) is summarized and grouped on carrier’s pick-up routes (data from VLC).

Specific shipments help reveal the root causes for delayed or early goods for the carriers which arrive with the highest goods volume on different days (data from VCCS).

Figure 5. The three layers with which the transport-network is analyzed.

With the help of transport-booking history from VLC and supplier data from CDC, it is possible to rank which carriers that have the largest impact on the goods reception. The purpose is to find those carriers which have the largest amount of shipments arriving randomly on different days. If a carrier always arrive on the exact same time, with the same amount of goods, it is possible to steer the carrier so that it arrives with its goods when it is the most appropriate for the goods receptions work-load. In contrast, if there is random variation in the transport-time, it is impossible to actively choose specific days on which certain carriers are supposed to arrive.

Finally, with knowledge about which carriers have the largest impact on the CDC goods reception, and knowledge about how reliable the measured transport-time data is, it is possible to perform root cause analysis and find the underlying causes to varying transport-time for those selected case-carriers. With specific knowledge about certain vehicle routes, it is possible to aggregate an overall transport-time performance indicator which can be used as a benchmark towards VLC and thus demand higher customer service.

3.2. Applying the Data to Balancing Goods for per Weekday

In addition to demanding higher customer service from VLC and thereby obtaining a more evenly distributed goods volume; it is also possible to look at agreed shipping days and their balance over the weekdays. With access to data for specific shipments, it is of course possible to extract which weekday the goods were sent, as well as which articles and how many or order-rows that was called off. Thus, it is also possible to manage so that only appropriate articles have the same shipping days, whereas inappropriate article combinations can be spread over different weekdays. In addition, it is also possible to monitor increases and decreases in the goods volume sent over time.

Gaining access to this detailed information requires going beyond the established transport-time measure and extract single shipment data from PULS. Then, the data needed to be translated to a usable format which was done mainly with the help of the computer tool Excel. Please refer to appendix A for details on how to administer this data.

3.3. Working Method

We have been working on this project throughout the summer and autumn semester. Along the way we have gained an insight into the Volvo Cars is structured and works. We have had a tough time finding the materials, but thanks to long and instructive interviews with employees at Volvo Cars, we have been able to get answers to our questions. This led to a lot of new issues during such operations. We have initially focused on being able to do a job that should be easy to read but at the same time give a good presentation of thesis work.

Before starting the thesis the time was devoted to seek information and read about Volvo Cars products and look on data to get a basis for our work. The meeting in Volvo Cars started with a task specification that was presented which provided a basis to start with the thesis. At the second meeting we got introduced with more staff people. Some of the initial work was done by understanding how the Volvo Cars looks and get a feeling which people work with which tasks. Nevertheless the thesis has also contributed to the understanding of the problems are courses that we read during our study period, primarily knowledge of Supply Chain Management, Material Planning and Control, Management and Physical Distribution, Organization Leadership and Change, Freight Transport Systems, Information Systems for SCM, and Customer Relationships.

In order to collect the facts we needed to complete this work, we have used different methods. We have chosen the most common methods such as interviews, Internet review, literature review and analysis by measuring and calculating. We used information from Volvo Cars system to get a base to work. The interviews that were carried out were at Volvo Cars in their different departments, with suppliers and also Volvo Logistics (VLC). We got a good insight into the company and also better connect with workers and ongoing meetings at Volvo Cars. It was through the interviews and statistical data that we caught most of the material that we used. Subsequently, there were analyses by measuring and calculating the data from Volvo Cars and other suppliers system. Finally, we used the literature on the theory that supports the report. Using these methods, we have compiled all the facts to our work.

3.4. Qualitative Interviews

During the thesis project there were a lot of personal interviews and telephone interviews. According Lekvall and Wahlbin (2001) interviews can be more or less structured. In a structured interview, the same questions for all respondents or informants. The partially structured interview used in place a number of areas of questions. In a non-structured interview, the interviewer is not enough knowledge of the area to ask structured questions, but can be seen as an explore and exploratory talks.

There are two different methods in interviews that are informant interview and respondent interview. Informant interview seeks to facts and answers to the questions you have by asking people who are expected to possess specific knowledge of the area. Respondent interview is to try to get answers to general opinions and answers (Lekvall and Wahlbin, 2001). We have during our interviews mainly used informant interviews. The interviews that were partially structured and formed from statistical data were the basis for the report. Before the interviews were prepared custom queries based on the current candidate's knowledge in the field. During the interviews, we used active listening. The interviews became more character of talk and conversation as we constantly had to ask supplementary questions. During the interview, the person had the opportunity to comment and describe other processes and events in the company. The people interviewed were chosen based on their qualifications and experience depending on the facts the authors needed.

3.5. Literature Search

The literature search was done by systematic search of the university's records and databases, where we then went looking for books or reading the information electronically. During the limited perspectives and resources is secondary information to be preferred, however, the information sender critically examined and compared with other sources. Some of the information found through other old reports localities reference lists. Even articles were found by searching on the internet when we critically examined the sources. Other material written material and information from internal data system from Volvo Cars was also on hand.

3.6. Analysis Procedure

The work began with an overview of how transport situation and inbound flow looked like, and to identify the external flows to the company. This could be done by gathering information from the company's computer system. What was sought was important to get a picture of the nature of the mission. Description of current situation meant that we systematically went around and interviewed, calculated data, followed up the data, surveyor entire Volvo Cars inbound flows and supplies. The process required observations and notes while doing the information search and also relevant literature has been studied continuously throughout the work. Further the authors performed root cause analysis on case-by-case basis in order to find the underlying causes to varying transport-time for selected case-carriers.

3.7. Study Visit

Some study visits were made at other departments of Volvo Cars and at their transport provider VLC. The purpose with the visit was to gain more understanding how VLC´s acting and cooperation between the partners contribute to the transport variations. The study visit last for few hours were the authors could interview transport planner and study the cross docking.

3.8. Other Data Collection

Much of the information the authors adapted to selection from the data system. Example of this kind of selections are, goods reception data, arrival precision, MFG/SHP adresses, planning report, supplier/carrier data and so on. The access to the ERP system that Volvo Cars uses enabled the studies of data directly from the system and contributed to better understanding of how they work. The authors could also precede from some various compilations that include in the regular report/follow-up within the company. The reporting of transport disturbances is an example of this kind of documents. Other written material that the authors used was for instance information material from Volvo Cars. Much of the data collection was made during different meetings that the authors participated in every week. At this meeting the authors got foremost information about ongoing changes.

3.9. Method Limitations

The authors used literature and internet search to broaden their information. The theories that were used as references are mostly known and proven. Hence in some areas it was hard to find good material and therefore we needed case examples to strengthen information from articles published on internet, which could be a grade of lower scientific range. The authors chosen to concentrate on books and articles more than information from the internet because they believe that the information you find on the internet is not as safe and credible as the information you find in books and articles. However, used information published on the internet and articles that are classified as second-hand information on those occasions when other sources were not available. The problem with this type of sources is that you read a person's interpretation of an original work. At worst, this may have occurred in several steps. To some extent we have sought to counter the weaknesses of these sources by critically examining the sender and also compared with other sources.

This work is based on interviews, discussions, and own interpretations, which can cause difficulty in examining how the conclusions would be if someone else repeats and perform the same work. The interviews conducted with employees at Volvo Cars were never recorded so it was impossible to verify what was said. It is possible that we misunderstood or forgotten some of the people interviewed. This we tried to reduce this by throughout the interviews conducted discussion where they always had the opportunity to ask following questions. We can through discussions have affected the responses by our own views but we believe the risk to be small. Accurateness has been taken to ask supplementary questions to clarify our questions.

A weakness with interviews is that the informant at times may have been influenced by external factors such as stress, phone calls, people who got interruptedly etc. and therefore not been able to focus on the issues fully. This weakness is difficult for us to counter. The ambition has been to conduct interviews in a way that maximum information is reached. On occasions where confusion arose was the same informant could be reached after the interview for clarification. The authors felt, however not that the people which got interviewed were inhibited, despite some disruptions. The goal was always to get as much information as possible out of each interview, but emphasis was also on people's own views, it is debatable whether this was achieved in every situation. The interviews that were made in the different areas, the authors still find that the interviews gave a good basis to analyze and draw conclusions from.

4. Analysis

This section first presents the data source and on which CDC's current transport-time measuring is based. Then, the measure is discussed and its shortcomings are lined out. This is followed by an application of the analysis tools which were presented in the method section, and the shortcomings in the data which affect the quality of the research. Finally, with the shortcomings in mind, the analysis tools are tested on a number of case-studies and through those it was possible to deduct real causes for transport-time variation.

4.1. Transport-Time Data Source

In order to become acquainted with CDC's transport-time measure, some background in CDC's ERP systems is necessary. CDC has several different supporting IT-tools, which gathers data from a central database and provides the appropriate personnel with suitable data. For example, purchasing responsible make use of one data interface, whereas procurement responsible uses another. Since the procurement responsible monitor and control the material flow from suppliers to CDC, the transport-time measure is collected from this interface.

The procurement ERP system allows CDC personnel to order and administer each article which has been purchased. Each article has its own 'page', to which several different properties are tied. Among them and particularly interesting to this thesis are data about the manufacturer and the manufacturer's shipping location. Manufacturer data is important for procurement and quality reasons, as well as other reasons that are crucial in the process of obtaining material from suppliers. However, the shipping location is the only one that is important when measuring transport time, since it contains the geographical location of the warehouse from which the goods were actually shipped. Please refer to figure 6 for a graphical representation of the hierarchy.

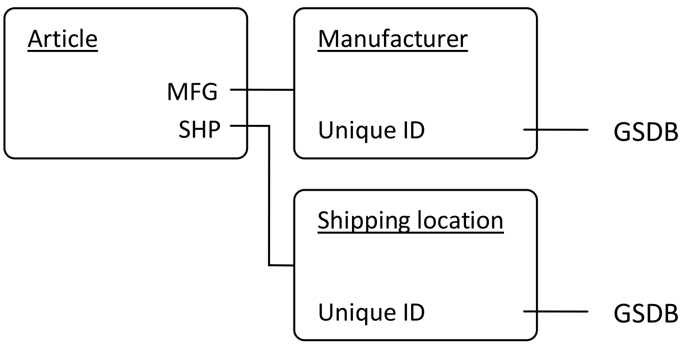


Figure 6. The article-manufactiring-shipping hirarchery.

Every four weeks, at the approximate end of each month, the procurement ERP system automatically loops through all articles registers the time between each shipping occasion and each corresponding receiving occasion during the period. Hence, for each article, the time-difference between the printing of the transport manifest and its registration at CDC is CDC's definition of transport-time. Note that transport manifests do not necessarily need to be printed on a physical paper. A majority of suppliers sends a signal through EDI which tells CDC that goods has been made ready for shipping (shipping pre-advice), which according to regulations is only allowed to be made on the same day as which the goods leave the supplier.

This difference is compared with an agreed transport-time, which is entered into both CDC's and VLC's systems upon the entry of a new supplier and when a supplier changes location. Weekdays are taken into account in both VLC's and CDC's systems. The weekday is five days long, and weekends are not accounted for. Thus, a supplier with allowed shipping day on Thursday and three days transport-time is consequently expected to arrive on Tuesday the following week. Neither of the systems account for national holidays that occur during weekdays. This is appropriate, as both systems then measure transport-time in the same manner. According to Slack and Lewis (2002) this is not unusual that there are different delivery dates to expect to a single order which means that it is more complicated in practice than in theory.

Reporting of the transport-time performance is done per manufacturer. The system counts the number of orders which have been placed at each shipping location, and calculates the percentage of order-rows which have arrived after zero, one, and up to eleven days. Then, the aggregate monthly data is presented in tables where one row represents one manufacturer and month. Table 1 contains a snippet of transport precision data from such a report with three manufacturers and one four-week period each. For example, for supplier C6T3A 73,6% of the orders have arrived after one day, and the remaining after either zero or two days.

Supplier	Day 0	Day 1	Day 2	...	Day 11	>Day 11
C6T3A	7,5%	73,6%	18,8%		0	0
6652A	0	0	29,4%		0	0
ALTXA	0	0	28,5%		0	0

Table 1. Transport performance for three different suppliers.

Note that the table is pivoted on manufacturer's addresses and not on the shipping location. Hence, a manufacturer with several shipping locations with different transport-time will render an unusable measure. For example, assume that one shipping address has zero days transport-time, and the other has one day transport-time. Also assume they ship equal amount of goods and both have perfect deliveries. Then the same amount of transport bills will be 50% on day zero and 50% on day one. Also note that the snippet of data in table 1 is not complete. The actual data-file contains information such as the correct number of days according to the procurement ERP system, the number of transport bills that have been sent during the period, the name of the manufacturer, the supplier's city, and supplier's country.

4.2. Shortcomings in the Transport-Time Measure

Fundamentally, the transport-time measure suffers from administrative errors and the concept of transport-time itself. Since the transport-time measure is a highly labor-intensive process, the probability of mistakes is imminent. White (1996) mean that the work with measure a delivery performance it is not an easy task but the problem is to measure and how it should be measured. Furthermore, since transport-time does not count weekends; in order to gain a high measure VLC must not do any operations on weekends.

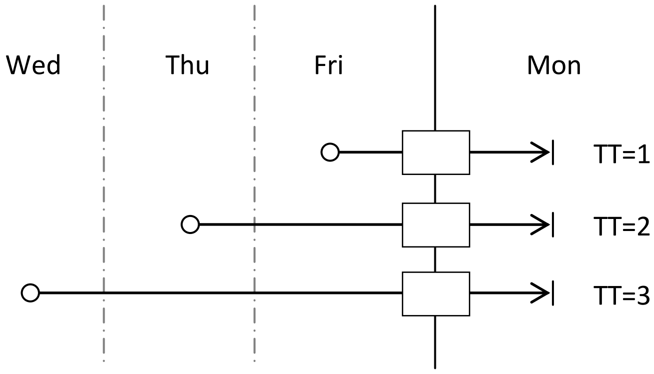


Figure 6. Work on weekends is measured as transport-time deviation.

Since both VLC and CDC are closed on weekends, it may seem rational that the measure should consider weekends as non-working days. However, this appears not to be the case. Consider an example of a supplier with the agreed pick-up days Wednesday, Thursday, and Friday. With an agreed transport time of three days, the supplier's goods are expected to arrive on Monday, Tuesday, and Wednesday respectively. However, study the situation presented in figure 6. If the carrier is working on the weekend, for example if there are a vessel departures on Friday, Saturday and Sunday, goods will be waiting at the port of Gothenburg at Monday morning. All goods arrive on Monday, which is good and manageable. But with the existing transport time measure, a transport time of one, two and three days are registered. This gives the impression of a transport-time variation which needs urgent management, even though all goods actually arrive the same day.

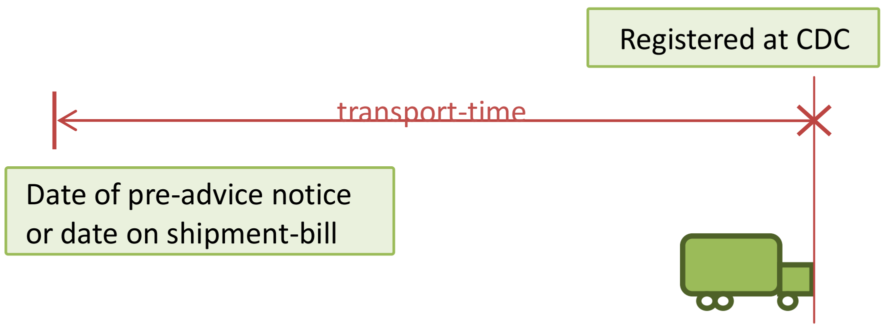


Figure 7. The transport-time measure is dependent on paper handling and administration.

Furthermore, administration of transport documentation is another source of transport-time variation. Figure 7 illustrates the definition of transport-time. When a shipment arrives at the CDC goods reception, transport-time is calculated as the time between the date of today and the date when the goods shipment was registered as 'ready for shipping' at the supplier.

From the supplier's side, if the outbound goods personnel print the transport documentation one day early, one day of transport-time will be added to the measuring, even though it does not exist in reality. There need to be some agreement between the parties which Skoog and Widlund (2001) say that both parties in a negotiation need to have a contract that is clear and leaves nothing open for interpretation. It can be difficult for the supplier to verify the other partner accuracy which means that it is important that the supplier document any assumptions and limitations. Measuring 21 suppliers in the Gothenburg region, where transports are deemed to have a negligible effect on transport-performance and all deviations can be derived to administrative faults, the total transport-time precision was 93%. Consequently, on average 93% of all orders arrived on the zero days and 7% arrived randomly with longer transport-time.

Furthermore, it may happen that the supplier's production planners and outbound personnel does not have sufficient communication, which leads to insufficient carrier capacity being booked towards what is actually produced and marked as ready for shipping. Mason et. al, (2007) says there are factors that cause time delays, order batching effects, rationing and gaming, duplication activities, larger inventory to reduce backlog and lack of coordination etc. This could be avoided through collaboration within vertical and horizontal integration and further it would optimize the transport management. Hence, the excess goods will be standing one day extra on the supplier's dock, waiting for pick-up the day after. Rodrigues et. al (2008) state that "insufficient fleet capacity can be a cause of disruption of transport operations, delaying the delivery process to customers" which is a problem for late arrivals.

Table 2. Summary of administrative causes to transport-time imprecision.

CDC goods reception	**Probability**	**Effect**
Transport documentation is missing	1,5%	Possibly one day extra transport-time
Mistakes by stansen personnel	0,2%	Negative transport-time
If there pre-advice was not made, and there is no date on the transport bills, today is entered as sending date	Low	0 days transport time

At CDC's goods reception on the other hand, table 2 summarizes the factors which contribute to the virtual transport-time variation based on the measure manual nature. Missing transport documentation account for the largest addition of measured transport-time, based on the goods receptions data from 2010, at least 1,5% of the trucks do not have the proper transport papers with them when arriving at CDC. Papers may be lost or handled improperly by the carriers, the customs, or by supplier's outbound personnel. Freight documentation with amount of collies is taken care of since knowledge of the amount of collies transported is vital for economic reasons for VLC and the carrier. This is typical what Gadde and Håkansson (2001) explain that parties can establish consensual confidence through high involvement relationship and if the company evaluate together with the supplier it will bring bigger confident and communication. This will make that the suppliers not to feel uncomfortable and lead that they are taking care of the documentation with amount of collies.

Negative transport time accounts for approximately 0,2% of all transports according to the same data source. These are obviously erroneous, and thus strengthen the argument that the current way of measuring transport time is not accurate enough to be used in order to demand higher customer service from VLC. The only robust measure from the goods reception is the date when the goods arrive. Therefore, what would make the transport precision measure more reliable is measuring whether goods have been shipped and arrived on the correct day of the week.

Finally, if a supplier does not use EDI to send pre-shipment advices, the goods reception personnel must enter all transport-documentation manually into CDC's ERP system. If the date of shipping is unclear or missing, then the date of today is entered into the system. This routine makes it hard or even impossible to distinguish between obvious erroneous transport-times and shipments which are actually sent with zero days' transport-time. Slack and Lewis (2002) talks about misunderstanding that can arise between supplier and customer and it often happens that the provider thinks that it performs in a specific way while the customer has another view of the perform.

4.3. Shortcomings in the Data-Source's Applicability

White (1996) says the historically data is the most regular source which is an internal collection and it is easier to measure than external measurement. Companies have become more customers driven there the external source mostly consists of customers and client and can give information that the internal source is unable to provide. Being able to detect flaws in VLC's performance on an aggregate level, followed by root cause analysis on specific flows is the first and most straight forward application of the measure which this thesis aims to test. In order for a root cause analysis to give specific and actionable results, it is required to ask specific questions. With general and broad questions, the answers will be general in nature as well. The transport-time measure and its presentation play a crucial role in this inquiry process. With a measure which is so detailed that specific shipments can be questioned, VLC can track trailer numbers, deviation reports, and which carrier who was responsible for the pick-up and delivery.

Ideally CDC should have a ranked list of carriers, on which have the carriers with largest transport-time imprecision weighted on amount of collies is listed. Then it is possible to investigate and query those carriers with the most impact on the goods reception. With suppliers grouped per carrier, it is possible to investigate exactly which suppliers that are the most significant contributor to the carrier's transport-time imprecision. With both carrier and supplier known, it is possible to investigate specific shipments from the supplier by the chosen carrier, so that root causes for the transport-time deviation can be explored and quantified.

```
Carrier -> GSDB (Collies) -> Specific shipments
```

However, the best available data today is:

```
Carrier ->GSDB (Order rows) ->Specific shipments (case-by-case basis)
```

Now the main problems will be reviewed and described. Therefore, the current challenges in the transport-time measure are The Arrival-day problem, The Collie-orders problem, The Article SHP (shipping site) problem, The MFG-SHP (Manufacturing –Shipping site) problem, The Carrier-GSDB (Global Supplier Database) problem which are described below:

- **Specific shipments; the Arrival-day problem**. Without attending this problem, it is only possible to monitor transport-time, but impossible to manage on which day specific suppliers and carriers arrive with goods.
- **The Collie-orders problem**. The best way of ranking which suppliers and carriers that cause the most work-load for the goods reception, is based on statistical regression between the

number of call-offs and the amount of inbound collies. Hence, the supplier and carrier ranking is possibly showing a misleading prioritization.

- **The Article-SHP problem**. In early 2011, the property shipping-location was entered into the CDC ERP system. This means that even though one supplier have the possibility of having different transport-times entered for each shipping location, it is more likely that the information has been copied from the old MFG location onto all SHP sites. Hence, the procurement responsible are working with an erroneous transport-time.
- **GSDB; the MFG-SHP problem**. The existing way of measuring transport-time, is calculating the transport-time for each article presenting the data summarized over manufacturing site. Hence, those suppliers with more than one shipping location are unusable. Currently, 15% of all supplier data and 20% of all order call-offs have been removed due to this challenge.
- **The Carrier-GSDB problem**. In order to summarize transport-time imprecision which is measured per supplier, into carriers which can be managed by VLC, data about which carrier that picks up which goods is necessary. This data is given from VLC, who are the ones contracting carriers' pick-up locations; but 8% of all suppliers' ID does not exist in VLC's database. When a supplier is missing in the transport-booking history, the suppliers will be summarized per country instead of carrier. Furthermore, VLC claims that only one carrier pick up goods at only one geographical location, this is only true only in 80% of the cases. One out of five times, on average, there is a different carrier which picks up goods.

4.3.1. Arrival-Day Problem

The promised delivery date should be specified as either a date or a time interval. By using time interval it accepts delivery any time in the given interval without that the delivery precision should be affected negatively. But if using delivery with specific date, then both late and early deliveries are measured as negative time delivery (Jonsson and Mattsson, 2005).The issue that the transport-time measure punishes VLC for transporting goods on weekends is a flaw which stems from the measure itself. What makes this an especially distressing issue is that arrival day is currently not possible to measure and manage. For example, with the bare knowledge that the transport-time was one day, gives no information whether the shipment was sent on the correct day, and neither on which week-day had the shipment arrived.

In order to address this issue, it is necessary to list which shipments were performed for each day of the month, rather than a simple summary over the month's transport-time. This information can be easily collected in PULS' image 5107 (page in Volvo Cars ERP system), where the three first digits of the 'löpnummer' contains information about week and day arrived, and 'avsdat' contains information about when the goods was pre-advised through EDI.

The result is illustrated in figure 8, which shows and example from the supplier SMR Automotive Mirrors in Great Britain. The supplier is only allowed to send shipments on Wednesdays, but apparently goods have also been shipped on Fridays. According to Fugate et. al, (2009) says that collaboration make a advantage through mutual respect, trust, information sharing, mutual ownership of decisions and a shared responsibility for good results between the participants. Nevertheless it is possible to measure and manage which day of the week goods should arrive, since the measure shows both shipping date and arrival date. For this supplier, with shipments every two days, it is also possible to circumvent the issue with transport-documentation being printed one day early. Discarding shipments which has been sent one day early, this sample contains 96% of the orders shipped.

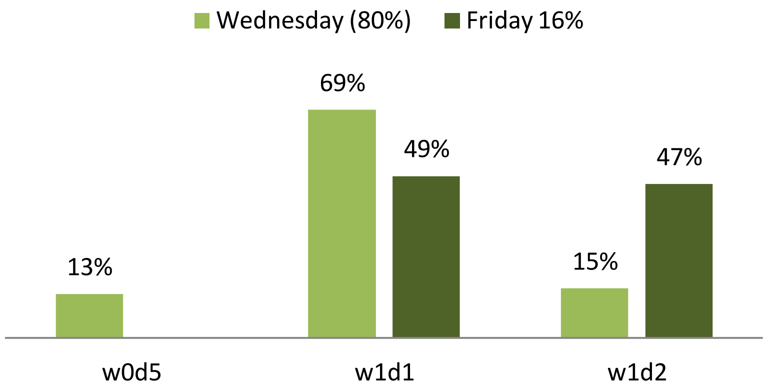


Figure 8. Arrival day measured for supplier SMR Automotive mirrors.

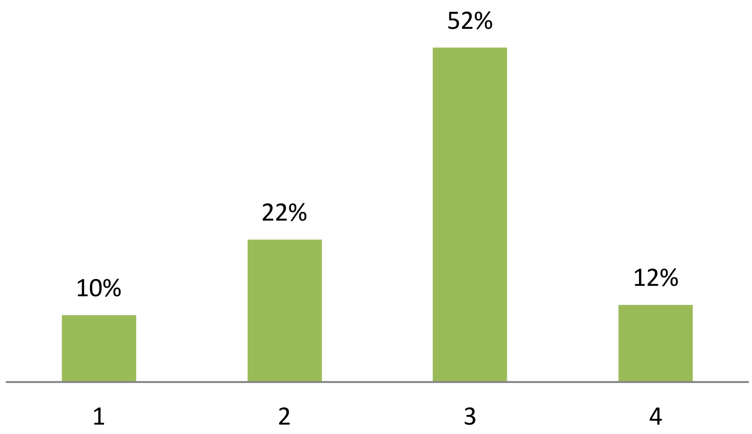


Figure 9. Transport-time measured for supplier SMR Automotive mirrors.

In contrast, the existing measure of transport-time alone produces results as seen in figure 9. From this graph it is impossible to guess that the transport-time = 3 is Monday, and is caused by from shipments on both Wednesdays and Fridays. Also note the two measures in figures 8 and 9 are not from the same time-period, hence the percentages differ.

4.3.2. Orders-Collie Problem

The group of suppliers that has most spreading in transport-time has been prioritized in order to find the largest impact on the goods reception. However, this measure is based on order-rows instead of collies, which does not directly influence CDC. A better measure of supplier importance is the number of collies. This data is not available in the current IT system however. Figure 10 shows the correlation between the number of call-offs and the number of inbound collies to CDC. Statistical regression between the amount of collies arriving at the CDC goods reception and the number of call-offs shows a correlation of 0,75 and R^2 = 0,56. Consequently, at least 56% of the variation in the amount of collies are explained by the latent variable call-offs, whereas the rest of the variation is explain by other factors.

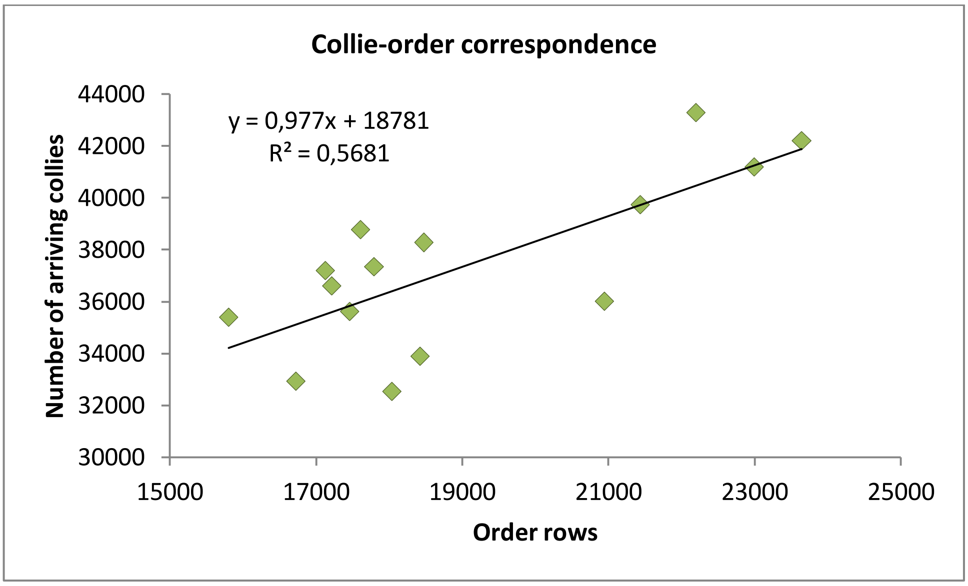


Figure 10. The variation in the amount of inbound collies are 57% explained by the number of order rows.

In pseudo mathematical terms, explanatory variables can be explained as follows.

```
# kolli = f(orders, quantity, package size, ...)
```

but the aim is to find a function `g(x)` so that

```
# kolli ~= g(orders) + e
```

where `e` is an error term. The question which R^2 answers is how many percent of the variation in `f(x)` that `g(x)` explains, and how much is left to the error term.

4.3.3. Article-SHP Problem

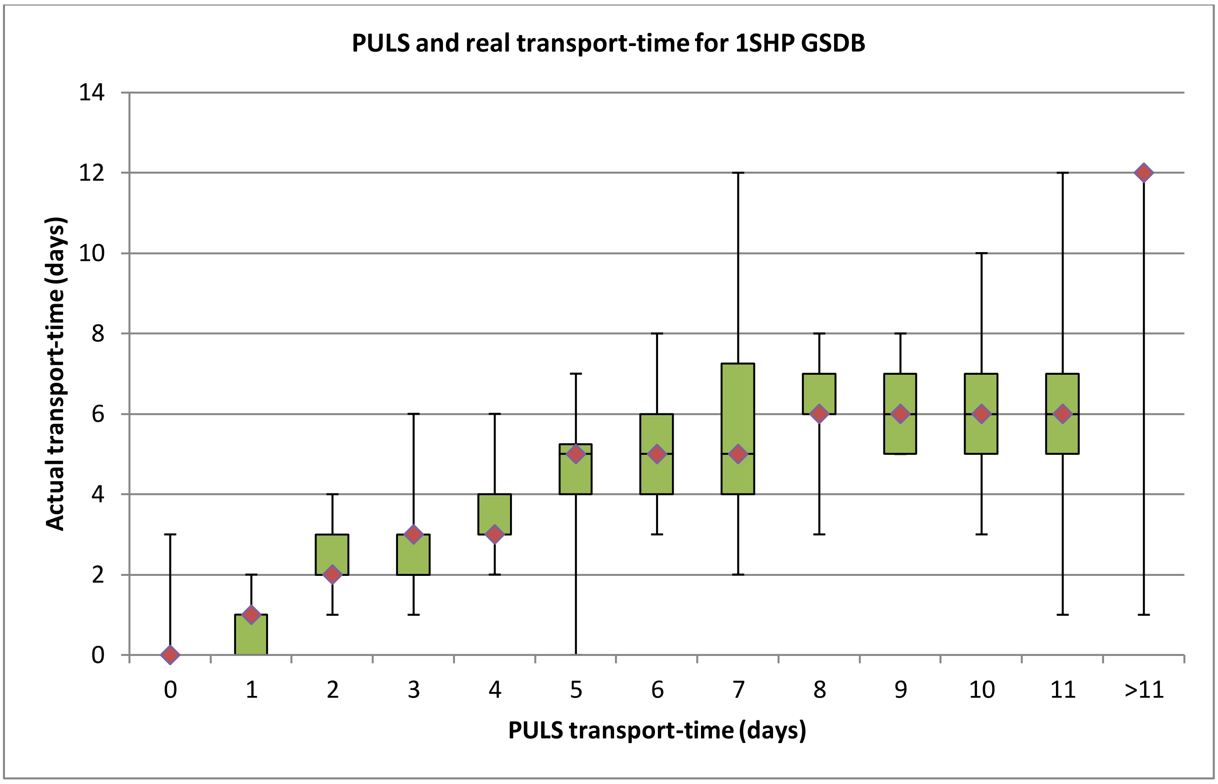


Figure 11. Correspondence between real transport-time and the figure in PULS.

In early 2011, the property shipping-location was entered into the CDC ERP system. This means that even though one supplier have the possibility of having different transport-times entered for each shipping location, it is more likely that the information has been copied from the old MFG location onto all SHP sites. Hence, the procurement responsible are working with an erroneous transport-time.

Figure 11 shows the correspondence between the transport-time entered in PULS (horizontal axis) and the actual transport time (vertical axis). Only those suppliers with one shipping location have been included, hence 15% of the GSDB codes are missing. Interestingly, the relationship is logarithmically shaped, with an upper limit close to six days transport-time. In other words, the procurement responsible is working with inaccurate information on transport-time.

Safety stock and tied capital is not significantly affected by this figure. According to experts at CDC, the safety stock is proportional to total lead time to the power of 0,63. Total lead time in turn equals the sum of supplier production time, transport-time, and incoming delivery time. Production time is normally three to four weeks, transport time is one to four days, and incoming delivery time one to two days. Average weighted transport time difference between the mean transport-time and the figure entered in PULS is 0,8 days.

4.3.4. MFG-SHP Problem

The MFG-SHP problem renders 15% of all GSDB codes transport-time measure unusable, which answers to 20% of the total order volume. Therefore, the carriers that are thought to have the largest impact on the goods reception may not at all be as important as the current measure proclaims. The cause of the problem is illustrated in figure 12. The current transport-time measuring measures the transport-time for each article, and summarizes the report on the MFG GSDB. Hence, for all those suppliers with more than one shipping location, the transport-time probability distribution will be overlaid as illustrated.

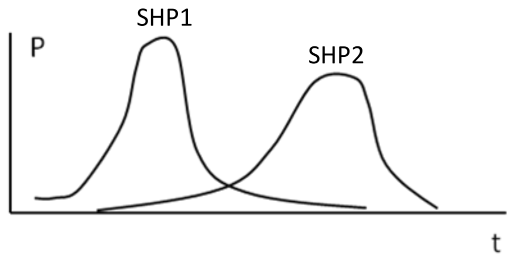


Figure 12. Illustration of the MFG-SHP problem.

4.3.5. Carrier-GSDB Problem

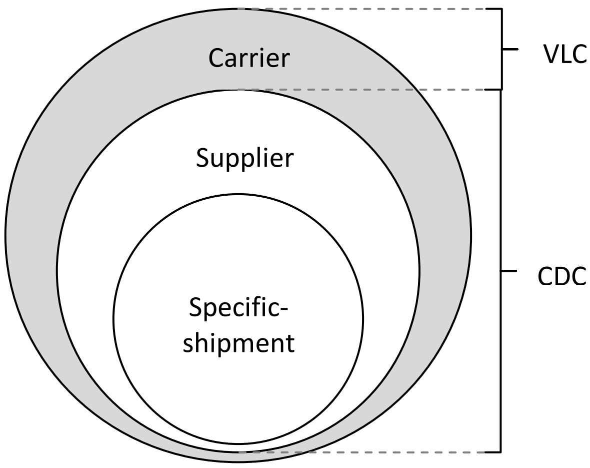


Figure 13. Illustration of the steps between GSDB and Carriers.

CDC measures transport imprecision based on suppliers. However, managing one supplier at the time overlooks the fact that one carrier may pick up goods from several suppliers. A measure that instead summarizes several suppliers based on the existing transport network, also takes e.g. milk-rounds and common transport hubs into account. Therefore, grouping suppliers based which carrier that is responsible for pick-up is the first step in creating the transport KPI. Figure 13 illustrates this concept.

VLC possess data about which carriers that picks up goods for which suppliers. Which carrier that does the pick-up changes on a daily-planning basis. Hence, allocating only one supplier to the transport imprecision of a group of suppliers will without doubt generate erroneous data. However, as long as the fault is measurable and within acceptable limits, the carriers still make a very good starting point for managing the transport network.

Table 3 shows sample data from VLC's ATLAS history. The percentages are based on the amount of transport bookings which the different carriers have picked up during 2011. In order to reduce complexity, the largest percentage in table 3 has been chosen to alone represent all transports allocated for each supplier. Hence, carrier DSV is assigned all transport-time imprecision for supplier D20LA, even though the carrier only answers to 82% of the transport bookings.

Supplier/Carrier	117603	414144	DSV GB	Ewals DE	Schenker CZ
CGCGA					100%
D20LA	18%		82%		
T5BVB		81%		19%	

Table 3. Percent of collies picked up by differnet carriers.

For carriers with only a number and not a name, sufficient name data has not been provided by VLC. The number is then an internal working id in VLC, which can be translated on case-by-case basis. 8% of the suppliers which are active and send shipments are not registered in VLC's transport booking system, and answer for 17% of all order call-offs. Instead of being ranked per carrier, these suppliers will instead be ranked by country. The reason for missing GSDB codes may originate from any of the following possible causes.

(1) CDC's supplier ID does not exist in VLC's database.
(2) The supplier has routine pick-ups and does not book transports through VLC.
(3) The supplier is arranging own transports and does not use VLC.

4.4. Root Cause Analysis on Selected Cases

CDC has over one thousand different suppliers which are geographically spread all over the world, and approximately one hundred different carriers which transport the goods between the supplier sites and Gothenburg. Many suppliers are so called 'low-frequency suppliers', with only a few shipments per month or even a year. Yet other suppliers deliver full truck loads several times in a week. Therefore, as a first step in the analysis, it is important to know which carriers and suppliers to address.

Figure 14 shows carriers where the corresponding suppliers' total volume of orders have arrived on different days. The vertical axis shows the percentage of the total amount of orders which have not arrived on the same day. The delivery precision can be defined as the number of customer orders delivered on the promised delivery time in relation to the total or the delivery precision measure the proportion of placed orders which are delivered at the right agreed time (Mattsson and Jonsson, 2003)(Jonsson and Mattsson, 2005). Hence the delivery precision is mostly calculated as a percentage which shows the amount of orders that are delivered on time (Slack and Lewis, 2002).The data is based on transport time measuring from January to May in 2011. As can be seen from the graph, 39% of the transport imprecision stems from only five of the over 80 carriers which VLC have contracted on behalf of CDC.

The goods reception has archives with truck and collie arrival statistics for CDC. As can be seen in figure 15, Ewals DE, Rhenus DE, Sandahls SE, DSV GB are all among the largest in terms of carried goods. And absolute correspondence with figure 14 is not expected, since it illustrates transport-time imprecision rather than the carriers' good volume. Hence, a comparison between the graphs strengthens the confidence in using call-offs as good method of ranking carriers' transport-time imprecision.

The following sections present and describe case-studies conducted at DSV, Rhenus, and Sandahls. Ewals has not been included since both German carriers are deemed to suffer from the same categories of challenges. Detailed analysis of the cases is detailed, and conclusions are drawn from each of them.

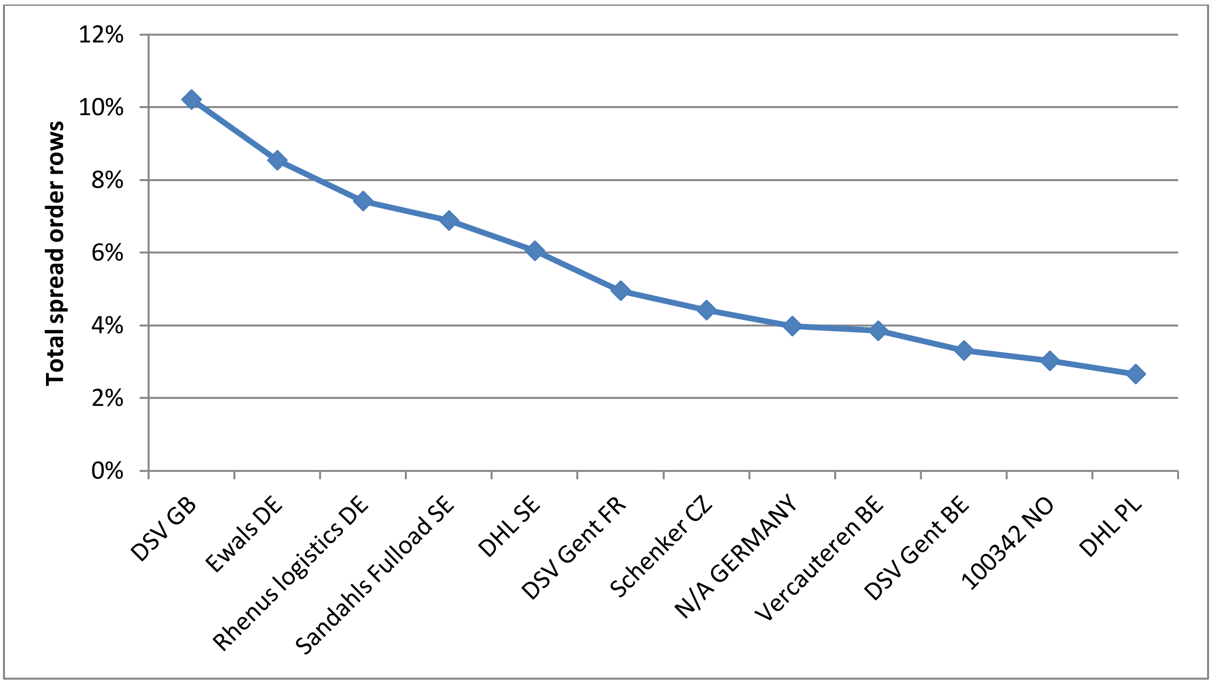


Figure 14. Ranking of carrier's transport-imprecision based on order rows.

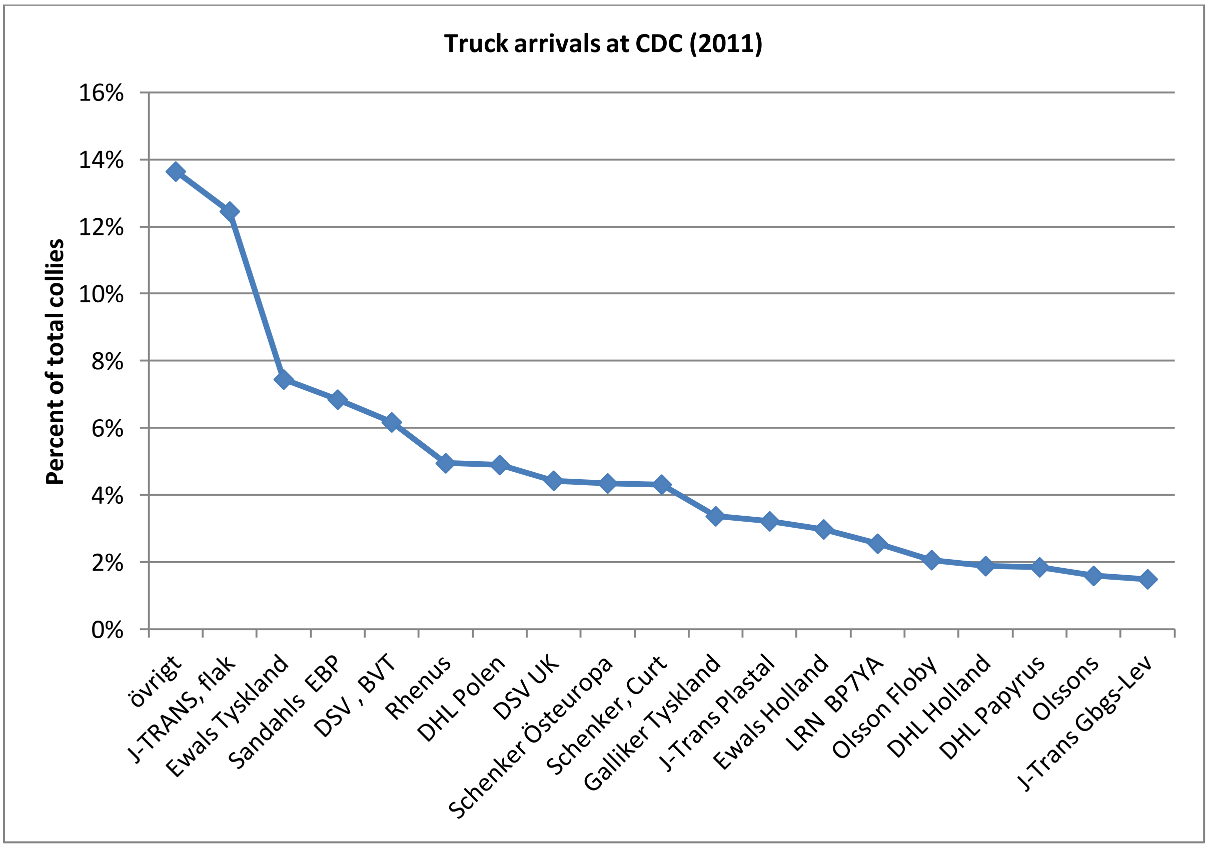


Figure 15. Carrier goods volume according to goods reception's archives.

4.4.1. DSVGB

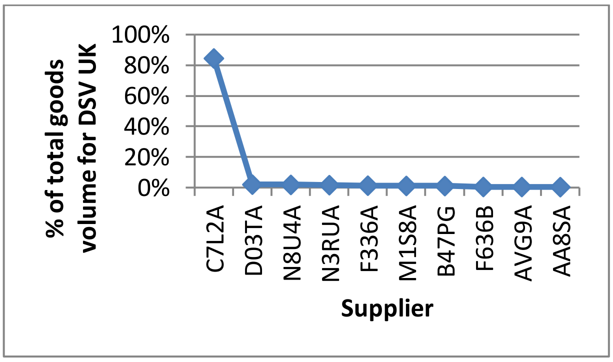


Figure 16. (a) Carrier supplier breakdown, C7L2A is the largest contributor to imprecision.

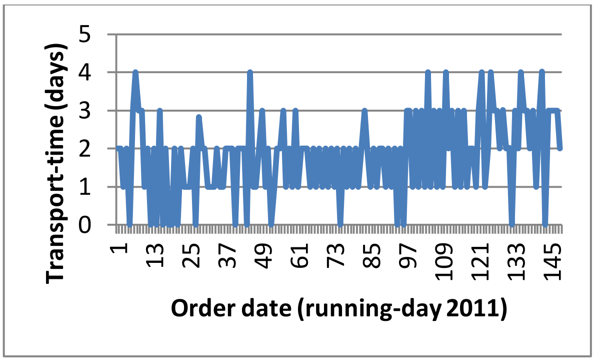


Figure 16. (b) Transport-time data, C7L2A arrival time to CDC.

Figure 16 shows (a) the relative importance of suppliers which are being carried by DSV UK, and (b) the measured transport-time from supplier C7L2A to CDC. As can be seen, the dominant supplier which drives more than 80% of the spread orders from Great Britain is C7L2A, or SMR Automotive Mirrors. According to the old transport-time measuring, the transport-time lies between zero and four days which is obviously not plausible with this spread.

With the new way of presenting data as shown below in table 4, the arrival distribution for goods sent on Wednesday is 13% and then arriving on Friday. Further goods is sent on Wednesday and 69% arrive on Monday in the following week, and 15% on arrive on Tuesday the week after. For goods sent on Friday, 49% arrive on the following Monday and 47% arrive on the following Tuesday. Table 4 summarizes the arrival distribution. Furthermore, it is evident that most goods is sent on Wednesday and only 16% on Friday. It is worth noticing that the only allowed shipment day for SMR is Wednesday, hence the causes for this deviation is interesting to investigate.

According to the responsible procurer, the cause was delivery problems from second tier suppliers which have caused SMR to book extra transports at their own cost. Since early summer 2011 this problem has been resolved however. Interestingly, with this new way of representing data, this type of challenges is uncovered, which was not possible to see with the previous report.

Day sent/ arrived	w0d4	w0d5	w1d1	w1d2	w1d3	w1d4	Sent	%
Wed	1%	**13%**	**69%**	**15%**	1%		7355	80%
Fri			**49%**	**47%**	2%	2%	1433	16%

Table 4. Arrival data for DSV GB and SMR Automotive mirrors.

Except for a small percentage of goods being flown to CDC, almost exclusively all goods from UK is transported with vessel via the port in Immingham, or in rare occasion the port in Tilbury which operates at a much smaller scale. In total in 2011, 0,3% of all goods from all destinations was using flight and transport mode.

Vessels with semi-trailers bound for different destinations in Sweden departs once daily from Immingham, including the weekend. From Tilbury there are two departures weekly. The transport schedule from Immingham is 03:00 Tuesday, 05:00 Wednesday, Thursday, Friday, Sunday, and 11:00 Saturday. The transport time is 27 or 28 hours. Tilbury vessels depart Tuesday 02:00 and Saturday 12:00. The transport time for these vessels is also 28 hours. This data is based in interviews with DSV's personnel in both Gothenburg and Great Britain, as well as VLC's traffic controller who is responsible for the United Kingdom

Sent (Wed)	w0d4	w0d5	w1d1	w1d2	w1d3
2010-01-06			100%		
2010-01-13			100%		
2010-01-20				100%	
2010-01-27				100%	
2010-02-03			100%		
2010-02-10			100%		
2010-02-17				100%	
2010-02-24			100%		
2010-03-03			100%		
2010-03-10			100%		
2010-03-17		100%			
2010-03-24			100%		
2010-03-31				99%	
2010-04-07			100%		
2010-04-21			100%		
2010-04-28			100%		
2010-05-05			100%		
2010-05-12			100%		
2010-05-19			100%		
2010-05-26					100%
2010-06-09			100%		
2010-06-16				100%	
2010-06-23			100%		
2010-06-30	100%				
2010-07-07		100%			
2010-07-14			100%		
2010-07-21			100%		
2010-07-28				100%	
2010-08-04			100%		
2010-08-11				100%	
2010-08-18			100%		
2010-08-25			100%		
2010-09-01			100%		
2010-09-08			100%		
2010-09-15			100%		
2010-09-22			100%		
2010-09-29			100%		
2010-10-06			100%		
2010-10-13			100%		
2010-10-20			100%		
2010-10-27			100%		
2010-11-03			100%		

Sent (Wed)	w0d4	w0d5	w1d1	w1d2	w1d3
2010-11-10			100%		
2010-11-17			100%		
2010-11-24			100%		
2010-12-01			100%		
2010-12-08			100%		
2010-12-15			100%		
2010-12-22				100%	
2011-01-05			100%		
2011-01-12			100%		
2011-01-19			100%		
2011-01-26				100%	
2011-02-02			100%		
2011-02-09			100%		
2011-02-16				100%	
2011-02-23			100%		
2011-03-02			100%		
2011-03-09			100%		
2011-03-16		100%			
2011-03-30			100%		
2011-04-13		98%			2%
2011-04-20				100%	
2011-04-27			100%		
2011-05-04			100%		
2011-05-11			97%		3%
2011-05-18		98%		2%	
2011-05-25			100%		
2011-06-01				100%	
2011-06-08			100%		
2011-06-15			100%		
2011-06-22			100%		
2011-06-29			100%		
2011-07-06				100%	
2011-07-13			100%		
2011-07-20			100%		
2011-07-27			100%		
2011-08-03			100%		
2011-08-10		100%			

Table 5. Arrival day probability distribution for SMR Automotive Mirrors.

Table 5 shows the arrival day distribution for SMR with gods sent on Wednesdays throughout 2010 and 2011. The dates 6-July, 1-July, 20-April, 16-February, 26-January 2011, and 11-August, 28-July, 16-June, 31-March, 17-February, 27-January, 20-January 2010, were all transported between Wednesday and arrived on Tuesday the following week, or with four days transport-time. None of these twelve shipments have carrier reported deviations, which implies that the carrier in Great Britain have encountered no transport related problems. There is no transport time-table implemented for CDC, which implies that the goods are never intentionally held waiting anywhere in the transport chain. Consequently, it is assumed that the shipments have reached Immingham harbor before Friday on the week of shipment.

Local haulers and carriers are employed to carry the goods from the ferry to CDC, and it is rarely DSV which carries its own goods between the harbor and the different Volvo destinations it may be loaded with. The local carriers schedule pick-up of a certain amount of different jobs during a day, for example picking up one Ewals trailer in the harbor, transporting it to PVH, and then picking up a DSV trailer and transporting it to CDC.

The cause why some trucks have arrived on Friday week zero is that full trailers are shipped immediately to the harbor without first being cross-docked in DSV's UK cross-dock. Those shipments going through the cross-dock have to wait for the scheduled departure which is imminent on goods which are going towards Gothenburg. Those times it happens that a full truck is filled by only CDC or Volvo goods the truck is shipped immediately to Immingham and can therefore catch the ferry one day early.

Two key lessons can be learned from this case. First of all, there is no mechanism which stops goods that have arrived early. Shipments are simply transferred as fast as possible through the transport network, and there are no control mechanisms which ensure that goods arrive exactly on the agreed transport-time. Secondly, the transport-systems bottleneck is either in Immingham harbor or in Gothenburg. Rodrigues et. al (2008) explains that delivery delays and low capacity utilization will occur if the transportation is not managed in an integrated and collaborative way. Furthermore lack of information where the truck is can reduce the visibility for the customer which can contribute to late arrivals. Likewise inefficient transport scheduling can damage the effectiveness at hubs or docks due to more unpredictable arrival times.

4.4.2. Rhenus Logistics DE

Rhenus is one of the two major players in Germany, where Ewals takes care of northern Germany and Rhenus is responsible for the south. Two more carriers are picking up goods from the same suppliers as Rhenus are responsible for. These are DSV Ghent, which have handled 1% of the transport bookings in 2011, and DB Schenker rail which answers to 6% of the transport bookings. The remaining 93% is handled by Rhenus.

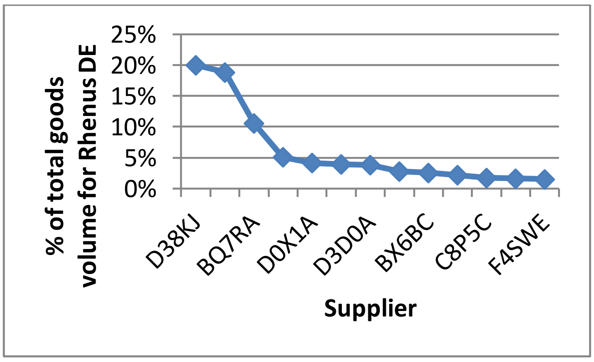


Figure 17. (a) Carrier supplier breakdown, D38KJ is the largest contributor to imprecision.

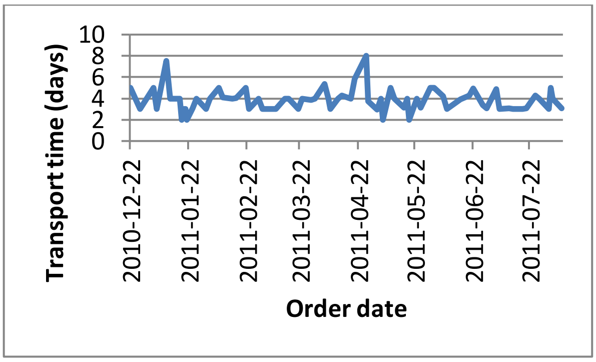


Figure 17. (b) transport-time data, D38KJ arrival time to CDC.

As can be seen in figure 17, the three largest suppliers answer to approximately 50% of the transport variation for Rhenus DE. D38KJ, 'ZF Lenksysteme', has been chosen for case-study analysis, with the aim of finding general conclusions about the southern and northern German transport markets. Furthermore, as can be seen in the figure, the variation in transport-time does not show any specific characteristics except for that of random noise.

The arrival precision probability distribution can be seen in table 6. The supplier has two assigned pick-up days, and for goods sent on Monday, the transport-time distribution is 23% with two days, 46% three days, and 26% with four days transport-time. For goods sent on Wednesday, 52% arrive on Friday and 38% on the following Monday.

Day sent/ arrived	w0d3	w0d4	w0d5	w1d1	w1d2	w1d3	Orders	%
Mon	**23%**	**46%**	**26%**	3%		1%	706	59%
Wed			**52%**	**38%**	8%	2%	496	41%

Table 6. Transport time distribution for Rhenus and supplier D38KJ.

Figure 18 illustrates the different paths goods may take from Southern Germany to Gothenburg and CDC. A telephone interview with Mikael Schmidt from the German Rhenus head office made it possible to draw this map of the German-Swedish transport setup.

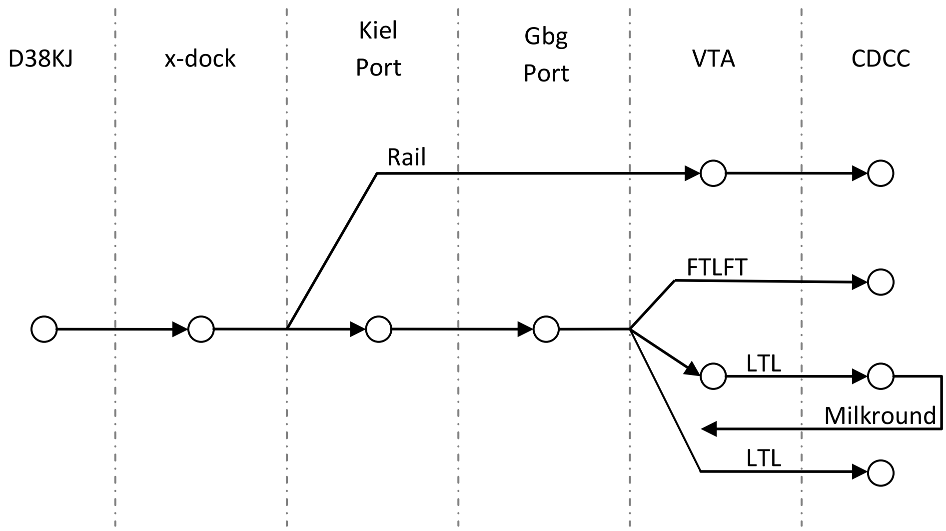


Figure 18. Rhenus transport setup from Germany to CDC.

Supplier pick-up is done between 09 and normal closing time, which is approximately 17:00 or 18:00. After the carrier's milk-round is finished, goods are transported to a cross-dock owned by Rhenus which is located in Schwieberdingen. Here, goods are sorted on destination country and postal code, and checked that the amount of collies correspond to the amount on the freight bill. Arrival time is also reported and documented in Rhenus' database.

After the cross-dock in Schwieberdingen, the shipment is either routed to a rail connection or to the ferry in Kiel. Also in exceptional cases goods are routed to Ghent. Based on monitoring data from Rhenus Germany, as well as an interview with one of the transport planners in the Rhenus Gothenburg, it was possible to understand that full loaded trucks depart from the harbor immediately to CDC, whereas LTL trucks are either routed via VTA or takes part of milk-round drop-offs in Sweden. Rhenus physically carries the goods from Germany to Sweden, where after a Swedish carrier takes over the haulage between the harbor and CDC and other customers. This may be J-trans, which operate in the Gothenburg area, or any other carrier which Rhenus has contracted.

Hence, the two most probable routes from Germany to Sweden are either by ferry through Kiel, or via rail which is administered by DB Schenker. On a daily basis, 36 semi-trailers are transported on rail through Germany all the way to Arendal, where VLC's terminal is located. The ferry arrives at Gothenburg harbor 09:00 in the morning on a daily basis. Unloading time is approximately two to three hours, and the semi-trailer is hence picked up and transported from the harbor between 11:00 and 12:00. Allowed arrival time windows are 07:00 to 09:40, and 13:00 to 16:00.

DB Schenker has very strict security issues, and one-way packages which are not possible to safely and securely fasten on the train are not allowed. Hence, the rail setup is very rarely used for goods bound for CDC, due to the nature of the goods. There are many small but frequent shipments, with goods packed in end-consumer 'one-way' paper boxes. These do not live up to the security standards required by DB Schenker. Trains are loaded between 23 and 02, and depart early morning. Rhenus transports approximately 7-10 trailers on a daily basis, which are planned the day before.

The type of deviations which Rhenus experience can be split in two parts. First, full loads of goods are arriving seemingly randomly between two and five days of transport-time. Secondly, some shipments have been split in parts, and some goods have arrived earlier than the rest. Rodrigues et. al (2008)discuss many causes of uncertainties can be linked to a participant that is responsible for planning, organizing, procuring and managing the transport operation. But it can be reduced through better supply chain control mechanism and also by sharing entire information to other participants. The most significant transport variation stems from variation in full loads arriving on different days, even though it is significantly more common for D38KJ to suffer from split shipments than for C7L2A (DSV GB).

Table 7 shows a few dates with quite typical arrival distribution. Some of these have used rail as transport mode, and some have used road. There is no statistical evidence which proclaims that rail would take longer time than road or vice versa. The arrival day probability distribution is hence the same for both modes.

In addition to the causes of transport-time imprecision which was already reported for DSV UK, split shipments are much more common for Rhenus than for DSV. This can be explained by the usage of different transport modes, as well as cross-docking at the VTA terminal. For example, 4th of April 2011, there was 17% arrived after two days and 83% after four days. This type of difference can be explained with that the Viking rail (Boat to Sweden) used instead of the Road and vessel.

Sent date	w0d3	w0d4	w0d5	w1d1	w1d2
2010-12-22					
2010-12-27		100			
2011-01-03			100		
2011-01-05			100		
2011-01-10				1	
2011-01-12				100	
2011-01-17		100			
2011-01-18	100				
2011-01-19			100		
2011-01-20				100	
2011-01-21				100	
2011-01-24	92	8			
2011-01-26				100	
2011-01-31	87	13			
2011-02-02				100	
2011-02-07			100		
2011-02-09				90	10
2011-02-14		100			
2011-02-16				77	23
2011-02-21			97	3	
2011-02-23			100		
2011-02-28	9	91			
2011-03-02			100		
2011-03-07	100				
2011-03-09			100		
2011-03-14		100			
2011-03-16				100	
2011-03-21	100				
2011-03-23				100	
2011-03-28		100			
2011-03-30				100	
2011-04-04		17		83	
2011-04-06				100	
2011-04-07				100	
2011-04-11		100			
2011-04-13				81	19
2011-04-18		100			
2011-04-20					24
2011-04-27			71	22	7
2011-05-02	71	4			
2011-05-04				100	
2011-05-05			100		
2011-05-09		4	96		
2011-05-11				100	
2011-05-16	89	11			
2011-05-18				100	
2011-05-19			100		
2011-05-23		100			
2011-05-25			96		4
2011-05-30			100		
2011-06-01					100
2011-06-06	2	83	15		
2011-06-08			100		
2011-06-15			1	99	
2011-06-20		99		1	
2011-06-22				6	94
2011-06-27	88	12			
2011-06-29			95		5
2011-07-04		5	95		
2011-07-06			100		
2011-07-11	97	3			
2011-07-13			100		
2011-07-18	100				
2011-07-20			86	14	
2011-07-25		98	2		
2011-07-27				100	
2011-08-01	100				
2011-08-02				100	
2011-08-03				100	
2011-08-08	95	5			

Table 7. Arrival probability distribution for Rhenus DE and D38KJ.

In order to decrease the variations in demand it can be done through better demand forecasting techniques and to improve the visibility of information between the parties (Rodrigues et. al, 2008). For early shipments it is also possible that another Swedish customer have asked for a speed-up request. For example, if goods to PVH and CDC share a truck and the production asks Rhenus to ensure that the goods arrive faster than normal, this phenomenon affect both flows which can be reduced with more information sharing. The production has active time-window steering in the VTA terminal, whereas CDC does not. Hence, as goods arrive in the harbor, the local transportation subsidiaries are expected to transport the trucks as soon as possible to the customer destination. This happens approximately three to four times per day, but for all destinations in Rhenus scope.

Currently, the local carriers which carry goods from the harbor to CDC does not get any information about when the trailer is supposed to arrive at CDC, but only information about how many trucks that will arrive are given. Hence, if a truck is early, it is simply funneled through the network as fast as possible without hold-up.

The most significant cause for of split shipments for Rhenus and not for DSV GB, is that Rhenus transports approximately three times larger truck volume. During 2011, 13% of all DSV's shipments made with more than one truck, and for Rhenus the same measure were 65%. Hence, some of the trucks have been held up at an earlier location, not able to meet the time-window requirement at CDC, whereas some trucks made it on time to the customer destination.

The dates 3-January, 7-February, 21-February, 9-May, 30-may, and 4-July all arrived one day later than agreed upon. None of these dates had carrier reported transport deviations, which means that the problem is either with the rail (6% of all shipments), in the Kiel harbor, or in the Gothenburg area. Since the same type of characteristics appear in both UK and Germany, it is reasonable to argue that the harbor is less likely to be the bottleneck, compared to any transport network node in Gothenburg. PJO'Grady (1990) addresses the primary problems to strive for simplicity and to develop systems that detect problems which can tackle bottlenecks by increasing capacity or to outsource and change bad suppliers.

4.4.3. Sandahls SE

The most significant supplier for Sandahls SE, is 'EBP Olofström AB'. This supplier is solely being transported by Sandahls and there are no competing carriers in the area. Figure 19 shows its arrival distribution and its trend over time. Note that around new-year 2010/2011, a sudden change from one zero days transport-time to one was imposed. Most probably the time-window agreement with CDC and VLC was rearranged at this time, so that Sandahls are allowed to arrive both in the afternoon and also in the morning. The rationale is that the work-load for CDC should be smoothened out over the day, so that not all goods arrive for example in the afternoon.

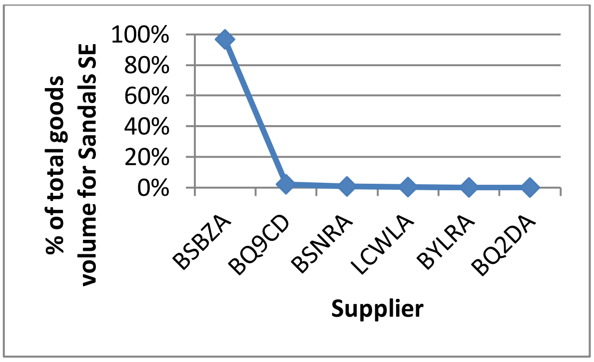


Figure 19. (a) Carrier supplier breakdown, BSBZA is the largest contributor to imprecision

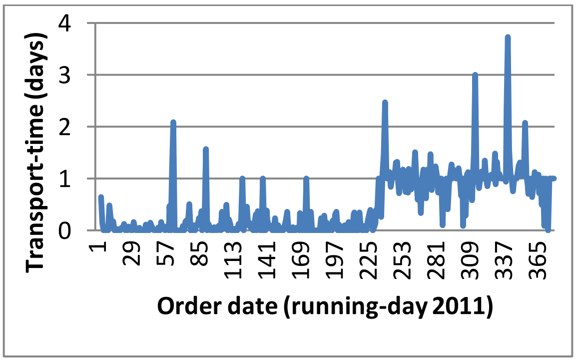


Figure 19. (b) transport-time data, BSBZA arrival time to CDC.

Every morning, EBP calls Sandahls by telephone and books the number of trucks which will be used throughout the day. Usually one to four trucks (or parts of trucks) are booked. The agreed pick-up time varies depending on when goods are ready for departure, but normally the goods are picked up between 12:00 and 18:00. The working hours of EBP however stretches from 06:00 to 22:00.

There is no departure schedule, but trucks depart as soon as the capacity is filled. Currently, it is allowed for Sandahls to arrive at CDC between 06:30 and 08:30 in the morning, and between 15:00 and 20:00 in the afternoon. The transport time between Olofström and Torslanda is approximately four hours.

EBP's production rather often suffers from priority orders; goods that arrive day one and needs to be departed on day two. This gives rise to non-planned capacity that was not ordered during the telephone call to Sandahls in the morning. Hence, the goods do not fit in the arriving truck, which results in the goods standing on the outbound docks until the day after. Rodrigues et. al(2008) state that "insufficient fleet capacity can be a cause of disruption of transport operations, delaying the delivery process to customers". Other uncertainties can be lack of vehicle configuration, lack of drivers, defective vehicles and carrier flexibility or delivery frequency which can contribute to delivery delays.

Day sent/ arrived	w0d1	w0d2	w0d3	w0d4	w0d5	w1d1	w1d2	Orders	%
Mon	18%	**74%**	9%					5429	32%
Tue		10%	**79%**	8%	2%			3131	19%
Wed			13%	**76%**	8%	2%	2%	3486	20%
Thu				15%	**66%**	17%	2%	2769	16%
Fri					2%	**93%**	5%	2135	13%

Table 8. KPI for managing arrival days for Sandahls and EBP Olofström.

In summary, the arrival precision for Sandahls and EBP are shown in table 8. Root cause analysis has revealed the following causes for the transport-time variation.

- Day zero:
  Depending on EBP's availability of goods and Sandahls availability of trucks, cargo may be driven immediately from EBP Olofström to CDC and unload at the afternoon time window.
- Day one (agreed transport-time):
  Trucks do not arrive in time to meet the afternoon time window, and wait overnight to unload their goods in the early time window.
- Day two:
  More goods than expected are produced at the supplier, and do not match the capacity plan which was made in the morning. The goods are finished, marked for transport and transport bills are produced, but the goods cannot fit onto the cars. However, from now on there is a dead-line at 11:00 (set by the person responsible for outbound deliveries from EBP), so that no goods may be marked as transported after this time.

Table 9 shows a few typical transport-time scenarios for Sandahls. The date to the left is the sending date, on which the goods was ready to be shipped, the column labels are the transport-time in days, and the data shows the amount of article call-offs which have arrived on the different days.

Comparing this data with the goods receptions archives, it can be seen that five trucks have arrived on the seventh of April; three at the opening hour, and two at night. This makes sense, since 36 articles was shipped on the sixth which had 172 cubic meters of volume before packaging. The same holds true for the eighth and eleventh (eighth was a Friday and eleventh was the following Monday). No trucks arrived on the eighth, but five trucks came on the eleventh. Two in the morning and three in the afternoon.

Sent date	Day 0	Day 1	Day 2
2011-04-06		36	
2011-04-07	22		1
2011-04-08		14	
2011-04-11	62	24	

Table 9. Typical scenarios for Sandahls SE and the supplier EPB Olofström AB.

A business should have an agreement or contract if the business is of great importance and it is vital to spend more time and money in order to get a good contract. A contract may contain parts as which the parties are, their rights and responsibility during the contract, termination agreements, penalties for break of contract and so on. Even if the contract cannot treat everything, the key conditions between the parties should be contracted (Molin, 2002). The key lessons to be learned from this case is that the transport precision here seems to be rather bad, but in fact this is exactly what has been agreed upon through managing allowed arrival time or time-windows. Furthermore, VLC argues that this inconsistency in transport-time is impossible; which further strengthens the conclusion that VLC does not actively monitor and control transport-time for shipments bound for CDC. Indeed, only transport-related deviations from the plan are reported. Sandahls does not view this way of handling of goods as a transport deviation, and thus VLC does not know about it. Neither does VLC measure the transport-time between EBP and CDC. Slack and Lewis (2002) talks about that only to measure internally can´t tell that other participants have the same picture of the performance. Hence the customer can require things from the supplier that they don't know. Parties that are not on the same opinion lead to misunderstanding due to strategic decisions are taken wrong. A supplier can for instance focus on a certain performance that is irrelevant for the customer or that the supplier thinks it perform better then they actually do.

4.4.4. Carriers in the Gothenburg Area

Drawing upon the conclusions in the British DSV and German Rhenus cases, the transport network's bottleneck has been pinpointed to Gothenburg. In order to confirm this, a survey was given to all chauffeurs coming to CDC, with the purpose of finding what the most frequent reason for transport deviation is.

Hypothetically, local carriers collect several semi-trailers in the harbor every day. As soon as one 'job' is completed the chauffeur is given the next assignment, which may be to collect yet another semi-trailer from the harbor and transport it to any customer location in Sweden or Gothenburg. The survey therefore aimed to confirm this, and if that is the case, measure how often the time during a day is not enough to complete all assigned transportation assignments. The result would then be that a semi-trailer would wait until the day after, exactly like the Rhenus and DSV cases are suggesting.

The result of the survey is illustrated in table 10, exactly as chauffeurs filled in the fields. Only those semi-trailers which were picked up in the harbor, or from the VTA rail has been included. Hence, flows from irrelevant destinations, e.g. Swedish, Norwegian, and other have not been included in the research. Fugate et. al, (2009) says that companies are dependent on other organizations resources as for instance in the supply chain management there are third-party providers (transportation organizations) that are the link between parties. But even if parties try to keep collaboration the success still depend on to get right amount of goods, right condition, at right place and at right time. The reliability of transportation becomes very important there the participants need to decide what and how much resources should be used in order to make it good for both parties. The shippers and the carriers need to put resources to improve the operational activities and processes at the dock exchange there strategic collaboration is important in order to achieve the goals.

One important thing that prevents the driver from being on road is "waiting to unload and load material at the dock is one of the most time consuming" (Fugate et. al, 2009).Two lessons can be learned from this survey; first of all, there seems to be time-delay problems for some Volvo destinations in Gothenburg. Secondly, it is not possible to conclude at which transport network node that problems occur. However, from interviews with the route planning responsible at J-trans and one of the operational group-leaders at VTA, there are indications that VTA is having problems with delays. According to J-trans, even though a truck does arrive on the assigned time, waiting times may vary between two to six hours before the goods is loaded or unloaded; instead of being attended immediately and ready within 90 minutes as planned. Fugate et. al, (2009) says that the "the operational collaborative focus should be on dedicating resources and implementing processes to make the shipping and receiving dock exchange more efficient and to reduce the amount of time a driver waits at the dock door". The dock exchange needs to be more efficient and effective to reduce the waiting time which the carriers are dependent on. Finally "the longer a truck waits at a dock door or in the facility yard to unload or to load, the greater the opportunity for stock outs and reduced customer satisfaction".

Carrier	Semi-trailer carrier	Number of transports per day, and how often is the time not enough to finish all these jobs?	Which are the most common causes, if the time during a day is not enough for completing all transport jobs?
Wackfelt	Import, picked up at VTA	2-10, I am assigned one trailer at the time	
Wackfelt	Ewals, Belgium	3-4, Rarely	
J-trans	Rhenus	5-6, 2-3 times per week	Queues at Volvo.
J-trans	DSV GB	5-7, nevver	?
Wackfelt	Ewals	Approx 7,2-3 times per week	Waiting time at Volvo
J-trans	Rhenus	5-6, several times per week	Waiting time at (un)loading locations
J-trans	DSV Belgium	1-10, seldom	"Should" work in one day
Wackfelt	Rail, Rhenus	1-10	
GA-åkeri	Schenker	6-7, time us usually enough	Queues

J-trans	DSV	5-6, rarely	Queues in traffic, papers missing, technical trailer problems
Wackfelt	DFOS	3-8	

Table 10. Survey results: are the transport bottleneck in Sweden? And if so, where is it?

4.5. Factors Contributing to Transport-Time Deviation

Two different transport-time deviation types exist. On the one hand shipments may be split, for example if goods are left at a cross-dock in the transport network. On the other hand, all the goods may be early or late, for example if it was left at the supplier's dock or was delayed at a pick-up or drop-off point. According to case-study data, the second type has the most significant impact on the goods reception and is hence the most interesting type for this study.

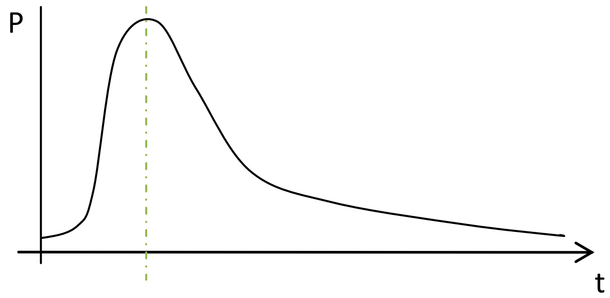


Figure 20. For each shipment, the transport-time probability distribution is beta shaped.

The delivery accuracy is dependent by the time delivery settings and how well it is kept with the operational control system. Due to wrong time settings many deliveries can be delayed, rather than disturbance or insufficient planning (Mattsson and Jonsson, 2003).The agreed transport-time is fixed to a certain constant, where after the transport-time's probability distribution is beta shaped. For a carrier in for example southern Germany, a shipment can as earliest arrive on the same day, which only occur in exceptional cases such as rush orders. There is also the agreed time, which may be the most probable, but goods can also arrive late for different reasons. The delay can be only one day, two days, or the goods may even be lost forever with decreasing probability. Figure 20 illustrates this concept with a graph over transport-time on the horizontal axis and arrival probability on the vertical.

First of all, it is worth noticing that there is a problem with early and late arrivals at all. Hence, the first conclusion is that there are insufficient quality control routines at VLC. Even though this is not sufficient as the only root cause, it is worth mentioning and keeping in mind while negotiating terms about new contractual agreements with VLC. Molin (2002) state that a business should have an agreement or contract and if the business is of great importance it is vital to spend more time and money to create a good agreement. A contract may contain parts as their rights and responsibility, penalties for break of contract etc. It cannot treat everything but it should focus on the key conditions that will apply within the participants.

CDC's agreement with VLC states that transports need to be as inexpensive as possible. Therefore, in contrast to PVH, shipments are not cross-docked at VTA before arrival and VLC is not keeping a transport time-table for CDC. Instead, VLC relies on customer KPIs and carrier deviation reports for measuring transport performance. Furthermore, for suppliers which are part of milk-rounds with varying order quantities, a truck may sometimes become full with goods bound for Gothenburg and sometimes not. Full truck loads are shipped immediately to the harbor and thus have the chance to catch an early vessel. Sometimes however, when the goods need to be cross-docked, the goods wait for the next scheduled departure and are shipped with the vessel the day after. Mason et. al, (2007) mean that companies focus on transactions rather than partnership which can be a fail factor in integrated transport management. It is concluded that "a collaborative supply chain simply mean that two or more independent companies work jointly to plan to execute supply chain operations with greater success than when acting in isolation".

Case studies from DSV UK and Rhenus Germany suggests that the transport network's bottleneck is in Sweden. From seven dates with delayed delivery from UK, and six delayed shipments from Rhenus, there were no deviation reports from any of the carriers. Hence, the bottleneck is either in both harbors, or in Gothenburg.

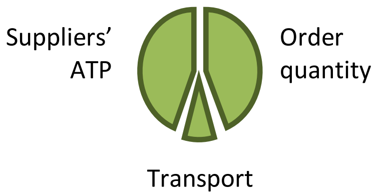
Furthermore, it is worth mentioning that deviation reports from both Germany and Poland reveal that if pick-up day was not respected, there is enough buffer time built into the transport-time so the carrier have always arrived on time anyway.

Split shipments arise when all goods was not picked up at the suppliers dock, when goods was left at a terminal, or when some goods were sent immediately and some had to wait one day extra. The last phenomenon occurs when there are several trucks arriving to Gothenburg, and some of them are unloaded at CDC the same day, but the other are held up at earlier locations. Interviews with J-trans' traffic manager, who is active in the Gothenburg region, as well as an operations responsible at the VTA terminal, points towards that VTA is the largest contributor to one day extra transport-time. This is however not confirmed with any rigorous statistical data. Fugate et. al, (2009) explain that the strategic relationships affect the operational decisions as for instance companies focus on the operational activities between shippers and carriers that result from the strategic management decisions to collaborate and decide. Furthermore the failure of collaboration comes from top management support, improbable expectations, authority imbalances and lack of shared aims.

For suppliers with varying goods volume, the amount of goods can vary between only a few pallets to several full trucks, and everything in between. For example, one supplier may send one and a half truck which both arrives at the same time in Gothenburg. Then one will be collected in the harbor and driven immediately to CDC, whereas the other will be either delivered by milk-round, or sent to VTA for cross-docking depending on the weight agreement between VLC and the specific carrier. In the German case, the vessel arrives in Gothenburg at 09, where after it takes approximately two to three hours to unload, and then transportation to VTA. Consequently, for such goods from Germany, the LTL flow will miss the last scheduled departure and not make it in the same day to CDC. The other truck which is picked up full however, is much more likely to arrive at CDC on the same day.

5. Results

This section presents the results of this project; the reasons for the measured transport-time variation and shortcomings in the current transport-time measure. Issues with the measure are presented, root causes for transport-time deviation are discussed, and a process with which to demand higher customer service from VLC is outlined.



Transport does not have the largest impact on the inbound goods volume variation; 18 trucks arriving on the same hour cannot be caused by transport-time imprecision alone. However, transports are a preferred variable for managerial reasons.

Figure 21. Transports are a minor contributor to variation in inbound truck volume but are easily managed.

Variation in transport-time cannot alone cause the variation in the number of inbound trucks which arrive at the CDC goods reception. Since the significant part of transport-time deviation varies between plus or minus one day, it is unreasonable to argue that the measured variation of plus or minus five trucks from the median, is caused only by transport-time imprecision. Figure 21 gives an illustration of the context within which this thesis project was conducted.

However, for reasons stated in the introductory section, transport-time was chosen for study in this thesis. The result is that the current transport-time measuring is unreliable, and it is not correct that only 45% of all shipments arrive on the correct day. This is due to the MFG-SHP problem, the Article-SHP problem which were described in the analysis, and due to the nature of the measure itself. The measure and its reliability is covered in more detail in section 5.1.

Furthermore, main area of practical applicability are using the measure to level the inbound goods flow to CDC's goods reception. Two tracks were found for this. First, the transport-time data can be used to rank and select those suppliers with the most work-load impact on the goods reception, and then perform root cause analysis on these with the purpose of reducing transport-time variation. Second, the data can be used to balance suppliers' outbound shipping days. VCC may decide upon which days in the week which articles are allowed to send, and thus balance the work-load over the day at CDC. Further details are covered in section 5.2.

5.1. Measuring of Transport-Time

Due to the manual nature of the transport-time measuring, a calibration measure revealed that the maximum obtainable transport-time precision is approximately 93%. Furthermore, since the measuring measures transport-time and takes weekends into account, VLC only obtains a high rank if no work is performed on weekends. Thus, if goods have been placed in a harbor on e.g. a Friday, and it was shipped over the weekend, CDC will register an early arrival. Thus, the authors conclude that measuring arrival-day performance is a better way of using the data than measuring transport-time.

5.2. Areas of Practical Applicability

Three main usage areas have been identified for the transport-time data. First of all, CDC can find trends in their orders over time and thus on a systematic basis find suppliers which benefit from using a FTL flow or should go back to LTL. Secondly, suppliers agreed shipping days may be managed and the outbound goods flow balanced over the weekdays. Third, the data can be used to rank carriers and initiate root-cause analysis projects on those suppliers and carriers with the largest impact on CDC's goods reception.

5.2.1. Trends in Order-Volume Over Time

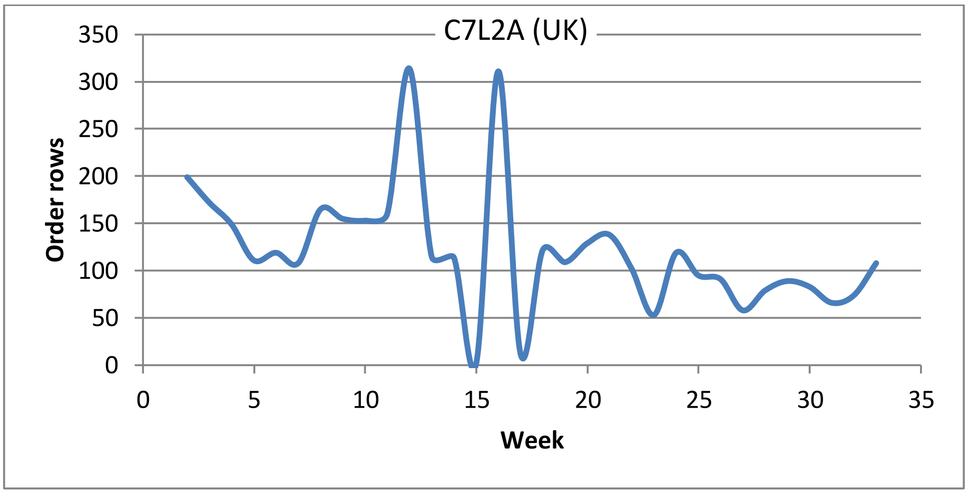


Figure22. Order trend the 35 first weeks of 2011.

Figure 22 shows an example of how data can be used to distinguish seasonal trends, and investigate whether managerial actions should be taken for a supplier or not. In this case for example, it is likely that the goods reception has complained about heavy workload in weeks 12 and 16. With this graph, it is obvious that those occurrences are instantaneous, and an appropriate action is investigating why the demand fluctuates, rather than immediately change shipping days which is the current well-established tool which CDC uses.

5.2.2. Goods Balance Over Week Days

With the help of the analysis this thesis has generated, it is possible to see on which weekdays goods have been sent. For example, one supplier has agreed shipping days on Monday, Wednesday, and Friday. With the help of shipping data, managers may decide which articles should be changed from one day to another; with the purpose of leveling the amount of inbound goods per day.

Figures 23 and 24 exemplify how this can be used. It is clear that approximately 50% of all goods is shipped on Mondays, and the rest on Wednesdays and Thursdays. This is according to agreement so no responsibility can be given to the supplier in order to leveling the flow. Instead, this helps CDC managers to see which articles to move from one day to another. For example, four articles are the single most significant articles (marked as red), followed by seven medium-large (marked as blue). A first step CDC managers thus may take is to allow the 'red' articles also to be shipped on Tuesdays, but keep the rest of the articles as they are.

In conclusion, it is also important to note that almost all articles from this specific supplier have similar in physical dimensions. Thus, it is easy to define 'importance' as volume times number of sent items. For suppliers with widely varying weight and volume characteristics in their articles, more sophisticated methods may have to be used to distinguish which are the 'red' articles

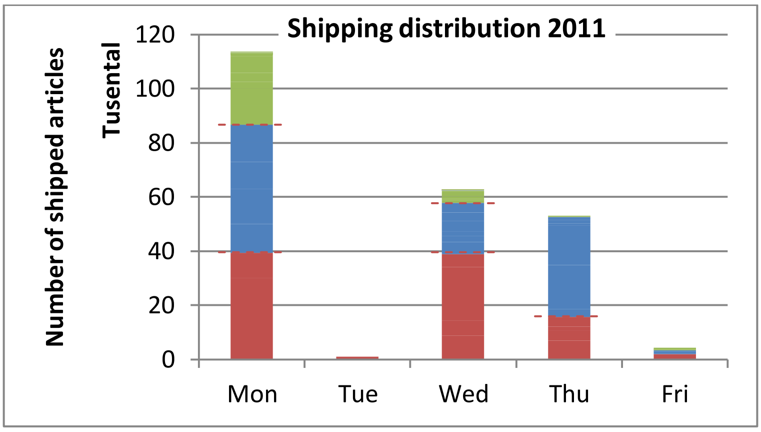


Figure23. Distribution of shipped articles over the weekdays.

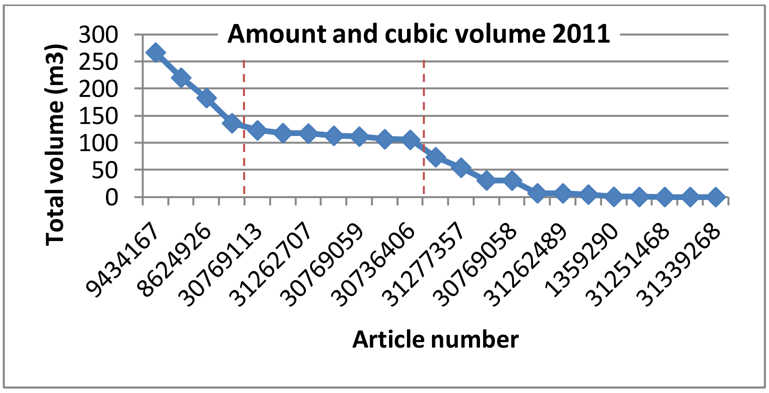


Figure24. Articles with the largest number shipped times volume (m3) during 2011.

5.2.3. Demanding Higher Customer Service From VLC

Finally, the data can be used to perform root cause analysis on specific goods flows and thus pressure VLC to provide higher customer service. The analysis section describes the details of how this is carried out in practice. Volvo Cars need generally to put higher request on their transport provider VLC. It can for example be that the suppliers should report fast to Volvo Cars if a supply will be late. In order to control if the supplies will come in time, Volvo Cars has wont the suppliers to be called up, but this in other hand it is not sure that Volvo Logistics will fulfill the deliver. White (1996) concludes that measured data should get compared with a reference in order to strength that it is reliable. Hence it can be compared within the company where the new data get compared with the historically data. Another thing is that the competition is increasing so the company can also do a benchmarking and compare the data with competitors in order to stay more competitive.

6. Conclusion and Discussion

This section outlines the added knowledge in the practice of measuring transport-time, and how data which makes such measure possible can be applied in ways which not only monitor logistics providers but also control the amount of shipped goods during the different days of the week.

The existing possibility of evaluating supplier importance with regards to the goods reception, is based on the number of call-offs. This is a rather blunt measure, since the number of call-offs does not account for the order volume. Hence, a call-off for e.g. 100 tires is equal to an order of e.g. 100 dipsticks. Furthermore, there is neither any differentiation between 100 tires and 1 tire. Both are counted as one order-row or call-off.

The MFG-SHP- and Article-SHP problem make that the measuring is unreliable which can be updated but the authors mean that it is not needed if CDC will measure arrival-day performance instead of measure transport-time. Other more appropriate actions is to investigate why the demand fluctuates much at some moments which contribute to heavy workload at the goods reception. Moreover, CDC can with help of shipping data see how it affects the workload over the weekdays which can be leveled out by changing the shipping days.

Both VLC´s and CDC´s systems don´t account for national holidays and weekends but VLC is working on the weekends which make the measure diffuse and wrong. So since the transport-time doesn't count this and in order to gain higher measure VLC must not work on weekends but if CDC start measure arrival day performance it will not have any matter. The VTA terminal is the largest contributor to one day extra transport-time which means as Fugate et. al, (2009) highlights that the dock exchange need to be more efficient and effective or to plan better in order to reduce the amount of time trucks waits at the dock door.

From the supplier's side, it often happens that the outbound goods personnel print the transport documentation one day early there one day of transport-time will be added to the measuring which is not reality or that transport documentation is missing. There need to be some agreement between the parties which Skoog and Widlund (2001) say that both parties in a negotiation need to have a contract that is clear and understanding what and how things should be done.

A more accurate measure of supplier importance is the number of shipped collies. However, it must be kept in mind that this is not perfect either. How the goods are loaded and the collie weight are two other important factors which contribute to working time. For example, if there are 10 different suppliers on the same truck, with three of those missing transportation papers, extra time spend on administration and creating acceptable work-around solutions results. Furthermore, if the goods are heavy, there might be restrictions on how many collies a fork-lift can carry, which may have negative impact on the goods reception's efficiency.

The reliability of case-study research may also be questioned. The causes for transport-time deviation and the transport-network's bottleneck are found with a rather small amount of data support. However, the tools for following up transport-time deviation enable very specific inquiry and ability to follow up the causes for arrival day deviation for specific transports. Hence, all reasoning is based on indications from past data, rather than the ever so popular feelings and emotions of traffic managers and operators. Thus, the method is as solid as the underlying data. And the conclusions are therefore as reliable to initiate and steer a discussion with the logistics provider, but not reliable enough to use as a benchmark or explicitly demand higher customer service from VLC. VLC does not actively monitor and control transport-time for shipments bound for CDC. Hence CDC haven´t any specific transport agreements which make it hard to demand higher performance from VLC which means that they need to change the contractual agreements and put higher request on their transport provider VLC with help of their own transport measure.

Ideally, all ordered shipments should arrive exactly on the agreed transport-time. Jonsson and Mattsson (2005) say that freight should not be delivered too late or too early. At CDC, this is managed through the measure of transport-time, which reveals whether or not there is potential transport-time variation for specific carriers on specific routes. According to White (1996) the performance measures can be designed in several ways depending on what the company wants to measure. However, during this thesis project it was found that measuring arrival-day is a better performance indicator than measuring transport-time. Neither CDC nor its logistics provider is open on weekends, and goods can therefore not be received on weekends, hence the transport-time measure rightfully only counts working days as days on which goods are transported.

However, in CDC's case the transport network is rather large and several nodes in the network actually do perform transport work on weekends. One such example is harbors, which ship goods during all days in the week. Consider an example of a supplier with allowed shipping days on Thursday and Friday, and with an agreed transport-time of three days. Not counting the weekend, goods should therefore arrive on Tuesday and Wednesday the following week respectively. However, since vessels depart all days in the week, it is likely that all goods from this supplier always arrive on Monday. All goods arrive on one single day which is manageable and very good; but the transport-time measure registers one and two days transport time respectively. What appears to be a situation which needs managerial action appears to be a flaw in the nature of the measure itself. Fugate et. al, (2009) don´t understand how one collaborative relationship which is built on a strategic level with conclusions about allocation, sharing and management of resources are later facilitated on an operational level. Moreover the failure of collaboration comes from top management support, improbable expectations, authority imbalances and lack of shared aims. The strategic relationships affect the operational decisions and allocation of recourses in order to improve performance e.g. where companies focus on the operational activities between shippers and carriers that result from the strategic management decisions.

Furthermore, manual administration of the measure, which in CDC's case is based on transport manifests also give rise to human errors and mistakes. Stefansson and Lumsden (2009) say that there is information management which includes paperless and automated proof of delivery (POD) confirmations, and proof of collection (POC) control. Possibly, the measure of transport-time measures the time between POC and POD. Without an automated system, it is possible that such system is highly manual and therefore subject to human errors as administration mistakes and lost papers. By looking at suppliers in the immediate vicinity of CDC, where the road transport itself is deemed to have no significant effect on the transport-time, it was found that 93% of all shipments arrive on the agreed day. Thus, it may be concluded that the highest obtainable precision in a measure with high level of manual input is only correct in nine cases out of ten.

Additionally, two types of transport-time variation were found. Either, the entire shipment arrives on random days or a shipment may be split and arrive partly on one day and partly on another. Contrary to popular belief, it was found that split shipments does not mainly appear when goods is left at a terminal due to capacity restrictions. Rather, when several trucks are sent from the same supplier, a few will be shipped day one, whereas the rest will be shipped another day. Thus, trailers are waiting in the harbor for pick-up by local haulers, which do not have the capacity to handle all the trucks on the same day. In this case, it was therefore concluded that the main source of transport-time variation is Gothenburg-based haulers capacity restrictors and thus inability to forward all goods which has been agreed with VLC. According to Rodrigues et. al (2008), outsourcing can contribute to increasingly complexity of supply networks and impact on factors as for instance information visibility and communication between parties. The authors state that "insufficient fleet capacity can be a cause of disruption of transport operations, delaying the delivery process to customers". Other uncertainties can be lack of vehicle configuration, lack of drivers, defective vehicles and carrier flexibility or delivery frequency. Hence if the transportation is not managed in an integrated and collaborative way it can contribute to delivery delays and low capacity utilization.

When collecting goods with milk rounds it increase the degree of filling it may require greater safety margins in order to keep delivery precision, since there are more loading and unloading. Lumsden (2006) explain that is doesn't need to be rapid or short deliveries but the deliveries should be made at a predetermined time or within a time window. Furthermore, there are goods that are more sensitive than others which should be transported with direct shipments and with high fill rate, which can lead to longer delivery times.

Finally, it was also concluded that logs of transport manifests can be used for much more than only measuring variation in transport-time. With knowledge about which weekday goods were shipped, statistics over which articles and how much goods are shipped on each day can be monitored. This way, it is possible for managers to level the amount of outbound goods from suppliers over the different days in the week.

7. Recommendations

It is recommended to first address the MFG-SHP and arrival-day issues. Then, a benchmarking procedure and uncovering of root-causes in the transport network will pressure VLC to deliver higher customer service. Last, it is recommended to solve the Collie-GSDB problem, which allows CDC to reach excellence in inbound logistics monitoring and control. Left unattended is the Article-SHP problem and Carrier-GSDB problem, which are deemed too be of inferior concern to the inbound logistics performance.

Following the results of this thesis, it is recommended to implement the action plan stated below. CDC will then gain the ability to monitor and control transport-related issues in the inbound goods flow, in contrast to only monitoring some of the challenges as is the case today.

1. Short-term: Develop a systemic approach to measuring arrival day performance for all suppliers, in contrast to measuring arrival day on case-by-case basis.
   a) Then CDC will know how many orders that were sent on each week-day, and hence gain the ability to monitor if the agreed pick-up days are respected. Furthermore, it will be possible to balance the goods flow on the different shipping days.
   b) Monitoring arrival day rather than transport-time circumvents the problem with low transport-performance if carriers work on weekends, and gives an almost 100% accurate arrival probability distribution for each supplier.
2. Long-term: Discuss and implement possible solutions with VLC for the transport-related issues this thesis has revealed. Reformulate transport agreements to take arrival day rather than transport-time into consideration.
3. Desirable: Optimize the goods reception manning-level through adding the amount of collies to the suppliers' EDI pre-advice shipment; which is the same data as VLC already receives.

Initially, in short term, it is recommended to develop a systemic approach to measuring arrival day performance rather than transport-time performance. The rationale is that arrival day gives an almost 100% accurate measure of VLC's transport performance, and it is thus possible to accurately demand higher customer service. Furthermore, CDC gains the possibility to monitor and control whether the agreed pick-up day is respected, how well balanced the pickup days are in terms of goods volume, and how much goods that have arrived from each supplier at each day of the week. Also, with the transport-time KPI in use today, it is not possible to measure VLC's total transport performance. Thus it is not possible to demand higher customer service based on this KPI.

It is recommended to discontinue the current transport-time measure and instead invest efforts in the DIG-IT system. Hence, these efforts will solve the Arrival-day problem, and in the same time circumvent the MFG-SHP problem by gathering data from the 5107 image in PULS and summarize the report sheet on SHP. However, the Collie-GSDB problem is not resolved, and order call-offs is still the best way of ranking suppliers' and carriers' in terms of the work-load imposed on the goods reception.

Secondly as a longer term project, with a reliable transport-performance KPI, a discussion with VLC about how to solve root causes to the transport issues can be initiated. Also, reformulating the agreements with emphasis on arrival day rather than the vague transport-time is also made possible.

At the moment of writing, this is only possible on a case-by-case basis. However, the only possibility of ranking which suppliers and carriers to address first is order call-offs. Hence, efforts which aim at having the largest possible impact on the goods receptions work-load are estimated through order-lines rather than the amount of collies. Thus, efforts may appear to have less impact than expected, since the currently existing ranking tool is an insufficient description of reality.

Third and desirable, even though not necessarily feasible at CDC Gothenburg, it is recommended that suppliers communicate the amount of transported collies upon POC. The result is an almost perfect match between the amount of collies and supplier, which makes it possible to manage suppliers upon request of the goods reception. Furthermore, by using information about collies rather than order-call offs in the arrival-day KPI, it is possible to use the KPI for operational follow up and immediate cause analysis for immense truck arrival at the CDC goods reception.

Currently, the only way of estimating the amount of inbound goods, which affect both the goods reception as well as the rest of the warehouse, are the amount of order call-offs, order volume, and order monetary value. These measures give a somewhat accurate estimate for capacity planning, but it is not sufficient to plan for fluctuating optimal personnel level. In order to optimize personnel utilization, it is necessary to know how many collies which are outbound from each supplier. The planning horizon is illustrated in figure 25. 14% of all orders arrive on day zero, 78% between one and four days, and 8% on five days or more. Hence, it is possible to plan approximately 86% of the amount of inbound collies at least one day in advance, and 8% with one week pre-notice. It is recommended to create a forecasting model for the goods reception's optimal manning needs, since asking for perfectly leveled ordering as well as top-class supplier delivery capacity is simply not feasible.

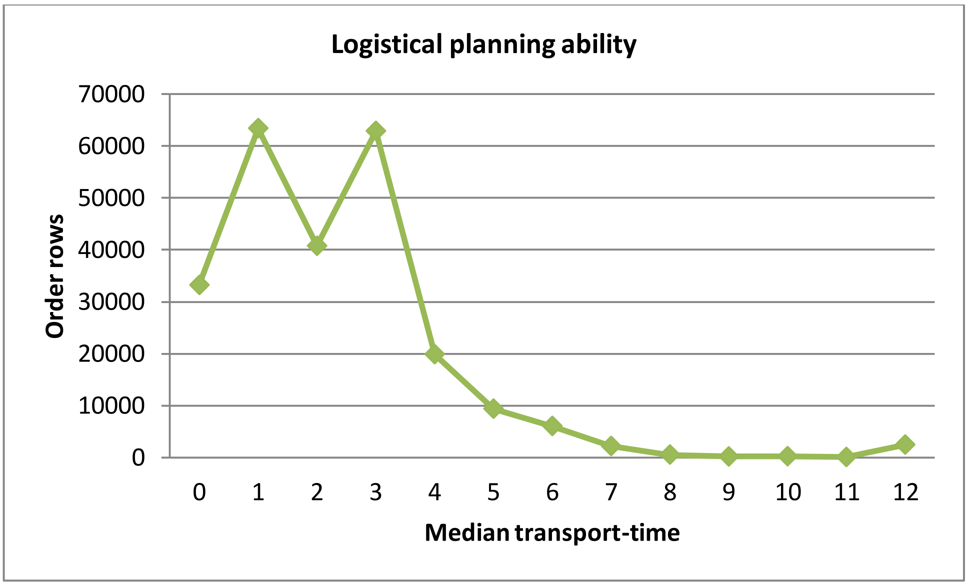


Figure 25. Transport-time distribution after goods pick-up.

Two possibilities of implementing the supplier collie reporting is either to join the VLC initiative and obtain live data from ATLAS, or to regulate suppliers so the amount of collies are part of the EDI file which is sent to CDC upon shipment pre-advice. VLC is currently expanding the ATLAS booking platform, so that the amount of collies, and weight and volume will be entered by carriers upon goods collection. Joining this initiative will then not account for ATLAS' missing GSDB codes, and it will also make CDC even more dependent on VLC. Alternatively, if the supplier registers the amount of collies as part of the transport-documentation routine, the data will be sent immediately to CDC. The freight bills are already filled in with the amount of collies, so the collie-counting routine already exist, but the challenge is implementing this figure in CDC's IT system.

Remaining challenges are the Article-SHP problem and the Carrier-GSDB problem. Resolving the Article-SHP problem gives procurement responsible a better overview on how long the actual transport time is. The effect on safety stock however is marginal. The Carrier-GSDB problem also does not matter much in the context. For those suppliers who are missing in the ATLAS booking data will be grouped on country instead of carrier.

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A. Case-Study Data Preparation

This section describes how the thesis outcomes can be used in future case-studies and how to demand higher customer service from VLC. In essence, this section specifies how to extract so detailed information from the existing transport manifests so that there is no doubt but that the responsibility for change is indeed on VLC and not CDC or any of its suppliers.

First, one must evaluate which carriers that generate the most unforeseen work for the goods reception. Since transport-problems are solved on a case-by-case basis, it is important to approach the cases which have the most relevance to CDC. With all shortcomings from the previous section in mind, figure A1 gives a rough estimate of which carriers that have the most significant impact on the CDC goods reception. The horizontal axis shows the carriers, which have been extracted from VLC's transport booking data. The vertical axis shows the percentage of total volume of orders which have not arrived on the same day. Hence, the graph shows a ranked list of which carriers which generate the most volume variation in incoming orders to the goods reception.

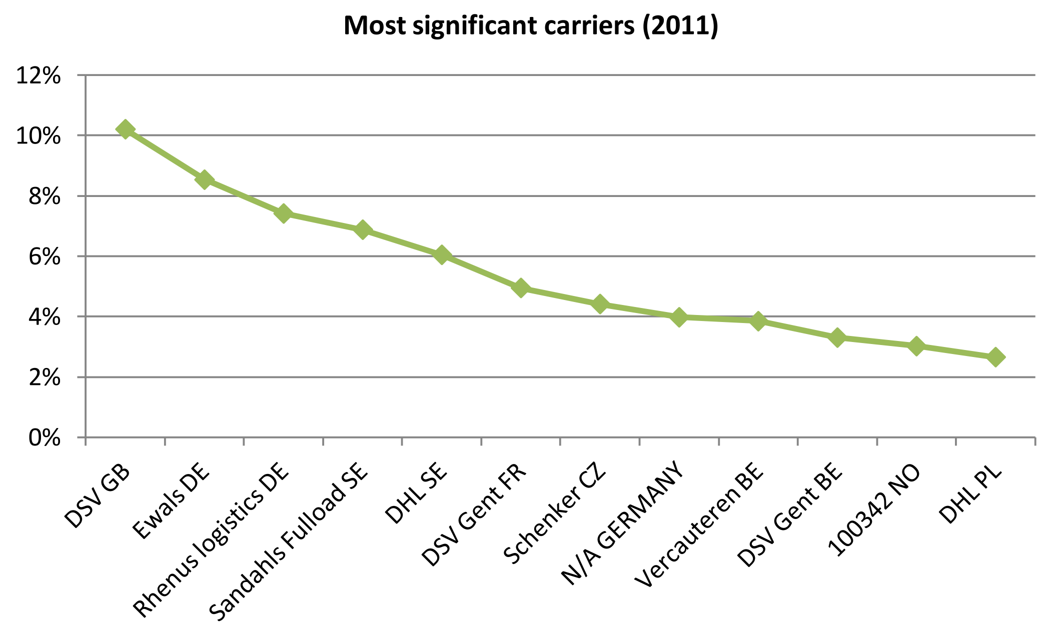

Figure A1. Ranking of carriers which spread the most goods.

Those carriers who have been replaced with a number do not have a name in the ATLAS booking history. Carriers named N/A means 'not available', which infer that the corresponding GSDB code does not exist in the ATLAS mapping file. Hence, the 'N/A carriers' are aggregate data over all suppliers in a certain country, which does not have any carrier assigned to them.

Secondly, when a carrier has been chosen, to narrow down the scope further it is now time to choose suppliers. Most usually, one or a few supplier corresponds to a significant fraction of the carrier's spread volume. For that or those suppliers, more detailed data than the normal transport-time measuring is necessary. It is necessary to know each and every shipment for a specific supplier during a certain period of time. Image 5107 in the procurement ER system PULS contains the data displayed in table A1 for each article and shipment.

1IDLEVNR-INL	IDARTNR	KVANTMOT	REC DATE	KVAVIS	SENT DATE	IDPTYP IDKOLLI	LÖPNR	Sent
D0MNG	988840	3.000	10.014	3.000	100.105	R32	1.409.887	2010-01-05
BSBZA	9492249	20	10.015	20	100.107	R32	1.412.865	2010-01-07

Table A1. Data about specific shipments, extract from image 5107 in PULS.

Attention is needed when handling this data. `Rec date` does not correspond to the day when the goods arrived at CDC's goods reception, but the day when the articles were registered as put on the shelves (R32). Instead, the field `löpnr` contains the necessary information about when the goods were registered as received at the CDC gate (R31). The following step guides the process on extracting the most useful information from this table.

When creating the actual transport KPI, a few columns must be added to table A1. Those are `Received`, TT, `Sent weekday`, `Rec weekday`, `week`, `week+day`, which are explained in the following paragraphs.

`Received` translates `löpnr` into a workable date-format that Excel recognizes. The following formula extracts the three first digits and translates them between the current week and day format, and returns a usable Excel-date format. Note that this formula must be modified when other data than shipments from 2010 or 2011 are being analyzed.

```
=DATE(YEAR(sent);1;1)+(IF(MID(Löpnr;2;1)=".";
LEFT(Löpnr;1);LEFT(Löpnr;2))1)*7+
IF(YEAR(sent)=2010;4;3)+(IF(MID(Löpnr;2;1)=".";
MID(sent;3;1);MID(H3;4;1))-1)-1
```

TT is the transport time in working days between `sent` and `received`.

```
=NETWORKDAYS(sent;received)-1
```

`Sent weekday` is important to track how much goods was sent on non-agreed pick-up days, as well as circumventing the administrative measure problem with transport-bills being printed too early. The following formula returns the weekday, given the `sent` field.

```
=WEEKDAY(sent)-1
```

`Rec weekday` calculates which day of the week the goods was received, which circumvents the problem with transport-time and weekends.

```
=IF(MID([Löpnr];2;1)=".";MID([[Löpnr];3;1);MID([[Löpnr];4;1))
```

`Week` calculates how many weeks the shipment has taken; in addition to knowing which weekday the goods arrived the analyst must also know how many working weeks and weekends that have passed since the goods departed at the supplier.

```
=INT(IF(MOD(sent weekday+TT;5)=0;(sent weekday+TT-1)/5;
(sent weekday+TT)/5))
```

Finally, the arrival day KPI is constructed as

```
="w"&week&"d"&rec weekday
```

The result is illustrated in table A2. In this example there are have two different suppliers; one with shipping Tuesday and one with shipping on Friday. One of the supplier's goods arrived on Thursday and one of them arrived on Monday. The article numbers and how many of each articles that were received are also specified. Through this measure it is made possible to manage how much goods, and from which suppliers, goods arrive on the different days of the week.

1IDLEVNR-INL	IDARTNR	KVANTMOT	Sent weekday	week+day
D0MNG	988840	3.000	2	w0d4
BSBZA	30762259	24	5	w1d2

Table A2. Arrival day KPI in non-graphical format for two different suppliers.

Furthermore, apart from the managerial benefits from measuring arrival day instead of only transport-time is the benefit that this can be used to accurately demand higher customer service from VLC. However, in order to manage all suppliers' arrival date, this KPI must be systematically implemented and not only extracted on case-by-case basis.