Impact of lean maturity assessments

Measuring the moderation of lean maturity assessments in a warehousing environment to support a lean transformation at Rhenus Warehousing Solutions.

Author:	L.J. (Laurens) Anthonise
MSc Program:	Supply Chain Management
Faculty:	Tilburg School of Economics and Management
SNR:	2090359
ANR:	563949
Supervisor:	Prof.dr.ir. J.C. (Jan) Fransoo
Second Reader:	S.I. (Iman) Moosavi
Company Supervisor:	M. (Mark) van Klinkenberg
Date:	7-6-2024
Word Count (Main Part):	12,713 Words

Abstract

Purpose

This research paper is written for Rhenus Warehouse Solutions to investigate whether the use of lean maturity modelling has quantitative impact for warehouse performance. In its introduction in 2020, it has made qualitative improvements within the company, and improved employee satisfaction. However, it remained undecisive if it improved the warehouses' output, quality, and overall operations. It could strengthen the idea that it would lead to improved warehouse performance for Rhenus locations all around the world. It is aimed at experts in warehousing environments to gain better understanding in lean warehousing with tools such as lean maturity modelling to support the lean transformation.

Methodology

The Difference-in-Difference approach was applied to indicate a break in trend to visualize whether the use of lean maturity modelling moderates the relationship between a lean transformation and warehouse performance. To establish a measurement for performance, 9 KPIs related to time, quality, utilization, and productivity were focussed on to gain insight in the different warehouse dimensions of inbound, storage and outbound.

Findings

The DiD approach indicated that the moderation effect is positive for the average outbound throughput time, picked items per man-hour, and safety. A negative moderation effect is visible for the storage accuracy. An improbable moderation effect is established for the remaining KPIs; average inbound throughput time, putaways per man-hour, location utilization, incoming goods accuracy, and perfect orders.

Originality

This thesis presents an original contribution to the field of lean warehousing through the exploration of the moderation effect of lean maturity modelling. Unlike previous studies, that applied maturity modelling in lean manufacturing environments, this research applies its principles to a warehousing environment.

Keywords: Lean Transformation, Lean Warehousing, Warehouse Performance, Maturity

Preface

This thesis represents the final step of my Master` in Supply Chain Management at the Tilburg University of Economics and Management. It also represents a period of almost 8 months of hard work on the topic of lean warehousing and warehouse performance. These months have been a valuable learning experience to my scientific, professional, and personal development.

Therefore, I would like to thank Rhenus Warehousing Solutions for the opportunity to write my thesis at the company. It has been a pleasure to work in the challenging environment of a multinational firm. I would like to thank Mark van Klinkenberg, my company supervisor, for his support and steering during the project. I would also like to thank prof.dr.ir. Jan Fransoo, my university supervisor. I am grateful for both their input, feedback, and flexibility.

Finally, I would like to thank my family and close friends for supporting, encouraging, and stimulating me in their own ways during my educational experience. Thank you for all the help, opportunities, and support. Without you, I could not have done this.

Laurens Anthonise
Tilburg, 2024

List of Abbreviations

AITT	Average Inbound Throughput Time
AOTT	Average Outbound Throughput Time
CBSLAP	Class-Based Storage Location Assignment Policy
CVI	Content Validity Index
CVR	Content Validity Ratio
DiD	Difference-in-Difference
IGA	Incoming Goods Accuracy
LU	Location Utilization
PIpMH	Picked Items per Man-Hour
PO	Perfect Orders
PpMH	Putaways per Man-Hour
QMMG	Quality Management Maturity Grid
RWS	Rhenus Warehousing Solutions
SA	Storage Accuracy
SKU	Stock Keeping Units
VAL	Value Added Logistics
WP	Warehouse Performance
WMS	Warehouse Management System

List of Tables and Figures

Table of Contents

1. Introduction

1.1. Background

Warehouses are facing increased fluctuations in demand and supportive services over the past years, stressing efficiency and waste reduction (Volodymyr et al., 2020). To cope with this shift, the lean ideology could be applied (Autry et al., 2005, Baruffaldi et al., 2020; Pereira et al., 2020). With its main principles originally aimed at the manufacturing environment, service industries were the first to apply the principles in the '90, because of their special characteristics compared to the manufacturing environment, such as intangibility (Gupta et al., 2016). Consequently, other industries saw its potential to create a competitive advantage, which led to the adoption of lean principles in the service industry and reached the distribution and warehousing sectors (Abushaikha et al., 2018; Bonilla-Ramirez et al., 2019; Douglas et al., 2015).

Rhenus Warehousing Solutions (referred to as RWS) is also undergoing this development. Rhenus is a third-party logistics service provider with hubs in the south of Country "A", situated close to the highway with 350 employees, and 40.000m^2 of storage area. The lean- and continuous improvement ideology arose within in the company a decade ago and is being implemented on all levels at their site. Three years ago, the department introduced the lean maturity model to measure progress across the site, with its aim to improve warehouse performance and reduce waste.

1.2. Problem Indication

Rhenus recognized the possible pitfalls that come with introducing lean- and continuous improvement ideology and used a gradual approach towards more an automated and optimized warehouse ecosystem. Moreover, Rhenus introduced an internal lean maturity assessment tool in 2020, to monitor the development of implementing lean. However, sites outside of Country "A" do not work with this model to monitor performance. Rhenus Country "A" is looking for ways to externalize this concept and make it the global golden standard. Consequently, the question arises: "Does the yield of improvement increase whilst working with a lean maturity model". Rhenus in Country "A" is convinced that lean maturity positively contributes to continuous improvement and would like to have research done whether this is true, to apply its ideology on a global scale.

Existing literature has indicated that maturity models' purpose is requiring improvement measures for different levels of maturity in the current level of a measurement, desired goal, and quantifiable means to achieve the desired goal (Salhieh & Alswaer, 2021). Likewise, Schiele (2007) puts it:

“Maturity describes the stages which an organisation is expected to go through in its quest for greater sophistication”. Despite maturity models being present on a supply chain level of analysis, there is not a specific maturity model for the lean warehousing aspect of supply chain management linked to improved warehouse performance. Nonetheless, preliminary efforts have developed lean warehouse maturity models (Razik et al., 2017), assessment tools (Mahfouz, 2011; Sobanski, 2009), warehouse audits (Anđelković et al., 2016), and best practices (Dotoli et al., 2016) on a global-, national- or industry specific level of analysis (Salhieh & Alswaer, 2021; Fraser et al., 2003). In further detail, Razik et al. (2017) suggested a warehouse maturity model aimed at identifying the biggest problems affecting warehouse performance in Moroccan companies. However, their proposed model focusses exclusively on identifying obstacles to performance improvement and does not provide a comprehensive approach. In addition, the efforts to target the warehouse performance did not identify the impacts of warehouse practices and the causational cause. Furthermore, literature has suggested different performance initiatives to evaluate current warehouse performance. Moreover, use specific activities in a warehousing environment (Faber et al., 2013; Goomas et al., 2011; Lao et al., 2011).

This emphasis on warehouses within the supply chain resulted in studies performed improving warehouse functions with the available resources through minimizing non-value adding activities in the warehouse processes. However, differences arise among performance measures in warehousing contexts. Staudt et al. (2015) made the distinction between *direct* and *indirect* warehouse performance measures. *Direct* in this context are metrics that are easily computable and can be expressed mathematically. Whereas *indirect* in this context requires more sophisticated tools of measurement. For both, a classification is made to evaluate its dimensions. Direct performance measures are:

- *Time*
- *Quality*
- *Costs*
- *Productivity*

Examples of indirect performance measures are:

- *Labour*
- *Value Adding Logistics (VAL)*
    - De Koster and Balk (2008) divide VAL activities in high and low categories. Low activities include labelling, whereas high activities being sterilization and order assembly.
- *Inventory Management*
- *Warehousing Automation*
- *Customer Perception*
- *Maintenance*

Each of the topics envelop a diverse range of detailed KPIs, forming a holistic cluster by bringing together different aspects of warehousing (Staudt et al, 2015).

Connecting the variables of interest in this research creates a better understanding in its relationship. The evaluation of lean in warehouse activities by Pereira et al. (2020) confirms that applying lean principles can lead to significant improvement in warehouse performance, resulting in waste reduction, improvement of the lead-times and better value creation. In addition, findings of Shah and Khanzode (2017) resulted in a proposal on lean warehousing that improves efficiency and reduces waste in warehouse operations. Moreover, Abushaikha et al. (2018) indicated that a positive relationship between warehouse waste reduction and operational performance was present. Tahboub and Salhieh (2019) confirmed this relationship, focussing on the relationships among lean warehouse waste reduction practices through and operational performance.

Moreover, the few empirical studies confirm the literature, indicating that lean warehousing leads to reduced operating and lead time, increases productivity and minimizes inventory. However, empirical proof remains limited, because it has not been researched in many different contexts, and Critical Success Factors (CSFs) are mainly applied on an industry level of analysis. Moreover, there has been little application of lean on a company level. Furthermore, a summary of the literature by Demirkesen & Bayhan (2022) focussed on lean implementation in the construction industry, and found that *Management Commitment*, *Customer Satisfaction* and *Lean Training* were the most significant success factors. On the other hand, *Market Share* and *Government Incentives* were less significant.

1.3. Theoretical Contributions

This research departs from the previously examined context, i.e., lean warehousing and warehouse performance, by investigating whether working with lean maturity modelling contributes to extended improved warehouse performance. It complements research proposed by Battista & Schiraldi (2013) and Salhieh & Alswaer (2021), which stated that maturity models prescribe potential for warehouse performance improvement. Therefore, maturity models need to acknowledge current and future levels of maturity to come to various improvement performance measures. Current literature indicates that maturity models positively affect warehouse performance. Lean principles and warehouse performance share the same relationship.

However, the combination of lean warehousing and lean maturity assessment is an under-researched topic. This is because a positive relationship has been established between lean and warehouse performance, similarly between maturity assessments and warehouse performance. Moreover, the combination of the two constructs has been explored, but indicated that it lacks empirical support to support its claim (de Visser, 2014). That is why this study provides insight into the extent to which lean maturity modelling contributes to improved performance in warehousing moderated by lean maturity modelling.

1.4. Managerial Implications

This research is aimed at providing insight into the aspect whether the use of a lean maturity model contributes to a lean transformation to improve warehouse performance. Since Rhenus in Country "A" is certain that lean maturity positively moderates the relationship between lean transformation and warehouse performance, it wants to make a case to apply it to Rhenus Europe. By researching this topic, it could strengthen its proposition and incentivise other Rhenus sites to apply the same principles and ideology. Improving warehouse performance could potentially lead to cost reduction, increased warehouse productivity, and increased inventory accuracy (Lee et al., 2017).

1.5. Problem Statement

To what extent can a lean transformation be improved to increase warehouse performance, moderated through lean maturity modelling?

1.6. Conceptual Model

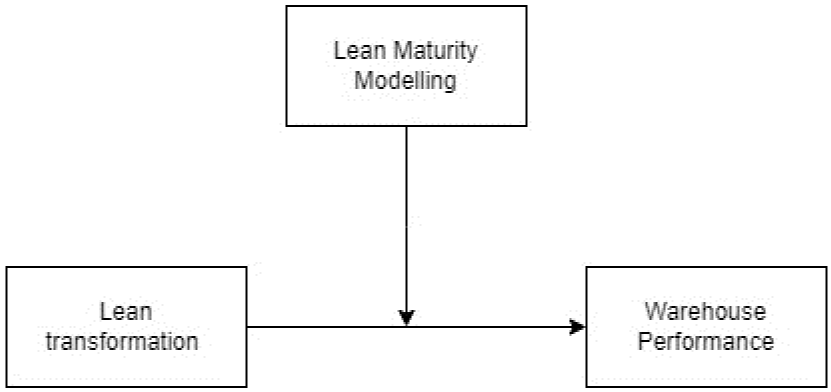

Figure 1: Conceptual Model

1.7. Research Questions

To answer the research question, the sub-questions are structured the following:

- Theoretical questions
  - What is Lean Maturity Modelling?
  - What are the characteristics in warehouse performance at Rhenus?
  - How do problems in warehousing affect warehouse performance?
  - What is a lean transformation and how does it affect warehouse performance?
- Empirical question
  - To what extent does Lean Maturity Modelling moderate the relationship between a lean transformation and warehouse performance?

2. Literature Review

This chapter highlights the theoretical grounding of the constructs related to warehousing and its contextual factors. Followed by methods on how to empirically analyse warehouse performance. To make the transition to the lean approach in a warehousing environment, it is necessary to understand its definition, process, and typology. The subsequent step is to understand what the state of current literature is regarding the relationship between lean warehousing principles and warehouse performance. Moreover, measuring the impact of lean warehousing on warehouse performance, and the concept of maturity modelling are of equal importance to gain understanding in its probable moderating property.

2.1. Warehousing

Different aspects influence how effective and efficient a warehouse operates. Complex decisions in this context are the rule rather than the exception. Considerations on warehouse design and policy choices are essential to get right for functioning warehouses (Bartholdi & Hackman, 2019). According to Rouwenhorst et al. (2000), there are only two types of warehouses: distribution warehouses and production warehouses. Others propose seven different types: raw materials, finished products, distribution centres, bonded, public, contract, and overflow warehouses (Manzini et al., 2015). To summarize, regardless of the authors' viewpoint, different types of warehouses need to have their own set of requirements and priorities.

2.1.1. Contextual factors in warehousing

In the operations management literature, a generally accepted theory is that the externally orientated context influences the technical fit of the warehouse operations (Sousa & Voss, 2008). Jahre et al. (2016) add to that by specifying that the characteristics of the market, the products, and the processes determine the way warehouses in supply chains are managed. In the management sciences literature, there is consensus among researchers on two organizational and contextual factors: complexity (other terms used: internal variety, detail complexity or static complexity) and uncertainty (other terms used: environmental dynamism or dynamic complexity)(Zailani & Rajagopal, 2005). Since complexity is aimed inwards in an organization, it is in scope of this research's literature review. Uncertainty is aimed outwards and, although indirectly influences warehouse performance, a nuisance variable in this research. Nevertheless, peripheral factors will be considered since it impacts the external validity but are not of key focus of this research.

2.1.1.1. *Design and resources*

2.1.1.1.1. Physical layout

The best warehouse layout is one that makes the most of the space whilst focus on a reduction in time spent travelling and the number of points of contact (Gu et al., 2010). During the design phase, the warehouse's working areas and space need to be taken into consideration. This capacity is closely linked to productivity and safety in the warehouse. Whilst it is desirable to have high storage utilization, too high utilization results in a dramatic decline in productivity and safety. It is important to note that it is favourable to focus on high equipment- and cube utilization rates. However, as Frazelle (2015) observed, a negative consequence of aiming for near-perfect utilization rates (approximately > 85%) is a powerful decline in productivity and safety, as visualized in Figure 2. In addition to the overall capacity requirements, various processes necessitate sufficient space to operate effectively. This, in turn, influences the need for capacity. Likewise, the spatial demands of different departments and zones within the warehouse will also impact the overall capacity requirements.

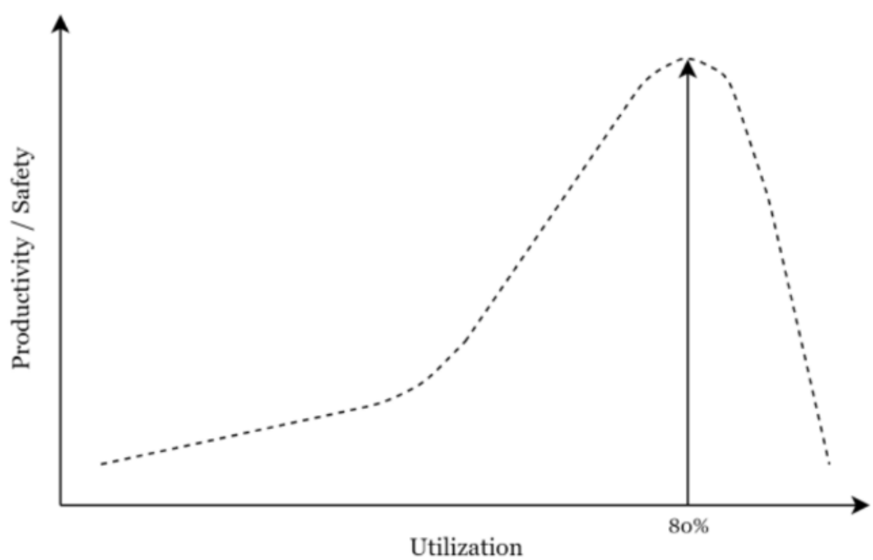

Figure 2: Warehouse productivity VS Utilization rates (Frazelle, 2015)

To achieve an optimum between enough space to operate effectively and efficiently, and overall utilization could be divided into two parts. The facility configuration i.e., receiving, sorting, picking etc., and the storage configuration, which is the layout of how the goods are stored. Considerations related to the storage configuration are the width and length of the number of aisles, and their orientation (De Koster et al., 2007; Gu et al., 2007). In addition, the configuration of the doors proved to have a profound effect on processes efficiency (Bartholdi & Hackman, 2019).

2.1.1.1.2. Complexity and throughput

Complexity is a consequence of the ‘inner’ boundary of the environment, i.e., the organization itself. Complexity refers to the variety and volume of the elements in an environment (Hatch, 1998). Warehousing systems can be characterized by the stock keeping units (SKUs) that must be stored and picked, the processes to store and pick these products, and the orders that request the delivery of these products. Complexity increases as the number and diversity of SKUs, order lines, and processes increase. In general, if the number of SKUs increases, more storage space (often different type and control logic) will be needed, and more products must be registered and managed in the warehouse information system. Some warehouses have a greater number and/or variety of processes and some of these activities are labour intensive and have substantial impact on order throughput time. The number of order lines is an indicator for the total amount of work in order picking and thereby for work done in the warehouse. In general, most of the warehouse work is in order picking (Masae et al., 2020). It conceptualizes environmental complexity regarding warehouse performance as the complexity of the task a warehouse must perform. Thus, warehouse complexity is defined by:

- The number of different SKUs handled in the warehouse.
- The total number of SKUs handled in a warehouse for a given period.
- The number of processes.
- The variety in processes carried out by the warehouse.
- The number of processed order lines by the warehouse for a given period.

Overall complexity affects warehouse performance through the comprehensibility of the work to be done. Similarly, it influences the throughput of a warehouse, which is directly related to the number of SKUs pass through the process.

2.1.1.1.3. Automation

Automation is another area of concern for warehouse design (Kembro et al., 2018). Automation can mean different things, but the idea behind it is to utilize machines in different contexts to reduce the need for manual labour (Bartholdi & Hackman, 2019). Furthermore, companies also employ automation solutions to accommodate growth and improve customer service (Baker &

Halim, 2007). There are different types of automation for different applications. An example of this is pallet-placed storage, which can be automated with an automated storage and retrieval systems. In addition, pallets can be transported with automated vehicles (Bartholdi & Hackman, 2019; Baker & Halim, 2007). However, every level of automation involves high investment costs (Baker & Halim, 2007). According to Varila et al. (2005), this principle increases with size. The proposed level of automation requires the right prerequisites such as throughput. In Figure 3, the framework proposed by Varila et al. (2005), provides an assessment tool to indicate which level of automation is appropriate for different contexts. Here it becomes clear that to come up with an automation solution, volume needs to be sufficient to flow through the warehouse or that the differences in SKUs are both high and complex. Additionally, choosing the correct automation and the correct level of automation is important for the efficiency of the solution, on account of getting it wrong can decrease efficiency (Baker & Halim, 2007).

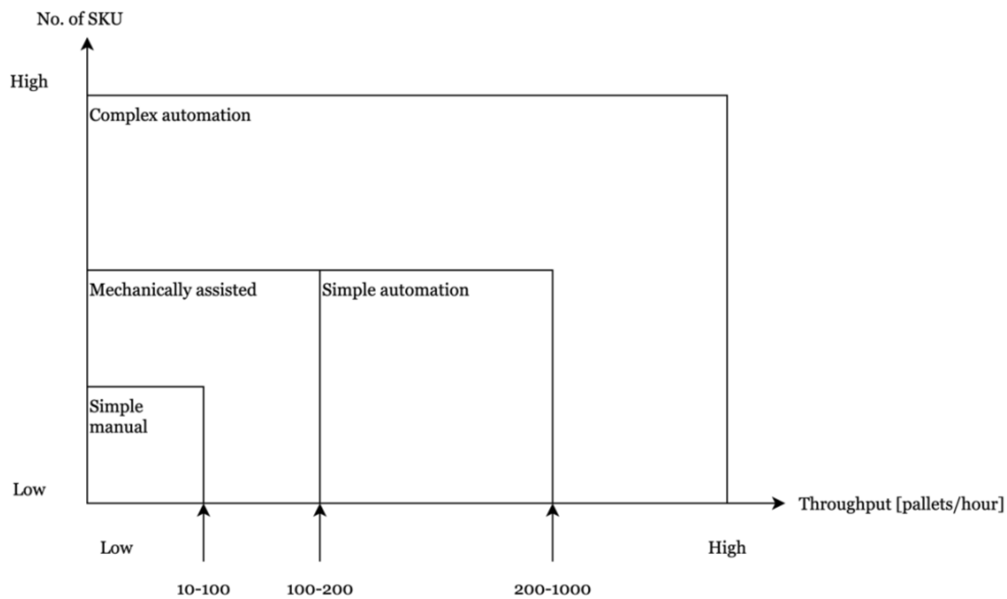

Figure 3: Assessment of the level of automation (Varila et al., 2005)

2.1.1.2. Policy choices

2.1.1.2.1. Storage

Storage assignment is one of the most important factors affecting the performance of picking in warehousing. Selecting the appropriate storage assignment policy leads to an improvement in the performance of picking (Chan & Chan, 2011). The storage allocation policies which assign products to storage locations generally fall into three broad categories: random storage, dedicated storage, and class-based storage (Hausman et al., 1976). Random and dedicated storage are extreme cases of the class-based storage policy. Random storage has all products in a single class and dedicated storage has each of the products assigned to a separate class.

The main idea of class-based storage location assignment policies (CBSLAP) is to divide items into classes. Each class is then assigned to a dedicated area of the warehouse. This implies the possibility that the storage policy within an area is random, but it is not always the case. An advantage of this is that fast-moving products can be stored in proximity of inbound and outbound while the flexibility and high storage space utilization of random storage are applicable.

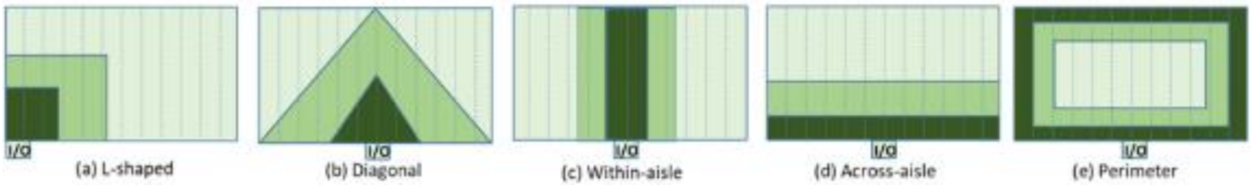

Figure 4: Variations of class-based storage policies (Bahrami et al., 2019)

Generally, there are two kinds of class-based storage, dedicated purposes (Liu, 1999), and ABC classification. (Ashayeri et al., 2002). On the other hand, storage assignment is mainly divided into the products and frequency of incoming customer orders. For products, Brynzér and Johansson (1996) pointed out that CBSLAP focused on product characteristics can increase the accuracy of picking and reduce order retrieval time. Most studies used turnover rate as its main principle to classify items for storage assignment (Chiang et al, 2011), but other criteria, visualized in Figure 5, may also be applied for this purpose. To specify, the dimensions given of dedicated CBSLAPs are serving as examples. Other options that improve CBSLAP fall under the similar category.

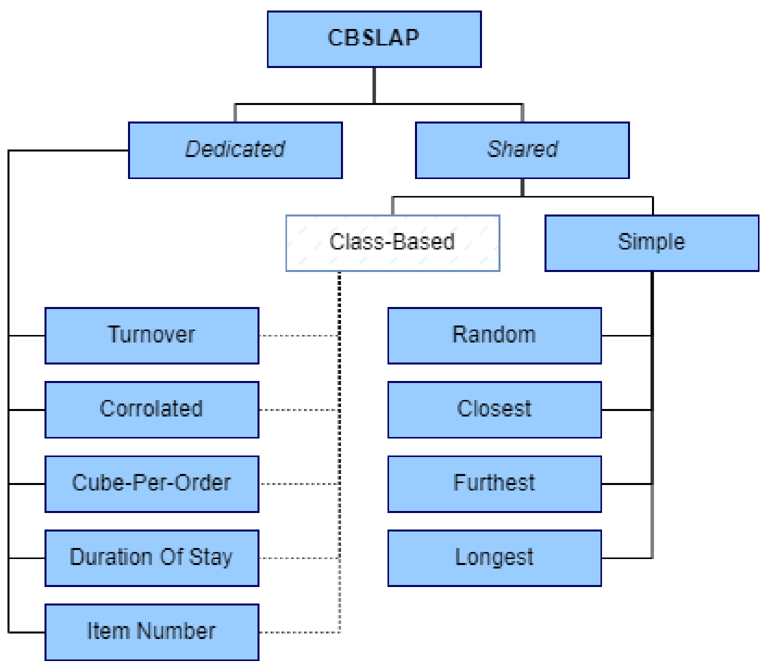

Figure 5: Classification of storage policies

2.1.1.2.2. Picking

The efficiency of picking operations is closely tied to the configuration of classes and aisles. Reducing the number of aisles would increase the capacity of each class or storage space. Consequently, it leads to a reduction in freedom of movement, which can cause congestion. To conclude, there is no fixed rule to define a class barrier (number of distinct classes, percentage of different items per class, and percentage of the total pick volume per class) for picking in the warehousing literature. Likewise, the optimal picking depends on the contextual factors. This leads to the discussion on how a combination of different factors (storage assignment policies, routing policies and pick volumes) affect warehouse performance.

2.1.2. Warehouse performance

There are many methods for classifying warehouse performance measures (Kusrini et al., 2018). Performance warehouse is based on traditional logistics performance measures include 'hard' and 'soft' metrics. The first one considers quantitative measures such as order cycle time, location utilization rates and costs. In addition, the second deals with qualitative measures like the overall perceptions of customer satisfaction and levels of loyalty. In line with other warehouse performance measures, the model of Frazelle classifies performance measured condensed into 25 KPIs, as is visible in Figure 6 (Frazelle, 2015; Kusrini et al., 2018).

	Financial	Productivity	Utilization	Quality	Cycle Time
Receiving	Receiving cost per line	Receipts per man-hour	% Dock door utilization	%Receipts processed accurately	Receipt processing time per receipts
Putaway	Putaway cost per line	Putaways per man-hour	% Utilization of putaway labor and equipment	% Perfect putaways	Putaways cycle time (per putaway)
Storage	Storage space cost per item	Inventory per square foot	% Locations and cube occupied	% Locations without inventory discrepancies	Inventory days on hand
Order picking	Picking cost per order line	Order lines picked per man-hour	% Utilization of picking labor and equipment	% Perfect picking lines	Order picking cycle time (per order)
Shipping	Shipping cost per customer order	Orders prepared for shipment per man-hour	% Utilization of shipping docks	% Perfect shipments	Warehouse order cycle time

Figure 6: Warehouse KPIs (Frazelle, 2015)

In literature, there is no agreement among researchers which KPIs are the most suitable to measure warehouse performance. Therefore, out of the highlighted KPIs in Figure 6, the most crucial KPIs for warehouse activities were identified utilizing the analytical hierarchy process. In accordance with their corresponding categories, these were:

- Put aways per man hour (Productivity)
- Put aways cycle time per put away (Cycle time)
- % of locations and cube utilization rates (Utilization)
- Order picking cycle time per order (Cycle time)
- Orders prepared for shipment per man-hour (Productivity)
- % perfect shipments (Quality)

In this research, similar indicators of the model of Frazelle will be applied, because it is in line with measurement parameters proposed by previous researcher and considered relevant for the warehouse environment. More KPIs related to lean warehousing in combination with warehouse performance are mentioned in Chapter 2.3.1.

Laosirihongthong et al. (2018) built on the model of Frazelle by making an extensive literature review, identifying warehouse performance measures, and presented a conceptual framework. The Q-sort method was used to classify measures into four groups. Then, utilizing the opinions of decision-makers from different industries, a fuzzy analytical hierarchy process (FAHP) was adapted to rank each performance metric inside each category. Its outcome demonstrates that controlling warehouse operations is dominated by the financial performance category across the different industries studied. This outcome could be perceived as ambivalent compared to Frazelle, where no financial performance indicators were prioritized.

Karim et al. (2020) evaluated the model by Staudt et al. (2015) mentioned in Chapter 1.2., and added a more in-depth level distinction for warehouse productivity performance indicators by highlighting the activity indicators and input resources of the warehouses. Examples of added productivity indicators are equipment picking productivity, labour putaway productivity, or space staging area utilization. Its importance lies in its support to the warehouse performance measurement system. It is less focused on measuring the individual performance of each warehouse and overall productivity, and more towards the effectiveness and efficiency of an action or activity owing to customer demand and complete order fulfilment.

2.2. Lean Principles

Lean originates from the Toyota Production System (TPS), invented by Taiichi Ohno. Its goal is to create a continuous flow by elimination of waste. The two main methods to reduce waste are just-in-time (JIT) and autonomation. JIT means that parts go only to the next process after a trigger of end customer demand. Autonomation refers to mechanization with a human feeling (Ohno, 1978). By these principles it tries to reduce non-value adding activities (Womack et al., 1991; Ohno, 1978), such as:

- Defects
- Overproduction
- Waiting
- Unnecessary motion
- Unnecessary inventory
- Transporting
- Inappropriate processing

Womack et al. (1991) describes TPS as a production system capable of delivering the benefits of both mass-production and crafts production. By doing so Toyota cut costs and improved the flexibility of their operation. Most elements of the TPS have a high applicability within manufacturing companies (Womack et al., 1991).

2.2.1. Lean in a warehousing environment

To minimize non-value adding activities, warehouses must identify its wastes. The following seven wastes of lean production are converted to a warehouse environment.

(1) Defects: When items are damaged in the warehouse handling process, and repair or disposal is required. A drawback of this is that more items are returned or written off, leading to an increase in cost. These must then be processed, for which additional effort is required. When this type of error is detected, at the time of delivery, it requires improvised and non-standardized actions which stops the flow of the process.

(2) Waiting times: Waiting occurs when employees are ready, but due to the unavailability of products, machines, or the system in general, makes them unable to move to its subsequent step in the process. A typical example of waiting is during administrative processes for incoming goods, such as for checking that the products delivered match the invoices.

(3) Unnecessary transportation: This waste becomes evident in the unnecessary movement of products, workers, and forklift operators in warehouses. This type of waste becomes increasingly difficult when SKUs are not following the corresponding fitting storage- and picking policy, which can result in longer order retrieval times.
(4) Extra movement: This type of waste shares similarities with unnecessary transportation and occurs when employees must store or retrieve items in ergonomically uncomfortable locations. Meaning employees must reach or bend over to select items.
(5) Excess inventory: Inventory accumulation in warehouses leads to the overuse of storage space and low employee productivity due to obstructions caused.
(6) Unutilized resources: The examples of waste mentioned lead to the use of resources below their capacity. This also applies to employee’s talent, skills, and knowledge.
(7) Over-processing: This type of waste consists of excessive use of materials whilst not adding value to the customers demand or supporting processes.

Besides all research on lean in a warehousing context, practical examinations can also be useful to create a broader insight in the process of adopting lean practices in a warehousing environment. Practice was explored by conversations with lean warehousing specialist from practice and by guided warehouse tours through different warehouse locations. According to experts on lean warehousing, is that it is heavily culture-oriented and less about its implemented practices and its corresponding KPIs. Within a production environment lean is, by focusing on customer demand instead of relying on forecasts, focused on creating pull and flow. The focus on pull and flow is less relevant in a warehousing context since almost all warehouse processes are driven by customer orders.

Lean warehousing accentuates the importance of process visualization and performance measurement. In all warehouses visited, independent departments had their own information boards with an overview of department specific KPIs that are measured on a daily base. Examples of such KPIs are safety incidents, work pleasure, productivity rates, project progress. The information board functions as a starting point of every day. Employees gather around the board discussing the KPIs of the day before, as well as expected workload for that day, potential problems, and potential preventive- and improvement actions. Together, the employees are responsible for the KPIs to create commitment within the team to the performance.

Top and middle management apply the value stream mapping (VSM) practice to focus on broader scales. VSM provides a guideline for process redesign and aims to reduce non-value adding steps in warehousing. Operational team leads indicated that value stream mapping is a complicated process for warehouse operations. Warehouses, compared to production environments, are more organized based on functional departments rather than on value streams. Consequently, VSM involves multiple departments making the mapping process more complicated.

On a more detailed level, lean warehousing mostly focusses on reducing travel distances to create efficiencies in storage and picking. Therefore, practices as ABC storage and flow picking are usually present in all warehouses. All these principles are not specific to lean warehouses and are also applied to non-lean warehouses. Nevertheless, the focus on waste reduction should increase its significance. Literature indicates that management is not always aware of the importance of these kinds of improvements and rather focus on tangible measurable practices (Salhieh & Alswaer, 2021). The warehouses involved have different opinions on the benefits of lean principles in the warehouse. However, all experts stated that increased productivity is hard to measure. Especially, since increased productivity can be the effect of external changes in environment or customer orders. First-tier clients have stated that they are impressed by the lean principles in the warehouse, because they look structured, clean, and more advanced than traditional warehouses. An external classified report studied the influence of lean on productivity and employee satisfaction. This study did not prove its improvements in productivity and employee satisfaction caused by lean practices by focusing on hard KPI related to warehouse performance. Its outcome was that improvements were present, but too marginal to exclusively state that its improvements could be caused by other circumstances.

2.3. Maturity Models

The concept 'maturity' is grounded in theory as 'a state of being complete, perfect, or ready' (Wagire et al., 2020). Having their roots in the field of quality management, maturity models imply progress from a current state to a future, more advanced state. They can be seen as audit tools to evaluate the current stage of a measured state. Adapted from the Quality Management Maturity Grid (QMMG), came that organisations evolve through five phases. These are in order, *uncertainty, awakening, enlightenment, wisdom,* and *certainty* (Sen et al., 2006). All are met during an organisation's climb towards managerial excellence.

Several benefits come from a mature warehousing process. Schneider (2008) proved in the data warehousing industry that the duration of a warehouse project can become more predictable if the process is mature. Whereas, data warehouse projects are usually very expensive, both at the time of initial installation and during operation. However, as the data warehousing process continues to move toward higher levels of maturity, the process becomes more manageable. That, in turn, could provide more predictable project durations.

2.3.1. Lean maturity modelling

Lean techniques have found their way into the warehouse environment, but the conditions of the warehouse environment differ from those in the production environment. Notably, the less technical nature of the warehouse allows more flexibility in process configuration. Another difference is that the higher degree of manual work in a warehouse causes increased fluctuations in process cycle times (Dehdari & Schwab, 2012). Understandably, it prompts the question if the lean techniques that were developed for the production environment are applicable in the warehouse environment. Whilst differences exist, some of the verified measurement techniques used in the production environment are also used in studies in the warehouse environment. From the literature, the components share the following similarities:

- The initial stage is to prepare implementation, where the environment has limited awareness about lean practices. A need to create a climate for change, where there is sporadic process optimization.
- The managed stage involves basic lean principles, and senior leaders adopt a common lean vision, and is communicated to the rest of the company. People are enabled and involved in processes.

- The defined stage is where parameters have been identified and vision is understood by most of the employees. This phase involves value stream management.
- The quantitatively managed stage is a proactive culture where the common vision is shared by the extended firms. Flows are implemented and there is a combined system of lean practices in place.
- The optimized stage is where there is being built on change and focus on continuous improvement. Stakeholders have internalized the new vision. Aim is to maintain continuous improvement and look for perfection.

The existing literature regarding intermediary levels of maturity has been condensed more extensively in Appendix 1.1.

Most studies, such as Reuter (2009), use KPIs to measure the impact of the lean techniques. However, it does not include a measurement of the lean maturity of the operation that improves the performance indicator (Reuter, 2009). Other studies used an assessment to analyse the lean maturity but did not relate it to the development of the performance indicator (Sobanski, 2009; Mahfouz, 2011). All the in-depth, verified, and reliable studies that measure the impact of lean techniques on the production environment were performed using a combination of the evaluation techniques. The studies on warehouse performance measure KPIs but they do not correspond their results to lean maturity measurements. Additionally, different samples are also not compared between each other. Other studies measure the level of lean maturity but do not link it with the development of the performance indicators. A comparison of warehouse performance indicators for warehouses that improve the lean maturity with warehouses that use other techniques is not known. This means that the applicability of verified measurement procedures for the impact of lean techniques in warehouses is still being studied.

Examples of KPIs measured to calculate the level of maturity in prior research in a warehousing environment are the following:

- % of on-time orders
- % of complete orders
- % of supplier orders received damage free
- % of accurate documents received
- Put away accuracy

- Total orders picked per hour
- % of orders shipped OTIF
- Process uptime / downtime
- Maintenance frequency
- Picks per employee per hour

A more extended overview regarding lean maturity measurement parameters in production- and warehousing environments is made in Appendix 1.2. This is to identify frameworks for benchmarks and success cases in the literature, while gathering relevant parameters to incorporate in this research.

2.4. Effect of Lean Warehousing on Warehouse Performance

A significant link between lean warehousing and improved warehouse performance has been proved by Sharma & Shah (2016) and Shah & Khanzode (2017). Two other studies to measure the relationship between waste reduction practices and their impact on warehouse performance (Abushaikha et al., 2018; Tahboub & Salhieh, 2019). Both indicated the existence of a significant positive relation of the waste reduction level on warehouse performance. The same construct applied to the external distribution performance. Furthermore, different case studies in the literature were found that had applied lean practices to the warehouse environment and investigated its effect on warehouse performance. Table 1 displays an overview of the studies conducted on applying lean to the warehouse environment and their results. It shows that the application of lean in the warehouse operations has positive effects on process time and productivity.

Table 1: Literature overview the relationship between lean practices and warehouse performance

Reference	Impact on Warehouse Performance
Garcia (2003)	Reduction of order processing time by 50% and lead time by 25%.
Cook et al. (2005)	Decrease of inbound cycle time by 71% and 76% decrease in inventory levels. The required storage space decreased by 51%.
Gopakumar et al. (2008)	Lean on the receive process of a warehouse, results in reduced turnaround time. From customers perspective reduced waiting time.
Dharmapriya & Kulatunga (2011)	Improved layout resulted in improvement on travel distance (reduced by 30%) and resource utilization.
Jaca et al. (2012)	Increase of productivity with 9,34% in overall warehouse productivity.
Dehdari (2013)	Increase of warehouse productivity by at least 5%.
Chen et al. (2013)	Experimental results show reduction of processing time, saving operational time.
Dotoli et al. (2015)	Improvements in the performance of the production warehouse.
Bashir et al. (2020)	Significant reduction in warehouse order processing time and labour cost.
Raghuram & Arjunan (2022)	Reduction of the travel distance by 88%.

2.5. Conclusion

The studies in the production environment analysed the impact of lean techniques on performance indicators. Several studies with a high sample size analysed the impact by combining the results of lean maturity studies and performance indicators. A positive impact of lean techniques on performance indicators is supported by many different independent studies. The similar approach was applied to the warehousing environment and the level of lean maturity was analysed using a lean assessment tool to support a lean transformation. In addition, performance indicators were analysed to determine the level lean maturity and indicated similar results.

Although researchers identified the potential of lean within a logistics environment, empirical evidence of the benefits implementing lean within these environments is limited. Neither in lean warehouses for analysing a correlation between higher maturity and higher performance nor between lean warehouses and warehouses without lean techniques for analysing how each group performs. Whereas different proposed models have a high level of attainment of the lean criteria, most papers do not focus solely on warehouse operations.

Meanwhile, research has indicated that different contextual factors have a profound impact on overall warehouse performance. Aspects such as physical layouts, levels of automation, throughput, complexity, and policy choices directly influence warehouse performance. In addition, maturity models help to pave the way for the lean transformation to commence. Literature has indicated that (top) management behaviour plays a key role in a lean transformation and is encouraged by a top-down approach. This alignment with lean warehousing, that accentuates the importance of process visualisation and performance measurement, is required since warehousing is a strong competitive market, where sites need a strong customer- and long-term vision. And these sustainable improvements are driven by engaged employees.

In conclusion, there is a gap between the levels of evidence for the impact of lean techniques on performance indicators in the different environments to encourage a lean transformation. It is currently not possible to determine the impact of lean approaches on performance indicators within the warehouse environment. Thus, this study is aimed to close this gap in evidence. Unfortunately, none of the existing lean maturity assessments that focus on internal warehouse operations are thorough enough to resolutely say that lean maturity assessments support a lean transformation in a warehousing environment.

3. Methodology

3.1. Research Nature

This research used a longitudinal comparative design to investigate the relationship between maturity and warehouse performance. The research wanted to examine the prevalence of lean maturity in relation to warehouse performance. An advantage of longitudinal research is that it allows insight into cause-and-effect relationships between constructs. Research has focussed on internal performance across Rhenus locations, leading to a site level unit of analysis, where these sites are viewed as independent entities.

The research, adopting a deductive approach, has taken place in the first six months of 2024. Because of this limited time, in combination with '*continuous improvement'* being a dynamic construct, the research could potentially be under informative of the relationship it is describing.

Since implementation occurred in 2020, it is important to know what the trends in warehouse performance were before the moment of lean implementation. The time horizon has gathered information from 2017 to end 2023 to ensure internal validity.

3.2. Research Strategy

A comparison between the focus group, that consists of sites that work with lean maturity modelling to assess warehouse performance, and control group, the sites outside of Country "A" that do not work with lean maturity modelling, is made. The outcome will be that a trendline follows from the gathered KPIs related to warehouse performance. The question arises whether a difference in trendline will occur after the moment of implementation. This Difference-in-Difference (DiD) approach followed an intuitive interpretation and could result in a causal effect using observational data. DiD focusses on change rather than absolute levels, having the ability for control groups to start at different levels of the outcome.

Moreover, the goal of this research is to investigate whether there is an observable change in the outcome trendline in the intervention group compared to the control group. Figure 7 graphically explains its aim. The intervention in this context is the implementation of lean maturity modelling to assess warehouse performance. The 'treatment' in this context means the implementation of lean practices in the warehouse.

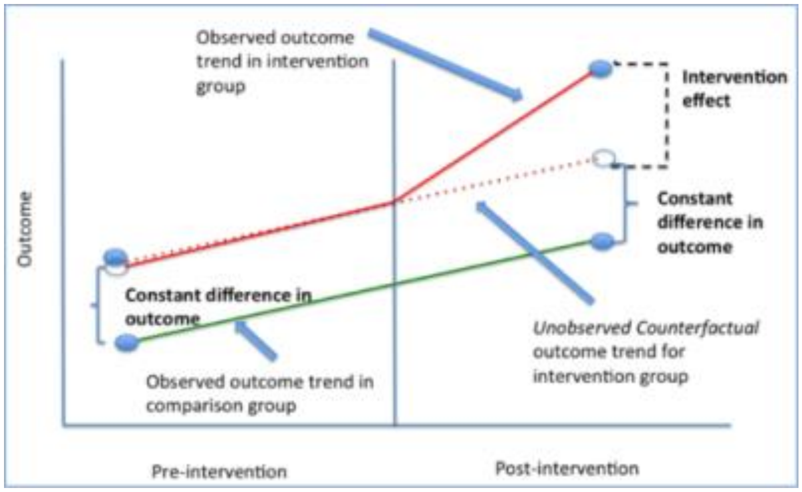

Figure 7: Graphical explanation of Differences-in-Difference (DiD) estimations.

With focus- and control group, in combination with the data of from the population of interest, the DiD estimate of policy impact can be written as follows (Fredriksson & De Oliveira, 2019):

$$DiD = (\bar{y}_{s=FocGr,t=Now} - \bar{y}_{s=FocGr,t=Start(2017)}) - (\bar{y}_{s=ConGr,t=Now} - \bar{y}_{s=ConGr,t=Start(2017)})$$

Here, $\bar{y}$ represents the outcome variable of the average values equating the KPIs of different warehouse locations. The group is ordered by s because the policies are implemented at the corresponding state level where *FocGr* and *ConGr* are the respective focus group and control group. Finally, t is time.

DiD research approaches rely on the assumption of parallel trends. Meaning that the treatment group and control group must follow similar patterns. Detectible or not, nuisance variables may cause the level of the variable of interest to differ between treatment and control but must be constant over time. One can lend support to the assumption, however, using several periods of pre-treatment data, showing that the treatment and control groups indicate a similar pattern in pre-treatment periods. If such is the case, the conclusion that the estimated impact comes from the treatment itself, and not from a combination of other sources. This includes those that cause the difference before treatment, becoming more credible. However, trends from the period before treatment cannot be checked in a dataset with a short trend assumption before the moment of treatment. Therefore, in general, such studies are less robust. A certain period before the moment of treatment is highly desirable and certainly a recommended "best practice" in DiD studies. (Shang & Rönkkö, 2022)

There are extra considerations for the use of Difference-in-Difference approach. With a non-random assignment to the focus group that receives treatment, there is always the concern that the treatment group could have followed a different trend than the control group. If, however, one can control external factors that differ between the groups, which would lead to differences in time trends (and if these factors are exogenous), then the true effect from the treatment can be estimated. More DiD considerations can be found in Appendix 2.2.

Below, each independent variable is explained what it entails, and how it is calculated. Chapter 2 indicated that lean warehousing involves a layered structure of underlying concepts. The main concepts involve underlying constructs, that consist of operational constructs. Each warehouse location has measured it themselves. The goal is to give a better understanding in its context, and how it applies to warehouse performance. Variables are available since they are measured within RWS.

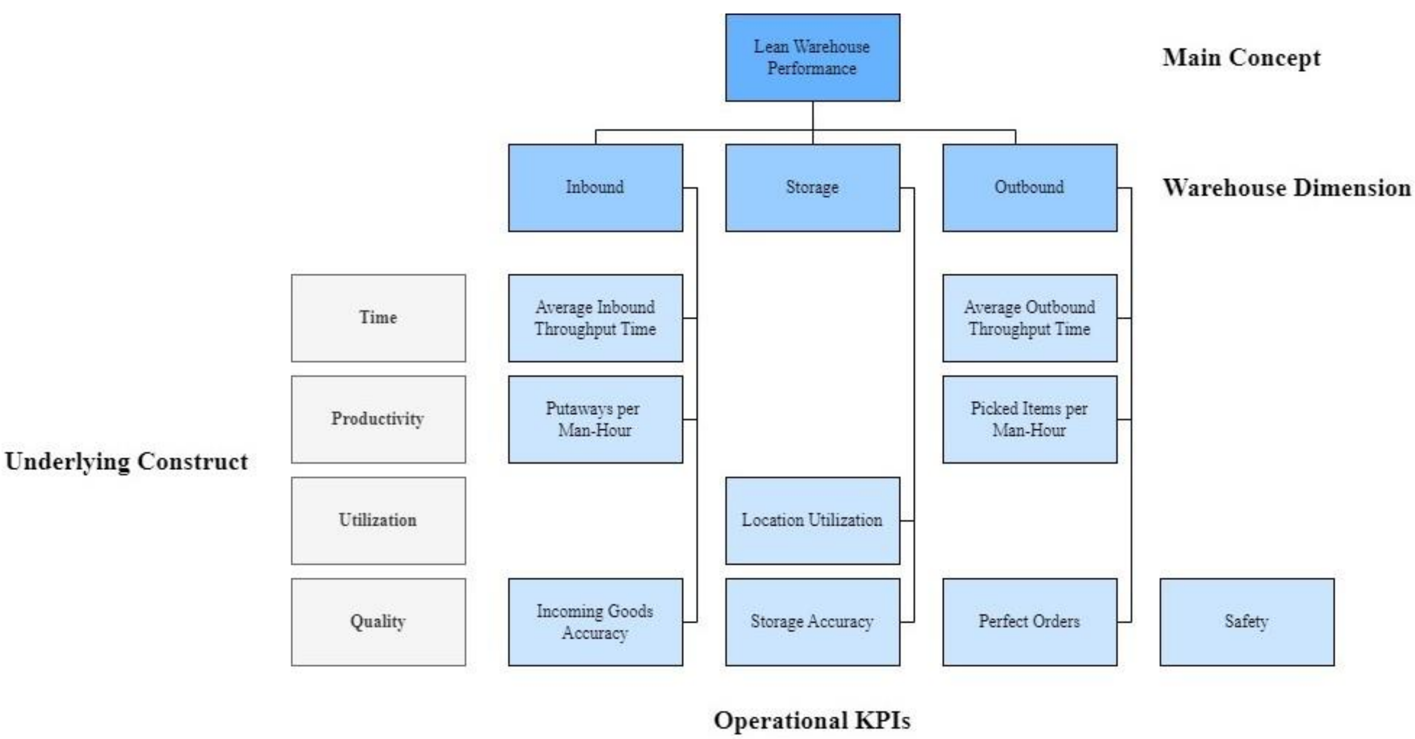

Figure 8: Measurement model structure

Time

Average Inbound Throughput Time – The duration of a product from the moment that it is unloaded to when it is stored in the designated place.

$$Average\ Inbound\ Throughput\ Time = \frac{\sum_{i=0}^{n} Waiting\ time\ before\ putaway + \sum_{i=0}^{n} Putaway\ time}{\#\ of\ Putaways}$$

Average Outbound Throughput Time – Outbound is the process where products are retrieved from specified storage locations, initiated by customer orders, and prepared for shipment. In practice, order picking process is the most labour-intensive of all warehouse processes, and prone to mistakes. It may consume as much as 60% of all labour activities in the warehouse (Drury, 1988). Order picking, in combination with order preparation, is largely influenced by the level of automation. Nevertheless, the analysis will be grouped to assure an equal comparison in the DiD research setup.

$$Average\ Outbound\ Throughput\ Time = \frac{\sum_{i=0}^{n} Order\ Picking\ Time + \sum_{i=0}^{n} Processing\ Time + \sum_{i=0}^{n} Order\ Completion\ Time}{\#\ of\ Picked\ Items}$$

Productivity

Putaways per man-hour – Is related to the average capacity of the workforce with regards to its warehouse input productivity measurements. Putaways are related to the inbound process, where the goods move from the receiving department to inside the warehouse.

$$Putaways\ per\ ManHour = \frac{Average\ Number\ of\ Putaways\ per\ Day}{\#\ of\ Inbound\ Employees}$$

Picks per man-hour – Is related to the average productivity of the workforce with regards to its warehouse output parameters.

$$Picked\ Items\ per\ ManHour = \frac{Average\ Number\ of\ Picked\ Items\ per\ Hour}{\#\ of\ Picking\ Employees}$$

Utilization

General utilization inherently differs from productivity since it measures the time a variable is allocated to working on a task and productivity measures the amount of work that gets done within that allocated time.

Location utilization – It refers to the total used space relatively to the total available storage space.

$$Location\ \ Utilization\ Rate\ (\%) = \frac{\#\ of\ Used\ Storage\ Locations}{Total\ \#\ Locations}$$

Quality

Incoming Goods Accuracy – Is related to the level of quality that the receiving department maintains. Since the goods come in, and are booked in the WMS before storage, it is of key importance that this process is coordinated accordingly to prevent mistakes later in the warehousing process.

$$Incoming\ Goods\ Accuracy\ (\%) = \left(\frac{Total\ Correctly\ Putaway}{Total\ Putaway}\right) * 100$$

Storage Accuracy – Is related to the accuracy of the stored items in the warehouse.

$$Inventory\ Accuracy\ (\%) = 100 - \left(\left(\frac{\sum_{i=0}^{n} Incorrect\ Storage\ Locations}{\sum_{i=0}^{n} Total\ Storage\ Locations}\right) * 100\right)$$

Perfect Orders – Is related to the ratio of orders that are shipped full in time and are in accordance with the order from the customer.

$$Perfect\ Order\ Rate = \frac{Number\ of\ Perfect\ Orders}{Total\ Orders}$$

<u>People</u>

The last KPI is related to the People aspect of Lean warehousing practices to support a Lean transformation.

Safety Incidents – Is related to the construct of warehouse safety. The better organized and lean a warehouse is, the less accidents happen in operations.

$$Staff\ Incidents = \sum_{i=0}^{n} Safety\ accidents\ per\ site\ per\ year$$

In the literature, there is emphasis on the *people* and *waste* aspects of a warehouse with regards to lean and performance. KPIs corresponding to these constructs could potentially be employee satisfaction or scrap rates. However, the ability to research these constructs to its full extent is limited due to its time frame and sample size. Nevertheless, the researcher acknowledged its importance.

3.3. Data Collection

Primary data collection

Empirical research involved extracting and analysing quantitative data about warehouse performance information from existing company databases, utilizing archival research methods. The advantages of using archival data are that it saves time in data collection and provides consistent and reliable information about the past. However, the significant disadvantage of archival data is that it might be incomplete. For missing values provided by the warehouse sites, data is interpolated. Because sites measure KPIs in different time intervals, yearly measurements are divided in an equal weekly, monthly or quarterly interval to enrich the parallel trends assumption as much as possible. Contextual factors are involved to explain anomalies in trends. These interviews have taken place with site management and (continues improvement (CI)) Engineers from sites in Country “A” and Country “B”, to ensure data reliability provided by these sites.

Secondary data collection

The literature review integrated secondary data from scientific journals and textbooks. The primary objective is to clarify the concepts of existing theoretical frameworks related to lean management, lean maturity, and their connections with performance. Sources related to lean must possess levels of authenticity and credibility (Sinha & Matharu, 2019). The goal of this is to answer the sub-questions of this research related to what Lean Maturity is in a warehousing context, and what its impact is on warehouse performance.

Despite the literature on lean management, only a limited number of articles have been published in high-impact scientific journals. In this research, the quality of a scientific journal is gauged by its rank on the SCImago Journal and Country Rank. The sources referenced in this research are preferably drawn from premium journals, but the scarcity of publications in these journals necessitates the inclusion of sources from other journals.

Sampling frame

Research participants were selected based on specific inclusion criteria, ensuring they possess the necessary characteristics to qualify for the study. The key criteria for the focus group were that only Rhenus Warehousing Solutions sites are under investigation and use maturity models to assess their warehouse performance. This group for this research consisted of 8 possible locations that are investigated on their warehouse performance and their corresponding CI department manager is contacted. If there is no CI department present, the site manager is the main contacted.

Those Rhenus Warehousing Solution sites that are not involved in lean maturity assessment are in the control group of this research. These consist of 30 locations across Country “B”.

Faber et al. (2017) states that extra classification is required to prevent conflicting results in measuring warehousing performance. This implies that all sites in both groups should share similarities in size and level of automation, or at least be categorized and compared.

3.4. Data Analysis

Initially, the data is organized and cleaned in Excel to prepare it for analysis and conclusion drawing. Cleaning involves removing missing data, outliers, or transforming variables. For the archival quantitative data to research warehouse performance, paired *t*-tests will be applied to test its significance. This is done in SPSS. The outcomes are structured per quarter and a trendline will be added to indicate pre- and post-treatment developments.

The informal qualitative interviews are recorded and served as an exploratory tool. This involved reviewing key themes extracted from the interviews. This is done to gain deeper understanding of respondents' perception on adjustments aimed at improving lean warehouse performance.

3.5. Reliability

The research reliability refers to how consistent a method measures a variable of interest. For this research, the reliability is medium-to-high, since different focus groups, industry, product catalogue, and time frames will directly influence the outcome of the research. However, the variables of interest remain the same, and with the DiD approach would show the same indication, but different values. It is then to the researcher to interpret the values to draw conclusions from it. Moreover, a distinction is made for a more detailed description of the types of reliability and its consequences.

Test-retest reliability is the ability to redo the experiment in similar context. External environmental factors should be minimized to achieve the highest test-retest reliability. Therefore, the gathering of information for this research, as well as administering it, is done under the same instructions and conditions. In addition, the time between requesting data from the Country "A" RWS sites is done at the same time as the Country "B" RWS sites. Nevertheless, the control group consisted of a larger sample, so requesting all the data is more time consuming.

Interrater reliability is related to the level of consistency and coherence in response from the sites. Since the quantitative approach of this research, this is of less importance. Nevertheless, the discrepancies in quantitative data are explained with qualitative information to explain trends or behaviour. Since Lean core principles are aimed at change management, there is a need to clarify contextual factors to interpret outliers in the data. This qualitative information gathering will lead to triangulation to assess the interrater reliability. So, the qualitative interviews are set up to confirm (behavioural) trends amongst sites in Country "A" and Country "B".

3.6. Validity

The DiD approach's validity relies on the parallel trends' assumption. Moreover, the assumption that there are no time-varying differences present between the focus group and the control group. To assess the overall validity of this research, this aspect is divided into three different types to indicate how the research takes precautionary steps to ensure the highest degree of validity.

Construct validity is the degree of how well the research approach measures the concept it is aiming to evaluate. The aim is to create convergence in validity to select a small list of KPIs approved by RWS CI engineers, as well as operational support engineers. Chosen KPIs, seen in Figure 8, are in accordance with the KPIs picked by Staudt et al. (2015). From their research, it was indicated that these are the KPIs that are expected to have the greatest influence on warehouse performance in term of impact, tangibility, and perceptibility. During consultation of the model proposed by Visser (2014), the list was shortened to facilitate RWS, coming to a total of 9 KPIs. In accordance with the Lean principles, the people aspect plays a key role to support change, explaining the addition of the safety KPI.

Content validity is related to the degree of how well the research covers all parts of the relevant aspects of the construct it aims to measure. For this research, the aim is to focus on quantitative constructs. However, since all underlying constructs have different angles to assess warehouse dimensions i.e., productivity or people dimensions, the content validity could be in risk to an extent. This is due to time constraints, as well as having to pick important KPIs to ensure richer data reliability. For the chosen KPIs, a content validity ratio is calculated where the content validity index of the entire research approach indicates whether the test is accurately measuring what it is intended to measure, according to field experts, to give answers to the main questions. Experts are CI Engineers, Engineers, and Operational Managers. The extended list can be found in Appendix 3.1. Its outcome indicated that the chosen KPIs are of importance in this research context.

4. Results

The results are structured per KPI in pre- and post-treatment developments. To make the link to the development across the complete timeline, the development for both groups is divided into period before, and after implementation. For the outliers in data are explained per KPI through the contextual factors mentioned in Chapter 2.1.1. The complete timeline can be found in Appendix 3.2. Whether the parallel trend assumption is violated pre-treatment is decided in Chapter 5. Since there is no fixed number of N measures for each KPI, contextual factors will be considered. Also, the DiD will be stated in addition with paired t-tests. Done to indicate whether the average value of the sample is significantly different to a random value in the sample, because the deviation from its corresponding trendline is high for some KPIs.

4.1. Time

In this dimension, it is important to note that, due to measurement constraints, *N* is relatively small for the total amount of sites. Additionally, the sites that don't actively measure the AITT and AOTT have made the agreement with the customer to store or prepare products within certain time frames. This is often within 24 hours for inbound, and within 12 hours for direct, and 48 for indirect for outbound.

4.1.1. Average Inbound Throughput Time

AITT refers to the total duration of the incoming goods procedure. This involves receiving, booking the items in the WMS, and placing it into the warehouse location. Over the past 7 years, the course of the AITT has developed, visualized in Figure 9.

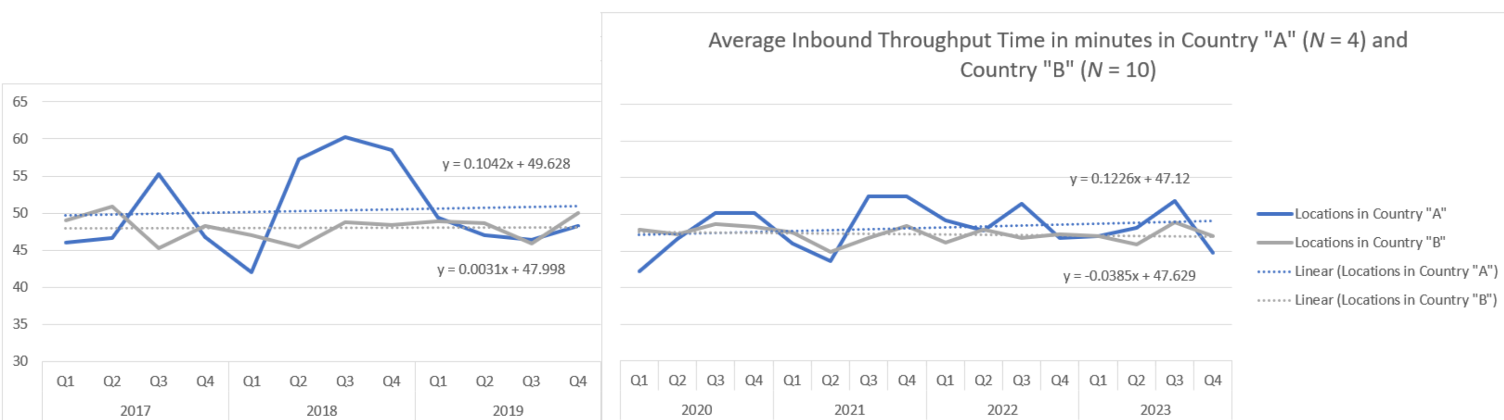

Figure 9: AITT 2017-2023

As is visible in Figure 9, the average AITT in Country “A” is pre-treatment slightly rising, (Country “A”: μ = 50; σ = 5.9049 -- Country “B”: μ = 48; σ = 1.7996) while Country “B” is staying the same over the three years. However, when looking at the values, the two countries do not follow a similar trend. Additionally, the variability also decreases post-treatment, indicating higher levels of process control. Comparing it to post-treatment, it becomes visible that both linear lines diverge more compared to pre-treatment, but it appears very minor (Country “A”: μ = 48; σ = 3.1320 -- Country “B”: μ = 47; σ = 1.0666). Statistical analysis indicated insignificance ($p > .05$).

4.1.2. Average Outbound Throughput Time

Like AITT, the construct of AOTT is heavily subjected to warehouse configuration, level of automation and storage policies. The reason that Country “A” has an average lower value is because of sites operating with an automatic outbound conveyer system to serve as an improved outbound method. Similarly, the overall trend downwards across all sites is because of revised pick routing, and single-client sites focussing on customer satisfaction to emphasize reliability.

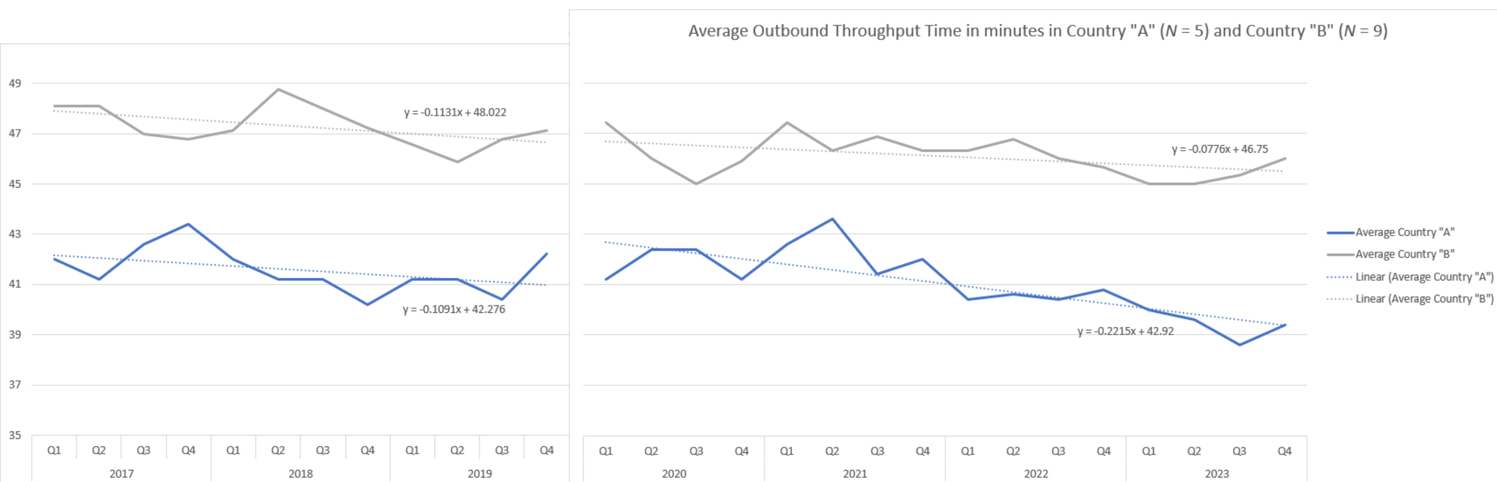

Figure 10: AOTT 2017-2023

What is striking is that both trendlines appear to move downwards over the total tracked period. Especially pre-treatment, the lines almost run parallel, while the actual values lead to believe the parallel trends assumption is violated (Country “A”: μ = 41.57; σ = 0.9099 -- Country “B”: μ = 47.29; σ = 0.8116). Furthermore, post-treatment, both trends continue to decrease over the following years, with both trendlines diverging more. (Country “A”: μ = 41.04; σ = 1.3331 -- Country “B”: μ = 46.09; σ = 0.7890). Statistical analysis indicated significance ($p < .001$).

4.2. Productivity

This underlying construct is divided into two aspects: inbound and outbound related performance indicators. It will first define the statistical outcomes of both KPIs, highlighting significant trends, deviations, and correlations that provide insight into the efficiency of its standardized processes. Following this, the analysis will shift to identify strengths and areas for improvement. Since both KPIs had different methods to measure its productivity e.g., in SKUs, order lines, orders, products, there were difficulties in establishing overlap across sites. The reason SKUs were chosen is because it was a known aspect of every outgoing order across all sites.

It is important to note that the number of employees involved in the outbound and inbound are in a ratio of approximately 4:1 across all sites. Meaning that for every inbound employee, which are mainly forklift drivers, there are four employees responsible for picking the SKUs, packaging, and preparing the orders for further transport.

4.2.1. Putaways per Man-Hour

PpMH is the average duration it takes from receiving goods to the moments it receives a place in the warehouse according to the WMS. The reason for a discrepancy in averages is because certain single-client sites in Country "B" have automatic receival stations, where complete pallets are unloaded from the truck via conveyor robots, scanned, booked in, and put away in the warehouse. These have a significant impact on the average inbound capacity.

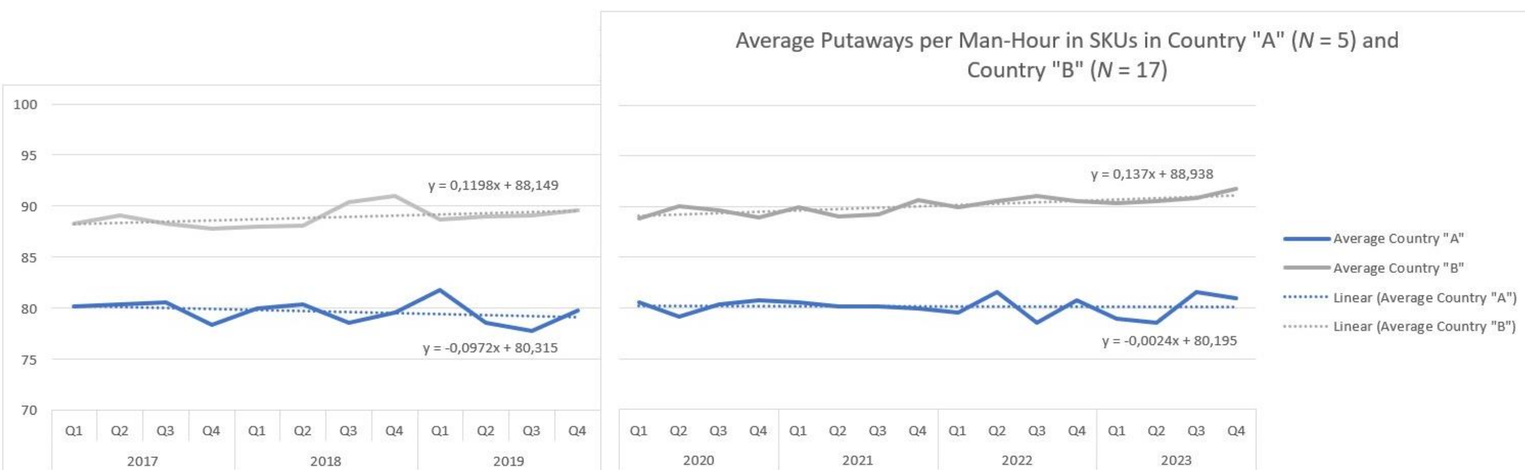

Figure 11: PpMH 2017-2023

Pre-treatment diversion, as is illustrated in Figure 11, visualizes that Country "B" is more efficient in PpMH compared to Country "A" and is also improving at a faster rate (Country “A”: $\mu = 80$; $\sigma = 1.1392$ -- Country “B”: $\mu = 89$; $\sigma = 1.3696$). Trendlines continue post-treatment and are not affected in both groups, indicating that having lean maturity modelling does not influence inbound warehouse performance indicators. Also, post-treatment indicated a slight increase in both countries, since the negative trendline in Country “A” turns less negative. Both countries show positive trends, but the efficiency and improvement rate are more pronounced in Country "B" (Country “A”: $\mu = 80$; $\sigma = 0.9518$ -- Country “B”: $\mu = 90$; $\sigma = 0.6816$). Similarly, both trends’ variability also decreases post-treatment. Statistical analysis indicated significance ($p < .001$).

4.2.2. Picked Items per Man-Hour

Comparing the axis of the productivity related KPIs indicates that PIpMH is lower than the PpMH. This is mainly because all multi-client sites are manual picking warehouses, which is more labour intensive. Some single-client sites, situated only in Country "B", have a partial automatic storage and retrieval system (AS/RS). Some sites in Country "A" are also experimenting with AS/RS, with various results.

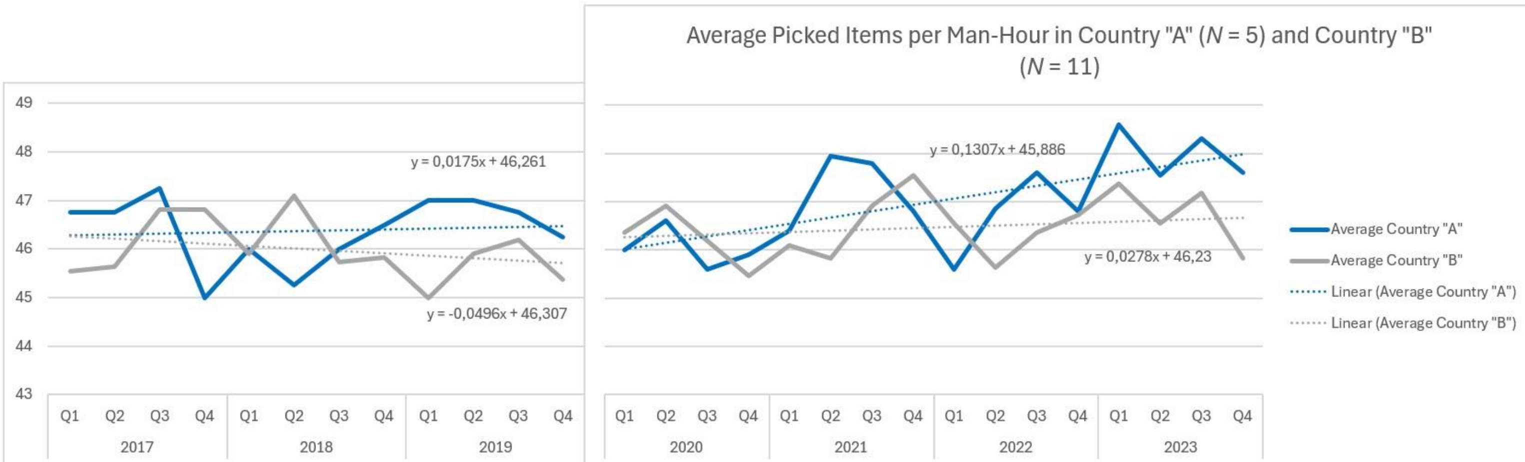

Figure 12: PIpMH 2017-2023

Due to the scaling of the axis, it appears that variance is higher compared to Figure 11 but it is lower, visible by the trendlines' formula in Figure 12.

Pre-treatment, both countries' trendline appears to follow a diverging course. However, there is a slight decline in Country "B", whilst Country "A" appears to fluctuate around the same value (Country "A": $\mu = 46.38$; $\sigma = 0.7031$ -- Country "B": $\mu = 45.98$; $\sigma = 0.6344$). This changes after implementation and both countries appear to pick up their productivity, with Country "A" diverging clearly compared to its counterpart (Country "A": $\mu = 47.00$; $\sigma = 0.9510$ -- Country "B": $\mu = 46{,}47$; $\sigma = 0.6191$). It is important to mention that the variability also increased in Country "A", whilst decreasing in Country "B". Statistical analysis indicated significance ($p < .05$).

4.3. Utilization

4.3.1. Location Utilization

LU is the fill-rate of the warehouse and is calculated by the locations occupied compared to the total available locations, expressed as a percentage. The high response rate (Country “A” = 100%; Country “B” = 96%) is because of the high availability of data. Most single-client sites have a relatively low location utilization rate since the client pays to use the warehouse in its entirety. In these places, RWS is the not in control of the flow of goods, and only serves as intermediary storage, where customer demand pulls the items from storage. For multi-client sites, the use of storage is divided per customer, where a customer pays for the storage expecting to use. For this, they get a dedicated storage area in the warehouse to store their products. Costs vary because of type of product and how it fits warehouse operations.

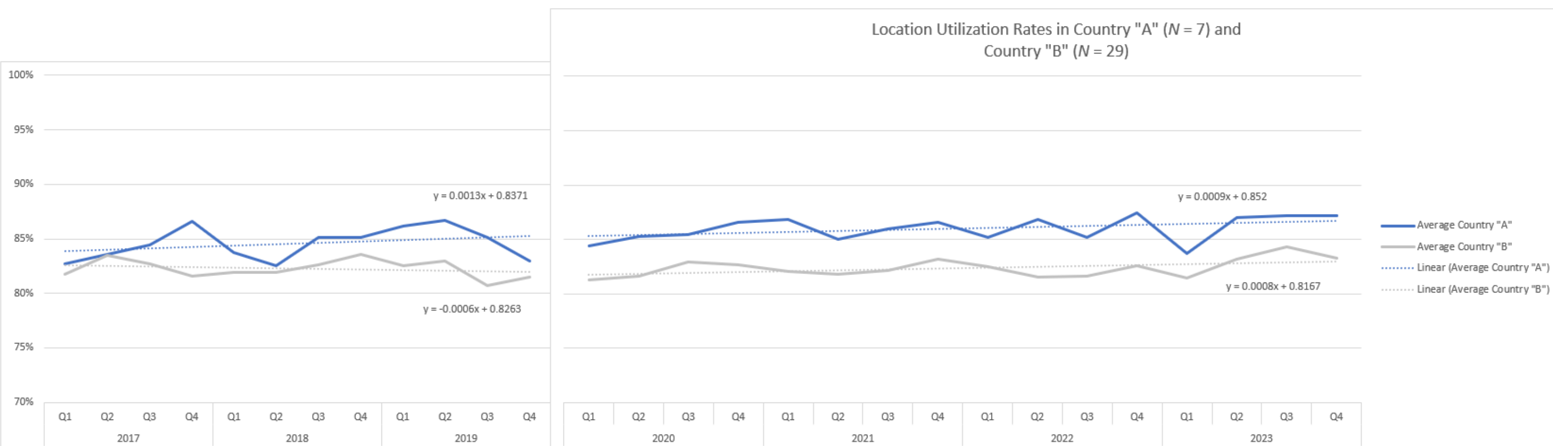

Figure 13: LU 2017-2023

The trendlines in Figure 13 indicate a slight diversion pre-treatment (Country “A”: μ = 85%; σ = 0.0147 -- Country “B”: μ = 82%; σ = 0.00854), and almost becomes parallel post-treatment (Country “A”: μ = 86%; σ = 0.0112 -- Country “B”: μ = 82%; σ = 0.00839). Statistical analysis indicated significance ($p < .001$).

4.4. Quality

The quality aspect of the warehousing KPIs is less informative due to its lower sample size compared to the other underlying constructs of lean warehouse management. Nevertheless, the outcomes provide insights in how a lean transformation impacts warehouse performance on its internal and external quality.

4.4.1. Incoming Goods Accuracy

IGA is related to the amount of goods received that are putaway in the warehouse. It is a quality measure to ensure supplier reliability and serves as a control tool to negotiate agreements. In Figure 14 is visible how this progress developed from 2017 to 2023. All sites have agreements with their supplier to perform above a pre-determined grade of delivery excellence. This is expressed in a percentage of rejected items. The reason for a low response rate (Country “A” = 42%; Country “B” = 30%) is because some sites only check this if this pre-determined grade is not met. And if it is met, sites just lose track of its development.

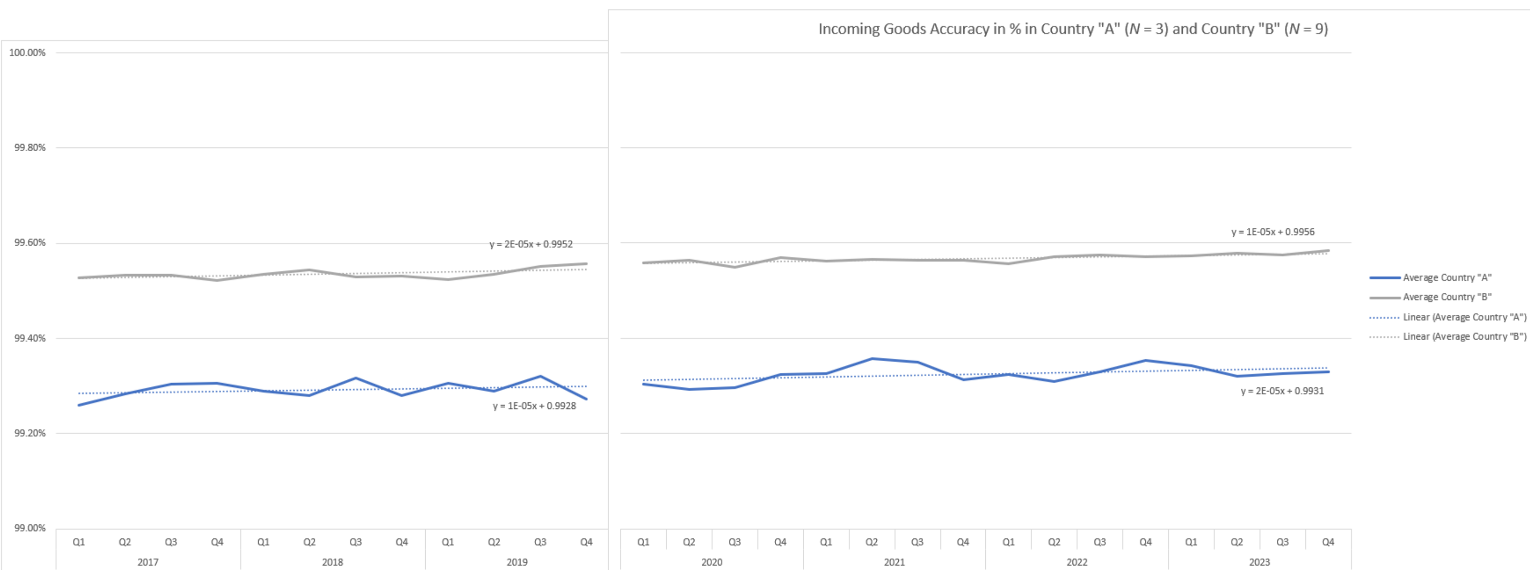

Figure 14: IGA 2017-2023

What is clear is that pre-treatment, both average values from Country “A” and Country “B” are similar (Country “A”: μ = 99,29%; σ = 0.0002 -- Country “B”: μ = 99,54%; σ = 0.0001). After implementation, the values of both aspects do not diverge as much compared to pre-treatment trendlines. (Country “A”: μ = 99,33%; σ = 0.0002 -- Country “B”: μ = 99.57%; σ = 0.0001). Statistical analysis indicated significance ($p < .001$).

4.4.2. *Storage Accuracy*

Storage accuracy is checked once per year at most. It is related to how well the WMS corresponds with what is in storage. In a perfect world, if all instructions were followed, the accuracy of total storage capacity is 100%, but accidents happen during operations. This KPI indicates the status of a warehouse site. It indicates how prone warehouse processes are to mistakes. Since the interval of an accuracy check is not frequent, the response rate and data reliability are lower compared to other KPIs (Country "A" = 29%; Country "B" = 20%). The accuracy check intervals are further explained in Figure 24 in Appendix 3.2 (highlighted in bold). Most sites are aware of the storage accuracy as an important measure, to resolve a low accuracy level takes effort that does not directly bring in revenue and is viewed as tedious work. For the overview of Figure 15, the missing values per quarter are interpolated to smoothen out the trajectory.

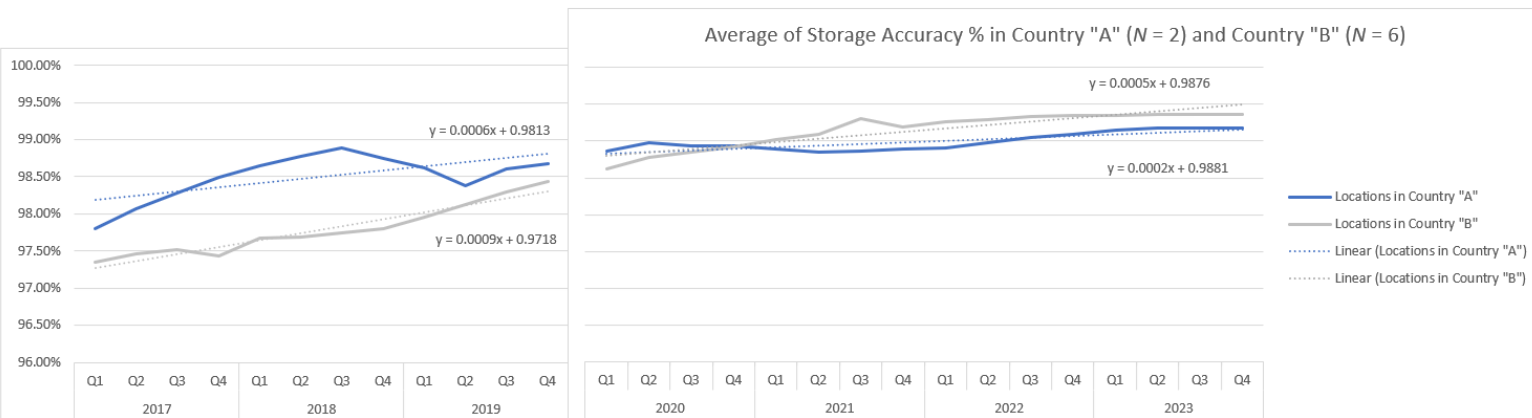

Figure 15: SA 2017-2023

Noticeable is that both trendlines seem to converge pre-treatment (Country "A": $\mu = 98.50\%$; $\sigma = 0.0031$ -- Country "B": $\mu = 97.97\%$; $\sigma = 0.0035$). This is mainly because the small sample size of Country "A" is prone to outliers. The dip can be explained via a new implemented CBSLAP in one of the sites. This negatively impacted the storage accuracy due to program connectivity issues, looking at the trendline's equation. Post-treatment indicates a turning point where Country "B" overlaps the average of Country "A" and leads to diverging trendlines post-treatment (Country "A": $\mu = 99.00\%$; $\sigma = 0.0012$ -- Country "B": $\mu = 99.15\%$; $\sigma = 0.0024$). Statistical analysis indicated significance ($p < .05$).

4.4.3. Perfect Orders

PO means the percentage of orders that is sent on time in full. This information has been obtained by all the customer service departments and compared the number of complaints with order numbers over the last years. In combination with agreements made with the customers, and how those two constructs are related to each other, it is possible to understands its development. Since percentages are small but have a large impact on the total flow through the warehouse on a monthly scale, the scaling on the axis is set to indicate the difference pre- and post-treatment as large as possible.

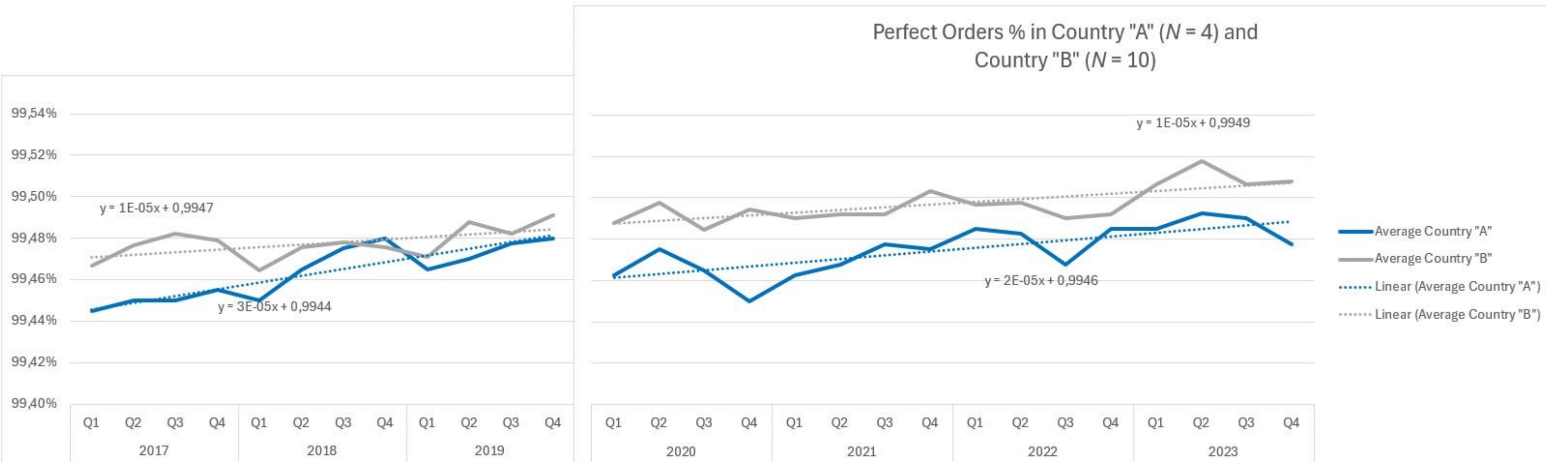

Figure 16: PO 2017-2023

It is important to note in the figure above that the pre-treatment trendlines appear to be converging, since Country "A" appears to catch up on Country "B" (Country "A": $\mu = 99.46\%$; $\sigma = 0.00013$ -- Country "B": $\mu = 99.48\%$; $\sigma = 0.000078$). But what is striking is that post-treatment, both trendlines appear to run parallel (Country "A": $\mu = 99.48\%$; $\sigma = 0.000117$ -- Country "B": $\mu = 99.50\%$; $\sigma = 0.000089$). Statistical analysis indicated significance ($p < .001$).

4.4.4. *Safety*

Safety is the total number of reported incidents. A high response rate (Country “A” = 71,42%; Country “B” = 73,33%) indicates the involvement of sites in safety. Moreover, RWS’ focus on safety as internally highly regarded. In addition, its culture encourages safety incidents to report incidents, regardless of its impact, to create a hazardless environment for its workers.

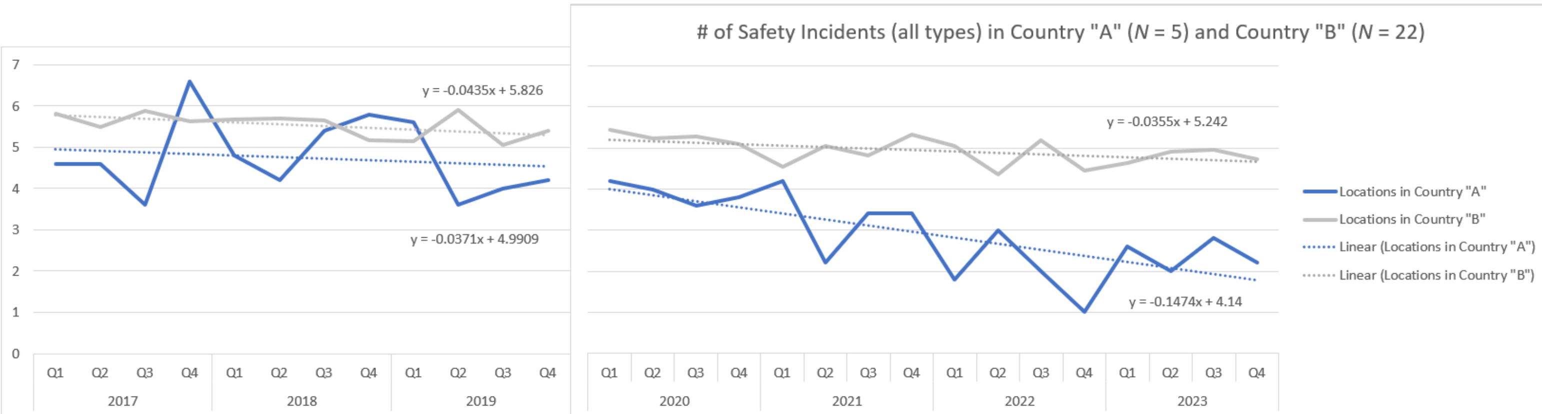

Figure 17: Safety 2017-2023

The figure above indicates a clear diversion after moment of implementation. Pre-treatment trendlines of both averages follow a parallel trend, although the deviation in Country “A” is higher than Country “B” (Country “A”: $\mu = 4.75$; $\sigma = 0.9307$ -- Country “B”: $\mu = 5.5$; $\sigma = 0.2907$). Post-treatment, a clear deviation in number of reported safety accidents is visible in both trendlines. Both trendlines move downwards and whilst the total reported accidents decrease over time post-treatment, the variability also increases in both countries (Country “A”: $\mu = 2.8875$; $\sigma = 0.9632$ -- Country “B”: $\mu = 4.9$; $\sigma = 0.3247$). Statistical analysis indicated significance ($p < .001$).

5. Conclusion

The research provides insight in the impact of the usage of the lean maturity model in a warehousing environment. It compared 9 KPIs used in a warehousing environment over a timeframe of 7 years in Country "A" and Country "B". Based on the results section of this research, an indication is made to the following main research question of this research:

'To what extent can a lean transformation be improved to increase warehouse performance, moderated through lean maturity modelling?'

Existing literature has indicated that the use of lean practices improves warehouse performance. This research contributes to it by analysing on which dimensions of warehousing, the use of the maturity assessment has its impact. This relationship between lean practices and warehouse performance is not for all cases positive. The constructs for this research to investigate warehouse performance were based on time, productivity, utilization, and quality. Table 2 indicates the moderating role of the use of the Lean Maturity Model between the relationship of a Lean Transformation and Warehouse Performance.

Table 2: Moderating Effect per KPI

KPI	Apparent Moderating Effect Lean Maturity Modelling	DiD estimate
Average Inbound Throughput Time	Improbable Moderation	0.8000
Average Outbound Throughput Time	Positive Moderation	- 0.4889
Putaways per Man-Hour	Improbable Moderation	- 2.6722
Picked Items per Man-Hour	Positive Moderation	0.5773
Location Utilization	Improbable Moderation	0.0288
Incoming Goods Accuracy	Improbable Moderation	0.00013
Storage Accuracy	Negative Moderation	- 0.0064
Perfect Orders	Improbable Moderation	- 0.000083
Safety	Positive Moderation	- 1.3037

The conclusion will continue to elaborate on the apparent moderating effect, structured per KPI.

Average Inbound Throughput Time

The reason for the violation in the pre-treatment parallel trend assumption may be of a new receival system at one of the sites in Country "A" that was implemented without direct success. Since it took a year to adjust the retrieval system to the customers' wishes, there is a slight decrease in trendline visible post-treatment, where a slight diversion in trendlines across countries appear. Since the deviation is very small to notice over time, it is inconclusive to reason that lean maturity modelling moderates the relationship between a lean transformation and warehouse performance, and therefore influences AITT.

Average Outbound Throughput Time

Pre-treatment is visible that almost the two trendline appear parallel. Moving downwards with slope *0.1* across the first period, it is striking that post-treatment the two variables largely diverge. The pace in which AOTT was decreasing in Country "B" is almost halved, whereas it doubles in Country "A". The two trendlines diverge post-treatment, indicating a possible positive moderation role when maturity modelling is used in a warehousing context to support a lean transformation.

Putaways per Man-Hour

Both trendlines appear to diverge slightly in both pre- and post-treatment. The trendlines appear to continue this course post-treatment. In Country "B" there were sites with completely automatic pallet receival systems in place, leading to an increase in capacity, but also in throughput time. Leading to a reduction in manual labour and cost, a domino effect followed within Country "B" sites to adopt similar systems. The reason for Country "A" to remain behind is a portion of the sample size of sites being single client, thus reducing the applicability for this type of receival system. When solely looking at Figure 11, it appears that lean maturity modelling negatively moderates the relationship between a lean transformation and warehouse performance.

Picked Items per Man-Hour

In both time frames, the trendlines appear to diverge. Pre-treatment, Country "A" improves over time, whilst Country "B" decreases. Post-treatment implies both countries have increased PIpMH, but comparing the differences between periods indicates that the divergence is greater post-treatment. The reason for this may be a greater attention to the level of automation within RWS to optimize warehouse performance.

Location Utilization

The outcomes for LU are very linear, with low variability across the timelines in Figure 22 in Appendix 3.2. Pre-treatment indicates parallel trends, but post-treatment does not appear to have influenced LU rates across both countries, since both trends appear to continue as they did pre-treatment. Therefore, it is improbable to indicate whether lean maturity has a moderating role in the relationship between a lean transformation and warehousing performance.

Incoming Goods Accuracy

As stated in Chapter 4.4., all sites have agreements with their customers to ensure reliability and quality. Like the LU values, the trendlines for IGA rates follow a similar pattern. Post-treatment follows a similar parallel development compared with pre-treatment. Therefore, it is improbable to conclude that this KPI moderates the relationship between a lean transformation and warehousing performance.

Storage Accuracy

It is logical when having more frequent intervals to check the status of storage accuracy would lead to higher warehouse storage accuracy, which leads to less wasted time for pickers to navigate the warehouse. However, the developments of the SA values are a consequence of actively thinking about the storage process, related to inbound. Comparing pre- and post-treatment, the outcomes indicate a negative moderating effect since Country “B” improves at a better rate. However, explorations of practice indicate a more top-down emphasis on internal warehouse quality in Country “B” than Country “A”, whilst not actively promoting a lean transformation across sites.

Perfect Orders

Converging values pre-treatment indicates an advancing development in Country “A”, but it appears to die down post-treatment. Both trendlines continue to run parallel post-treatment. An explanation for this development could be the increased customer-oriented focus across RWS, but it is improbable that the use of lean maturity assessments to grade performance is the main reason that warehouse performance in moderated when supporting a lean transformation.

Safety

The results for this KPI indicate the biggest difference among all performance metrics, with an indicative parallel trends development pre-treatment. Post-treatment clearly indicates a reduction in reported safety incidents, highlighting that the data could convey a positive moderating role between a lean transformation and warehouse performance.

From the results above, a trend appears that the impact of using lean maturity modelling is mostly visible on the outbound aspect of a warehousing environment. A possible argument for this is the fact that there is an emphasis on outbound quality and reliability since that is the place in the warehouse where money is made. Furthermore, the ratio of employees on outbound and inbound is approximately 4:1 across RWS sites in both countries. Since a Lean transformation is heavily aimed at changing people's perspective, the effects are more noticeable in places where more people are involved. This will be further explained in Chapter 6.1.

6. Discussion

This chapter characterizes their theoretical and practical input while also acknowledging the study's limitations and proposes an indication for future research. Its purpose is to contextualize the results within the broader academic conversation, offer practical insights for warehousing experts, critically assess the constraints of the research design, and suggest directions for further scholarly inquiry.

6.1. Theoretical Contributions

This part will compare the general trends across KPIs in a warehousing environment to the current literature. In both cases, it contributes to the growing research body on lean in a warehousing and logistics environment. In recent years, different researchers have studied the implementation of lean practices in the warehouse. Although these studies give an overview of practices implemented in the warehouse, research towards the effect on warehouse performance is limited.

This research confirms the positive relationship between a lean transformation and warehouse performance, and extents the literature by applying the lean maturity models as a moderator in a warehousing environment, as is done in Chapter 1.7. Before, the lean maturity model had a positive moderating role within ETO environments (Chiera et al., 2021), and this research confirms that its ideology applies to warehousing dimensions. However, the extent to which it is visible within the warehousing environment only extends to the outbound dimension.

Moreover, the outcomes are in line with the traditional lean implementation research that argues that lean principles lead to improved warehouse performance (Raghuram & Arjunan, 2022; Abushaikha et al., 2018; Chan & Chan, 2011; Shah & Khanzode, 2018). This finding relies on the theoretical approach that implies that lean warehousing is linked to employee satisfaction, with the foundation of lean being oriented towards the perception of people.

This research reveals important results with regards to contextual factors in a warehousing environment. Like Kembro et al. (2018) and Tahboub & Salhieh (2019), this study distinguishes between sites that receive treatment and those that do not. Fluctuations in demand and levels of automation appear to be the largest influence on warehouse operations. However, there is no distinction made between warehouse dimension, so it remains unclear if it applies only to the outbound dimension, as would be in line with the outcomes of this research.

Moreover, the application of the DiD approach in warehouse environments contains many external factors that interfere between results, such as market fluctuations, client demands, and supplier reliability leading to the impossibility to state a direct causational effect. Additionally, due to the interpretation of the parallel trend assumption for both pre-treatment and post-treatment makes it is impossible to conclude that the internal use of lean maturity modelling leads to more improvement in the outbound dimension. It is only an audit tool, and it highlights which aspects within different warehouse dimensions are substandard. It is then to focus on an individual site level to act upon the results from the lean maturity model.

6.2. Managerial Recommendations

The outcomes stress an added value in the outbound dimension in a warehousing environment because of the use of the lean maturity model. From the company's perspective, it was indecisive if there were aspects within the warehousing context that benefitted from the use of the model. Regular employee satisfaction surveys indicated that they did, but KPIs related to warehouse performance did not indicate similar trend developments.

The outcomes of the results could strengthen the position of the sites in Country "A", and promote similar practices in other countries, creating a worldwide standard in warehouse assessment within the company. Outside of perceived improvement, there is evidence to support the claim that lean maturity models positively moderate the relationship between a lean transformation and warehouse performance to a certain extent.

In the future, a decision could be made to focus on a certain warehouse dimension to specialize in to maximize added value within RWS. This could be the inbound dimension to 'catch up', or the outbound dimension to maximize added value for the customer. Outside of RWS, it could support a decision to focus on a specific dimension to improve warehouse operations.

6.3. Research Limitations

The DiD research approach is useful to estimate causal relationships, but it has some limitations:

(1) Parallel trend assumptions

- Varying pre-treatment values lead to accept or refuse a parallel trends assumption. If this assumption is violated, the estimates may be biased. Verifying this assumption can be challenging, especially if there are unobservable factors that influence the trends differently across groups.

(2) Confounding variables

- A warehousing environment is much more complex than it is in this research. Individual sites attempt to improve their warehouse operations as much as possible, where those developments could also lead to improved warehouse performance, and the research acknowledges their confounding influence in the DiD estimates.

(3) Heterogenous treatment effects

- DiD assumes that the post-treatment development is homogenous across all sites. Since this varies across sites over time, the average interpreted post-treatment results may not be as accurate.

(4) Generalizability

- The results from a DiD analysis are often specific to the context and period studied. Generalizing the findings to other contexts, populations, or time periods can be problematic if the underlying assumptions do not hold in those contexts.

(5) Sample selection

- Since the research takes place within RWS, there might be bias in the results since companies have different qualities and focus points. It would be understandable that when the same DiD approach is applied to a different third-party logistics provider in a warehousing environment, the outcomes could be different.

(6) Attrition

- When the treatment and control groups over time decide to stop or change measuring KPIs from different moments in time, it can bias the DiD estimates. Ensuring that attrition is not systematically related to the treatment is important for obtaining unbiased estimates. During the data gathering period, there were sites amid closing permanently due to reorganisations, impacting measurement intervals.

6.4. Future Research Directions

From Chapter 5, it was highlighted that the moderation effect of maturity modelling in lean warehousing to support a lean transformation is mostly noticeable in the outbound dimension of the warehouse. For future research, its moderation effect could potentially be better understood when focussing solely on outbound related KPIs. The initial reaction when conducting the research was that employees indicated that it was very broad. It could deepen the knowledge on how the model influence different aspects of outbound, such as, picking, packing, staging, and loading.

Another possible direction could be to match warehouse types together. Different types of distinctions could be made based on level of automation, number of employees, type of client, and client agreements. Especially the type of products largely influences warehouse operations. The academic literature indicates similar developments, so a more detailed approach to compare related KPIs per department is key in gaining a deeper understanding in the construct’s boundary conditions.

References

Abushaikha, I., Salhieh, L., & Towers, N. (2018). Improving distribution and business performance through lean warehousing. *International Journal of Retail & Distribution Management*, 46(8), 780–800. https://doi.org/10.1108/ijrdm-03-2018-0059

AlManei, M., Salonitis, K., & Tsinopoulos, C. (2018). A conceptual lean implementation framework based on change management theory. *Procedia CIRP*, *72*, 1160–1165. https://doi.org/10.1016/j.procir.2018.03.141

Anđelković, A., Radosavljević, M., & Stošić, D. (2016). Effects of lean tools in achieving lean warehousing. *Economic Themes*, *54*(4), 517–534. https://doi.org/10.1515/ethemes-2016-0026

Ashayeri, J., Heuts, R., Valkenburg, M., Veraart, H., & Wilhelm, M. (2002). A geometrical approach to computing expected cycle times for zonebased storage layouts in AS/RS. *International Journal of Production Research*, *40*(17), 4467–4483. https://doi.org/10.1080/00207540210153901

Autry, C. W., Griffis, S. E., Goldsby, T. J., & Bobbitt, L. M. (2005b). Warehouse Management Systems: Resource commitment, capabilities, and organizational performance. *Journal of Business Logistics*, *26*(2), 165–183. https://doi.org/10.1002/j.2158-1592.2005.tb00210.x

Bahrami, B., Piri, H., & Aghezzaf, E. (2019). Class-based Storage Location Assignment: An Overview of the Literature. *Department Of Industrial Systems Engineering and Product Design,* Ghent University, Belgium. https://doi.org/10.5220/0007952403900397

Baker, P., & Halim, Z. (2007). An exploration of warehouse automation implementations: cost, service, and flexibility issues. *Supply Chain Management*, 12(2), 129–138. https://doi.org/10.1108/13598540710737316

Bartholdi, J. J., III, & Hackman, S. T. (2019). *WAREHOUSE & DISTRIBUTION SCIENCE 0.98.1* (0.98.1). The Supply Chain & Logistics Institute. https://www.warehouse-science.com/book/editions/wh-sci-0.98.1.pdf

Baruffaldi, G., Accorsi, R., Manzini, R., & Ferrari, E. (2020). Warehousing Process Performance Improvement: a tailored framework for 3PL. *Business Process Management Journal*, *26*(6), 1619–1641. https://doi.org/10.1108/bpmj-03-2019-0120

Battista, C., & Schiraldi, M. M. (2013). The Logistic Maturity model: application to a fashion company. *International Journal of Engineering Business Management*, *5*, 29. https://doi.org/10.5772/56838

Bento, G. D. S., & Tontini, G. (2018). Developing an instrument to measure lean manufacturing maturity and its relationship with operational performance. *Total Quality Management & Business Excellence*, *29*(9–10), 977–995. https://doi.org/10.1080/14783363.2018.1486537

Bonilla-Ramirez, K. A., Marcos-Palacios, P., Quiroz-Flores, J. C., Ramos, E., & Alvarez-Merino, J. C. (2019). Implementation of Lean Warehousing to Reduce the Level of Returns in a Distribution Company. *IEEE Transactions on Engineering Management*. https://doi.org/10.1109/ieem44572.2019.8978755

Brown, C. J., Collins, T. R., & McCombs, E. L. (2006). Transformation From Batch to Lean Manufacturing: The Performance Issues. *Engineering Management Journal*, *18*(2), 3–14. https://doi.org/10.1080/10429247.2006.11431689

Brynzér, H., & Johansson, M. I. (1996). Storage location assignment: Using the product structure to reduce order picking times. *International Journal of Production Economics*, *46–47*, 595–603. https://doi.org/10.1016/0925-5273(94)00091-3

Camuffo, A., & Gerli, F. (2018). Modelling management behaviours in lean production environments. *International Journal of Operations & Production Management*, *38*(2), 403–423. https://doi.org/10.1108/ijopm-12-2015-0760

Chan, F. T., & Chan, H. (2011). Improving the productivity of order picking of a manual-pick and multi-level rack distribution warehouse through the implementation of class-based storage. *Expert Systems with Applications*, *38*(3), 2686–2700. https://doi.org/10.1016/j.eswa.2010.08.058

Chiang, D. M., Lin, C., & Chen, M. (2011). The adaptive approach for storage assignment by mining data of warehouse management system for distribution centres. *Enterprise Information Systems*, *5*(2), 219–234. https://doi.org/10.1080/17517575.2010.537784

Chiarini, A., & Brunetti, F. (2019). What really matters for a successful implementation of Lean production? A multiple linear regression model based on European manufacturing companies. *Production Planning & Control*, *30*(13), 1091–1101. https://doi.org/10.1080/09537287.2019.1589010

Dehdari, P. and M. Schwab (2012). Produktionsumfeld vs. Lagerum- feld. In: K. Furmans and H. Wlcek (eds.), *Arbeitskreisbericht*, Volume 1, p. 16–20. DVV Media Group.

Dehdari, P. (2013). Measuring the Impact of Techniques on Performance Indicators in Logistics Operations, Ph.D thesis, Karlsruher Instituts für Technologie, Karlsruhe.

De Koster, R., Le-Duc, T., & Roodbergen, K. J. (2007). Design and Control of Warehouse Order Picking: A Literature review. *European Journal of Operational Research*, *182*(2), 481–501.
https://doi.org/10.1016/j.ejor.2006.07.009

De Koster, R., & Balk, B. M. (2008). Benchmarking and monitoring international warehouse operations in Europe. *Production and Operations Management*, 17(2), 175–183.
https://doi.org/10.3401/poms.1080.0013

Demirkesen, S., & Bayhan, H. G. (2022). Critical success factors of lean implementation in the construction industry. *IEEE Transactions on Engineering Management*, 69(6), 2555–2571.
https://doi.org/10.1109/tem.2019.2945018

Dotoli, M., Epicoco, N., Falagario, M., & Cavone, G. (2016). A timed Petri Nets model for performance evaluation of intermodal freight transport terminals. *IEEE Transactions on Automation Science and Engineering*, *13*(2), 842–857.
https://doi.org/10.1109/tase.2015.2404438

Douglas, A., Douglas, A., & Ochieng, J. (2015). Lean Six Sigma implementation in East Africa: Findings from a pilot study. *The TQM Journal*, 27(6), 772–780.
https://doi.org/10.1108/tqm-05-2015-0066

Faber, N., De Koster, R., & Smidts, A. (2013). Organizing warehouse management. *International Journal of Operations & Production Management*, *33*(9), 1230–1256. https://doi.org/10.1108/ijopm-12-2011-0471

Fraser, P., Moultrie, J., & Gregory, M. (2003). The use of maturity models/grids as a tool in assessing product development capability. *IEEE International Engineering Management Conference*. https://doi.org/10.1109/iemc.2002.1038431

Frazelle, E. H. (2015). World-Class warehousing and material handling. https://new.sf.bg.ac.rs/index.php?p=show_detail&id=10955&keywords=

Fredriksson, A., & De Oliveira, G. M. (2019). Impact evaluation using Difference-in-Differences. *RAUSP Management Journal*, *54*(4), 519–532. https://doi.org/10.1108/rausp-05-2019-0112

Galeazzo, A. (2019). Degree of leanness and lean maturity: exploring the effects on financial performance. *Total Quality Management & Business Excellence*, *32*(7–8), 758–776. https://doi.org/10.1080/14783363.2019.1634469

Goomas, D. T., Smith, S. A., & Ludwig, T. D. (2011). Business activity monitoring: Real-Time group goals and feedback using an overhead scoreboard in a distribution centre. *Journal of Organizational Behaviour Management*, *31*(3), 196–209. https://doi.org/10.1080/01608061.2011.589715

Gu, J., Goetschalckx, M., & McGinnis, L. F. (2007). Research on Warehouse Operation: A Comprehensive Review. *European Journal of Operational Research*, 177(1), 1–21. https://doi.org/10.1016/j.ejor.2006.02.025

Gu, J., Goetschalckx, M., & McGinnis, L. F. (2010). Research on warehouse design and performance evaluation: A comprehensive review. *European Journal of Operational Research*, *203*(3), 539–549. https://doi.org/10.1016/j.ejor.2009.07.031

Gupta, S., Sharma, M., & Sunder, M. V. (2016). Lean Services: A Systematic Review. *International Journal of Productivity and Performance Management*, 65(8), 1025–1056. https://doi.org/10.1108/ijppm-02-2015-0032

Hatch, M. J. (1998). Organization theory: modern, symbolic, and postmodern perspectives. *Choice Reviews Online*, 35(06), 35–3404. https://doi.org/10.5860/choice.35-3404

Hausman, W. H., Schwarz, L. B., & Graves, S. C. (1976). Optimal storage assignment in automatic warehousing systems. *Management Science*, *22*(6), 629–638. https://doi.org/10.1287/mnsc.22.6.629

Jahre, M., Kembro, J., Rezvanian, T., Ergün, Ö., Håpnes, S. J., & Berling, P. (2016). Integrating supply chains for emergencies and ongoing operations in UNHCR. *Journal Of Operations Management*, *45*(1), 57–72. https://doi.org/10.1016/j.jom.2016.05.009

Jane, C., & Laih, Y. (2005). A clustering algorithm for item assignment in a synchronized zone order picking system. *European Journal of Operational Research*, *166*(2), 489–496. https://doi.org/10.1016/j.ejor.2004.01.042

Jørgensen, F., Matthiesen, R., Nielsen, J., Johansen, J. (2007). Lean Maturity, Lean Sustainability, Advances in Production Management Systems. IFIP — *The International*

Federation for Information Processing, vol 246. Springer, Boston, MA. https://doi.org/10.1007/978-0-387-74157-4_44

Karim, N. H., Rahman, N. S. F. A., Hanafiah, R. M., Hamid, S. A., Ismail, A. Z., Kader, A. S. A., & Muda, M. S. (2020). Revising the warehouse productivity measurement indicators: ratio-based benchmark. *Maritime Business Review*, 6(1), 49–71. https://doi.org/10.1108/mabr-03-2020-0018

Kembro, J., Norrman, A., & Eriksson, E. (2018). Adapting warehouse operations and design to omni-channel logistics. *International Journal of Physical Distribution & Logistics Management*, 48(9), 890–912. https://doi.org/10.1108/ijpdlm-01-2017-0052

Kusrini, E., Novendri, F., & Helia, V. N. (2018). Determining key performance indicators for warehouse performance measurement – a case study in construction materials warehouse. *MATEC Web Of Conferences*, 154, 01058. https://doi.org/10.1051/matecconf/201815401058

Lao, S. I., Choy, K. L. T., Ho, G., Tsim, Y. C., & Chung, S. H. (2011). Determination of the success factors in supply chain networks: A Hong Kong-based manufacturer's perspective. *Measuring Business Excellence*, *15*(1), 34–48. https://doi.org/10.1108/13683041111113231

Laosirihongthong, T., Adebanjo, D., Samaranayake, P., Subramanian, N., & Boon-itt, S. (2018). Prioritizing warehouse performance measures in contemporary supply chains. *International Journal of Productivity and Performance Management*, 67(9), 1703–1726. https://doi.org/10.1108/ijppm-03-2018-0105

Lee, C. K. M., Lv, Y., Ng, K. M., Ho, W., & Choy, K. L. T. (2017). Design and application of Internet of Things-based warehouse management system for smart logistics. *International Journal of Production Research*, 56(8), 2753–2768. https://doi.org/10.1080/00207543.2017.1394592

Liu, C. (1999). Clustering techniques for stock location and order-picking in a distribution center. *Computers & Operations Research*, 26(10–11), 989–1002. https://doi.org/10.1016/s0305-0548(99)00026-x

Maasouman, M. A., & Demirli, K. (2015). Development of a lean maturity model for operational level planning. *The International Journal of Advanced Manufacturing Technology*, *83*(5–8), 1171–1188. https://doi.org/10.1007/s00170-015-7513-4

Mahfouz, A. (2011). An Integrated Framework to Assess "Leanness" Performance in Distribution Centres. *Dublin Institute of Technology*. https://doi.org/10.21427/d70g69

Manzini, R., Bozer, Y. A., & Heragu, S. S. (2015). Decision models for the design, optimization and management of warehousing and material handling systems. *International Journal of Production Economics*, *170*, 711–716. https://doi.org/10.1016/j.ijpe.2015.08.007

Masae, M., Glock, C. H., & Grosse, E. H. (2020). Order picker routing in warehouses: A systematic literature review. *International Journal of Production Economics*, 224, 107564. https://doi.org/10.1016/j.ijpe.2019.107564

Nesensohn, C., Bryde, D. J., Ochieng, E., & Fearon, D. (2014). Maturity and maturity models in lean construction. *Construction Economics and Building*, *14*(1), 45–59. https://doi.org/10.5130/ajceb.v14i1.3641

Ohno, T. (1978). Toyota Production System: Beyond Large-Scale production. http://dx.doi.org/10.4324/9780429273018

Pakdil, F., & Leonard, K. M. (2014). Criteria for a lean organisation: development of a lean assessment tool. *International Journal of Production Research*, *52*(15), 4587–4607. https://doi.org/10.1080/00207543.2013.879614

Pereira, C. M., Anholon, R., Rampasso, I. S., Quelhas, O. L. G., Filho, W. L., & De Santa-Eulália, L. A. (2020). Evaluation of lean practices in Warehouses: An analysis of Brazilian reality. *International Journal of Productivity and Performance Management*, *70*(1), 1–20. https://doi.org/10.1108/ijppm-01-2019-0034

Raghuram, P., & Arjunan, M. K. (2021). Design framework for a lean warehouse – a case study-based approach. *The International Journal of Productivity and Performance Management/International Journal of Productivity And Performance Management*, *71*(6), 2410–2431. https://doi.org/10.1108/ijppm-12-2020-0668

Razik, M., Radi, B., & Okar, C. (2017). Development of a maturity model for the warehousing function in Moroccan companies. *International Journal of Engineering and Technology*, 9(2), 280–290. https://doi.org/10.21817/ijet/2017/v9i1/170902303

Reuter, C. (2009). *Logistikrelevante Lösungen auf der Basis von Lean-Management bei kleinen Losgrößen und hoher Variantenvielfalt*. Ph.D. thesis, Universität Stuttgart, Heimsheim. https://doi.org/10.18419/opus-4161

Rouwenhorst, B., Reuter, B., Stockrahm, V., Houtum, V. G. G., Mantel, R. J., & Zijm, W. H. (2000). Warehouse Design and Control: Framework and Literature review. *European Journal of Operational Research*, *122*(3), 515–533. https://doi.org/10.1016/s0377-2217(99)00020-x

Salhieh, L., & Alswaer, W. (2021). A proposed maturity model to improve warehouse performance. *International Journal of Productivity and Performance Management*, *71*(8), 3724–3746. https://doi.org/10.1108/ijppm-01-2021-0043

Schiele, H. (2007). Supply-management maturity, cost savings and purchasing absorptive capacity: Testing the procurement–performance link. *Journal Of Purchasing and Supply Management*, 13(4), 274–293. https://doi.org/10.1016/j.pursup.2007.10.002

Schneider, M. (2008). A general model for the design of data warehouses. *International Journal of Production Economics*, *112*(1), 309–325. https://doi.org/10.1016/j.ijpe.2006.11.027

Sen, A., Sinha, A. P., & Ramamurthy, K. (2006). Data Warehousing Process Maturity: An Exploratory Study of Factors Influencing User Perceptions. *IEEE Transactions on Engineering Management*, *53*(3), 440–455. https://doi.org/10.1109/tem.2006.877460

Sen, A., Ramamurthy, K., & Sinha, A. P. (2012). A Model of Data Warehousing Process Maturity. *IEEE Transactions on Software Engineering*, *38*(2), 336–353. https://doi.org/10.1109/tse.2011.2

Setianto, P., & Haddud, A. (2016). A maturity assessment of lean development practices in manufacturing industry. *International Journal of Advanced Operations Management*, *8*(4), 294. https://doi.org/10.1504/ijaom.2016.084150

Shah, B., & Khanzode, V. (2018). Designing a lean storage allocation policy for non-uniform unit loads in a forward-reserve model. *Journal of Enterprise Information Management*, *31*(1), 112–145. https://doi.org/10.1108/jeim-01-2017-0018

Shang, G., & Rönkkö, M. (2022). Empirical research methods department: Mission, learnings, and future plans. *Journal Of Operations Management*, *68*(2), 114–129. https://doi.org/10.1002/joom.1171

Sobanski, E. B. (2009). Assessing Lean Warehousing: Development and Validation of a lean Assessment tool. A doctoral dissertation. https://shareok.org/bitstream/11244/7781/1/Sobanski_okstate_0664D_10476.pdf

Soliman, A., & Gadalla, M. A. (2014). Measuring and Tracking of Lean Manufacturing Transformation. *ASME 2014 International Manufacturing Science and Engineering Conference*. https://doi.org/10.1115/msec2014-4119

Sousa, R., & Voss, C. (2008). Contingency research in operations management practices. *Journal Of Operations Management*, *26*(6), 697–713. https://doi.org/10.1016/j.jom.2008.06.001

Staudt, F. H., Alpan, G., Di Mascolo, M., & Rodriguez, C. M. T. (2015). Warehouse performance measurement: a literature review. *International Journal of Production Research*, 53(18), 5524–5544. https://doi.org/10.1080/00207543.2015.10304665

Tahboub, K. K., & Salhieh, L. (2019). Warehouse waste reduction level and its impact on warehouse and business performance. *Industrial and systems engineering review*, 7(2), 85–101. https://doi.org/10.37266/iser.2019v7i2.pp85-101

Tavčar, J., Demšar, I., & Duhovnik, J. (2018). Engineering change management maturity assessment model with lean criteria for automotive supply chain. *Journal Of Engineering Design*, *29*(4–5), 235–257. https://doi.org/10.1080/09544828.2018.1463513

Tortorella, G. L., Marodin, G. A., Fogliatto, F. S., & Miorando, R. F. (2014). Learning organisation and human resources management practices: an exploratory research in medium-sized enterprises undergoing a lean implementation. *International Journal of Production Research*, *53*(13), 3989–4000. https://doi.org/10.1080/00207543.2014.980462

Varila, M., Seppänen, M., & Heinonen, E. (2005). Effects of automation on cost accounting: A case study in warehouse logistics. *7TH MANUFACTURING ACCOUNTING RESEARCH CONFERENCE*.

https://researchportal.tuni.fi/en/publications/effects-of-automation-on-cost-accounting-a-case-study-in-warehous

Verrier, B., Rose, B., & Caillaud, E. (2013). Sustainable Manufacturing through Lean and Green Approach: Best practices and Indicators. *ASME 2013 International Design Engineering Technical Conferences and Computers and Information in Engineering Conference.* https://doi.org/10.1115/detc2013-13073

Verrier, B., Rose, B., & Caillaud, E. (2016). Lean and Green strategy: the Lean and Green House and maturity deployment model. *Journal of Cleaner Production*, *116*, 150–156. https://doi.org/10.1016/j.jclepro.2015.12.022

Vickson, R. G., & Lu, X. (1998). Optimal product and server locations in one-dimensional storage racks. *European Journal of Operational Research*, *105*(1), 18–28. https://doi.org/10.1016/s0377-2217(97)00023-4

Vidyadhar, R., Kumar, R., Vinodh, S., & Antony, J. (2016). Application of fuzzy logic for leanness assessment in SMEs: a case study. *Journal Of Engineering, Design and Technology*, *14*(1), 78–103. https://doi.org/10.1108/jedt-05-2014-0029

Volodymyr, M., Harmash, O., & Ovdiienko, O. (2020). World Trends in warehouse logistics. *Ìntelektualìzacìâ logìstiki ta upravlìnnâ lancûgami postačan'*, *2*, 32–50. https://doi.org/10.46783/smart-scm/2020-2-3

Wagire, A. A., Joshi, R., Rathore, A. P. S., & Jain, R. (2020). Development of maturity model for assessing the implementation of Industry 4.0: learning from theory and practice. *Production Planning & Control*, *32*(8), 603–622. https://doi.org/10.1080/09537287.2020.1744763

Womack, J. P., Jones, D. M., & Roos, D. (1991). The machine that changed the world. *Long Range Planning*, *25*(3), 126. https://doi.org/10.1016/0024-6301(92)90400-v

Zanon, L. G., Ulhoa, T. F., & Espôsto, K. F. (2020). Performance measurement and lean maturity: congruence for improvement. *Production Planning & Control*, *32*(9), 760–774. https://doi.org/10.1080/09537287.2020.1762136

Zailani, S., & Rajagopal, P. (2005). Supply chain integration and performance: US versus East Asian companies. *Supply Chain Management: An International Journal*, *10*(5), 379–393. https://doi.org/10.1108/13598540510624205

Appendix

1. Literature review

1.1. Intermediary levels and goals of Lean Maturity

Table 3: Overview of intermediary levels of maturity in modelling

Number	Environment	Lean Maturity Level Indicators	Reference
1	Manufacturing	Five levels of maturity developed: • Sporadic production optimisation • Basic Lean implementation • Strategic Lean interventions • Proactive Lean culture • Lean in the Extended Manufacturing Enterprise	(Jørgensen et al., 2007)
2	Manufacturing	Five levels of Lean maturity, which describe as: • Level 1 - Senior leaders have various views of Lean, none of them well defined. • Level 2 - Senior leaders adopt a common Lean vision. • Level 3 - Lean vision has been communicated and understood by most of the employees. • Level 4 - Common Lean vision is shared by the extended enterprise. • Level 5 - Stakeholders have internalized.	(Nesensohn et al., 2014)
3	Manufacturing	Highlighted phases for Lean implementation: • Prepare implementation. • Define value. • Identify flow of value. • Design production system. • Implement flow. • Implement pull system. • Look for perfection.	(Tortorella & Fogliatto, 2014)
4	Manufacturing	Five proposed key milestones for Lean maturity • Strategy deployment • People-enabled processes • Value stream management • Application of lean tools • Techniques and extended enterprise	(Setianto & Haddud, 2016)
5	Manufacturing	A five-level maturity framework is presented: • Limited awareness of lean practices (Initial stage)	(Verrier et al., 2016)

		• Occasional basic lean practices (Managed stage) • Conduction of separately regular Lean practices (Defined stage) • Conduction of combined regular Lean practices (Quantitatively managed stage) • Continuous improvement by monitoring (Optimized stage)	
6	Manufacturing	The applied maturity model regards three phases: • A need to create the climate for change. • Communicate the vision. • Build on the change and promote continuous improvement to sustain it.	(AlManei et al., 2018)

1.2. Lean Maturity Parameters

Table 4: Overview of lean maturity measurement parameters

Number	Environment	Lean Maturity Parameters	Reference
1	Manufacturing	The level of lean maturity is evaluated by the level of integrated lean tools and the absence of lean wastes.	(Verrier et al., 2013)
2	Manufacturing	Lean maturity is measured by the level of adoption of the following identified Lean principles: • Dependency on flexible manpower • Continuous flow • Material supply • Quality assurance • Product/process quality planning • Standardised work • Production levelling	(Tortorella et al., 2014)
3	Manufacturing	Five proposed levels of lean transformation based on the following parameters: • Lean leadership • Lean fundamentals (5S, zero defect, visual management) • Heijunka • End-to-end pull • Jidoka.	(Soliman & Gadalla, 2014)

4	Manufacturing	Lean maturity is assessed by analysing dimensions such as: • Time effectiveness • Quality • Process cost • Human resources • Delivery • Customer • Inventory	(Pakdil & Leonard, 2014)
5	Manufacturing	Seven proposed Lean parameters: • People • Facilities management • Working conditions • Production process • Quality • Just-in-time • Leadership aspects	(Maasouman & Demirli, 2015)
6	Manufacturing	Level of maturity is measured via dimensions regarding: • Managerial responsibility • Engagement on manufacturing • Workforce • Customer/supplier focus	(Vidyadhar et al., 2016)
7	Manufacturing	Lean maturity is assessed based on eight main parameters: • Strategic planning • Quality at source • Processes and tools • Problem solving • Respect for people • Continuous improvement • Supplier integration • Customer focus	(Bento & Tontini, 2018)
8	Manufacturing	Lean maturity is assessed by: • Process flow • Leadership • Customer-defined value	(Tavčar et al., 2018)

		• Knowledge management • Continuous improvement culture	
9	Manufacturing	Lean maturity is assessed as the level of adoption of lean practices.	(Camuffo & Gerli, 2018)
10	Manufacturing	Lean implementation is measured via dimensions such as: • Lean principles adoption • Leadership • Quality • Strategy • Production Management System development	(Chiarini & Brunetti, 2019)
11	Manufacturing	Lean maturity is assessed as a variable associated to the total number of years of lean manufacturing adoption.	(Galeazzo, 2019)
12	Warehousing	Maturity is assessed based on: • % of on-time orders • % of complete orders • % of supplier orders received damage free • % of accurate documents received • Put away accuracy • SKU damage free • % # of orders picked per hour greater than a certain threshold • % of orders shipped on time • % of orders completed • % of orders delivered damage free	(Salhieh & Alswaer, 2021)
13	Warehousing	Maturity is assessed based on the following parameters: • Supplier involvement • Customer involvement • Statistical Process Control • Total Preventive Maintenance / 5S • Employee involvement • Pull/flow relationship • Cross-docking measurements	(de Visser, 2014)

2. Methodology

2.1. CVR & CVI

Content Validity Ratio (CVR) is to assess the form of inter-rater reliability, as well as the content validity of the research. The setup is to ask the perception of (CI) Engineers and Operational Managers on the KPIs chosen to investigate. These KPIs are taken from Figure 8. The CVR makes a distinction between important and unnecessary KPIs, to indicate whether the chosen KPIs are fitting for this research. On the other hand, CVR does not identify missing aspects of the underlying constructs. The formula used to calculate the CVR is the following:

$$CVR[KPI_X] = \frac{N_e - \left(\frac{N}{2}\right)}{\left(\frac{N}{2}\right)}$$

Where:

N = The total number of experts questioned, in this list 13 in total.

N_e = The number of experts that labelled the KPI as "critical to take up in this research"

Table 5: Content Validity Matrix & Index

KPI / Expert	KPI_1 (AITT)	KPI_2 (AOTT)	KPI_3 (PpMH)	KPI_4 (PIpMH)	KPI_5 (LU)	KPI_6 (IGA)	KPI_7 (SA)	KPI_8 (PO)	KPI_9 (S)
1. (E)	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2. (CI-E)	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
3. (E)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
4. (E)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
5. (E)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
6. (CI-E)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
7. (E)	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
8. (O.M)	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
9. (E)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
10. (E)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
11. (O.M)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
12. (O.M)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
13. (O.M)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Total "Yes"	**13/13**	**12/13**	**12/13**	**13/13**	**12/13**	**12/13**	**13/13**	**13/13**	**12/13**

CVR	**1**	**0.8462**	**0.8462**	**1**	**0.8462**	**0.8462**	**1**	**1**	**0.8462**

(E) = Engineer, (CI-E) = Continuous Improvement Engineer, (O.M) = Operations Manager

Note that the outcomes are values between -1 and +1. The closer to +1, the higher the content validity. The Content Validity Index (CVI) is the average of the CVR. For Table 5 this would imply the following:

$$CVI = \frac{\sum_{i=0}^{n} CVR}{9} = \frac{8.231}{9} = 0.9146$$

This CVI outcome indicates that the KPIs of interest are valid and are fitting in the aim of this research.

2.2. DiD Considerations

There are more methods of making DiD more robust. Matching, as the name suggests, is when treatment and control group observations are matched, which should reduce bias. First, suppose of cross-sectional studies with one differing variable that is relevant for treatment assignment and outcomes. Similarly, even if states of one group are more likely to be treated, there are still treatment and control states of both types. In this case, separate treatment effects would be estimated per category. The average treatment effect is then collected by labelling the number of treated groups in each category. When the number of control variables grows and/or take on many contextual factors, such exact matching is typically not possible, since the comparison decreases.

A second approach using control variables is the synthetic control method. Like DiD, it aims at balancing pre-intervention trends in the outcome variables. Inspired by matching, the method minimizes the intermediary distance between the values of the covariates in the treatment and control groups, by choosing different weights for the different control regions. The post-treatment difference also depends on a weight factor for all covariates. These weights are chosen to fit such that the pre-intervention trend in the control group is as close as possible to the pre-intervention trend for the treatment group.

3. Results

3.1. Consulted Experts

Table 6: List of Consulted Experts

Location	Function
A_Site_1	Continuous Improvement Specialist & Manager Operational Excellence
A_Site_2	Logistics Engineer & Continuous Improvement Specialist
A_Site_3	Logistics Engineer
A_Site_4	Logistics Engineer
A_Site_5	Continuous Improvement Specialist
A_Site_6	Team Lead Engineering
A_Site_7	Logistics Engineer
B_Site_1	Head of Operational Excellence
B_Site_2	Site Management
B_Site_3	Logistics Engineer
B_Site_4	Team Lead Engineering
B_Site_5	Continuous Improvement Specialist
B_Site_6	Continuous Improvement Specialist
B_Site_7	Site Management
B_Site_8	Quality Control
B_Site_9	Team Lead Engineering
B_Site_10	Site Management
B_Site_11	Logistics Engineer
B_Site_12	Logistics Engineer
B_Site_13	Logistics Engineer
B_Site_14	Project Controller
B_Site_15	Operational Excellence Manager
B_Site_16	Quality Manager
B_Site_17	KVP-Manager
B_Site_18	Project Manager
B_Site_19	Project Manager
B_Site_20	Team Lead Engineering
B_Site_21	Process Control
B_Site_22	Practioner Operational Excellence
B_Site_23	Continuous Improvement Specialist
B_Site_24	Logistics Engineer
B_Site_25	Quality Manager
B_Site_26	Operations Excellence Manager
B_Site_27	Operations Excellence Manager
B_Site_28	Logistics Engineer
B_Site_29	Logistics Engineer
B_Site_30	Continuous Improvement Specialist

3.2. Timelines per KPI

AITT

Average Inbound Throughput Time in minutes
CONFIDENTIAL

Locations in Country "A"

Year	Quarter	A_Site_1	A_Site_2	A_Site_3	A_Site_4	A_Site_5	A_Site_6	A_Site_7	Average Country "A"
2017	Q1	62	-	-	-	-	44	32	46
	Q2	59	-	-	-	-	46	35	47
	Q3	69	-	-	-	55	60	37	55
	Q4	35	-	-	-	53	63	36	47
2018	Q1	36	-	-	-	66	29	37	42
	Q2	68	-	-	-	63	60	38	57
	Q3	79	-	-	-	67	62	33	60
	Q4	79	-	-	-	62	58	35	59
2019	Q1	76	-	33	-	59	47	32	49
	Q2	83	-	35	-	50	38	29	47
	Q3	66	-	39	-	53	36	38	46
	Q4	62	-	40	-	68	35	36	48
2020	Q1	49	-	29	-	49	49	35	42
	Q2	59	-	29	-	53	58	34	47
	Q3	58	-	49	-	67	39	38	50
	Q4	60	-	36	-	59	57	39	50
2021	Q1	69	-	35	-	52	38	36	46
	Q2	61	-	27	-	48	46	36	44
	Q3	65	-	35	-	63	61	38	52
	Q4	69	-	37	-	57	68	31	52
2022	Q1	58	-	31	-	52	63	42	49
	Q2	49	-	39	-	51	68	32	48
	Q3	43	-	40	-	64	65	45	51
	Q4	58	-	26	-	46	62	42	47
2023	Q1	44	-	39	-	59	47	46	47
	Q2	68	-	35	-	56	39	43	48
	Q3	65	-	34	-	52	61	47	52
	Q4	43	-	27	-	60	55	39	45

Locations in Country "B"

Year	Quarter	B_Site_1	B_Site_2	B_Site_3	B_Site_4	B_Site_5	B_Site_6	B_Site_7	B_Site_8	B_Site_9	B_Site_10	B_Site_11	B_Site_12	B_Site_13	B_Site_14	B_Site_15	B_Site_16	B_Site_17	B_Site_18	B_Site_19	B_Site_20	B_Site_21	B_Site_22	B_Site_23	B_Site_24	B_Site_25	B_Site_26	B_Site_27	B_Site_28	B_Site_29	B_Site_30	B_Site_31	Average Country "B"
2017	Q1	-	57	-	-	-	-	38	-	39	-	-	-	27	-	-	45	-	-	-	39	-	-	88	57	-	51	-	-	-	-	-	49
	Q2	-	55	-	-	-	-	42	-	43	-	-	-	31	-	-	52	-	-	-	42	-	-	91	55	-	47	-	-	-	-	-	51
	Q3	-	49	-	-	-	-	38	-	35	-	-	-	28	-	-	54	-	-	-	43	-	-	68	52	-	40	-	-	-	-	-	45
	Q4	-	60	-	-	-	-	36	-	36	-	-	-	27	-	-	49	-	-	-	35	-	-	94	49	-	48	-	-	-	-	-	48
2018	Q1	-	62	-	-	-	-	35	-	40	-	-	-	29	-	-	43	-	-	-	31	-	-	101	43	-	39	-	-	-	-	-	47
	Q2	-	49	-	-	-	-	29	-	42	-	-	-	33	-	-	44	-	-	-	30	-	-	77	58	-	46	-	-	-	-	-	45
	Q3	-	55	-	-	-	-	31	-	39	-	-	-	32	-	-	46	-	-	-	39	-	-	89	56	-	52	-	-	-	-	-	49
	Q4	-	43	-	-	-	-	34	-	36	-	-	-	30	-	-	55	-	-	-	35	-	-	94	57	-	51	-	-	-	-	-	48
2019	Q1	-	58	-	-	-	-	37	-	48	-	-	-	24	-	-	52	-	-	-	38	-	-	83	62	-	38	-	-	-	-	-	49
	Q2	-	63	-	-	-	-	35	-	45	-	-	-	26	-	-	50	-	-	-	36	-	-	91	48	-	44	-	-	-	-	-	49
	Q3	-	44	-	-	-	-	33	-	40	-	-	-	29	-	-	58	-	-	-	33	-	-	86	44	-	46	-	-	-	-	-	46
	Q4	-	63	-	-	-	-	39	-	43	-	-	-	25	-	-	53	-	-	-	43	-	-	90	47	-	47	-	-	-	-	-	50
2020	Q1	-	57	-	-	-	-	33	-	38	-	-	-	22	-	-	49	-	-	-	42	-	-	105	43	-	42	-	-	-	-	-	48
	Q2	-	53	-	-	-	-	36	-	36	-	-	-	20	-	-	47	-	-	-	43	-	-	92	56	-	43	-	-	-	-	-	47
	Q3	-	59	-	-	-	-	29	-	33	-	-	-	29	-	-	43	-	-	-	40	-	-	104	52	-	49	-	-	-	-	-	49
	Q4	-	42	-	-	-	-	41	-	47	-	-	-	24	-	-	45	-	-	-	46	-	-	90	50	-	50	-	-	-	-	-	48
2021	Q1	-	43	50	-	-	-	35	-	42	-	-	-	28	-	-	42	-	-	-	39	-	-	89	61	-	46	-	-	-	-	-	48
	Q2	-	44	42	-	-	-	32	-	43	-	-	-	23	-	-	39	-	-	-	36	-	-	83	66	-	41	-	-	-	-	-	45
	Q3	-	47	49	-	-	-	38	-	41	-	-	-	31	-	-	50	-	-	-	38	-	-	85	50	-	39	-	-	-	-	-	47
	Q4	-	49	48	-	-	-	41	-	39	-	-	-	35	-	-	56	-	-	-	37	-	-	86	53	-	40	-	-	-	-	-	48
2022	Q1	-	52	35	-	-	-	35	-	35	-	-	-	32	-	-	44	-	-	-	34	-	-	90	52	-	53	-	-	-	-	-	46
	Q2	-	43	46	-	-	-	36	-	32	-	-	-	30	-	-	51	-	-	-	35	-	-	91	58	-	57	-	-	-	-	-	48
	Q3	-	46	40	-	-	-	31	-	40	-	-	-	29	-	-	49	-	-	-	40	-	-	83	59	-	51	-	-	-	-	-	47
	Q4	-	50	41	-	-	-	42	-	43	-	-	-	25	-	-	46	-	-	-	38	-	-	88	52	-	48	-	-	-	-	-	47
2023	Q1	-	39	55	-	-	-	35	-	41	-	-	-	26	-	-	38	-	-	-	46	-	-	91	56	-	43	-	-	-	-	-	47
	Q2	-	55	35	-	-	-	40	-	46	-	-	-	23	-	-	45	-	-	-	33	-	-	92	44	-	46	-	-	-	-	-	46
	Q3	-	63	49	-	-	-	38	-	42	-	-	-	30	-	-	47	-	-	-	39	-	-	88	43	-	50	-	-	-	-	-	49
	Q4	-	57	44	-	-	-	34	-	40	-	-	-	34	-	-	40	-	-	-	34	-	-	86	48	-	53	-	-	-	-	-	47

Figure 18: AITT Data Sheet

AOTT

Average Outbound Throughput Time in minutes
CONFIDENTIAL

Locations in Country "A"

Year	Quarter	A_Site_1	A_Site_2	A_Site_3	A_Site_4	A_Site_5	A_Site_6	A_Site_7	Average Country "A"
2017	Q1	77	-	23	-	35	42	33	42.00
	Q2	69	-	25	-	36	44	32	41.20
	Q3	72	-	24	-	35	46	36	42.60
	Q4	73	-	26	-	38	47	33	43.40
2018	Q1	74	-	23	-	36	43	34	42.00
	Q2	71	-	26	-	34	44	31	41.20
	Q3	69	-	25	-	35	45	32	41.20
	Q4	70	-	21	-	36	44	30	40.20
2019	Q1	73	-	22	-	36	46	29	41.20
	Q2	69	-	23	-	37	43	34	41.20
	Q3	68	-	22	-	35	42	35	40.40
	Q4	70	-	23	-	36	46	36	42.20
2020	Q1	71	-	25	-	33	47	30	41.20
	Q2	73	-	21	-	34	48	36	42.40
	Q3	71	-	23	-	33	46	39	42.40
	Q4	71	-	26	-	32	43	34	41.20
2021	Q1	75	-	25	-	35	43	35	42.60
	Q2	73	-	26	-	36	47	36	43.60
	Q3	75	-	23	-	32	45	32	41.40
	Q4	74	-	21	-	36	44	35	42.00
2022	Q1	69	-	22	-	38	43	30	40.40
	Q2	68	-	23	-	37	46	29	40.60
	Q3	62	-	26	-	36	47	31	40.40
	Q4	63	-	23	-	36	46	36	40.80
2023	Q1	66	-	25	-	34	45	30	40.00
	Q2	69	-	21	-	33	43	32	39.60
	Q3	62	-	23	-	35	42	31	38.60
	Q4	60	-	23	-	36	46	32	39.40

Locations in Country "B"

Year	Quarter	B_Site_1	B_Site_2	B_Site_3	B_Site_4	B_Site_5	B_Site_6	B_Site_7	B_Site_8	B_Site_9	B_Site_10	B_Site_11	B_Site_12	B_Site_13	B_Site_14	B_Site_15	B_Site_16	B_Site_17	B_Site_18	B_Site_19	B_Site_20	B_Site_21	B_Site_22	B_Site_23	B_Site_24	B_Site_25	B_Site_26	B_Site_27	B_Site_28	B_Site_29	B_Site_30	Average Country "B"
2017	Q1	-	41	-	-	-	-	39	-	65	-	-	-	62	-	-	47	-	-	-	42	-	-	37	-	47	53	-	-	-	-	48.11
	Q2	-	42	-	-	-	-	41	-	66	-	-	-	61	-	-	42	-	-	-	43	-	-	38	-	48	52	-	-	-	-	48.11
	Q3	-	41	-	-	-	-	39	-	63	-	-	-	63	-	-	43	-	-	-	42	-	-	36	-	47	49	-	-	-	-	47.00
	Q4	-	43	-	-	-	-	38	-	62	-	-	-	59	-	-	41	-	-	-	44	-	-	37	-	47	50	-	-	-	-	46.78
2018	Q1	-	42	-	-	-	-	37	-	64	-	-	-	57	-	-	45	-	-	-	45	-	-	38	-	45	51	-	-	-	-	47.11
	Q2	-	43	-	-	-	-	40	-	62	-	-	-	60	-	-	45	-	-	-	46	-	-	41	-	46	56	-	-	-	-	48.78
	Q3	-	41	-	-	-	-	42	-	63	-	-	-	63	-	-	44	-	-	-	43	-	-	40	-	43	53	-	-	-	-	48.00
	Q4	-	39	-	-	-	-	41	-	56	-	-	-	61	-	-	47	-	-	-	42	-	-	39	-	48	52	-	-	-	-	47.22
2019	Q1	-	40	-	-	-	-	39	-	56	-	-	-	61	-	-	46	-	-	-	41	-	-	35	-	47	54	-	-	-	-	46.56
	Q2	-	42	-	-	-	-	36	-	54	-	-	-	60	-	-	43	-	-	-	44	-	-	32	-	47	55	-	-	-	-	45.89
	Q3	-	43	-	-	-	-	38	-	58	-	-	-	59	-	-	47	-	-	-	43	-	-	34	-	46	53	-	-	-	-	46.78
	Q4	-	41	-	-	-	-	41	-	59	-	-	-	62	-	-	48	-	-	-	40	-	-	36	-	45	52	-	-	-	-	47.11
2020	Q1	-	46	-	-	-	-	40	-	53	-	-	-	63	-	-	49	-	-	-	42	-	-	37	-	46	51	-	-	-	-	47.44
	Q2	-	40	-	-	-	-	38	-	54	-	-	-	64	-	-	51	-	-	-	39	-	-	35	-	44	49	-	-	-	-	46.00
	Q3	-	39	-	-	-	-	39	-	56	-	-	-	59	-	-	43	-	-	-	42	-	-	36	-	43	48	-	-	-	-	45.00
	Q4	-	42	-	-	-	-	37	-	55	-	-	-	57	-	-	46	-	-	-	45	-	-	34	-	46	51	-	-	-	-	45.89
2021	Q1	-	41	-	-	-	-	39	-	57	-	-	-	60	-	-	48	-	-	-	46	-	-	35	-	48	53	-	-	-	-	47.44
	Q2	-	45	-	-	-	-	40	-	53	-	-	-	59	-	-	42	-	-	-	44	-	-	35	-	47	52	-	-	-	-	46.33
	Q3	-	41	-	-	-	-	40	-	56	-	-	-	60	-	-	45	-	-	-	41	-	-	36	-	49	54	-	-	-	-	46.89
	Q4	-	40	-	-	-	-	42	-	52	-	-	-	63	-	-	47	-	-	-	40	-	-	37	-	45	51	-	-	-	-	46.33
2022	Q1	-	46	-	-	-	-	39	-	54	-	-	-	58	-	-	48	-	-	-	39	-	-	35	-	46	52	-	-	-	-	46.33
	Q2	-	43	-	-	-	-	41	-	54	-	-	-	62	-	-	46	-	-	-	46	-	-	36	-	43	50	-	-	-	-	46.78
	Q3	-	42	-	-	-	-	42	-	53	-	-	-	61	-	-	43	-	-	-	43	-	-	34	-	47	49	-	-	-	-	46.00
	Q4	-	41	-	-	-	-	39	-	56	-	-	-	60	-	-	42	-	-	-	42	-	-	35	-	46	50	-	-	-	-	45.67
2023	Q1	-	45	-	-	-	-	38	-	51	-	-	-	58	-	-	42	-	-	-	39	-	-	35	-	44	53	-	-	-	-	45.00
	Q2	-	44	-	-	-	-	39	-	50	-	-	-	57	-	-	45	-	-	-	38	-	-	35	-	45	52	-	-	-	-	45.00
	Q3	-	39	-	-	-	-	40	-	53	-	-	-	56	-	-	47	-	-	-	40	-	-	34	-	48	51	-	-	-	-	45.33
	Q4	-	40	-	-	-	-	41	-	56	-	-	-	60	-	-	48	-	-	-	41	-	-	36	-	42	50	-	-	-	-	46.00

Figure 19: AOTT Data Sheet

PpMH

PpMH in SKU

CONFIDENTIAL

		Locations in Country "A"								Locations in Country "B"										
		A_Site_1	A_Site_2	A_Site_3	A_Site_4	A_Site_5	A_Site_6	A_Site_7	Average Country "A"	B_Site_1	B_Site_2	B_Site_3	B_Site_4	B_Site_5	B_Site_6	B_Site_7	B_Site_8	B_Site_9	B_Site_10	B_Site_11
2017	Q1	86	-	93	-	78	77	67	80	56	-	96	-	-	-	-	-	79	91	106
	Q2	88	-	95	-	77	73	69	80	60	-	99	-	-	-	-	-	81	88	100
	Q3	86	-	99	-	73	75	70	81	55	-	95	-	-	-	-	-	77	84	105
	Q4	79	-	88	-	80	79	66	78	62	-	92	-	-	-	-	-	75	90	104
2018	Q1	86	-	89	-	82	81	62	80	56	-	95	-	-	-	-	-	77	94	106
	Q2	87	-	90	-	79	77	69	80	59	-	99	-	-	-	-	-	76	95	107
	Q3	81	-	91	-	77	78	66	79	58	-	101	-	-	-	-	-	81	92	110
	Q4	82	-	93	-	83	75	65	80	61	-	100	-	-	-	-	-	83	91	103
2019	Q1	88	-	84	-	84	82	71	82	62	-	94	-	-	-	-	-	74	94	102
	Q2	85	-	89	-	75	79	65	79	55	-	95	-	-	-	-	-	75	96	109
	Q3	84	-	84	-	82	75	64	78	59	-	92	-	-	-	-	-	79	90	112
	Q4	85	-	92	-	81	76	65	80	60	-	96	-	-	-	-	-	80	89	114
2020	Q1	90	-	95	-	77	79	62	81	62	88	99	-	-	-	-	-	72	86	105
	Q2	85	-	85	-	81	77	68	79	63	89	102	-	-	-	-	-	83	87	106
	Q3	88	-	92	-	75	80	67	80	59	92	97	-	-	-	-	-	84	89	103
	Q4	83	-	89	-	77	82	73	81	55	86	95	-	-	-	-	-	81	90	105
2021	Q1	84	-	90	-	77	77	75	81	57	84	93	-	-	113	-	-	79	93	101
	Q2	82	-	86	-	80	79	74	80	52	80	99	-	-	119	-	-	73	86	99
	Q3	85	-	88	-	75	81	72	80	58	82	98	-	-	112	-	-	71	86	104
	Q4	89	-	83	-	73	80	75	80	59	92	100	-	-	116	-	-	80	89	109
2022	Q1	90	-	85	-	78	79	66	80	53	85	94	-	-	115	-	-	82	91	114
	Q2	91	-	92	-	79	77	69	82	59	84	94	-	-	116	-	-	84	90	106
	Q3	85	-	94	-	77	75	62	79	62	86	96	-	-	120	-	-	86	95	108
	Q4	83	-	95	-	81	79	66	81	63	86	97	-	-	116	-	-	83	91	110
2023	Q1	84	-	88	-	75	80	68	79	61	83	99	-	-	113	-	-	81	95	109
	Q2	78	-	87	-	76	81	71	79	58	86	93	-	-	108	-	-	75	92	113
	Q3	88	-	93	-	77	79	71	82	57	88	99	-	-	107	-	-	74	94	105
	Q4	85	-	91	-	79	77	73	81	60	91	96	-	-	115	-	-	78	89	106

		B_Site_12	B_Site_13	B_Site_14	B_Site_15	B_Site_16	B_Site_17	B_Site_18	B_Site_19	B_Site_20	B_Site_21	B_Site_22	B_Site_23	B_Site_24	B_Site_25	B_Site_26	B_Site_27	B_Site_28	B_Site_29	B_Site_30	Average Country "B"
2017	Q1	79	88	-	81	85	-	-	130	49	-	-	-	78	77	-	93	99	-	125	88
	Q2	81	85	-	84	85	-	-	131	51	-	-	-	79	82	-	93	101	-	126	89
	Q3	84	90	-	79	83	-	-	133	44	-	-	-	72	88	-	95	100	-	129	88
	Q4	76	84	-	85	85	-	-	137	48	-	-	-	74	75	-	95	103	-	119	88
2018	Q1	77	85	-	83	89	-	-	138	47	-	-	-	75	76	-	92	99	-	119	88
	Q2	78	86	-	81	82	-	-	140	48	-	-	-	79	73	-	92	97	-	117	88
	Q3	82	82	-	89	86	-	-	142	45	-	-	-	82	74	-	95	98	-	129	90
	Q4	83	89	-	90	89	-	-	142	46	-	-	-	82	75	-	91	101	-	130	91
2019	Q1	80	86	-	82	85	-	-	141	49	-	-	-	81	72	-	89	96	-	132	89
	Q2	75	89	-	81	89	-	-	139	51	-	-	-	80	79	-	88	94	-	128	89
	Q3	76	88	-	76	90	-	-	139	52	-	-	-	84	74	-	91	95	-	128	89
	Q4	79	84	-	88	81	-	-	140	52	-	-	-	85	73	-	93	93	-	126	90
2020	Q1	82	89	-	86	84	-	-	131	56	-	-	-	82	76	-	91	96	-	125	89
	Q2	75	90	-	85	85	-	-	135	57	-	-	-	85	72	-	94	94	-	129	90
	Q3	75	84	-	82	82	-	-	137	61	-	-	-	77	79	-	95	96	-	131	90
	Q4	73	86	-	86	86	-	-	139	62	-	-	-	84	72	-	89	101	-	122	89
2021	Q1	79	85	-	89	88	-	-	129	59	-	-	-	85	74	-	90	100	-	121	90
	Q2	83	87	-	83	91	-	-	127	58	-	-	-	86	72	-	90	93	-	125	89
	Q3	84	82	-	86	79	-	-	130	59	-	-	-	82	72	-	96	98	-	127	89
	Q4	77	86	-	87	76	-	-	133	55	-	-	-	89	76	-	92	97	-	119	91
2022	Q1	75	89	-	88	75	-	-	132	59	-	-	-	83	74	-	95	93	-	121	90
	Q2	78	90	-	91	79	-	-	136	62	-	-	-	85	75	-	91	91	-	118	91
	Q3	75	76	-	81	89	-	-	128	65	-	-	-	86	76	-	90	102	-	117	91
	Q4	79	84	-	83	73	-	-	130	62	-	-	-	85	77	-	89	103	-	119	91
2023	Q1	70	86	-	82	72	-	-	138	64	-	-	-	82	74	-	87	104	-	126	90
	Q2	82	88	-	79	83	-	-	139	65	-	-	-	81	78	-	85	99	-	125	91
	Q3	84	89	-	84	85	-	-	141	60	-	-	-	80	72	-	88	98	-	130	91
	Q4	85	86	-	86	81	-	-	137	62	-	-	-	86	71	-	91	99	-	132	92

Figure 20: PpMH Data Sheet

PIpMH

PIpMH in SKU

CONFIDENTIAL

		Locations in Country "A"								Locations in Country "B"										
		A Site 1	A Site 2	A Site 3	A Site 4	A Site 5	A Site 6	A Site 7	Average Country "A"	B Site 1	B Site 2	B Site 3	B Site 4	B Site 5	B Site 6	B Site 7	B Site 8	B Site 9	B Site 10	B Site 11
2017	Q1	-	35	55	-	42	-	55	46.75	-	-	54	-	-	77	-	34	-	-	29
	Q2	-	36	53	-	42	-	56	46.75	-	-	53	-	-	75	-	33	-	-	30
	Q3	-	37	52	-	43	-	57	47.25	-	-	55	-	-	77	-	35	-	-	31
	Q4	-	33	50	-	45	-	52	45.00	-	-	56	-	-	79	-	31	-	-	33
2018	Q1	-	32	58	-	41	-	53	46.00	-	-	58	-	-	81	-	30	-	-	29
	Q2	-	29	59	-	42	-	51	45.25	-	-	55	-	-	82	-	35	-	-	30
	Q3	-	33	54	-	39	-	58	46.00	-	-	53	-	-	77	-	37	-	-	27
	Q4	-	36	57	-	37	-	56	46.50	-	-	56	-	-	79	-	38	-	-	26
2019	Q1	-	37	58	-	36	-	57	47.00	-	-	57	-	-	76	-	35	-	-	25
	Q2	-	35	56	-	38	-	59	47.00	-	-	59	-	-	74	-	35	-	-	28
	Q3	-	32	55	-	40	-	60	46.75	-	-	56	-	-	79	-	34	-	-	29
	Q4	-	29	54	-	41	-	61	46.25	-	-	54	-	-	80	-	31	-	-	31
2020	Q1	42	32	58	-	39	-	59	46.00	-	-	53	-	-	81	-	34	-	-	30
	Q2	45	35	59	-	40	-	54	46.60	-	-	55	-	-	83	-	36	-	-	34
	Q3	44	31	60	-	41	-	52	45.60	-	-	55	-	-	76	-	33	-	-	32
	Q4	46	33	53	-	44	-	54	45.90	-	-	53	-	-	79	-	31	-	-	29
2021	Q1	46	34	55	-	42	-	55	46.40	-	-	56	-	-	81	-	30	-	-	27
	Q2	48	35	56	-	45	-	56	47.95	-	-	53	-	-	76	-	29	-	-	29
	Q3	48	35	58	-	42	-	56	47.80	-	-	56	-	-	78	-	35	-	-	28
	Q4	46	36	59	-	41	-	52	46.80	-	-	52	-	-	82	-	34	-	-	31
2022	Q1	45	36	53	-	39	-	55	45.60	-	-	56	-	-	79	-	35	-	-	32
	Q2	46	37	52	-	41	-	58	46.85	-	-	58	-	-	74	-	32	-	-	30
	Q3	46	39	54	-	42	-	57	47.60	-	-	54	-	-	73	-	37	-	-	34
	Q4	46	37	58	-	39	-	54	46.80	-	-	53	-	-	75	-	37	-	-	29
2023	Q1	47	38	55	-	44	-	59	48.60	-	-	52	-	-	78	-	33	-	-	29
	Q2	46	39	56	-	45	-	52	47.55	-	-	55	-	-	79	-	31	-	-	27
	Q3	47	41	56	-	42	-	56	48.30	-	-	56	-	-	81	-	31	-	-	30
	Q4	46	40	57	-	41	-	54	47.60	-	-	53	-	-	77	-	30	-	-	28

		B Site 12	B Site 13	B Site 14	B Site 15	B Site 16	B Site 17	B Site 18	B Site 19	B Site 20	B Site 21	B Site 22	B Site 23	B Site 24	B Site 25	B Site 26	B Site 27	B Site 28	B Site 29	B Site 30	Average Country "B"
2017	Q1	41	-	-	-	33	38	-	-	88	-	35	-	-	-	-	29	43	-	-	45.55
	Q2	40	-	-	-	31	40	-	-	90	-	37	-	-	-	-	31	42	-	-	45.64
	Q3	40	-	-	-	35	39	-	-	92	-	35	-	-	-	-	30	46	-	-	46.82
	Q4	41	-	-	-	33	37	-	-	87	-	38	-	-	-	-	36	44	-	-	46.82
2018	Q1	42	-	-	-	32	41	-	-	89	-	34	-	-	-	-	27	42	-	-	45.91
	Q2	43	-	-	-	36	42	-	-	88	-	38	-	-	-	-	28	41	-	-	47.09
	Q3	41	-	-	-	29	40	-	-	91	-	39	-	-	-	-	29	40	-	-	45.73
	Q4	39	-	-	-	30	39	-	-	92	-	36	-	-	-	-	30	39	-	-	45.82
2019	Q1	38	-	-	-	34	39	-	-	88	-	33	-	-	-	-	32	38	-	-	45.00
	Q2	40	-	-	-	32	44	-	-	85	-	36	-	-	-	-	29	43	-	-	45.91
	Q3	41	-	-	-	31	45	-	-	86	-	37	-	-	-	-	27	43	-	-	46.18
	Q4	41	-	-	-	33	38	-	-	84	-	35	-	-	-	-	27	45	-	-	45.36
2020	Q1	44	-	-	-	33	37	-	-	86	-	35	-	-	-	-	31	46	-	-	46.36
	Q2	39	-	-	-	34	36	-	-	88	-	37	-	-	-	-	32	42	-	-	46.91
	Q3	39	-	-	-	35	38	-	-	89	-	38	-	-	-	-	30	43	-	-	46.18
	Q4	42	-	-	-	32	34	-	-	91	-	34	-	-	-	-	28	47	-	-	45.45
2021	Q1	44	-	-	-	30	39	-	-	92	-	35	-	-	-	-	30	43	-	-	46.09
	Q2	43	-	-	-	28	42	-	-	93	-	37	-	-	-	-	29	45	-	-	45.82
	Q3	45	-	-	-	32	39	-	-	94	-	38	-	-	-	-	27	44	-	-	46.91
	Q4	40	-	-	-	37	41	-	-	95	-	39	-	-	-	-	31	41	-	-	47.55
2022	Q1	38	-	-	-	35	38	-	-	91	-	36	-	-	-	-	33	39	-	-	46.55
	Q2	37	-	-	-	35	35	-	-	94	-	37	-	-	-	-	25	45	-	-	45.64
	Q3	36	-	-	-	34	36	-	-	95	-	38	-	-	-	-	30	43	-	-	46.36
	Q4	38	-	-	-	31	38	-	-	93	-	41	-	-	-	-	33	46	-	-	46.73
2023	Q1	41	-	-	-	33	37	-	-	95	-	40	-	-	-	-	36	47	-	-	47.36
	Q2	42	-	-	-	37	39	-	-	92	-	39	-	-	-	-	29	42	-	-	46.55
	Q3	44	-	-	-	35	40	-	-	90	-	41	-	-	-	-	28	43	-	-	47.18
	Q4	42	-	-	-	30	39	-	-	89	-	42	-	-	-	-	31	43	-	-	45.82

Figure 21: PIpMH Data Sheet

LU

Location Utilization in %

CONFIDENTIAL

		Locations in Country "A"								Locations in Country "B"																														
		A_Site_1	A_Site_2	A_Site_3	A_Site_4	A_Site_5	A_Site_6	A_Site_7	Average Country "A"	B_Site_1	B_Site_2	B_Site_3	B_Site_4	B_Site_5	B_Site_6	B_Site_7	B_Site_8	B_Site_9	B_Site_10	B_Site_11	B_Site_12	B_Site_13	B_Site_14	B_Site_15	B_Site_16	B_Site_17	B_Site_18	B_Site_19	B_Site_20	B_Site_21	B_Site_22	B_Site_23	B_Site_24	B_Site_25	B_Site_26	B_Site_27	B_Site_28	B_Site_29	B_Site_30	Average Country "B"
2017	Q1	63%	92%	86%	95%	78%	88%	77%	83%	84%	88%	90%	71%	66%	85%	88%	86%	77%	63%	90%	93%	87%	90%	86%	78%	82%	83%	79%	86%	63%	88%	91%	74%	-	83%	86%	79%	91%	63%	82%
	Q2	70%	90%	88%	94%	78%	87%	78%	84%	84%	82%	94%	72%	69%	87%	89%	87%	74%	66%	89%	96%	84%	92%	93%	85%	88%	86%	75%	86%	66%	89%	93%	76%	-	86%	88%	86%	92%	68%	84%
	Q3	82%	89%	84%	96%	75%	90%	75%	84%	83%	79%	96%	73%	72%	88%	88%	85%	78%	70%	92%	94%	85%	88%	92%	86%	86%	82%	76%	87%	59%	91%	92%	79%	-	86%	85%	86%	89%	51%	83%
	Q4	75%	86%	84%	96%	82%	94%	89%	87%	88%	82%	93%	72%	75%	93%	86%	86%	72%	65%	87%	92%	83%	93%	90%	79%	82%	84%	73%	92%	50%	88%	94%	73%	-	89%	84%	83%	86%	53%	82%
2018	Q1	77%	87%	85%	92%	89%	85%	71%	84%	86%	85%	95%	77%	73%	87%	89%	88%	69%	64%	93%	91%	90%	81%	88%	89%	89%	86%	78%	83%	49%	82%	96%	75%	-	83%	79%	80%	92%	58%	82%
	Q2	82%	88%	86%	96%	74%	83%	69%	83%	87%	89%	93%	69%	62%	81%	91%	90%	75%	63%	87%	92%	87%	86%	86%	86%	90%	88%	72%	84%	48%	86%	92%	77%	-	82%	92%	83%	91%	68%	82%
	Q3	68%	94%	85%	94%	92%	89%	74%	85%	88%	90%	94%	65%	65%	84%	88%	85%	76%	66%	81%	90%	86%	89%	93%	82%	81%	89%	79%	85%	68%	87%	90%	74%	-	88%	92%	83%	93%	65%	83%
	Q4	67%	92%	83%	97%	95%	88%	74%	85%	90%	86%	95%	70%	74%	88%	90%	86%	83%	66%	92%	97%	84%	90%	90%	85%	79%	90%	74%	83%	63%	88%	93%	79%	-	84%	85%	84%	83%	72%	84%
2019	Q1	80%	97%	88%	98%	74%	87%	79%	86%	85%	86%	89%	73%	72%	87%	92%	87%	74%	68%	91%	93%	82%	92%	91%	88%	72%	87%	76%	89%	65%	84%	94%	80%	-	85%	79%	83%	89%	61%	83%
	Q2	88%	92%	90%	92%	89%	88%	68%	87%	86%	89%	93%	80%	71%	90%	90%	86%	72%	59%	85%	89%	89%	83%	83%	84%	79%	80%	75%	92%	71%	90%	95%	74%	-	89%	86%	83%	87%	75%	83%
	Q3	82%	90%	91%	88%	84%	90%	71%	85%	82%	78%	90%	73%	79%	93%	88%	84%	73%	53%	86%	90%	84%	87%	86%	83%	75%	83%	77%	87%	49%	93%	96%	70%	-	79%	85%	89%	92%	56%	81%
	Q4	67%	90%	88%	89%	82%	95%	70%	83%	81%	83%	83%	75%	69%	89%	90%	90%	75%	71%	93%	92%	89%	85%	89%	87%	76%	81%	79%	87%	55%	92%	90%	69%	-	86%	81%	83%	91%	53%	82%
2020	Q1	78%	92%	89%	90%	84%	83%	75%	84%	84%	84%	95%	77%	68%	88%	88%	88%	68%	60%	82%	91%	83%	89%	90%	88%	80%	89%	70%	88%	58%	82%	89%	68%	-	86%	83%	86%	89%	66%	81%
	Q2	76%	87%	87%	96%	89%	86%	76%	85%	82%	85%	92%	76%	73%	93%	87%	89%	78%	53%	89%	93%	85%	90%	87%	86%	86%	80%	71%	85%	59%	80%	90%	63%	-	84%	86%	88%	90%	68%	82%
	Q3	77%	89%	88%	94%	90%	87%	73%	85%	89%	81%	89%	80%	77%	90%	85%	83%	80%	67%	83%	94%	87%	91%	88%	86%	93%	85%	69%	86%	63%	84%	91%	68%	-	85%	88%	87%	93%	63%	83%
	Q4	60%	96%	86%	97%	94%	92%	81%	87%	82%	85%	88%	71%	80%	94%	86%	82%	83%	68%	92%	94%	88%	92%	85%	82%	61%	86%	69%	89%	62%	80%	96%	78%	-	89%	92%	89%	90%	64%	83%
2021	Q1	75%	97%	95%	92%	91%	88%	70%	87%	85%	89%	90%	73%	79%	88%	85%	84%	78%	67%	88%	91%	91%	95%	90%	79%	68%	83%	68%	87%	51%	86%	96%	65%	-	90%	87%	90%	87%	69%	82%
	Q2	63%	96%	90%	96%	86%	91%	73%	85%	86%	82%	92%	73%	73%	95%	88%	89%	74%	62%	89%	93%	82%	90%	93%	78%	74%	84%	73%	84%	58%	87%	93%	63%	-	87%	85%	89%	85%	71%	82%
	Q3	66%	93%	91%	96%	88%	93%	75%	86%	83%	85%	92%	82%	71%	98%	90%	92%	75%	61%	90%	90%	86%	86%	96%	79%	77%	83%	64%	82%	61%	89%	86%	74%	-	82%	83%	89%	86%	69%	82%
	Q4	68%	90%	85%	94%	92%	97%	80%	87%	81%	88%	93%	80%	69%	92%	91%	88%	74%	69%	96%	90%	87%	91%	92%	83%	79%	89%	70%	80%	63%	90%	85%	80%	-	83%	81%	86%	89%	73%	83%
2022	Q1	82%	96%	87%	88%	79%	82%	82%	85%	85%	88%	87%	69%	80%	91%	91%	87%	75%	73%	82%	94%	85%	88%	91%	81%	81%	92%	68%	89%	68%	83%	86%	68%	-	88%	84%	83%	93%	63%	83%
	Q2	88%	94%	88%	90%	84%	85%	79%	87%	80%	89%	86%	68%	73%	90%	92%	85%	83%	58%	83%	92%	89%	87%	90%	76%	86%	79%	69%	79%	59%	86%	84%	76%	-	89%	90%	87%	94%	65%	82%
	Q3	81%	88%	90%	89%	85%	86%	77%	85%	79%	87%	91%	77%	72%	89%	88%	86%	81%	63%	91%	89%	84%	90%	80%	87%	84%	76%	71%	89%	58%	90%	85%	72%	-	80%	92%	89%	85%	63%	82%
	Q4	75%	90%	85%	96%	93%	94%	79%	87%	85%	83%	92%	85%	74%	95%	87%	88%	76%	67%	89%	88%	83%	86%	88%	85%	85%	89%	73%	83%	63%	82%	86%	79%	-	82%	88%	83%	84%	66%	83%
2023	Q1	71%	88%	89%	87%	82%	93%	76%	84%	82%	82%	90%	72%	78%	93%	91%	87%	74%	59%	90%	89%	88%	84%	89%	88%	79%	83%	74%	86%	49%	85%	92%	70%	-	86%	86%	86%	83%	67%	81%
	Q2	77%	94%	85%	96%	88%	95%	74%	87%	86%	90%	93%	74%	77%	93%	88%	89%	79%	60%	87%	90%	86%	87%	89%	89%	76%	86%	75%	85%	68%	86%	93%	72%	-	88%	87%	83%	89%	68%	83%
	Q3	73%	92%	90%	89%	93%	92%	81%	87%	88%	88%	88%	80%	81%	95%	85%	89%	79%	61%	94%	95%	91%	90%	91%	92%	80%	81%	76%	88%	69%	88%	90%	78%	-	87%	87%	79%	92%	62%	84%
	Q4	82%	91%	92%	86%	95%	92%	72%	87%	88%	90%	94%	79%	74%	91%	91%	87%	82%	58%	92%	92%	88%	86%	94%	93%	75%	82%	69%	89%	55%	91%	91%	77%	-	84%	90%	84%	91%	58%	83%

Figure 22: LU Data Sheet

IGA

Incoming Goods Accuracy in %

CONFIDENTIAL

		Locations in Country "A"								Locations in Country "B"																														
		A_Site_1	A_Site_2	A_Site_3	A_Site_4	A_Site_5	A_Site_6	A_Site_7	Average Country "A"	B_Site_1	B_Site_2	B_Site_3	B_Site_4	B_Site_5	B_Site_6	B_Site_7	B_Site_8	B_Site_9	B_Site_10	B_Site_11	B_Site_12	B_Site_13	B_Site_14	B_Site_15	B_Site_16	B_Site_17	B_Site_18	B_Site_19	B_Site_20	B_Site_21	B_Site_22	B_Site_23	B_Site_24	B_Site_25	B_Site_26	B_Site_27	B_Site_28	B_Site_29	B_Site_30	Average Country "B"
2017	Q1	-	-	98.56%	99.86%	-	-	99.36%	99.26%	99.27%	99.62%	-	-	-	99.21%	-	-	-	99.41%	-	99.38%	-	-	-	-	-	-	99.63%	-	-	-	99.82%	-	-	99.74%	-	-	99.66%	-	99.53%
	Q2	-	-	98.63%	99.84%	-	-	99.38%	99.28%	99.26%	99.65%	-	-	-	99.23%	-	-	-	99.39%	-	99.40%	-	-	-	-	-	-	99.62%	-	-	-	99.83%	-	-	99.75%	-	-	99.67%	-	99.53%
	Q3	-	-	98.68%	99.82%	-	-	99.41%	99.30%	99.30%	99.62%	-	-	-	99.26%	-	-	-	99.42%	-	99.41%	-	-	-	-	-	-	99.59%	-	-	-	99.80%	-	-	99.76%	-	-	99.63%	-	99.53%
	Q4	-	-	98.64%	99.86%	-	-	99.42%	99.31%	99.31%	99.63%	-	-	-	99.24%	-	-	-	99.38%	-	99.39%	-	-	-	-	-	-	99.53%	-	-	-	99.83%	-	-	99.74%	-	-	99.65%	-	99.52%
2018	Q1	-	-	98.59%	99.82%	-	-	99.46%	99.29%	99.32%	99.64%	-	-	-	99.25%	-	-	-	99.40%	-	99.41%	-	-	-	-	-	-	99.56%	-	-	-	99.81%	-	-	99.75%	-	-	99.68%	-	99.54%
	Q2	-	-	98.55%	99.81%	-	-	99.48%	99.28%	99.28%	99.68%	-	-	-	99.20%	-	-	-	99.42%	-	99.38%	-	-	-	-	-	-	99.66%	-	-	-	99.87%	-	-	99.74%	-	-	99.67%	-	99.54%
	Q3	-	-	98.63%	99.85%	-	-	99.47%	99.32%	99.29%	99.62%	-	-	-	99.19%	-	-	-	99.43%	-	99.40%	-	-	-	-	-	-	99.62%	-	-	-	99.79%	-	-	99.76%	-	-	99.66%	-	99.53%
	Q4	-	-	98.59%	99.84%	-	-	99.41%	99.28%	99.30%	99.64%	-	-	-	99.23%	-	-	-	99.45%	-	99.36%	-	-	-	-	-	-	99.63%	-	-	-	99.78%	-	-	99.75%	-	-	99.64%	-	99.53%
2019	Q1	-	-	98.63%	99.87%	-	-	99.42%	99.31%	99.21%	99.61%	-	-	-	99.26%	-	-	-	99.39%	-	99.41%	-	-	-	-	-	-	99.61%	-	-	-	99.80%	-	-	99.74%	-	-	99.68%	-	99.52%
	Q2	-	-	98.65%	99.83%	-	-	99.39%	99.29%	99.23%	99.66%	-	-	-	99.24%	-	-	-	99.40%	-	99.42%	-	-	-	-	-	-	99.59%	-	-	-	99.81%	-	-	99.79%	-	-	99.67%	-	99.53%
	Q3	-	-	98.69%	99.82%	-	-	99.45%	99.32%	99.27%	99.68%	-	-	-	99.25%	-	-	-	99.41%	-	99.43%	-	-	-	-	-	-	99.62%	-	-	-	99.83%	-	-	99.78%	-	-	99.69%	-	99.55%
	Q4	-	-	98.58%	99.85%	-	-	99.39%	99.27%	99.29%	99.63%	-	-	-	99.25%	-	-	-	99.43%	-	99.45%	-	-	-	-	-	-	99.63%	-	-	-	99.86%	-	-	99.79%	-	-	99.68%	-	99.56%
2020	Q1	-	-	98.67%	99.87%	-	-	99.37%	99.30%	99.31%	99.67%	-	-	-	99.24%	-	-	-	99.42%	-	99.41%	-	-	-	-	-	-	99.68%	-	-	-	99.84%	-	-	99.75%	-	-	99.71%	-	99.56%
	Q2	-	-	98.63%	99.89%	-	-	99.36%	99.29%	99.29%	99.64%	-	-	-	99.28%	-	-	-	99.46%	-	99.40%	-	-	-	-	-	-	99.62%	-	-	-	99.87%	-	-	99.79%	-	-	99.72%	-	99.56%
	Q3	-	-	98.61%	99.90%	-	-	99.38%	99.30%	99.28%	99.65%	-	-	-	99.26%	-	-	-	99.39%	-	99.38%	-	-	-	-	-	-	99.65%	-	-	-	99.84%	-	-	99.80%	-	-	99.70%	-	99.55%
	Q4	-	-	98.69%	99.87%	-	-	99.41%	99.32%	99.30%	99.69%	-	-	-	99.29%	-	-	-	99.43%	-	99.39%	-	-	-	-	-	-	99.68%	-	-	-	99.85%	-	-	99.77%	-	-	99.73%	-	99.57%
2021	Q1	-	-	98.70%	99.86%	-	-	99.42%	99.33%	99.27%	99.68%	-	-	-	99.30%	-	-	-	99.42%	-	99.42%	-	-	-	-	-	-	99.71%	-	-	-	99.79%	-	-	99.76%	-	-	99.71%	-	99.56%
	Q2	-	-	98.73%	99.88%	-	-	99.46%	99.36%	99.30%	99.63%	-	-	-	99.32%	-	-	-	99.41%	-	99.43%	-	-	-	-	-	-	99.68%	-	-	-	99.82%	-	-	99.81%	-	-	99.69%	-	99.57%
	Q3	-	-	98.66%	99.91%	-	-	99.48%	99.35%	99.26%	99.65%	-	-	-	99.29%	-	-	-	99.45%	-	99.45%	-	-	-	-	-	-	99.66%	-	-	-	99.83%	-	-	99.78%	-	-	99.71%	-	99.56%
	Q4	-	-	98.65%	99.87%	-	-	99.42%	99.31%	99.28%	99.62%	-	-	-	99.30%	-	-	-	99.44%	-	99.41%	-	-	-	-	-	-	99.70%	-	-	-	99.81%	-	-	99.77%	-	-	99.74%	-	99.56%
2022	Q1	-	-	98.65%	99.89%	-	-	99.43%	99.32%	99.26%	99.59%	-	-	-	99.28%	-	-	-	99.42%	-	99.46%	-	-	-	-	-	-	99.67%	-	-	-	99.84%	-	-	99.81%	-	-	99.68%	-	99.56%
	Q2	-	-	98.62%	99.91%	-	-	99.40%	99.31%	99.31%	99.68%	-	-	-	99.24%	-	-	-	99.38%	-	99.45%	-	-	-	-	-	-	99.71%	-	-	-	99.85%	-	-	99.80%	-	-	99.72%	-	99.57%
	Q3	-	-	98.69%	99.92%	-	-	99.38%	99.33%	99.32%	99.69%	-	-	-	99.26%	-	-	-	99.46%	-	99.43%	-	-	-	-	-	-	99.69%	-	-	-	99.83%	-	-	99.79%	-	-	99.71%	-	99.58%
	Q4	-	-	98.72%	99.88%	-	-	99.46%	99.35%	99.29%	99.71%	-	-	-	99.29%	-	-	-	99.42%	-	99.39%	-	-	-	-	-	-	99.72%	-	-	-	99.83%	-	-	99.76%	-	-	99.73%	-	99.57%
2023	Q1	-	-	98.72%	99.90%	-	-	99.41%	99.34%	99.26%	99.67%	-	-	-	99.30%	-	-	-	99.47%	-	99.41%	-	-	-	-	-	-	99.68%	-	-	-	99.85%	-	-	99.83%	-	-	99.69%	-	99.57%
	Q2	-	-	98.69%	99.84%	-	-	99.43%	99.32%	99.25%	99.68%	-	-	-	99.32%	-	-	-	99.44%	-	99.45%	-	-	-	-	-	-	99.70%	-	-	-	99.86%	-	-	99.80%	-	-	99.70%	-	99.58%
	Q3	-	-	98.71%	99.87%	-	-	99.40%	99.33%	99.30%	99.69%	-	-	-	99.29%	-	-	-	99.43%	-	99.43%	-	-	-	-	-	-	99.69%	-	-	-	99.81%	-	-	99.82%	-	-	99.72%	-	99.58%
	Q4	-	-	98.68%	99.85%	-	-	99.46%	99.33%	99.31%	99.71%	-	-	-	99.28%	-	-	-	99.45%	-	99.46%	-	-	-	-	-	-	99.72%	-	-	-	99.82%	-	-	99.79%	-	-	99.71%	-	99.58%

Figure 23: IGA Data Sheet

SA

Storage Accuracy in %

CONFIDENTIAL

		Locations in Country "A"								Locations in Country "B"																														
		A_Site_1	A_Site_2	A_Site_3	A_Site_4	A_Site_5	A_Site_6	A_Site_7	**Average Country "A"**	B_Site_1	B_Site_2	B_Site_3	B_Site_4	B_Site_5	B_Site_6	B_Site_7	B_Site_8	B_Site_9	B_Site_10	B_Site_11	B_Site_12	B_Site_13	B_Site_14	B_Site_15	B_Site_16	B_Site_17	B_Site_18	B_Site_19	B_Site_20	B_Site_21	B_Site_22	B_Site_23	B_Site_24	B_Site_25	B_Site_26	B_Site_27	B_Site_28	B_Site_29	B_Site_30	**Average Country "B"**
2017	Q1	-	**96.36%**	-	-	**99.25%**	-	-	**97.81%**	-	-	-	-	**89.33%**	-	**99.86%**	-	-	-	**98.63%**	-	-	-	**99.14%**	-	-	-	**99.94%**	-	-	-	-	-	-	-	-	**97.23%**	-	-	**97.36%**
	Q2	-	96.86%	-	-	99.28%	-	-	**98.07%**	-	-	-	-	89.88%	-	99.87%	-	-	-	98.42%	-	-	-	99.17%	-	-	-	99.94%	-	-	-	-	-	-	-	-	97.46%	-	-	**97.46%**
	Q3	-	97.25%	-	-	99.31%	-	-	**98.28%**	-	-	-	-	90.22%	-	99.88%	-	-	-	98.26%	-	-	-	99.20%	-	-	-	99.94%	-	-	-	-	-	-	-	-	97.59%	-	-	**97.52%**
	Q4	-	97.66%	-	-	99.33%	-	-	**98.50%**	-	-	-	-	90.89%	-	98.88%	-	-	-	98.00%	-	-	-	99.21%	-	-	-	99.94%	-	-	-	-	-	-	-	-	97.71%	-	-	**97.44%**
2018	Q1	-	97.95%	-	-	**99.35%**	-	-	**98.65%**	-	-	-	-	91.34%	-	**99.89%**	-	-	-	97.79%	-	-	-	**99.22%**	-	-	-	99.94%	-	-	-	-	-	-	-	-	**97.88%**	-	-	**97.68%**
	Q2	-	98.15%	-	-	99.39%	-	-	**98.77%**	-	-	-	-	91.68%	-	99.90%	-	-	-	97.53%	-	-	-	99.18%	-	-	-	99.94%	-	-	-	-	-	-	-	-	97.90%	-	-	**97.69%**
	Q3	-	**98.36%**	-	-	99.41%	-	-	**98.89%**	-	-	-	-	92.01%	-	99.91%	-	-	-	97.39%	-	-	-	99.15%	-	-	-	**99.94%**	-	-	-	-	-	-	-	-	98.06%	-	-	**97.74%**
	Q4	-	98.06%	-	-	99.42%	-	-	**98.74%**	-	-	-	-	**92.35%**	-	99.92%	-	-	-	**97.33%**	-	-	-	99.12%	-	-	-	99.94%	-	-	-	-	-	-	-	-	98.15%	-	-	**97.80%**
2019	Q1	-	97.76%	-	-	**99.48%**	-	-	**98.62%**	-	-	-	-	93.04%	-	**99.92%**	-	-	-	97.53%	-	-	-	99.09%	-	-	-	99.94%	-	-	-	-	-	-	-	-	**98.20%**	-	-	**97.95%**
	Q2	-	**97.30%**	-	-	99.47%	-	-	**98.39%**	-	-	-	-	93.79%	-	99.92%	-	-	-	97.79%	-	-	-	99.07%	-	-	-	99.94%	-	-	-	-	-	-	-	-	98.23%	-	-	**98.12%**
	Q3	-	97.74%	-	-	99.46%	-	-	**98.60%**	-	-	-	-	94.55%	-	99.92%	-	-	-	97.98%	-	-	-	99.06%	-	-	-	**99.95%**	-	-	-	-	-	-	-	-	98.28%	-	-	**98.29%**
	Q4	-	97.92%	-	-	99.43%	-	-	**98.68%**	-	-	-	-	95.23%	-	99.92%	-	-	-	98.16%	-	-	-	99.05%	-	-	-	99.95%	-	-	-	-	-	-	-	-	98.31%	-	-	**98.44%**
2020	Q1	-	98.31%	-	-	**99.42%**	-	-	**98.87%**	-	-	-	-	96.11%	-	**99.92%**	-	-	-	98.35%	-	-	-	**99.03%**	-	-	-	99.95%	-	-	-	-	-	-	-	-	**98.36%**	-	-	**98.62%**
	Q2	-	**98.55%**	-	-	99.40%	-	-	**98.98%**	-	-	-	-	**96.82%**	-	99.92%	-	-	-	**98.47%**	-	-	-	99.01%	-	-	-	99.96%	-	-	-	-	-	-	-	-	98.46%	-	-	**98.77%**
	Q3	-	98.50%	-	-	99.37%	-	-	**98.94%**	-	-	-	-	97.16%	-	99.92%	-	-	-	98.49%	-	-	-	99.00%	-	-	-	**99.97%**	-	-	-	-	-	-	-	-	98.56%	-	-	**98.85%**
	Q4	-	98.50%	-	-	99.36%	-	-	**98.93%**	-	-	-	-	97.48%	-	99.92%	-	-	-	98.51%	-	-	-	98.98%	-	-	-	99.96%	-	-	-	-	-	-	-	-	**98.69%**	-	-	**98.92%**
2021	Q1	-	98.45%	-	-	**99.35%**	-	-	**98.90%**	-	-	-	-	97.96%	-	**99.93%**	-	-	-	98.52%	-	-	-	**98.97%**	-	-	-	99.95%	-	-	-	-	-	-	-	-	98.77%	-	-	**99.02%**
	Q2	-	**98.45%**	-	-	99.26%	-	-	**98.86%**	-	-	-	-	98.31%	-	99.93%	-	-	-	98.54%	-	-	-	98.99%	-	-	-	99.94%	-	-	-	-	-	-	-	-	98.87%	-	-	**99.10%**
	Q3	-	98.55%	-	-	99.18%	-	-	**98.87%**	-	-	-	-	**98.52%**	-	99.93%	-	-	-	**98.55%**	-	-	-	99.00%	-	-	-	99.92%	-	-	-	-	-	-	-	-	99.91%	-	-	**99.31%**
	Q4	-	98.65%	-	-	99.15%	-	-	**98.90%**	-	-	-	-	98.72%	-	99.93%	-	-	-	98.65%	-	-	-	99.01%	-	-	-	**99.91%**	-	-	-	-	-	-	-	-	**98.97%**	-	-	**99.20%**
2022	Q1	-	98.70%	-	-	**99.12%**	-	-	**98.91%**	-	-	-	-	98.88%	-	**99.94%**	-	-	-	98.79%	-	-	-	**99.02%**	-	-	-	99.91%	-	-	-	-	-	-	-	-	99.02%	-	-	**99.26%**
	Q2	-	**98.74%**	-	-	99.22%	-	-	**98.98%**	-	-	-	-	**98.89%**	-	99.93%	-	-	-	98.91%	-	-	-	99.06%	-	-	-	99.92%	-	-	-	-	-	-	-	-	99.08%	-	-	**99.30%**
	Q3	-	98.80%	-	-	99.29%	-	-	**99.05%**	-	-	-	-	98.91%	-	99.93%	-	-	-	**99.02%**	-	-	-	99.10%	-	-	-	99.92%	-	-	-	-	-	-	-	-	99.12%	-	-	**99.33%**
	Q4	-	98.83%	-	-	99.35%	-	-	**99.09%**	-	-	-	-	98.98%	-	99.93%	-	-	-	98.96%	-	-	-	**99.13%**	-	-	-	**99.93%**	-	-	-	-	-	-	-	-	**99.14%**	-	-	**99.35%**
2023	Q1	-	98.87%	-	-	**99.43%**	-	-	**99.15%**	-	-	-	-	99.05%	-	**99.92%**	-	-	-	98.92%	-	-	-	99.13%	-	-	-	99.93%	-	-	-	-	-	-	-	-	99.14%	-	-	**99.35%**
	Q2	-	**98.93%**	-	-	99.43%	-	-	**99.18%**	-	-	-	-	99.14%	-	99.92%	-	-	-	**98.89%**	-	-	-	99.13%	-	-	-	99.93%	-	-	-	-	-	-	-	-	99.14%	-	-	**99.36%**
	Q3	-	98.93%	-	-	99.43%	-	-	**99.18%**	-	-	-	-	**99.20%**	-	99.92%	-	-	-	98.89%	-	-	-	99.13%	-	-	-	99.93%	-	-	-	-	-	-	-	-	99.14%	-	-	**99.37%**
	Q4	-	98.93%	-	-	99.43%	-	-	**99.18%**	-	-	-	-	99.20%	-	99.92%	-	-	-	98.89%	-	-	-	99.13%	-	-	-	99.93%	-	-	-	-	-	-	-	-	99.14%	-	-	**99.37%**

Figure 24: SA Data Sheet

PO

Perfect Orders in %

CONFIDENTIAL

		Locations in Country "A"								Locations in Country "B"																														
		A_Site_1	A_Site_2	A_Site_3	A_Site_4	A_Site_5	A_Site_6	A_Site_7	**Average Country "A"**	B_Site_1	B_Site_2	B_Site_3	B_Site_4	B_Site_5	B_Site_6	B_Site_7	B_Site_8	B_Site_9	B_Site_10	B_Site_11	B_Site_12	B_Site_13	B_Site_14	B_Site_15	B_Site_16	B_Site_17	B_Site_18	B_Site_19	B_Site_20	B_Site_21	B_Site_22	B_Site_23	B_Site_24	B_Site_25	B_Site_26	B_Site_27	B_Site_28	B_Site_29	B_Site_30	**Average Country "B"**
2017	Q1	99.37%	-	-	99.17%	99.80%	99.44%	-	**99.45%**	-	99.22%	-	-	99.72%	-	99.67%	-	-	-	99.58%	-	-	99.42%	-	-	-	-	-	99.43%	-	-	99.86%	99.27%	-	99.33%	-	99.17%	-	-	**99.47%**
	Q2	99.38%	-	-	99.16%	99.81%	99.45%	-	**99.45%**	-		-	-	99.70%	-	99.66%	-	-	-	99.56%	-	-	99.38%	-	-	-	-	-	99.40%	-	-	99.85%	99.26%	-	99.30%	-	99.18%	-	-	**99.48%**
	Q3	99.40%	-	-	99.16%	99.79%	99.45%	-	**99.45%**	-		-	-	99.73%	-	99.62%	-	-	-	99.54%	-	-	99.41%	-	-	-	-	-	99.41%	-	-	99.87%	99.29%	-	99.31%	-	99.16%	-	-	**99.48%**
	Q4	99.41%	-	-	99.17%	99.78%	99.46%	-	**99.46%**	-		-	-	99.69%	-	99.63%	-	-	-	99.54%	-	-	99.43%	-	-	-	-	-	99.40%	-	-	99.86%	99.30%	-	99.29%	-	99.17%	-	-	**99.48%**
2018	Q1	99.39%	-	-	99.18%	99.81%	99.42%	-	**99.45%**	-		-	-	99.68%	-	99.60%	-	-	-	99.52%	-	-	99.45%	-	-	-	-	-	99.39%	-	-	99.83%	99.26%	-	99.28%	-	99.17%	-	-	**99.46%**
	Q2	99.39%	-	-	99.19%	99.80%	99.48%	-	**99.47%**	-		-	-	99.69%	-	99.62%	-	-	-	99.58%	-	-	99.42%	-	-	-	-	-	99.41%	-	-	99.86%	99.25%	-	99.30%	-	99.15%	-	-	**99.48%**
	Q3	99.42%	-	-	99.18%	99.79%	99.51%	-	**99.48%**	-		-	-	99.70%	-	99.63%	-	-	-	99.55%	-	-	99.41%	-	-	-	-	-	99.38%	-	-	99.88%	99.21%	-	99.33%	-	99.21%	-	-	**99.48%**
	Q4	99.40%	-	-	99.20%	99.82%	99.50%	-	**99.48%**	-		-	-	99.72%	-	99.64%	-	-	-	99.56%	-	-	99.42%	-	-	-	-	-	99.40%	-	-	99.85%	99.19%	-	99.38%	-	99.12%	-	-	**99.48%**
2019	Q1	99.40%	-	-	99.18%	99.83%	99.45%	-	**99.47%**	-		-	-	99.73%	-	99.69%	-	-	-	99.52%	-	-	99.38%	-	-	-	-	-	99.38%	-	-	99.86%	99.16%	-	99.38%	-	99.14%	-	-	**99.47%**
	Q2	99.43%	-	-	99.17%	99.81%	99.47%	-	**99.47%**	-		-	-	99.74%	-	99.71%	-	-	-	99.54%	-	-	99.45%	-	-	-	-	-	99.37%	-	-	99.85%	99.19%	-	99.39%	-	99.15%	-	-	**99.49%**
	Q3	99.39%	-	-	99.19%	99.83%	99.50%	-	**99.48%**	-		-	-	99.70%	-	99.71%	-	-	-	99.56%	-	-	99.37%	-	-	-	-	-	99.42%	-	-	99.85%	99.16%	-	99.40%	-	99.17%	-	-	**99.48%**
	Q4	99.38%	-	-	99.21%	99.84%	99.49%	-	**99.48%**	-		-	-	99.75%	-	99.65%	-	-	-	99.57%	-	-	99.42%	-	-	-	-	-	99.47%	-	-	99.83%	99.19%	-	99.39%	-	99.15%	-	-	**99.49%**
2020	Q1	99.40%	-	-	99.18%	99.83%	99.44%	-	**99.46%**	-		-	-	99.75%	-	99.72%	-	-	-	99.52%	-	-	99.43%	-	-	-	-	-	99.38%	-	-	99.84%	99.20%	-	99.42%	-	99.13%	-	-	**99.49%**
	Q2	99.41%	-	-	99.21%	99.85%	99.43%	-	**99.48%**	-		-	-	99.71%	-	99.69%	-	-	-	99.51%	-	-	99.46%	-	-	-	-	-	99.41%	-	-	99.85%	99.24%	-	99.43%	-	99.18%	-	-	**99.50%**
	Q3	99.42%	-	-	99.19%	99.84%	99.41%	-	**99.47%**	-		-	-	99.73%	-	99.65%	-	-	-	99.54%	-	-	99.45%	-	-	-	-	-	99.43%	-	-	99.81%	99.23%	-	99.40%	-	99.12%	-	-	**99.48%**
	Q4	99.40%	-	-	99.20%	99.81%	99.39%	-	**99.45%**	-		-	-	99.76%	-	99.65%	-	-	-	99.57%	-	-	99.44%	-	-	-	-	-	99.45%	-	-	99.84%	99.25%	-	99.38%	-	99.11%	-	-	**99.49%**
2021	Q1	99.41%	-	-	99.21%	99.85%	99.38%	-	**99.46%**	-		-	-	99.71%	-	99.63%	-	-	-	99.57%	-	-	99.45%	-	-	-	-	-	99.42%	-	-	99.85%	99.27%	-	99.39%	-	99.12%	-	-	**99.49%**
	Q2	99.40%	-	-	99.20%	99.87%	99.40%	-	**99.47%**	-		-	-	99.74%	-	99.68%	-	-	-	99.58%	-	-	99.39%	-	-	-	-	-	99.45%	-	-	99.82%	99.28%	-	99.38%	-	99.11%	-	-	**99.49%**
	Q3	99.42%	-	-	99.22%	99.84%	99.43%	-	**99.48%**	-		-	-	99.75%	-	99.70%	-	-	-	99.57%	-	-	99.40%	-	-	-	-	-	99.42%	-	-	99.81%	99.28%	-	99.41%	-	99.09%	-	-	**99.49%**
	Q4	99.40%	-	-	99.23%	99.83%	99.44%	-	**99.48%**	-		-	-	99.77%	-	99.72%	-	-	-	99.53%	-	-	99.44%	-	-	-	-	-	99.44%	-	-	99.84%	99.25%	-	99.42%	-	99.12%	-	-	**99.50%**
2022	Q1	99.43%	-	-	99.21%	99.85%	99.45%	-	**99.49%**	-		-	-	99.73%	-	99.67%	-	-	-	99.56%	-	-	99.46%	-	-	-	-	-	99.40%	-	-	99.85%	99.26%	-	99.41%	-	99.13%	-	-	**99.50%**
	Q2	99.43%	-	-	99.22%	99.87%	99.41%	-	**99.48%**	-		-	-	99.75%	-	99.65%	-	-	-	99.53%	-	-	99.48%	-	-	-	-	-	99.42%	-	-	99.83%	99.24%	-	99.43%	-	99.15%	-	-	**99.50%**
	Q3	99.44%	-	-	99.20%	99.83%	99.40%	-	**99.47%**	-		-	-	99.76%	-	99.69%	-	-	-	99.56%	-	-	99.43%	-	-	-	-	-	99.41%	-	-	99.82%	99.19%	-	99.45%	-	99.10%	-	-	**99.49%**
	Q4	99.42%	-	-	99.24%	99.85%	99.43%	-	**99.49%**	-		-	-	99.78%	-	99.71%	-	-	-	99.52%	-	-	99.46%	-	-	-	-	-	99.39%	-	-	99.80%	99.20%	-	99.43%	-	99.14%	-	-	**99.49%**
2023	Q1	99.43%	-	-	99.22%	99.81%	99.48%	-	**99.49%**	-		-	-	99.79%	-	99.73%	-	-	-	99.56%	-	-	99.45%	-	-	-	-	-	99.39%	-	-	99.84%	99.24%	-	99.44%	-	99.12%	-	-	**99.51%**
	Q2	99.45%	-	-	99.23%	99.80%	99.49%	-	**99.49%**	-		-	-	99.80%	-	99.68%	-	-	-	99.60%	-	-	99.49%	-	-	-	-	-	99.44%	-	-	99.84%	99.24%	-	99.42%	-	99.15%	-	-	**99.52%**
	Q3	99.49%	-	-	99.21%	99.82%	99.44%	-	**99.49%**	-		-	-	99.75%	-	99.72%	-	-	-	99.59%	-	-	99.50%	-	-	-	-	-	99.43%	-	-	99.81%	99.20%	-	99.45%	-	99.11%	-	-	**99.51%**
	Q4	99.45%	-	-	99.22%	99.81%	99.43%	-	**99.48%**	-		-	-	99.76%	-	99.73%	-	-	-	99.58%	-	-	99.48%	-	-	-	-	-	99.45%	-	-	99.80%	99.22%	-	99.43%	-	99.12%	-	-	**99.51%**

Figure 25: PO Data Sheet

Safety

Safety incidents in #

CONFIDENTIAL

		Locations in Country "A"								Locations in Country "B"											
		A_Site_	A_Site_	A_Site_	A_Site_	A_Site_	A_Site_	A_Site_	ge Coun	B_Site_	B_Site_	B_Site_	B_Site_	B_Site_	B_Site_	B_Site_	B_Site_	B_Site_	B_Site_	B_Site_	B_Site_
2017	Q1	4	5	5	1	8	-	-	**4.6**	-	7	4	8	7	5	-	-	2	8	-	6
	Q2	3	1	7	8	4	-	-	**4.6**	-	-	6	9	3	5	-	-	3	6	-	6
	Q3	4	0	4	4	6	-	-	**3.6**	-	-	9	8	8	6	-	-	2	7	-	7
	Q4	5	3	8	7	10	-	-	**6.6**	-	-	8	9	10	7	-	-	1	5	-	6
2018	Q1	2	3	6	4	9	-	-	**4.8**	-	7	6	8	9	6	-	-	2	8	4	7
	Q2	1	4	7	5	4	-	-	**4.2**	-	-	4	6	9	10	-	-	3	6	5	5
	Q3	3	5	7	6	6	-	-	**5.4**	-	-	7	4	6	14	-	-	4	8	4	6
	Q4	4	6	8	4	7	-	-	**5.8**	-	-	8	6	7	5	-	-	2	5	3	7
2019	Q1	3	9	6	6	4	-	-	**5.6**	3	7	10	7	4	6	3	-	1	7	5	7
	Q2	2	2	5	5	4	-	-	**3.6**	6	8	9	8	8	7	3	-	0	6	5	7
	Q3	0	5	6	6	3	-	-	**4**	4	5	6	7	7	4	4	-	0	2	4	8
	Q4	4	7	4	4	2	-	-	**4.2**	5	8	4	8	8	5	2	-	0	6	6	9
2020	Q1	6	2	2	5	6	-	-	**4.2**	6	9	5	6	8	6	1	-	2	7	5	6
	Q2	2	6	6	3	3	-	-	**4**	2	10	7	7	7	7	0	-	1	8	4	7
	Q3	4	3	4	4	3	-	-	**3.6**	6	9	9	8	6	5	0	-	3	3	5	8
	Q4	5	2	6	2	4	-	-	**3.8**	4	8	8	4	5	7	1	-	2	8	5	6
2021	Q1	6	4	4	5	2	-	-	**4.2**	7	5	4	3	4	5	3	-	1	5	6	4
	Q2	3	0	5	2	1	-	-	**2.2**	4	6	6	9	9	6	2	-	2	4	6	6
	Q3	4	1	7	3	2	-	-	**3.4**	5	5	7	3	3	8	1	-	3	6	4	5
	Q4	3	4	3	4	3	-	-	**3.4**	6	6	8	4	5	5	2	-	2	8	5	3
2022	Q1	2	2	2	1	2	-	-	**1.8**	4	4	8	9	8	7	0	-	2	4	6	7
	Q2	2	4	4	3	2	-	-	**3**	5	5	4	7	9	5	0	-	2	5	5	5
	Q3	1	3	3	2	1	-	-	**2**	3	6	6	7	7	6	2	-	3	4	7	6
	Q4	0	0	1	2	2	-	-	**1**	4	7	8	3	4	5	5	-	1	6	5	6
2023	Q1	4	3	4	2	0	-	-	**2.6**	6	6	6	7	6	7	3	-	0	7	4	7
	Q2	2	1	4	3	0	-	-	**2**	3	8	8	8	5	8	1	-	3	5	3	8
	Q3	2	5	4	2	1	-	-	**2.8**	6	7	7	6	6	5	2	-	2	6	4	6
	Q4	1	3	2	2	3	-	-	**2.2**	4	7	6	5	6	7	3	-	1	6	6	7

		B_Site_	B_Site_	B_Site_	B_Site_	B_Site_	B_Site_	B_Site_	B_Site_	B_Site_	B_Site_	B_Site_	B_Site_	B_Site_	B_Site_	B_Site_	B_Site_	B_Site_	B_Site_	Average Country "B"
2017	Q1	9	3	6	-	-	3	-	-	-	5	-	3	-	-	8	6	9	-	**5.8**
	Q2	8	3	5	-	-	2	-	-	-	5	-	2	-	-	10	7	8	-	**5.5**
	Q3	9	4	7	-	-	3	-	-	-	4	-	1	-	-	9	5	5	-	**5.9**
	Q4	10	3	6	-	-	2	-	-	-	3	-	3	-	-	8	3	6	-	**5.6**
2018	Q1	7	5	5	-	-	1	-	-	-	5	-	4	-	-	7	6	5	-	**5.7**
	Q2	8	7	7	-	-	0	-	-	-	6	-	5	-	-	6	7	3	-	**5.7**
	Q3	9	3	5	-	-	3	-	-	-	7	-	0	-	-	8	3	5	-	**5.6**
	Q4	11	5	6	-	-	2	-	-	-	2	-	1	-	-	9	5	4	-	**5.2**
2019	Q1	10	2	3	-	-	0	-	-	-	5	-	5	-	-	9	6	3	-	**5.2**
	Q2	9	4	8	-	-	4	-	-	-	3	-	3	-	-	10	5	5	-	**5.9**
	Q3	10	6	3	-	-	2	-	-	-	4	-	5	-	-	7	7	6	-	**5.1**
	Q4	9	3	5	-	-	3	-	-	-	6	-	3	-	-	6	8	4	-	**5.4**
2020	Q1	8	5	6	-	-	5	5	-	-	5	3	2	-	-	8	6	6	-	**5.5**
	Q2	7	5	7	-	-	2	5	-	-	3	5	0	-	-	10	3	8	-	**5.2**
	Q3	9	4	4	-	-	1	6	-	-	4	3	2	-	-	11	8	2	-	**5.3**
	Q4	10	3	6	-	-	0	7	-	-	5	4	3	-	-	9	7	0	-	**5.1**
2021	Q1	8	6	7	-	-	3	2	-	-	3	3	4	-	-	9	2	6	-	**4.5**
	Q2	7	2	3	-	-	2	3	-	-	5	5	4	-	-	7	8	5	-	**5.0**
	Q3	8	6	5	-	-	3	7	-	-	4	3	1	-	-	6	9	4	-	**4.8**
	Q4	9	4	5	-	-	4	3	-	-	3	2	6	-	-	8	11	8	-	**5.3**
2022	Q1	3	3	6	-	-	1	5	-	-	4	0	2	-	-	11	12	5	-	**5.0**
	Q2	8	5	4	-	-	2	3	-	-	2	0	3	-	-	6	9	2	-	**4.4**
	Q3	9	6	6	-	-	1	2	-	-	5	3	5	-	-	8	4	8	-	**5.2**
	Q4	10	2	4	-	-	0	5	-	-	3	2	3	-	-	7	5	3	-	**4.5**
2023	Q1	7	3	3	-	-	2	1	-	-	4	0	4	-	-	8	6	5	-	**4.6**
	Q2	8	5	3	-	-	0	4	-	-	3	3	6	-	-	7	5	4	-	**4.9**
	Q3	7	7	4	-	-	3	3	-	-	2	2	3	-	-	9	6	6	-	**5.0**
	Q4	8	2	2	-	-	0	5	-	-	4	2	3	-	-	9	8	3	-	**4.7**

Figure 26: Safety Data Sheet