Developing Internal Logistics in a Make-To-Order Environment

Case Gardner Denver Oy

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ABSTRACT

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Case Gardner Denver Oy

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The optimization of internal logistics holds a sizeable societal importance as efficient logistics contributes to the timely delivery of goods to customers, increasing customer satisfaction. By developing these processes, companies build trust and transparency in their operations, pivotal for any prosperous business environment. The study aims to enhance the make-to-order internal logistics of the Tampere plant of Gardner Denver Oy, by improving an array of key performance metrics, primarily the delivery reliability and through the enhancements in reliability, also inventory turnover, inventory value, capital turnover ratio and timeliness of invoicing and collection process.

The thesis focuses on the logistics processes at the end of the supply chain, where the finalized products await to be dispatched to the customers. By utilizing the current state of the company, using quantitative data in the form of open sales data and invoicing data, and qualitative data in the form of interviews conducted with professionals in different departments of the case company, the study develops a process model to improve delivery reliability through delivery date estimates, having an impact on the other key performance metrics as well. In studying potential causes of deteriorated delivery reliability, the research found four key variables, the order size, the number of days between the delivery date requested by the customer and the promised delivery date, the payment or pick-up risk of the shipment, and the country of origin of the customer.

The cause and effect of the key variables are thoroughly studied in support of the peer-reviewed theoretical literature to validate any recommendations in the proposed process model. The proposed process model anticipates improving the other key performance metrics by offering actionable recommendations for the case company to pinpoint and improve the internal logistics processes, eventually enhancing the overall efficiency of the supply chain and resulting in a functioning process model that the case company can develop through future data utilization and find additional variables that cause an effect on the overall delivery reliability and through future research on the subject affect the other key performance metrics researched as well.

Key words: internal logistics, make-to-order, delivery reliability, inventory management, working capital turnover, process model
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1 INTRODUCTION

In the contemporary landscape of manufacturing businesses and evolving consumer demands, companies face persistent pressure to enhance operational efficiency to deliver value to their customers. Within this context, optimizing internal logistics processes emerges as a fundamental cornerstone for success. Critical measures, such as delivery reliability and working capital turnover, are increasingly crucial in manufacturing industrial products and addressing customer needs in the realm of supply chain management.

The commissioner for the thesis is Gardner Denver Oy, the Finnish company of a global multinational industrial machinery concern Ingersoll Rand. The company provides machinery, such as compressors, blowers, and vacuum pumps. The concern specializes in compressor systems. (Gardner Denver Oy n.d.) The company’s history dates back to 1872 when Rand & Waring Drill & Compressor Company continued Simon Ingersoll’s invention, a steam-powered rock drill. The company innovated machinery such as electric motor-driven compressors and portable, oil-free, and pipeline compressors throughout the decades. In 2019, Gardner Denver announced a merger with Ingersoll Rand to create a global leader in flow creation in industrial technologies. (Ingersoll Rand n.d.)

The company operates primarily in a make-to-order environment. In such a setting, production is initiated upon receiving the purchase order for the customer. (Cambridge Dictionary n.d.) While Gardner Denver has functions that are not make-to-order both globally and domestically, the thesis focuses on improving the internal logistics processes specific to a make-to-order environment to improve logistics, taking the characteristics of the production type into account.

In a modern business setting where everything is connected seamlessly, a smooth flow of goods plays a pivotal role in meeting customer expectations and maintaining competitiveness. Furthermore, it is imperative to understand the significance of internal logistics and its magnitude for organizational performance. The objective of this thesis is to assess the current state of the case company’s internal logistics, focusing on the end of the supply chain, where the complete
tested products are ready to be delivered to the customer. The thesis seeks to find recommendations to positively impact critical key performance indicators such as delivery reliability, working capital turnover, and inventory value. Identifying such measures is essential for the company to pinpoint the areas of improvement and advancement operationally. To assess the current state of the processes and support any suggestions based on the research, the thesis sets diverse key performance indicators. By addressing these objectives, the study endeavors to gain valuable insights into internal logistics optimization for organizations operating in dynamic manufacturing environments.

Artificial intelligence has been used in the thesis to check and correct potential grammatical or structural errors.
2 THESIS PLAN

This chapter serves as an introductory discourse, presenting the thesis topics, objectives, research questions, methodology used, and the limitations of the study. Its purpose is to provide the reader with a comprehensive overview of the entire thesis framework with the key facets of the thesis in how the research is conducted.

2.1 Thesis topic

The primary focus of the thesis is the critical examination of the make-to-order internal logistics processes within Gardner Denver Oy. Presently, the company encounters recurrent instances when the products do not leave the warehouse as per schedule, consequently having a detrimental effect on key performance measures such as the reliability of the delivery, capital turnover ratio, and inventory turnover ratio. As these issues are prevalent in the company, the thesis focuses on improving these processes of the case company by analyzing the current state of the processes and identifying key areas to improve and optimize by finding characteristics of efficient and inefficient orders in its logistics framework, all culminating in actionable recommendations based on the analytical insight provided in the research.

2.2 Thesis objective and research questions

The research aims to develop a thorough understanding of the current congestion of the supply chain and leverage the available data to find potential areas of improvement with a concrete executable process plan. Currently, the case company struggles to allocate resources to gather an understanding of the data available to develop the internal logistics processes. The objective of the thesis is to create a clear action plan to improve internal logistics by focusing on the end of the supply chain, where finalized products await dispatch or pickup at the factory by the customer. The thesis revolves around the main research question:
“How to improve the internal logistics processes at the end of the supply chain at Gardner Denver Oy?”

As the emphasis of the study is at the end of the supply chain, it is crucial to find the correct processes that affect the performance of the supply chain from the point of having the product ready to the point of reception at the customer.

Any suggested actions to improve internal logistics processes at the end of the supply chain are measured by their potency to improve the four key factors:

• Delivery reliability
• Working capital turnover
• Inventory value and turnover
• Timely customer invoicing and collection

To help guide the thesis, a set of key performance indicators has been set up to inspect the efficiency of the given process. The sub-research questions set to form the process are:

How to improve delivery reliability in a make-to-order environment?
How does delivery reliability affect working capital turnover, inventory value, and timely invoicing?
What are the characteristics of well-functioning internal logistics in a make-to-order environment?
What effects do the internal logistics processes at the end of the supply chain have on the key factors?
How to improve timely invoicing at Gardner Denver Oy?

2.3 Data collection

The thesis employs a mixed approach, combining both quantitative and qualitative data to utilize all data available for the study. In the research, the quantitative data is derived from an analysis of sales logs provided by the case company.
Qualitative data is derived from interviewing the professionals in different departments of the case company to support any quantitative findings made during the process. The theoretical framework of the analysis is based on peer-reviewed literature. By applying data from the ERP system, the research can provide conclusions at the highest possible confidence level.

The data collection is conducted first by familiarizing oneself with the literature around the research questions on the thesis topic. The second step in the data collection is to collect reliable information and data patterns from the sales logs which will guide the design of the qualitative interviews. As the thesis is heavily quantitative, the interviews are used to explain any phenomena found in quantitative research and support any findings.

2.4 Reliability and validity

In academic research, reliability refers to the replicability of a specific study in terms of to which extent the experiment yields the same results when repeated. Validity refers to the credibility of the research in terms of how accurately it can assess the concept it is attempting to measure. (Colorado State University n.d.) The study aims to have as big of a sample as possible in any quantitative findings to ensure that the conclusions made reflect reality as well as possible and shed light on the current state of Gardner Denver Oy’s internal logistics processes. The quantitative data is collected consistently from the same source and reported with accuracy and transparency to reach the best possible result from an academic point of view. The qualitative data, despite being subjective in nature, is designed to reflect the truth as accurately as possible through careful interviewee and question selection. To increase the validity of the data, an array of professionals across different departments are interviewed.

2.5 Limitations

As the Ingersoll Rand concern is a massive multinational organization, the thesis focuses only on improving the supply chain management of the Tampere plant of
Gardner Denver Oy, located in Messukylä, Tampere. The thesis is not focused on the entire supply chain, as it is based on specific focal points at the end of the supply chain, where the tested products are ready to be sent to the customer, including storing, collecting, packing, and dispatching the final products to the customer. Management of these processes substantially affects the internal logistics and delivery reliability, therefore affecting the inventory and working capital management.

As the multinational concern has a vast array of functions internationally and domestically, the thesis excludes any spare parts-related functions, focusing only on the machinery initiated by the customer purchase order, helping to produce a cohesive report that will answer the research questions set. The thesis is limited to external customers outside the Ingersoll Rand corporation excluding intercompany customers. Additionally, any quantitative data such as the number of products sold in the study is scaled to ratio, as the raw numbers regarding the case company or their customers cannot be disclosed for confidentiality reasons.
3 THEORETICAL FRAMEWORK

The theoretical framework adopted in the study encompasses the key perspectives used in the research to support any findings made in the process. The literature research introduces the supply chain framework and the main concepts relevant to the thesis. The thesis aims to provide a profound understanding of the intricacies and challenges of internal supply chain management by introducing the literature concepts of the field to help provide valuable insights into this study.

3.1 Supply chain

The supply chain represents the collective of all firms, personnel, and infrastructure used to create and transport products to customers. As the stakeholders of the supply chain join in numerous processes, the members of the chain move physical material, information, and money to respond to the demand of customers to add value at distinct parts of the supply chain. (McKeller 2014)

As McKeller (2014) introduces in the basic linear supply chain model, certain entities flow from the supplier to the customer while certain entities flow from the customer in the direction of the supplier and the manufacturer (Figure 1.) In a make-to-order environment, the customer kicks starts the entire chain by placing a purchase order. This flow of information goes left to right to the manufacturer, as they need raw materials from the supplier to manufacture a product for their customer. Therefore, the flow of information, materials, and products always flows from the supplier in the direction of the customer. Money, the third main flow of the supply chain, flows from right to left, meaning that the customer pays the manufacturer who pays the supplier for the raw materials. The distributors and retailers work as intermediaries in the supply chain.
3.1.1 Make-to-order (MTO)

The company produces its products on a make-to-order basis, meaning that the manufacturing process starts only when the company receives an order from a customer (Cambridge Dictionary n.d.). Production is initiated by the purchase order reception from the customer, prolonging the delivery times, as production is kickstarted by the reception of the purchase order. However, make-to-order manufacturing is optimal when the customers demand specific details or customization from the product. In a make-to-order setting, the customers are often time and cost-sensitive, challenging the two main criteria in designing supply chains (Li & Womer 2012, 118-119).

Time and cost are often conflicting measurements in a make-to-order environment, as in instances such as choosing a quicker delivery for parts would shorten the lead time but increase the total cost of the operation (Li & Womer 2012, 118). On the downside, companies that use a make-to-order strategy are often challenged by material delays as the companies order the raw materials after receiving the purchase orders, extending the lead time, and harming delivery reliability (Prasetyaningsih et al. 2020). As the lead time is sacrificed, the companies can have lower inventory levels to respond quicker to fluctuations in demand.
3.2 Internal logistics

Internal logistics is defined as the collection of the internal supply processes, storage, transportation, and distribution of goods within the organization (Pinheiro de Lima et al. 2020, 3). The process of internal logistics begins with receiving the goods. The incoming goods are unloaded at the point of entry, moved to the warehouse, and placed in their specific location. After being placed at their location, the goods can be placed for production based on the customer’s order to the assembly line. (Figure 2.)

In addition to the material flow, internal logistics also considers the flow of information. The flow and exchange of information between the sender and recipient is a pivotal component in managing the goods as information flows at all points of the supply chain. (Marcysiak & Marcysiak 2021, 71-72.) An example of such information flow would be checking the condition and quantity of the goods on arrival and recording the information appropriately in the enterprise resource system.

![FIGURE 2. The internal logistics supply chain (Klug 2012).](image)

3.3 On-time delivery

On-time delivery, one of the key performance indicators of delivery reliability, measures the percentage of orders delivered before the promised date. In a make-to-order environment, where the company starts producing the goods after
receiving an order from the customer, the delivery time gets longer, as there is the time of production and sourcing of the materials to consider. (Logistiikan Maailma n.d.) At its simplest, on-time delivery can be measured by dividing the number of orders delivered to customers within the time window by the number of received orders. As a result, the company gets a percentage of how accurate its deliveries are from the customer's point of view. (Tainala 2023, 9.)

\[
on - time \ delivery = \frac{\text{orders delivered before scheduled date}}{\text{number of total orders}}\]

3.4 Order accuracy

Eyal Orgil (2024) describes order accuracy as a vital metric of delivery reliability as a number that marks out how well the content of the order matches the original purchase order from the customer, taking various aspects into account, such as the item’s correctness, quantities, and customizations requested by the customer (Orgil 2024).

Order accuracy is measured in multiple ways, such as the percentage of accurate orders, calculated by dividing the number of accurate orders by the total number of orders received and shown as a percentage. Optionally, order accuracy can be determined by taking merely specific aspects into account, such as the quantities and different customizations of the products in the purchase order. (Orgil 2024.)

3.5 Working capital management

Working capital management refers to any financial activity to ensure sufficient resources for operational expenses (CFI Team n.d.). Working capital management comprises five activities, liquidity management, accounts receivable management, inventory management, accounts payable management, and short-term debt management. These activities are pivotal in ensuring the company can invest the resources productively. (Figure 3.)
Liquidity management refers to a company’s ability to possess enough cash for its business needs or any unexpected expenditure. Accounts receivable management refers to activities that allow the company to have enough cash flow for operations while ensuring that the company gets paid by its customers on time for its daily business activities. Inventory management refers to inventory-related activities to ensure sufficient inventory to deal with any fluctuations in demand. Accounts payable refers to the payments the company is liable to pay, for instance to suppliers or other stakeholders. Paying accounts payable too early may reduce the liquidity available, while overdue payments have a detrimental effect on the reputation, commercial viability, and company’s creditworthiness. Short-term debt management refers to a company’s ability to possess enough liquidity to finance any short-term operations without taking uncontrolled risks. (CFI Team n.d.)

3.5.1 Net working capital

In working capital management, net working capital is a financial metric that comprises the arithmetic difference between the current assets consisting of inven-
tory, accounts receivable, varied materials, and spare parts and liabilities consisting of accounts payable, long-term liabilities, and accrued payable on the balance sheet. (Sagner 2010, 1-2.)

\[ \text{net working capital} = \text{current assets} - \text{liabilities} \]

### 3.5.2 Working capital circulation

The working capital cycle is the period that elapses from the moment of spending funds until getting capital from the customer to sell complete products (Zimon 2021). In a make-to-order environment, the cycle is initiated by the purchase of goods and materials, shifting the capital towards production, and used to convert the raw materials and components into complete sales products. At this point, the company is likely to be financially liable to the suppliers for the materials and components while having accounts receivable from the customers for the products manufactured and shipped. (Figure 4.)

![Figure 4. Circulation of working capital (Zimon 2021).](image)

### 3.6 Inventory

Managing inventory is constantly balancing between managing an elevated level of customer service without accruing excessive amounts of money for managing the inventory. As the amount of inventory directly affects the profitability and cash flow of the company, inventory management is seen as a pivotal function of a
successful manufacturer as the companies try to ensure the optimal levels of inventory to ensure maximum profitability and level of customer service. As in the make-to-order environment, the demand is often uncertain and difficult to estimate, companies use different methods to forecast the optimal levels of inventory. (Goyvaerts et. al. 2022, 2-20.)

In the manufacturing business, there are usually four different classifications for multiple types of inventories. They can be differentiated as pure raw materials, components that are not complete from production, products that are work-in-process, products waiting to be processed, and finished goods that are ready to be delivered to the customer. (Pozidis n.d.)

3.6.1 Inventory value

The inventory value is the value of the goods belonging to the inventory according to the company. It can also include procurement contracts in case they are relevant to the company. (Tilastokeskus n.d.) As in a make-to-order environment, the complete process is initiated by the purchase order from the customer, it is increasingly important to maintain low levels of inventory, as the final products often contain specific needs or customization that lose value when lying in the warehouse. According to Tim Vipond (n.d.), the components and raw materials needed for production are referred to as business inventories, as the company would need these to complete the customer orders sufficiently. (Vipond n.d.)

3.6.2 Average inventory

Average inventory is determined by dividing the amount of inventory at the end and beginning of the year by the number two. The number two in the formula represents the number of data points, respectively at the beginning and the end of the year. (Nasution 2020, 2.) As evident in the formula, the result can be prone to errors in case of fluctuations throughout the year. For instance, situations of an
enormous difference just outside the calculation points would skew the calculations, leaving the company with erroneous conclusions based on the data, eventually resulting in decreased operational performance.

\[
\text{average inventory} = \frac{(\text{inventory at the beginning of the year} + \text{inventory at the end of the year})}{2}
\]

3.6.3 Inventory turnover

Inventory turnover is the ratio between the cost of goods sold and the average inventory, where the cost of goods sold is divided by the average inventory (Nasution 2020, 2). Inventory turnover is a widely used ratio to gauge inventory efficiency, as the company can use the turnover ratio to plan orders and improve manufacturing lead times (Leonard & Main 2023).

As the companies using make-to-order planning initiate production based on the purchase orders set by the customers, the inventory turnover is high as the company is dedicated to keeping a minimal amount of goods in their inventory. Companies with higher inventory turnover ratios can suppress costs linked with inventory management, as the goods depart the premises faster, leaving less warehousing needed for parts or products. (Leonard & Main 2023.)

\[
\text{inventory turnover} = \frac{\text{cost of goods sold}}{\text{average inventory}}
\]

3.7 Role of timely collection in invoice processing

Timely invoicing of customers has a sizeable effect on efficiency, as the ideal time to invoice is right after the delivery as the company can get capital as soon as possible. When customer payments are delayed for any reason, a gap between the cash inflow and the forecasted cash flow is created. Efficient invoice processing can enhance customer relationships and give a professional image of the companies in terms of fostering long-term loyalty. (Gartner 2023.)
4 CURRENT SITUATION AT GARDNER DENVER OY

This section introduces the internal logistics at the end of the supply chain at the case company, examines the situation, and makes assessments based on quantitative and qualitative data collected. The data is used to find characteristics of efficient and inefficient orders and use that data to improve the internal logistics processes.

4.1 Internal logistics at the end of the supply chain at Gardner Denver Oy

The finished products go through logistics processes before they are ready to be sent to or picked up by the customer. The products need to pass tests to receive a certification for quality. After that, the goods are packed and stocked for pick-up. When the order is ready to be sent to the customer, customer service notifies the customer, and either the customer or Gardner Denver Oy will arrange the transportation of the products. Moreover, there can be additional inspections or tests for the products to be eligible for delivery. After that, the forwarder picks up the goods to be delivered to the customer. (Figure 5.)

![Internal Logistics Diagram](image)

FIGURE 5: Internal logistics at the end of the supply chain at Gardner Denver Oy

4.2 Backlog of open orders

The backlog is a document produced by the ERP system at Gardner Denver Oy when customer service signs the order to the system. Practically, it shows all the open sales orders yet to be delivered. The production unit confirms the expected departure date of the order that will appear on the order confirmation sent to the
customer. That expected delivery date appears as a ‘Goods issue date’ on the backlog. However, it is essential to note that the goods issue date is a departure date estimation, and the actual departure date depends on multiple factors throughout the supply chain. Additionally, the backlog shows the requested delivery date by the customer, which can differ from the goods issue date, in the case of a discrepancy between the customer and GD Oy about the delivery date in case the company cannot promise a delivery at the requested date. Moreover, the backlog introduces pivotal order information, such as the customer’s name, the products ordered, the size of the order, any comments on the order, inco-terms, and payment terms.

At times, there is a substantial risk of not getting that order invoiced within the same month as the expected goods issue date. That can be due to payment-related issues or the customer not being able to pick up their delivery on time. Sometimes the production department cannot finish the order on time. These issues affect the inventory and capital management measurements, making the backlog an instrumental tool in giving the research sufficient quantitative information to delve deeper into the data and find patterns to improve the internal logistics processes.

4.3 Risk factors and their effect on delivery reliability

This chapter identifies multiple risk factors to delivery reliability, evaluating and estimating how each risk factor affects delivery reliability to reach the best recommendations for the case company. The chapter shows correlations and causalities between a factor and delivery reliability and estimates how heavily each factor isolated correlates to reliability. To avoid bias and increase the reliability and validity of the findings, a comprehensive analysis of the backlog and invoicing data is conducted to have a large enough sample to analyze and to find confidence and statistical validity for the recommendations presented.

The section introduces a concept named risk factor. This factor measures the number of days this variable is estimated to cause negative delivery reliability to an order with that characteristic as a multiplier compared to an order without the
risk characteristic. For instance, risk factor 2,00 would imply that the order expects to take double the number of days to depart. The chapter introduces a term called date disparity, setting to illustrate the difference in the number of days between the requested delivery date by the customer and the eventual goods issue date for delivery. For confidentiality, raw numbers regarding the number of days are not shown, instead presenting the results as multipliers scaled. Additionally, all the figures showing the latency in the number of days late are scaled not to show absolute values.

4.3.1 Order size

Larger orders comprised of three or more items have a noticeable effect on delivery reliability. It is noteworthy to point out those orders are delivered late much more frequently than orders of smaller quantities as delivery reliability drops from 76% to 71% with the order size increasing. The smaller orders, consisting of 65% of all orders, consist of only 60% of the late orders. (Figure 6.)

<table>
<thead>
<tr>
<th>Order size</th>
<th>% of orders involved</th>
<th>% of late orders involved</th>
<th>% of orders late</th>
<th>% of orders on time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 or 2</td>
<td>65%</td>
<td>60%</td>
<td>24%</td>
<td>76%</td>
</tr>
<tr>
<td>3+</td>
<td>35%</td>
<td>40%</td>
<td>29%</td>
<td>71%</td>
</tr>
</tbody>
</table>

FIGURE 6: Delivery reliability per order size, 2023 orders

When assessing the risk factor associated with delayed delivery, the orders comprised of three or more items in quantity constitute 1,57 times more delay to delivery reliability on average in comparison to the smaller orders of 1-2 items in quantity. The days late and risk factor column excludes the raw numbers for confidentiality purposes and uses a multiplier instead to showcase to compare the numbers between different order sizes respectively in distinct groups. (Figure 7.) While the numerical value itself may carry significant value, it showcases a potentially detrimental effect on delivery reliability and over time, on other performance measures as well.
To study the impact of order size on delivery reliability, further analysis is conducted focusing on specific data points in the research. The challenges associated with order size do not appear straight after surpassing the barrier of two items in quantity per order. However, delivery reliability declines gradually as the order size increases, as the size is a risk factor. The risk factor, computed with the percentage of orders on time and the number of days late in case of delayed delivery, doubles in numbers with the orders of at least nine items in quantity. (Figure 8.)

4.3.2 Date disparity between the goods issue and requested delivery date

Due to the unavailability of date data for all open invoiced orders of 2023, the study relied on the monthly backlog data for analysis. The study compared the number of orders with a date disparity between requested delivery and goods issue data of 0 days with those showing a disparity of at least one day. It is essential to note that this does not give a statistical representation of the number of total orders in each group analyzed, as there are orders not appearing on the backlog list, departing on time between the monthly backlogs reported. Nonetheless, this gives the analysis a strong enough estimate to use as a base for any further research.
The orders with time between the requested delivery and goods issue date exhibit a higher latency in the delivery reliability as these orders are much more frequently late than the other orders. Additionally, the order size grows with the date disparity, highlighting the effect order size has on delivery reliability as the deliveries with a date disparity higher than 0 days have a risk factor of 1.92 times. Orders with a date disparity of at least 1 day have almost double the risk factor compared to orders without disparity between the requested delivery and goods issue date. (Figure 9.)

When dividing the data into three groups and assessing the orders with a date disparity between 1 and 60 days and the ones with higher separately, it is already evident that the date disparity causes a decreasing effect in the middle, as the delivery reliability drops to 70%. However, the orders are delayed more in the last category, making the orders with a date disparity of at least 61 days the riskiest category overall. (Figure 10.)

**FIGURE 9:** Date disparity between the goods issue and the requested delivery date

<table>
<thead>
<tr>
<th>Days between requested delivery and goods issue date on delivery reliability, days late on average</th>
<th>Days between requested goods issue and delivery date</th>
<th>Days late, scaled</th>
<th>% of orders on time</th>
<th>Risk factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date disparity 0 days</td>
<td>1.00</td>
<td>77%</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Date disparity 1+ days</td>
<td>1.53</td>
<td>71%</td>
<td>1.92</td>
<td></td>
</tr>
</tbody>
</table>

**FIGURE 10:** Date disparity between the goods issue and requested delivery date, grouped in three

<table>
<thead>
<tr>
<th>Days between order creation and goods issue date on delivery reliability, days late on average</th>
<th>Days between order creation and goods issue date</th>
<th>Days late, scaled</th>
<th>% of orders on time</th>
<th>Risk factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date disparity 0 days</td>
<td>1.00</td>
<td>77%</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Date disparity 1-60</td>
<td>1.35</td>
<td>70%</td>
<td>1.79</td>
<td></td>
</tr>
<tr>
<td>Date disparity 61+</td>
<td>1.89</td>
<td>74%</td>
<td>2.15</td>
<td></td>
</tr>
</tbody>
</table>

**4.3.3 Payment and pick-up and their effect on delivery reliability**

The case company has divided the potential risk to timely delivery into two dissimilar categories, payment, and pick-up risks. The first category covers all the
payment-related risks, for instance, if the customer has not paid the pre-payment on time for Gardner Denver Oy to proceed with the delivery according to the schedule. The latter category covers the pick-up-related risks, especially the cases where the company is organizing the delivery and cannot get the forwarder to pick up the goods on time.

The study has taken advances to study the effect of the orders marked as payment and pick-up risk orders on delivery reliability. The research found that the orders that are at any point marked as orders with payment or pick-up risk are heavily likelier to be late from its goods issue, as only 19% of those orders get delivered on time, compared to all orders that exhibit a delivery reliability of 75%. As evident in the data, all previously presented high factors are presented in the orders with payment or pick-up risk, as these orders have 1,11 times higher average order size, the difference between the goods issue date and the requested delivery date is over double the in days and the late orders are almost 2,5 times more delayed in days. Overall, this culminates in an elevated risk factor of 7,98, meaning that the orders with payment or pick-up risk cause almost eight times more delay on average. (Figure 11.) As the data poses the question of low delivery reliability of orders with such characteristics, the company would need to notice these risky orders earlier.

![FIGURE 11: Orders with payment or pick-up risk compared to all orders](image)

However, it is pivotal to notice that payment or pick-up risk marking is more of a separate cause and effect with order size and date disparity than an actual risk factor, even though it is important to note that the orders hold a tremendous amount of risk and highly correlate with the findings made on order size and date disparity. Furthermore, it becomes pivotal to way find to reduce this payment and pick-up riskiness, as this has a substantially negative effect on the entire operational performance.
4.3.4 Delivery country

The countries do not have equal delivery reliability in comparison to each other as some countries hold excessive order risk. In this assessment, the countries are represented with alphabet numbers to make sure individual customers cannot be recognized from the data. The study on delivery reliability within the customer countries of Gardner Denver Oy found five separate countries, all individually with sizeable yearly numbers of orders, low delivery reliability as a percentage of orders delivered on time, and high number of days late in case of late orders. These orders have been recognized as risky and used as risk factors in any following recommendations. (Figure 12.)

As presented (Figure 12), the study does not outright pick the five countries with the highest calculated days latency per order, as only the five countries, namely E, J, S, W, and X, highlighted in the figure, have both big enough sample size in terms of number of orders and worse enough delivery reliability to be pointed out as a risk country.

![Delivery reliability per country](image.png)

**FIGURE 12:** Delivery reliability per country, risk countries highlighted in red
5 INTERVIEWS

The interviews were conducted as a data collection method to shed light on any potential findings made in the research from multiple vantage points. The interviews focused on different departments relevant to the internal logistics processes in question as discussions inside the departments in the Tampere plant and globally with the accounts receivable department and the global operations leader responsible for multiple warehouses across the world. As the study delves deeper into the methodology employed in the thesis, uncovering the interviewing methods chosen, the chapter introduces the implementation of the interviews.

The interviews explained the gaps in knowledge to understand the quantitative insights from the data. The interviews were mainly conducted on Microsoft Teams, and the interviewees were informed that the results would be anonymous, not disclosing their identity from the responses. As the interviews were very informal and discursive, the questions were developed to support the insights from the quantitative data. Moreover, the section does not introduce thoroughly all of the questions and answers but summarizes the key insights of the interviews and their significance to the research.

5.1 Customer service

The Gardner Denver Oy customer service was interviewed as an open group interview, including the supervisor and three employees each responsible for conducting the daily communicative and operative tasks in managing the information flow in customer service. The interview was a half-structured discussion to allow any detailed questions on the topics emerging, and not tie any answers to a pre-determined set of answers, leaving more room for interviewees’ experiences regarding the topic. The group interview also allowed the interviewees to communicate with each other and leave room for any unprepared questions while still staying in a structured state.

The key finding from the interview (Appendix 1) is the discrepancy regarding the delivery reliability between the case company and the customer whether the
goods are ready to be delivered by the date agreed with the customer. This is especially pivotal with the customers with shipments via sea when the shipment takes weeks. Furthermore, in measuring delivery reliability, the customers usually have their own methods of calculating the reliability, not automatically aligning with how Gardner Denver Oy measures it. Additionally, the customer service representatives emphasized that any latency regarding the needed components from the supplier is perceived as the main reason in cases when Gardner Denver Oy cannot deliver on time.

5.2 Production department

As the insights from the quantitative data point out the causation between the risk factors mentioned and decreased delivery reliability, the interview heavily focused on finding the principal factors affecting delivery reliability of the entire supply chain process, focusing on the end of the supply chain. The interview was conducted with the production manager to ensure a full overview of the production department as a vital factor in the overall efficiency of the supply chain.

As the study is committed to improving delivery reliability through more accurate date estimates, it is pivotal to understand the process of deciding a delivery date that will be confirmed to the customer by the customer service department. According to the production manager, the main factor is the date when the customer desires to receive the goods. Whether that delivery date can be promised to the customer is mostly dependent on the availability of needed components from the supplier. Additional factors contributing to the estimation are the capacity to produce the order and overall forecast of a material group, as the production needs to align with the material and component forecasts to ensure the company does not have a shortage or overstock of a given component. (Appendix 2).

As the deliveries are heavily dependent on factors that are partly out of the reach of Gardner Denver Oy, it also scoped the potential solution to the problem more from focusing on the quickest possible delivery to getting the forecasts more accurate. To acknowledge the effect of late orders from the production point of view, the manager emphasized (Appendix 2) that one of the biggest reasons that cause
problems are the instances where the production has promised a certain delivery date for the customer and the supply chain has worked accordingly to get the order ready to be delivered or picked up by that date, but the customer either does not get their forwarder to pick up the goods or has not paid certain payments needed to ship the goods. In those cases, according to the production manager, it is essential to detect these customers and notify them beforehand so that the case company does not get financial harm from late deliveries, as it affects other important metrics, such as inventory value and capital turnover.

It is evident from the data (Figure 11) that the orders of payment or pick-up risk have substantial risk factors and exceptionally low delivery reliability. As those orders are often late for reasons out of the case company’s hands, it is essential to find ways to relay information between customer service and production to estimate the delivery dates more efficiently. When discussing with the production manager about the causation between order size and delivery reliability, the potential root problem is that the entire process does not consider the order size sufficiently to start the production early enough, causing delays eventually to the entire process.

5.3 Material and purchasing department

The interview with the material and purchasing departments shed light on what happens before the ready product is available to be shipped to the customer in the supply chain by interviewing a senior buyer and the materials manager of Gardner Denver Oy. The interview was conducted on Microsoft Teams as an informal discussion, using some pre-formed questions to steer the discussion into the topics beneficial to the study. However, the interviewees were not advised to answer directly the questions asked, prompting spontaneous sub-questions and topics during the discussion.

The case company uses a heavily structured process model to conduct any purchasing or materials handling (Appendix 3), ensuring that the case company can forecast a sufficient inventory level for the production of the orders without falling short of materials needed. The company has regulated suppliers for the materials
used in the main products ordered by customers. However, delivery reliability is sometimes affected by the lack of confirming the pivotal in case the availability of specific components at certain dates is not confirmed, causing delays at the end of the supply chain. The personnel interviewed were keen on reducing unneeded communication by having process models agreed upon by the personnel.

5.4 Accounts receivable department

The interview with the accounts receivable department of Ingersoll Rand was conducted over email for confidentiality reasons with the accounts receivable coordinator. As for the research in question, the link between delivery reliability and financial performance is crucial, the interview shed light on the details of payment and collection management as a part of a successful organizational structure. The structure of conducting the discussion over email did not leave for spontaneous sub-questions. However, the answers written were very diligent and opened up the challenges and processes of the department.

In accounts receivable management, the biggest challenges are customer-related in either dispute management or payment behavior, causing irregularities in payment times and deliveries in cases of pre-payments. Additionally, the customers sometimes require the case company to use their portals in invoicing, which causes delays in payments, as the accounts receivable department cannot use a standardized process. As the case company heavily relies on the numbers for each month-end and quarter-end, the company is committed to collecting the goods through discussions with the account or sales manager and the customer. Credit risk checks are conducted for new and existing customers to ensure the resources are used effectively to mitigate risks. (Appendix 4.)

The effectiveness of the accounts receivable department is measured by different metrics, such as tracking the customer payments and showing dispute reports, to forecast and measure the customers based on their profile with factors such as the payment age or value. The pivotal aspect of accounts receivable is to be aware of the cash collected each month and how the cash available affects the overall operational performance. (Appendix 4.)
5.5 Global operations leader

The global operations leader for Ingersoll Rand concern is responsible for implementing sales and communication processes between different warehouses, including any production or sales-related forecasts, and overseeing the operations so the warehouse can reach its maximum performance. The interview, similar to many other discussions in the research, was conducted over Microsoft Teams, with a pre-defined set of questions as a half-structured interview, leaving room for different sub-questions and topics that emerged.

The vital insight from the discussion is that the current downturn in the economy, both in terms of the increased costs of shipments and difficulty in delivering goods due to conflicts around the world, leading to situations where customers order more than they actually would need, ending the case company to processes orders. As already broken down in the research, the orders with bigger sizes in terms of units are less on-time and suffer from decreased delivery reliability. In the interview, it became clear that for an efficient operational framework, it is essential to have a forecasting process to collect the needed information, as the customers generally do not have similar practices or customer behavior to estimate operational performance. (Appendix 5.)

The global operations leader emphasized the importance of on-time delivery as the key metric to success, as delivery timeliness is vital to achieving constant and accurate capital turnover. Everything is optimized by having specific strategies to manage inventory measures, such as material safety stock and lead time. Data-driven decision-making is strongly present in operations, as payment issues have been more prevalent recently, strongly correlating with the current economic challenges that affect all industries and their operational environment. (Appendix 5.) In case payment issues remain prevalent in the upcoming years, it will be important for the companies to leverage their operations in an environment where the level of capital flow is in danger. Larger production numbers and increased payments are arguably harder to manage, which is in line with the importance of accurate forecasting processes, highlighted by the global operations leader.
5.6 Financial analyst

To understand the connection between delivery reliability and financial performance, an interview with the financial analyst of the case company was conducted. Conceptually, the discussion had comparable topics to the interview with the accounts receivable department, as the analyst highlighted the effects of late deliveries on working capital management and, subsequently, the overall operational performance.

The financial analyst highlighted the importance of outgoing deliveries as a foundation of successful working capital management and inventory value. In the end, if the case company cannot convert its orders into capital, the goods stay at the premises, increasing the inventory value and decreasing the working capital. The company cannot use the inventory waiting in storage to cover operational costs, such as expenses for the suppliers, as the inventory value is not comparable to liquid cash. The analyst emphasized how vital metric revenue is for the monthly income. Usually, a small lateness in deliveries is not that crucial, despite the forecasts being suboptimal, as the case company can usually gather capital by invoicing the customers the next month, at the latest. (Appendix 6.)

The company controls financial risks by conducting forecasts for the key performance metrics. Different departments can adjust their performance, such as personnel needed for production or materials needed, based on the number of orders the company expects to receive from its customers. Sometimes the forecasts need to be adjusted, especially when a customer is not able to receive and pay for the orders and the same customer has a lot of upcoming deliveries. (Appendix 6.)
6 DELIVERY RELIABILITY AS A DRIVING FACTOR OF PERFORMANCE

As the study heavily focuses on delivery reliability as the focal point of the quantitative research, it is pivotal to understand the importance of on-time delivery to other driving factors of operational supply chain performance, such as inventory value, capital turnover, and collection effectiveness.

6.1 Payment and delivery risks

This section consists of risk handling mechanisms and ways to mitigate the risks and any harm caused by the suboptimal delivery reliability to other key metrics, such as the capital turnover ratio and inventory value. The backlog analyzed divides the risks into two main categories, delivery and payment-related, and assesses their significance to the key metrics mentioned. The payment-related risks consist of situations such as missing pre-payments to proceed with the delivery. This type of incident has a detrimental effect on delivery reliability as the company cannot proceed with the delivery before getting the payment as forecasted. The delivery-related risks are usually related to customer pick-up as some customers prefer to use their forwarders to pick up and transport the goods, adding another variable in the mix, as the case company is dependent on the customer for the deliveries.

It is evident that those risk factors are the main reasons why the orders do not get delivered on time. This has a detrimental impact on operational metrics, such as capital turnover and inventory value and turnover, especially in cases where the orders are late for reasons not dependent on the case company. Sometimes, as evident from the interview with the global operations leader, the companies are not ready to receive and pay for the entire order in its entirety. That can create a bit of a stalemate, as the case company is not keen on stocking goods produced by the goods issue date. There are cases when the company needs to settle to deliver a set of machinery from the order and stock the rest for the next delivery to the customer. (Appendix 5.) However, these issues are more of a global challenge across different warehouses, a problem not specific to the Tampere plant,
as no data would indicate that this challenge would be especially prevalent in Tampere.

6.2 Delivery reliability and capital turnover

When delivery reliability worsens, it has a striking effect on the capital turnover ratio, as the company does not get to bill the customer as forecasted, which would free capital for any other functions relevant to the business. Supply chain performance has a significant impact on financial performance. That includes crucial measures, such as delivery reliability, response time to customer requests, and lead time. Therefore, the company should understand how decisions and processes affect financial performance. (Wisner 2011.) Timely invoicing is the key to ensuring the company gets an accurately forecasted inflow of capital to cover any daily operational costs.

An academic study on the effect of cash turnover, receivable turnover, and inventory turnover found that capital turnover, especially in receivables, has an impact on profitability (Eryatna et al. 2020). While important to understand that the research was conducted in a dissimilar environment to the one studied in the thesis, it still raises pivotal viewpoints about the importance of capital management.

The situation where the case company has to escalate cases of customers not paying by the due date is negative for the capital turnover. In the worst cases, the customer chooses not to pay for the orders ending up with the customer being on hold, meaning that no new orders are released for the customer. (Appendix 4.) This is the worst-case scenario, as the products often cannot be sold to other companies due to their customer-specific nature in a make-to-order environment, as the products may have parts or other customization specific to the customer order. In the end, it is crucial to understand the role of dispute management in capital turnover, as the customers may have issues preventing them from proceeding with payment, such as late deliveries or billing issues (Appendix 4).
6.3 Delivery reliability and inventory holding costs

In terms of inventory, in a make-to-order environment, an elevated level of delivery reliability positively constitutes low inventory value, as the company does not have to store the products, and the products can be dispatched as quickly as possible to the end customer. However, as evident in mapping the internal logistics of the company, sometimes the case company does not get to deliver on time as the customers may not get their forwarder to pick up the goods or the delivery is affected by societal aspects such as strikes. Despite that, delivery reliability has a massive impact on inventory metrics and is a vital part of improving internal logistics. To reduce inventory holding costs, data-driven decision making is the key to making accurate predictions of the flow of goods (Sharma 2023). Moreover, it is essential to note that make-to-order is designed to decrease the inventory needed (Leonard & Main 2023).

According to Selvarajah & Zhang (2013), it is crucial to find the trade-off point between the increase in holding cost and the decrease in delivery cost in the supply chain (Selvarajah & Zhang 2013, 117). Practically, in the case of Gardner Denver Oy, it may be more beneficial for the company to agree on a delivery a week later with the customer if by doing so the companies can save on delivery costs. However, holding the finished products shelved on the premises is not optimal if the delivery could be organized a week earlier. However, the situation described is better than the situation where the shipment would get delayed at the same time for production-related reasons as then the case company is less likely to get a positive trade-off with the increase in holding cost as the delayed shipment has not been made with a decrease in delivery cost in mind. As the financial analyst stated (Appendix 6), it is essential to understand that the inventory holding costs are heavily linked to delivery reliability. The orders that do not leave the premises on time increase the value of inventory, which directly affects the working capital available for the company to use for its operations.
7 RECOMMENDATIONS

This chapter serves as a basis to turn any practical insights into actionable recommendations to improve the make-to-order internal logistics of Gardner Denver Oy with the thesis scope in mind. Any recommended actions are based on the research done in the study and theoretical literature relevant to the subject in question. Improving the delivery date estimates is multifaceted and the process model introduced is not expected to create fully optimal delivery date estimates. However, by optimizing the risk factors detrimental to supply chain performance, the case company can aim for better overall performance measured by the key performance indicators.

7.1 Characteristics of an inefficient order

As the correlation between the date disparity of the goods issue date and the requested delivery date, the size of the order, the country of delivery, and the eventual latency of the order seems to be evident, the action plan focuses on pinpointing those issues to a separate sub-process of the internal logistics flow by utilizing the quantitative and qualitative data gathered during the process. Additionally, the smaller orders have less disparity between the order creation date and the goods issue date. It can mean multiple things, however, the likeliest explanation for the phenomenon is that when the order is due to be delivered sooner, the estimations for phases needed for an order to be deliverable are more accurate. The orders with payment or pick-up risk have decreased delivery reliability and correlate with the study about order size and date disparity to validate previous findings.

Moreover, as evident in the study, the delivery reliability decreases as the order size grows, making it essential to find the right balance between maximizing the delivery reliability without compromising too much on the latency, as large orders tend to have more latency than the small orders. It is evident that the concept of reliability is complex, as customers have diverse ways of measuring delivery reliability, not always aligning with how the case company sees the situation.
Inefficient orders from the delivery reliability point of view are characterized as larger with more difference between the goods issue date and the requested delivery date. In make-to-order manufacturing, too long delivery dates can cause the loss of customers as the agreements cannot be met. However, too short dates tend to cause production planning difficulties (Mezzogori et al. 2021, 958). Additionally, as the orders with payment or pick-up risk have staggeringly low delivery reliability and increased risk factors through increased order size and date disparity between the goods issue date and the requested delivery date, it is evident from the interviews that the customers struggle to deliver the payment or get the forwarder to pick up the goods on time to meet the forecasted delivery date. The delivery date estimates should take this into account to achieve higher accuracy and reliability. Moreover, the study found five countries carrying excessive risk in comparison to orders delivered to other countries.

**TABLE 1. High inefficient order risk factors and their effect on delivery reliability compared to orders without order risk**

<table>
<thead>
<tr>
<th>Inefficient order risk factor, high</th>
<th>Effect on delivery/order (estimated multiplier of days late compared to orders without order risk)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Order size, 3+ items in quantity</td>
<td>1,57</td>
</tr>
<tr>
<td>Number of days between the goods issue date and requested delivery date, 1+ days</td>
<td>1,92</td>
</tr>
<tr>
<td>Payment or pick-up risk</td>
<td>7,98</td>
</tr>
<tr>
<td>Country of delivery</td>
<td>16,54-53,15 depending on the country</td>
</tr>
</tbody>
</table>

The characteristics of an inefficient order have a high causation on delivery reliability. As the number of days between the requested delivery and the goods issue date, the number of days between order creation and the goods issue date could not be used to calculate their link to delivery reliability, an estimate has been made by using the backlog data available. This is considered in any recommendation suggested to the case company. However, as the causation is clear, this insight without full statistical confidence is included in the study regardless of what extent it causes deliveries to be late. The risk of the country of delivery is high as the countries compared to may have low sample sizes and thus skew the
risk factor of the countries with lower delivery reliability to disproportionally high numbers. (Table 1.) For this reason, the table illustrates the risk factor compared to orders without the risk factor, not purely to compare the impact of the risk factors to each other. The main insight is that being listed as payment or pick-up risked delivery is often a result of having elevated risk in terms of size, date disparity, and country of delivery more than a separate risk factor.

7.2 Optimization

The study has identified four issues in delivery reliability, the order size, the date disparity between the requested delivery date and the goods issue confirmed by the case company, the country of origin of the customer, and the payment or pick-up risk, with a solution for each one of them.

In improving reliability, the research focused on simulating what adjusting the goods issue dates with different numbers of days based on the riskiness would do to the overall reliability. The orders that are late are usually late tens of days when they are late, making it so that minuscule adjustments in terms of delivery reliability percentage would not make a sizeable difference overall. However, when finding the optimal way to approach the issue, the study found the point of balancing the goods issue date estimates, where larger orders are not overly represented in late orders in terms of delivery reliability and number of orders. The numbers were calculated by comparing them to the 2023 backlog of orders to see how the delivery reliability would have been by simulating the results by using different numbers of days as parameters.

For the orders of different order sizes, the study estimated the number of days that would need to manually be added to the goods issue date for realistic delivery reliability based on the data analysis above. The number of days added is a rough estimate and does not consider any contracts the case company may have with specific forwarders or companies. Any suggestions in this chart are purely based on the delivery reliability perspective and do not include other aspects. However, the figures have been made with realism in mind to help the case company proceed with an implementable process model. (Figure 8; Figure 13.)
The production would first calculate the goods issue date as currently. If they cannot match the requested delivery date by the customer, an addition of one week to the delivery estimate is recommended to avoid any rush to meet the customer’s requirements, as the delivery performance decreases when there is a disparity between the days, as evident from the data. (Figure 9; Figure 14.)

The study recognizes five risk countries to account for in the final process model. For confidentiality reasons, these countries are E, J, S, W, and X given that multiple countries are represented by singular companies, which does not qualify these countries to be labeled as risky due to insufficient sample. For the risk countries, an additional buffer of 5-7 days is advised, depending on the riskiness of the country. For the countries that not mentioned, no adjustments based on the riskiness of the country is advised. (Figure 12; Figure 15.)
7.3 Process chart

A process chart is introduced to improve delivery reliability and help the production department make more accurate estimates for the delivery dates. As the quantitative data does not outright pinpoint the areas of improvement to a specific internal logistics process, the qualitative analysis of the professionals and their expertise is pivotal. For orders with payment or pick-up risk, it is crucial to recognize the characteristics of such orders. The study aspired to avoid confirmation bias and used other factors to decrease the detrimental value of payment or pick-up risk, as the variables of order size and date disparity are already heavily present in the orders with payment or pick-up risk. However, it is pivotal to take the payment and pick-up risk into account, as the factor itself is an extreme depiction of the other risk factors presented.

The research ran a simulation with revised goods issue dates according to the process model (Figure 16) to evaluate the results. Additionally, the blue boxes in the chart represent the current situation, and the red boxes the actions suggested. The simulation tried to reach realistic results for the case company, as adding an infinite number of days to the goods issue date, therefore technically reaching 100% delivery reliability but having detrimental effects on any other factor would not be feasible under any circumstances. However, as the study did not have a focal point of optimal delivery reliability without compensating for the delivery time, the research settled on figures that would improve the delivery reliability with minimum changes on other operational aspects.

The process chart reads from left to right, introducing a simplified mapping of the delivery time estimations on the left side, optimized with the data provided by the case company. The right side of the chart represents the flow of goods and information in the supply chain, highlighting the target area in grey. The chart introduces the current challenges in blue and suggestions for the needed actions in red. The challenges are placed at their respective spots in the supply chain, however, some challenges in information flow are hard to pinpoint specifically to a single point in the chain. (Figure 16.)
The current delivery time estimate consists of components, such as design, availability, and delivery time. After that, the order goes to the production department under evaluation when the order would be ready to be delivered based on the capacity, resulting in the delivery time confirmed to the customer. The flow of the delivery date estimation is presented as a process chart by using the risk factors above, namely the order size, date disparity between the goods issue date, and the country of shipment. Additionally, the interviews are used to map recurring issues in the internal logistics process, primarily located in the information flow close to the estimated departure of the company. (Figure 16.)

Currently, orders with heavy payment or pick-up risk have deteriorated delivery reliability and supply chain functionality, as they are risky in all the vital risk factors studied. Adjustments to the delivery date estimates are proposed to reduce the riskiness. Moreover, the recurring challenges found during the interviews have been mapped to showcase the challenges. The biggest challenge found during the interview was with the orders that did not go in terms of the pick-up or payment process. The production site produces the order ready to be delivered at
the end of the goods issue date. However, as often the information flow is insufficient, the customer service ends up either getting confirmation of incoming payment too late or the customer or the case company ends up starting to arrange the delivery too late, resulting in a situation where the outgoing deliveries have unneeded storage at the premises, increasing the inventory value. (Figure 16.) In many instances, particularly when operating under time constraints, sometimes due to delivery time pressure, customer service requests the packing list from the warehouse to initiate the delivery. Customer service is pressured to initiate the delivery and asks for the warehousing to pack the goods as quickly as possible and deliver the packing list. While not evident from the data explicitly, this arguably leads to more mistakes and damaged goods inside the warehouse. Decreased delivery reliability directly affects the inventory value and working capital turnover, as orders that need to be stored on the company’s premises increase inventory value and decrease the working capital available for the company.

7.3.1 Benefits

The case company would be able to make more accurate delivery date estimations, and delivery reliability would improve as more orders get delivered on time. Less capital is tied to inventory, as customer service can start billing the orders as they leave the case company. However, it is still reasonable to point out that the suggestions alone do not speed up the supply chain process, merely building a foundation for more accurate delivery forecasting. Furthermore, more accurate delivery date estimates arguably aid in cases where the delivery or payment risk is increased. Dündar and Öztürk (2024) found that on-time delivery has a substantial impact on customer satisfaction and loyalty, as the study found a positive relationship between timely delivery and customer satisfaction. (Dündar & Öztürk 2024, 2688-2689.) The current economic situation and increased delivery costs make customers order more than they can receive to avoid disastrous situations – tying capital into inventory when the customer is not willing to receive and pay for the entire order as agreed.

Additionally, as the estimates are more accurate, there is less movement inside the warehouse, resulting in less need to store the finished goods as they depart
quicker for the customer. Furthermore, accurate estimates allow the customer service department more effective communication with the customer and increase the faith in the delivery time estimations. To gather evidence of any benefits caused by using the process chart, a pilot test is recommended. This would optimally be conducted with the orders in mind that are heavy in risk characteristics, such as targeting customers with large order sizes to gather data on whether the estimated positive impacts come to fruition.

Both the customer service department and the production department emphasized the importance of recognizing the customers that take more time to pick up the shipment or take longer time to get the goods delivered, especially in cases of sea shipments. The data shows that Gardner Denver Oy struggles to estimate the delivery date in cases of volatility regarding payment and pick-up-related risks, as there are factors that are not entirely dependent on the case company, resulting in a driving factor in finding a solution that will help delivery reliability and ensure improvements in the key facets of logistics. As being listed as payment or pick-up risk is the highest single decreasing factor of delivery reliability, the solution must support improving the processes that will help improve the delivery reliability of those orders to recognize what causes the order to be marked as payment or pick-up risk (Table 1).

By applying all these adjustments based on the risk factors presented, the study simulated the open orders of 2023 to project the potential changes in delivery reliability. If all the adjustments based on the risk factors were to be applied, the case company would have seen a sizeable increase in the percentage of orders delivered on time. As the orders lower in quantity are significantly less heavy in risk characteristics than the orders larger in quantity, the increase simulated is only evident in the larger orders as the orders of 7-8 items in size and nine or more in size grew 4 and 5 percentage points in the simulation, respectively. (Figure 17.)
When highlighting the adjustments made to the goods issue date for different risk characteristics, the shift in riskiness is evident in bigger orders. The orders of nine or more items in quantity were over double the amount of time late on average in comparison to the orders of 1 or 2 items in quantity in the beginning. However, these adjustments made a positive impact on the risk factor, reducing the riskiness to 1.85 times the days later. A similar trend was evident in the orders of 5-8 items in quantity. However, it is essential to note that these simulations are theoretical and simplified to isolate the change of a singular factor. (Figure 18.)

Assumingly, this should ensure that fewer entries will be placed on the payment or pick-up risk and thus have a decreasing effect on the entire supply chain. Minuscule changes to the delivery date promises can have a significant impact on overall delivery reliability, as highlighted in the simulations above.

### 7.3.2 Shortcomings

The potential shortcomings of implementing the process chart (Figure 16) would likely be related to conclusions based on insufficient data. Before implementing the actions recommended in the chart, more data collection and analysis of the topics proposed in the chart is recommended. The actions proposed are taken
with the potential of having insufficient data in mind while staying open to any potential false conclusions. Making changes to the current operational practices is always costly, and making further financial calculations of the potential benefits of implementing the actions pivotal to forecasting whether the benefits would offset the costs. The risk of over-optimization is always present. In maximizing the overall efficiency of internal logistics, the risk of optimizing processes to the extent of them becoming overly complex is present, making it difficult to operate.

7.4 Improvements on internal logistics processes

To address the core research question, the interviews were conducted to understand the entire operational process and find specific areas where the lack of delivery reliability is affecting. The machinery is manufactured to ensure that the oldest orders are produced first, eliminating situations where the newer orders would cause insurmountable delays to the older orders. However, as the production manager stated, the process currently does not take the order size into account optimally in processes such as painting the machinery in customized orders. The process chart presented would ensure a smoother process of orders and more even delivery reliability between orders of distinct sizes, improving the overall information flow and operational performance.

Implementing the processes introduced in the chart would allow the company to initiate the delivery process well on time to ensure that the orders do not end up marked as payment or pick-up risks, maximizing the possibility of reducing any storing at the end of the supply chain. In the optimal situation, the case company would try to reduce any storage after the order is ready to be dispatched to a minimum. As the improvements are mostly related to the information flow, the solution must address the challenges of the current economic environment. Customers tend to order more than they can receive due to increased delivery costs, increasing the chances of unneeded stocking as customers do not want to receive and pay for the entire lot.
8 CONCLUSION

The realm of internal logistics research holds societal importance as it plays a crucial role in the sustainability and resilience of the supply chain. The research has focused on augmenting the internal logistics processes of the case company. By improving this metric, subsequent improvements in key performance metrics studied, namely inventory turnover, capital turnover, and invoicing timeliness have been observed, highlighting their interconnectedness and impact on the entire operational performance. Through comprehensive research and analysis, the thesis has identified specific areas of improvement and their impact on performance through substantial quantitative and qualitative analysis. Ultimately, a resilient and fundamentally coherent supply chain management framework enables businesses to react effectively to different societal conditions and challenges, supporting economic growth and creating prosperity for the involved people around the globe.

The result of the research is a process chart that shows recommended actions to improve delivery reliability through precise delivery time estimations in cases of larger orders, increased number of days between the requested and confirmed delivery date, or certain countries of delivery. These orders are highlighted as having excessive payment or pick-up risk. Moreover, the study has found recurring issues and challenges during the qualitative research to enhance the end of the supply chain performance. These challenges are mostly related to the information flow inside the processes. The findings pinpoint valuable insights into the field of supply chain management, highlighting the need to address these challenges named in the process chart. All these multifaceted metrics have a substantial impact on the overall operational and financial performance. The study has established that multiple key factors, namely order size, number of days between the requested delivery date and the goods issue date, and country of origin as the pivotal factors that contribute negatively to delivery reliability. The findings on the key factors have laid the foundation for the process chart as key findings to build any improvements. Additionally, the qualitative research conducted found challenges in information flow, as in cases of increased risk of decreased delivery reliability, the company often struggles to get delivery or payment sorted to initiate delivery on time. The end of the supply chain is often rushed, causing customer
service not to have the packing list on time to start the delivery process, which has a detrimental effect on reliability. The current economic downturn causes the order sizes to increase as the increased delivery costs incentivize the customer to order more than they need, bringing the case company to a challenging environment.

Despite the limitations encountered during the research process, such as insufficient quantitative data to provide mathematically optimal adjustments for delivery date estimations, the study establishes a foundation for future research on internal logistics, offering practical recommendations for operational optimization in the field of internal logistics. By employing a substantial amount of data, the research can strengthen its reliability and validity as a foundation of the recommendations. In summary, the thesis underscores the significance of delivery reliability in enhancing other critical factors crucial to internal logistics success. The process chart introduced serves as a valuable instrument for Gardner Denver Oy to pinpoint further research on the subject, paving the way for continuous enhancement in internal logistics optimization.
REFERENCES


Tainala, A. 2023. Measuring and improving supplier delivery reliability. Lappeenranta-Lahti University of Technology LUT.


APPENDICES

Appendix 1. Interview questions for the customer service of Gardner Denver Oy

What has been the biggest challenge of your work in your department during the last twelve months?

What are the biggest factors that affect delivery reliability in your department?

How is the information flow within the departments and with the customers and freight forwarders ensured in your department?

Does the purchase order size affect how the orders are managed in customer service?

How is communication between the case company and the customer managed in situations when it is not possible to deliver at the requested delivery date? Are there differences between how the orders are overseen across different customers?

How is the effectiveness of invoicing ensured?

How is the service level and delivery reliability measured across the customers?
Appendix 2. Interview questions for the production manager of Gardner Denver Oy

Would any kind of process model to improve delivery date forecasts be useful in your work?

How does the process flow in terms of internal logistics when the compressor or unit is finished before it gets shipped to the customer?

Could you describe the process of how the delivery date is decided? What factors play into it?

How do late orders affect the work at the end of the supply chain?

As you see from the daily work of the production department, is there any specific part of the process that is not optimal at the moment? Especially when the finished products are not shipped on time to the customers.

What is done when noticed that the order does not get shipped on time?
Appendix 3. Interview questions for the material and the purchasing departments of Gardner Denver Oy

How is the material and component purchasing process conducted?

What kind of challenges there is in ensuring everything is in order from the delivery reliability point of view?

Is the information flow optimal, and what could be done to improve that?

How does the overall flow of materials handling change when comparing customers with established relationships to customers with newer partnerships?

Do any issues getting the finished products delivered affect the purchasing or materials handling?

How would you describe the current problems of the supply chain overall?
Appendix 4. Interview questions for the accounts receivable department of Ingersoll Rand

Overall, what would you say are the biggest challenges of the accounts receivable department at the moment?

How do you practically escalate cases when the customer does not pay by the due date? Especially in down payment cases to initiate the delivery process.

What kind of strategies or actions are there at the moment for improving the capital turnover and overall collection process?

What metrics does Ingersoll Rand have in measuring the effectiveness of the accounts receivable department?

How does Ingersoll Rand mitigate payment risks overall in your department?

Does Ingersoll Rand categorize customers based on the customer’s risk profile? Especially when processing new orders in cases where the customer has a history of overdue payments.
Appendix 5. Interview questions for the global operations leader of Ingersoll Rand

Firstly, could you describe the key responsibilities you oversee?

In general, what has been the biggest operational challenge in your work during the last twelve months?

Are there currently any ongoing trends that impact the operations in general? If so, what are those trends?

What key performance indicators are used in your work to measure efficiency in supply chain operations, inventory management, and overall financial performance?

How is data-driven decision-making implemented in your work? Could you describe the process?

What kind of action does Ingersoll Rand take to ensure maximum financial performance in terms of inventory and capital management? Especially in cases where the shipments are late for the forecasted delivery date, and the company cannot get the capital from the customer on time.
Appendix 6. Interview questions for the financial analyst of Gardner Denver Oy

Does delivery reliability play a part in calculating the financial indicators?

How is it shown in the reports if there are a lot of orders late and the company cannot convert orders into working capital?

Are there financial indicators that change rapidly if the company does not get orders delivered?

How does the case company control financial risks?

How does delivery reliability affect working capital turnover?