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Enhancing Warehouse Efficiency Of 3PL Warehouse: Suggesting Key Performance Indicators For Quality and Productivity

Master's thesis in Supply Chain Management

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Abstract

This master thesis explores the enhancement of warehouse efficiency in third-party logistics (3PL) environments by proposing new Key Performance Indicators (KPIs) for quality and productivity. The study focuses on XR Solutions, a prominent 3PL service provider in Sweden, which faces challenges in effectively assessing the operational performance of its warehouse in Skövde. Traditionally, XR Solutions has KPIs, which have proven insufficient in providing a comprehensive view of warehouse operations. This research aims to identify and recommend additional KPIs that align with the company's strategic goals and improve operational insights.

The thesis begins by examining the theoretical framework of performance measurement and the significance of KPIs in logistics operations. It then delves into analyzing the case of XR, finding the limitations of current performance metrics and the need for a broader set of indicators. Using Qualitative research methods, including interviews with key stakeholders and analysis of existing problems, the study identifies critical areas for KPI development.

The findings suggest that incorporating a wider range of KPIs, including qualitative measures, can significantly enhance the understanding of warehouse efficiency. These new KPIs focus on areas such as order accuracy, inventory turnover, and customer satisfaction, providing a more holistic view of performance. The study concludes that by adopting these proposed KPIs, XR Solutions can achieve better resource allocation, improved service delivery, and maintain a competitive edge in the 3PL market.

This research contributes to the field of supply chain management by offering a structured approach to integrate most effective KPI's in warehouse settings, emphasizing the importance of aligning performance metrics with strategic objectives. The recommendations provided are intended to guide XR Solutions in refining their performance evaluation processes, ultimately leading to enhanced operational efficiency and customer satisfaction.

Keywords:-Third-party logistics (3PL); Warehouse efficiency; Key Performance Indicators; Supply chain management; Performance measurement; Operational performance

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List of Acronyms

Below is the list of acronyms that have been used throughout this thesis listed in alphabetical order:

3PL	Third Party logistics
KPI	Key Performance Indicator
FTE	Full Time Equivalent
SCM	Supply Chain Management
CEO	Chief Executive Officer
WMS	Warehouse Management Systems
TOP	Total Orders Picked
TPT	Total Picking time
AF	Accuracy Factor

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1. INTRODUCTION

This chapter comprises well-defined research questions and an overview of the overarching goals of the study. It also includes the research problem's theoretical foundation. Along with the delimitation's, the broad scope of the research will also be covered.

1.1 Background

Supply Chain Management (SCM) according to Christopher (1999) is defined as a network of organizations that engage in a variety of processes and activities that connect the upstream and downstream in the supply chain to create value for end customers through products and services. Every stage of the supply chain, from manufacture to delivery, is critical to ensuring that their products or services reach customers on time and at an optimal cost.

This process involves everything from raw material procurement to finished product manufacturing, as well as warehousing, distribution and final consumer delivery. Over these various actors in the supply chain, warehouses play an important role in bridging the gap between production and delivery, ensuring that inventory is properly maintained to fulfil consumer demand and reduce variations (Christopher, 1999). Beyond typical storage, contemporary warehouses provide services such as consolidation, cross-docking and assembly to improve logistical operations and customer service.

Over the last decade, there has been a noticeable shift among organizations to outsource warehouse operations to external service providers notably to third party logistics service providers who specialize in carrying out warehouse and logistics operations. This strategy enables businesses to focus on their core capabilities while attaining cost saving benefits (Yang et al., 2021). Concurrently, modern third-party logistics (3PL) companies are exerting more impact on market dynamics, attempting to grow value-added structures inside logistical processes (Baruffaldi et al., 2020). This evolution implies a constant improvement of service offerings by 3PL service providers to obtain a competitive advantage in the logistics service provider sector, which includes specialized services adapted to market demands. Coupled with this massive growth of 3PL dominance in the modern supply chain, there is increased pressure on these providers to maintain high levels of customer satisfaction, as competition intensifies. Maintaining superior performance in key warehouse operations becomes crucial for 3PL providers to differentiate themselves from competitors and achieve cost benefits, (Lieb, 2008).

Performance evaluation is an important tool for 3PL warehouses to assess operational effectiveness and identify development areas to acquire a competitive advantage in the market (Gu et al., 2007). As Kincaid (1994) indicates performance measurement is critical for calculating comparisons and developing strategies for continuous development. Out of many available performance evaluation methods, key performance indicators have been utilized by many firms as an effective tool for evaluating an organization's operational

performance.

Out of many available performance evaluation methods, KPIs have been utilized by many firms as an effective tool for evaluating an organization's operational performance.

According to Parmenter (2020) KPIs are critical performance metrics that represent the most significant aspects of an organization's current and future success. They enable organizations to translate strategic objectives into actionable goals, effectively measuring and analyzing their progress, (Domínguez et al., 2019). Selecting the correct set of KPIs is crucial, as they ensure that performance measurement aligns with organizational objectives, translating strategic goals into measurable actions. This alignment allows organizations to track progress, identify gaps in performance and adjust strategies as necessary. Additionally, KPIs provide relevant and accurate information that supports data-driven decision-making, enabling managers to identify trends, diagnose issues and implement corrective actions based on reliable data, (Neely, 2002). As a result, choosing the most effective KPIs is essential to ensuring accurate performance assessment and promoting organizational performance.

1.2 Case Description

XR Solutions, a 3PL warehouse service provider, has been using KPIs to assess and improve the effectiveness of its warehouse operations. Currently, the organisation analyses two KPIs: **full-time equivalent (FTE) and Pallets in and out**. The FTE KPI measures the workload managed by each full-time employee during the fiscal year, allowing XR Solutions to optimise human resource allocation in their warehouse operations. Meanwhile, the Pallets In and Out KPI monitors product movement inside the warehouse, assisting with optimum inventory management and storage space utilisation. However, these current KPIs fall short of capturing the entire range of key warehouse performance measures, including material handling efficiency, on-time delivery rates, product returns, damage rates and order-picking accuracy. This gap gives XR Solutions an imperfect picture of their operational dynamics and obscures important areas where performance improvements are required.

To address these constraints, XR Solutions intends to improve its performance evaluation methodology by including a broader set of KPIs that are aligned with both strategic goals and current industry trends. These new KPIs will focus on key areas for improvement, providing a more comprehensive perspective of warehouse performance. The proposed KPIs would focus on two essential factors to ensure alignment with XR Solutions' organisational goals: quality and productivity.

XR Solutions understands the significance of routinely reviewing and updating their KPIs. This approach is reinforced by insights from the literature, such as insights provided by (Faveto et al., 2023). While XR Solutions acknowledges that following industry best practices can significantly improve performance evaluations does not base all its judgments solely on academic research. By integrating metrics than traditional KPIs, XR Solutions aims to gain a thorough grasp of warehouse performance, drive operational improvements, optimize resource allocation, and enhance service delivery in the competitive 3PL market

1.3 Research Questions

This thesis seeks to provide insightful analysis, strategic recommendations and thorough research to enhance the case company's performance evaluation process. These suggestions could be beneficial in improving the company's warehouse performance and they achieve a competitive advantage ahead of their competitors in the market. Based on the case description and key purpose of the master thesis described, two research questions have been formulated around which this entire thesis will revolve.

They are as follows:

- What are the most suitable KPIs for evaluating internal warehouse operations that align with the company's key problems and organizational goals?
- What are the benefits that the company could attain using the proposed set of KPIs?

1.4 Delimitation

This thesis study at XR Solution warehouse operations was conducted only to their warehouse located at Skovde region and the scope of this thesis study is restricted only to that warehouse operations. Secondly, this study does not include the external logistical operations and focuses on internal warehouse operations and addressing the performance issues internally. Other operational responsibilities like sourcing, external logistics transportation and customs and shipping operations are not the key focus.

Additionally, this thesis study will end till the suggestion of KPIs but will not include the implementation of the suggested KPI's and their outcomes. The study mainly uses data that is available within XR Solutions proprietary systems, which represent the company's own organizational culture, operational processes and strategic objectives. The internal dynamics of XR Solutions are still the major emphasis, even though benchmarking and contextualization may make use of external data and insights from other studies tackling related challenges. The research findings may not have direct relevance to other businesses with dissimilar operational or organizational environments since they are exclusive to the context of XR Solutions. Focusing on this context and useful insights it has the potential to enhance the case company's warehouse operational performance.

2. THEORY

This chapter presents an in-depth study of the theoretical foundations required to comprehend the role and significance of performance measurement and KPIs in warehouse operations. This chapter begins by outlining the significance of performance measurement in the supply chain, emphasizing its important role in attaining strategic objectives and continuous improvement in warehouse environments.

It addresses the different types of KPIs, their characteristics and their importance in providing a balanced perspective of financial and non-financial measures. The chapter is organized to provide a clear grasp of performance measurement needs, the definition and features of KPIs and the many viewpoints on their use and visualization in the context of strategic alignment.

2.1 Importance of performance evaluation

Optimizing and managing 3PL warehouses requires effective performance measurement. The warehousing business is highly competitive and dynamic, making it critical to evaluate and improve operational efficiency. 3PL providers may monitor critical parts of their business, like order accuracy, inventory turnover and delivery time-frames, with the use of effective performance measurement systems. This helps them stay competitive and satisfy client expectations (Ghalayini et al., 1997). Performance metrics, as noted by Gunasekaran and Kobu (2007), are essential instruments for assessing the effectiveness of logistics operations, promoting ongoing development and accomplishing strategic goals.

Furthermore, Neely et al. (1995) contend that the incorporation of comprehensive performance indicators can greatly improve the processes involved in making decisions, leading to better allocation of resources and improved operational results.

3PL service providers are aware that control and improvement of KPIs and measuring performance are challenging without adequate information on products, services or procedures. As a result, standardising performance measurement techniques is now crucial for fostering achievement and continuous development (Ghalayini et al., 1997). There are variations in the phrase "**performance measurement**" among the authors. For example, Franceschini et al. (2006) substitutes "key performance indicator" for "performance measure."

This performance indicator measure essentially compares the estimated and actual performance in terms of efficacy, efficiency and quality in terms of operations as well as the delivery of goods or services to their final clients (Ghalayini et al., 1997).

Researchers like Domínguez et al. (2019) assert that KPIs can be used to evaluate how well a organization is accomplishing its strategic objectives. In this instance, assessing the

performance of the organization entails quantifying and expressing particular outcomes using particular indicators. Selecting appropriate indicators for assessment and performance evaluation is an essential step in the process.

2.2 KPI and its Significance

KPIs are a more recent and effective method of performance measurement (Gunasekaran & Kobu, 2007). In order to measure organisational performance in a variety of industries, such as third-party logistics and warehouse management KPIs are essential. These KPI offer an approach for conducting a thorough evaluation of both conventional and contemporary operational techniques. KPIs, which include both financial and non-financial measurements, have developed into indispensable instruments for assessing organisational success over time (Velimirović et al., 2011). According to Bhatti et al. (2013), KPIs function as steady and constant markers that aid in impartial decision-making and direct focus towards the primary goals of the firm particularly profitability.

KPI's are a diverse array of measuring metrics used to evaluate and manage overall organisational performance (Bhatti et al., 2013). These indicators encompass various dimensions including **Time** (Mentzer & Konrad, 1991), (Spencer, 1993), (Neely et al., 1995), (Frazelle, 2004), (Chan & Qi, 2003), (Gunasekaran & Kobu, 2007), (Gallmann & Belvedere, 2011); **Quality** (Neely, 2002), (Stainer, 1997), (Frazelle, 2004), (Gallmann & Belvedere, 2010); **Cost** (Niven, 2002), (Mentzer & Konrad, 1991), (Beamon, 1999), (Chan & Qi, 2003), (Cai et al., 2009), (Keebler & Plank, 2009); **Financial aspects** (Parmenter, 2020); **Flexibility** (Frazelle, 2004); **Delivery reliability** (Gunasekaran & Kobu, 2007); **Employee satisfaction** (Li et al., 2009); **Customer satisfaction** (Neely, 2002); **Environmental/community impact** (Neely, 2002) and **Learning/growth** (Parmenter, 2020).

KPIs quantify how well an organization is performing, emphasizing the "how" and demonstrating how effective the process is being done. As stated by Kucukaltan (2016), measures are essential for improvement since without them, control is impossible and without control, management is impossible.

2.3 Strategic Alignment in KPI Development

Establishing and suggesting KPIs is not a simple or quick procedure, depending on the background and scope of the workplace. Franceschini et al. (2006) states that selecting the indicators that best reflect an organisation's core value-adding areas rather than selecting all the indicators is the most crucial step in developing a measurement system. Additionally, it is critical to identify indications that have an impact on the crucial operations that offer value for both the organisation and its clients. These KPIs are the most important factors when measuring the dimensions of operations or data (Franceschini et al., 2006); (Gunasekaran & Kobu, 2007).

While it is commonly assumed that having more metrics is preferable, supply chain performance review indicates that fewer, more specialized indications can be more useful in particular scenarios. According to Franceschini et al. (2006); Gunasekaran and Kobu

(2007), having too many metrics can cause information overload and inefficiency, making it difficult to focus on the most important performance areas. Consequently, businesses ought to begin their evaluation process with fewer distinct KPIs (Anand & Grover, 2015).

Several challenges can occur if KPIs are maintained generic rather than adjusted to the individual needs of each organization. General KPIs may not correspond to the firm's specific strategic objectives, resulting in a lack of emphasis on what genuinely drives success in that particular business setting (Parmenter, 2020). Without customisation, KPIs may fail to effectively evaluate the specific processes and activities crucial to the firm's operations, leading to poor performance appraisals (Neely, 2002). This misalignment can result in poor decision-making because decision-makers may not obtain the necessary facts to make educated decisions, impeding strategic planning and operational improvements (Bourne et al., 2018).

As a result, the KPIs must be tailored to the specific requirements of each firm. This customization ensures that the performance metrics are relevant and aligned with the firm's unique strategic objectives, operational processes, and market environment. Managers should consider organisational goals and objectives, market characteristics, business type, and technological competency when choosing the appropriate KPIs for a given logistics and supply chain organisation. By doing so, firms can achieve more accurate and actionable insights, enabling them to make data-driven decisions that drive continuous improvement and competitive advantage (Gunasekaran & Kobu, 2007), (Bourne et al., 2018).

Tailoring KPIs to these specific factors not only enhances the relevance and effectiveness of performance measurement but also fosters greater employee engagement and accountability, as staff can clearly see how their efforts contribute to the firm's success.

The research literature indicates some common characteristics associated with effective KPIs, which aid in their identification, comprehension and implementation across organisations and industries. According to Franceschini et al. (2006); Gunasekaran and Kobu (2007); Anand and Grover (2015); Chan and Qi (2003), KPIs share the following categorisation methodologies based on organisational aims and industrial settings:

- **Quantitative and qualitative KPIs:-** Quantitative KPIs use numerical metrics, such as revenue or production output, whereas qualitative KPIs focus on non-numerical factors such as customer satisfaction and brand perception.
- **Financial and Non-financial KPIs:-** Financial KPIs are associated with monetary performance measurements like as net profit or ROI, whereas non-financial KPIs assess factors such as product quality or employee engagement.
- **Internal Vs External KPIs:-** Internal KPIs track internal processes such as employee productivity, whereas external KPIs track elements outside the organisation, such as customer satisfaction or market position.
- **Strategic Vs Operational KPIs:-** Strategic KPIs are aligned with long-term objectives, such as market share growth, whereas operational KPIs are concerned with day-to-day activities, such as order accuracy or inventory turnover.
- **Direct and Indirect KPIs:-** Direct KPIs monitor the direct outputs of processes or

actions, under four key dimensions: Time, cost, quality and productivity, whereas indirect KPIs evaluate outcomes that are indirectly related to the organization's performance, such as customer loyalty or staff happiness.

These categorisations assist organisations in selecting the most relevant KPIs for their specific needs, ensuring that performance measurements are in line with strategic objectives and successfully drive operational success.

2.4 Classification of KPI's

There are various methods for categorising performance indicators and different authors have covered them in a variety of publications. Every strategy is seen to be the most successful way to categorise KPIs for a company. Mentzer and Konrad (1991), for example distinguish between direct and indirect indicators when classifying performance measurement. The four main dimensions of direct indicators are **time, cost, quality, and productivity/efficiency** as mentioned earlier in the previous sections.

The direct and indirect indicator classifications are used in this thesis to conduct its research. To succeed, any organisation needs to determine which metrics, measurements and performance indicators are strategically relevant to its particular environment (Faveto et al., 2023).

Performance measurements can be divided into two types: hard metrics, also known as **direct indicators**, which serve as the foundation of measurement, and soft metrics which arise from the need to provide customised services to customers in order to gain a competitive advantage and are often more complex and difficult to quantify. Understanding and properly employing these performance indicators is critical for any business wishing to measure and improve its performance completely.

Moving forward, the authors have identified direct KPIs as the most appropriate classification approach among all defined and existing methods. The next following subsections explain in detail the four dimensions of direct performance indicators: **Time, Cost, Quality, and Productivity**.

Each dimension is thoroughly examined, and all relevant KPIs from the literature are presented in detail.

2.4.1 Indicators related to Time

One of the most important aspects influencing how effectively a business succeeds is time. Time-based operations are a crucial concern for warehouse organisations seeking a competitive advantage over their competitors Gu et al. (2007); Mentzer and Konrad (1991) identified manufacturing lead time, delivery lead time, deadline performance, delivery frequency and rate of production introductions as time performance metrics. Neely (2002) identified the following time indicator metrics: time-to-market, distribution lead times, client delivery reliability, supply lead times, supplier delivery reliability, manufacturing lead time, standard run time, actual run time, wait time, setup time, move time,

inventory turnover, order carrying out time and mean (flexibility).

Inbound activities have receiving and putaway times, whereas Outbound activities have picking, shipping and delivery timings. It is noteworthy to observe that only two of these five markers might be used to define them: Order lead time for outgoing processes, and dock-to-stock time for incoming procedures. Because order lead time begins to be measured when a consumer puts an order, this indicator includes administrative time in addition to the given times.

The following table offers a thorough summary of the numerous time-related performance indicators utilized in logistics and supply chain management, as reported by prominent scholars who have investigated these metrics in the course of their research.

Indicators related to Time	Author's Reference & Year
Order lead time	Mentzer and Konrad (1991), Kiefer and Novack (1999), Rimiene (2008), Menachof, Bourlakis, and Makios (2009), Yang and Chen (2012).
Receiving time	Gu, Goetschalckx, and McGinnis (2007), Matopoulos and Bourlakis (2010)
Equipment downtime	Mentzer and Konrad (1991)
Dock to stock time	Ramaa, Subramanya, and Rangaswamy (2012)
Putaway time	Mentzer and Konrad (1991), De Koster, Le-Duc, and Roodbergen (2007), Yang and Chen (2012)
Order Picking time	Mentzer and Konrad (1991)
Delivery lead time	De Koster and Warffemius (2005)
Queuing time	Karagiannaki, Papakiriakopoulos, and Bardaki (2011)
Shipping time	Gu, Goetschalckx, and McGinnis (2007), Wang, Chen, and Xie (2010)

Table 2.1: Time related performance Indicators

2.4.2 Indicators related to Cost

Organizations utilize accounting systems that include efficiency and effectiveness measures to link internal performance metrics with external ones, as external stakeholders often focus on cost-based performance measures (Kassali & Idowu, 2007). Neely (2002) emphasize key cost performance metrics, such as manufacturing costs, value-added costs, selling prices, operational costs and service costs. Kassali and Idowu (2007) further identifies several specific metrics, including total product cost in relation to lead time, direct and indirect labor costs, labor productivity, capital productivity, machine productivity, percentage improvement in labor and perceived relative cost performance. These metrics are critical for assessing both internal efficiency and external cost competitiveness.

The following table offers a thorough summary of the numerous cost-related performance indicators utilized in logistics and supply chain management, as reported by prominent

2. THEORY

scholars who have investigated these metrics in the course of their research.

Indicators related to Cost	Author's reference & Year
Inventory Cost	Rimiene (2008); Cagliano et al. (2011), Gallmann and Belvedere (2011)
Order Processing Cost	Kiefer and Novack (1999), Rimiene (2008), Ramaa Subramanya, and Rangaswamy (2012)
Labour Cost	Cagliano et al. (2011)
Distribution Cost	Yang (2000)
Cost as a % of sales	Ramaa, Subramanya, and Rangaswamy (2012)
Maintenance Cost	De Marco and Giulio (2011); Johnson, Chen, and McGinnis (2010)

Table 2.2: Cost related Performance Indicators

2.4.3 Indicators related to Quality

Quality stands out as an important factor in every organization's success. Customers in today's competitive market expect high-quality products and organisations who can provide greater quality at a lower cost have a considerable advantage. Quality is primarily evaluated on three levels: input, output and throughput, or process quality. Most organisations prioritise quality because they have pledged to provide their clients with high-quality services and goods Rimiene (2008); Ramaa et al. (2012). To attain these quality goals, organisations use performance management systems to guarantee they are progressing in the right direction.

Conformance, as a dimension is strongly empirically related to quality. Gallmann and Belvedere (2011) established many quality indicators including customer satisfaction, input quality, output quality, cost quality and feedback from consumers. Menachof et al. (2009) further strengthened this by discussing metrics such as machine reliability, reworks, quality system expenses, customer satisfaction, returned goods, input and output quality, product dependability and machine reliability. Furthermore, Neely et al. (1995) included a variety of quality metrics, including performance, features, dependability, compliance, technical durability, serviceability, aesthetics, perceived quality, humanism and value.

The performance indicators important to quality dimensions that correspond to the company's problem description have been gathered from the accessible literature and listed accordingly. Various authors have used these KPIs in a variety of case scenarios in the manufacturing and warehouse industries. For this thesis case scenario, the most important KPIs were chosen and collected, along with the related authors' references. These criteria offer a thorough grasp of Quality-related problems in logistics and warehousing operations, and the measurement or improvement analysis of performance indicators aids in pinpointing areas for enhancement and maximizing the performance of the supply chain as a whole.

The below table depicts a thorough summary of the numerous cost-related performance indicators utilized in logistics and supply chain management, as reported by prominent

scholars who have investigated these metrics in the course of their research.

Indicators related to Quality	Author's Reference & Year
Orders shipped on time	Gallmann & Belvedere (2011)
Customer satisfaction	Gallmann & Belvedere (2011)
Cargo damage rate	Gallmann & Belvedere (2011)
Orders processed on time	Kusrini, et al., (2019)
Ratio of information processing costs per sale	Hiruwnwat, et al.,(2017)
Infrastructure cost per sale ratio	Hiruwnwat, et al.,(2017)
Maintenance cost ratio per sale	Hiruwnwat, et al.,(2017)
Storage cost per sale ratio	Hiruwnwat, et al.,(2017)
Labor cost per sales ratio	Hiruwnwat, et al.,(2017)
Receipt productivity	Ghaouta, et al., (2018)
Labor productivity and utilization	Laosirihongthong, et al., (2018)
% Order quantity according to order	Faozanudin & Susanto, 2019
% Rejected order	Faozanudin & Susanto, 2019
% of orders received with correct shipping documents	Laosirihongthong, et al., (2018)
% of products transferred without transaction errors	Laosirihongthong, et al., (2018)
Accuracy in order delivery	Laosirihongthong et al., (2018), Chen, et al., (2017)
Accuracy in taking orders	Laosirihongthong, et al., (2018), Buonamico, et al., (2017)
Inventory accuracy	Chen, et al., (2017); Hiruwnwat, et al., (2017), Laosirihongthong, et al., (2018), Buonamico, et al., (2017), Indrawati, et al., (2018)
Delivery on time	Ghaouta, et al., (2018), Ferdiansyah, et al., (2016), Buonamico, et al., (2017), Indrawati, et al., (2018), Chen, et al., (2017)
Product damage rate	Laosirihongthong, et al., (2018), Indrawati, et al., (2018), Chen, et al., (2017)

Table 2.3: Quality related Performance Indicators

2.4.4 Indicators related to Productivity

In the evaluation of KPIs in any business endeavour, but especially in warehouse management, productivity is a crucial factor (Frazelle, 2001). KPIs are measurable indicators of the efficacy and efficiency of different processes; productivity metrics, on the other hand, assess an organisation's ability to turn inputs into outputs. This emphasis on productivity aids in analysing present performance as well as pinpointing opportunities for development and resource allocation optimization.

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Any organisation looking to increase productivity, control expenses, boost worker performance, guarantee customer pleasure and aid in strategic decision-making needs to measure productivity using KPIs. Companies can obtain important insights into their operations, promote continuous development and achieve sustainable growth by concentrating on key productivity metrics. By putting in place a strong KPI framework that is customised to the organisation's needs, productivity metrics may successfully direct performance evaluation and strategic planning (Chan & Qi, 2003).

The table that follows shows the several productivity-related KPIs that have been covered by various authors. These KPIs offer a thorough grasp of productivity measurement despite varying interpretations and years of improvement. We can effectively monitor and improve warehouse operations if we all embrace these KPIs and customise them to our particular case scenario.

Indicators related to Productivity	Author's Reference & Year
Inventory Space Utilization	Ghaouta, et al., (2018), Ferdiansyah, et al., (2016), Kusriani, et al., (2018), Ramaa Subramanya and Rangaswamy (2012)
Equipment Utilization	Hiruwnwat, et al., (2017), Laosirihongthong, et al., (2018), O'Neill, Scavarda and Zhenhua (2008), Matopoulos and Bourlakis (2010)
Transport Utilization	Hiruwnwat, et al., (2017), Makaci, et al., (2017), O'Neill, Scavarda, and Zhenhua (2008), Matopoulos and Bourlakis (2010)
Lateness	Kim (2020)
Distance Reduction	Horta, et al., (2016), Yener & Yazgan (2019)
Receipt per Working Hour	Kusriani, et al., (2018), Ghaouta, et al., (2018)
Orders Prepared for Delivery	Kusriani, et al., (2018), Ghaouta, et al., (2018)
Pick-Up Productivity	Kusriani, et al., (2018), Ghaouta, et al., (2018)
Labour Productivity	Ghaouta, et al., (2018), Laosirihongthong, et al., (2018), De Marco and Giulio (2011)
Customer Satisfaction Level	Ghaouta, et al., (2018), Hiruwnwat, et al., (2017)
Response to Urgent Needs	Laosirihongthong, et al., (2018)
Transport Speed	Laosirihongthong, et al., (2018)
Delivery Flexibility	Laosirihongthong, et al., (2018)
Layout Configuration	Kusriani, et al., (2019)
Order Quantity	Elbert & KarlKnigge (2020)

Table 2.4: Productivity related performance Indicator

2.5 Current KPI's Measured in the company

The case organisation dealt in this study uses two KPIs to measure its operational performance. Full time equivalent (FTE) and pallets in and out are the terms used to describe

the KPIs. Looking more closely at each of the KPIs reveals that they each have advantages and disadvantages that can have a significant impact on the company's performance management.

2.5.1 Full time Equivalent (FTE)

In the warehousing industry, operations typically move more quickly. Workers are subjected to normal, high, and excessively light workloads. A workload that results in inefficiency at work is one that is either very light or hefty. When workers perform a disproportionate quantity of work compared to their workload, this is referred to as "**work overload**" (Amri, 2023). Burnout can result in both physical and mental tiredness, which lowers productivity. In the meanwhile, too low accountability suggests that a high volume of labour is utilised, necessitating additional funding for employees' salaries at the same productivity level for the company.

Overworked employees often become fatigued easily and become unproductive at work. It is advised to ascertain each employee's workload in order to remove any ambiguity among the staff. Therefore, FTE method is useful in this situation. In order to comprehend the amount of labour needed to complete activities effectively, workload analysis is essential. Research Scholars like Taufan et al. (2023) describe an analytical technique, FTE which entails evaluating task completion times to ascertain the ideal workforce requirements across various organisational divisions.

FTE method is a fundamental approach to workload analysis. FTE is the amount of time workers need to finish tasks; one FTE is equivalent to one full-time worker's workload during a 12-month period. Precise preparation is necessary for the efficient application of the FTE method, including defining the work unit under investigation, setting up efficient working hours, and figuring out time allowances (Taufan et al., 2023). Effective working hours in a given year must be understood in order to compute FTE accurately. This entails tallying the 365 days in a year and deducting days that are not used for business, such as weekends, public holidays, and days off for employees. FTE computations are based on the resulting effective working days and hours per day (Taufan et al., 2023).

By comparing necessary task completion durations against available effective working hours, the FTE approach facilitates the assessment of workload. By converting the number of workers required to complete tasks efficiently into the corresponding number of workload hours, this simplifies the measurement of work (Taufan et al., 2023).

FTE is calculated by the formula:

$$\text{FTE} = \frac{\text{Total activity time Allowance}}{\text{Total Available time}}$$

Workload intensity is the basis for categorising FTE numbers in accordance with defined norms. Overloading is indicated by an FTE index above 1.28; typical values fall between 1 and 1.28; underloaded labour is indicated by an index below 0.99. Within warehouse operations, these classifications help determine the ideal staffing numbers and workload

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balance (Taufan et al., 2023);(Kurniawan et al., 2022).

Workload Calculation Range	Classification of Work
0-0.99	Underload Work
1-1.28	Normal Work
>1.28	Overload Work

Table 2.5: Work Classification - Based on FTE

In the constantly shifting environment of warehouse operations, productivity and efficiency maximisation are critical. An important ally that offers a clear path to optimising staffing levels and workload distribution is the FTE technique. Warehouses can optimise resource allocation and guarantee that activities are completed within available working hours by utilising FTE calculations. (Taufan et al., 2023);(Kurniawan et al., 2022). This tactical method not only improves operational effectiveness but also gives decision-makers the ability to identify and quickly rectify workload inequalities.

In the end, using the FTE technique helps to create an agile and responsive warehouse environment, which leads to continued performance excellence and a competitive edge in the dynamic marketplace.

2.5.2 Pallets in and Pallets out

The "**Pallets In**" and "**Pallets Out**" KPIs are essential metrics used in warehouse operations to assess the efficacy and efficiency of material handling procedures. (Richards, 2011).

"**Pallets In**" calculates the quantity of pallets that arrive at the warehouse within a given time frame, offering valuable information on the amount of items arriving and the efficiency of the receiving process. This KPI is essential for inventory management because it supports precise stock level maintenance and the efficient use of resources, including manpower and storage space, to manage incoming items.

On the other hand, "**Pallets Out**" measures how many pallets are transported from the warehouse in a specified amount of time, indicating the efficiency of the outbound shipping process and the quantity of items that are leaving the facility. By guaranteeing prompt delivery of goods to satisfy consumer demand, this KPI has a direct impact on order fulfilment and customer happiness.

Effective picking, packing and shipping activities are indicative of efficient outbound processes, which in turn contribute to the overall efficiency of the supply chain (Shah & Mittal, 2019).

Warehouse managers must keep an eye on both the pallets in and out KPIs in order to identify problem areas and enhance overall performance. By identifying bottlenecks in the order dispatch and products receipt processes, these measures help to improve productivity and streamline operations. Pallets In and Pallets Out rates, for example can show

inefficiencies in the shipping or receiving operations, which can lead to corrective steps to enhance workflow and resource usage. Furthermore, these KPIs are used to assess operator performance and optimise resource allocation in the warehouse in addition to operational efficiency. Warehouse managers can evaluate the efficiency of labour allocation and storage space use by looking at trends in Pallets In and Pallets Out rates. To efficiently fulfil operational demands, this data-driven approach supports the decision-making process when it comes to staffing levels, equipment utilisation and workflow optimization.

Pallets In and Pallets Out KPIs are critical for improving customer happiness and service in addition to operational information (Shah & Mittal, 2019). Fast order fulfilment and shipment are indicated by a high Pallets Out rate, which enhances customer satisfaction and loyalty. By lowering order processing lead times and assuring timely delivery of goods, this metric-driven approach to warehouse management corresponds with customer expectations.

In the logistics and supply chain context, warehouse managers are enabled to maximise throughput, improve operational efficiency, and provide outstanding customer service through the thorough monitoring and analysis of Pallets In and Pallets Out KPIs. Warehouses can achieve sustainable development in competitive marketplaces, enhance process efficiency, and adjust to changing demand dynamics by utilising these performance metrics (Hompel & Schmidt, 2006).

3. METHODOLOGY

This chapter delves deeply into the research methods used for this thesis. The reader will learn more about the selected methodology, data collecting and analysis methods and literature research. The methodology approach structure stated by various research scholars like Yin (2017); Bryman and Bell (2015a); Bryman and Bell (2015b) and Creswell (2014) has been incorporated in this chapter.

Below is the flowchart description of how the research methodology is designed for this particular thesis study.

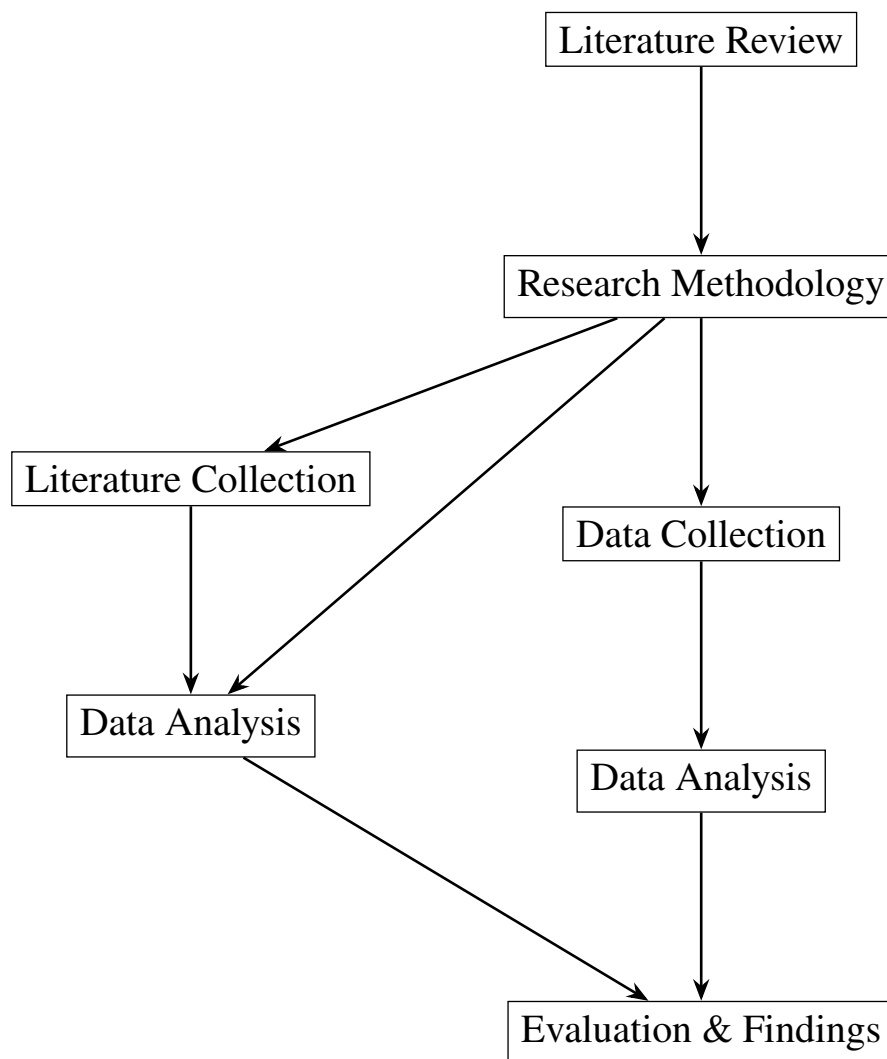


Figure 3.1: Flowchart of the Research Process

3.1 Research Approach

Bryman and Bell (2015a) state that the abductive reasoning approach is a widely used research strategy in qualitative research because it allows researchers to transition between the concept offered in the literature study and the actual data. In this thesis, the reason for using the abductive reasoning approach is that it allows for the smooth integration of theoretical ideas with empirical facts, guaranteeing that conclusions are theoretically informed and based on actual evidence (Bryman & Bell, 2015b). Finding the most rational and useful explanations for observed occurrences is the goal of abductive reasoning, which makes the research findings highly relevant to the problem statement. This thesis intends to provide both theoretical contributions and useful recommendations for industrial practice by utilizing abductive reasoning to gain deep, contextually grounded insights into the application of KPIs in warehousing and logistics.

This study is qualitative, which means that rather than focusing on collecting data from numbers, the data collection process is centred on interview responses and descriptions from key stakeholders in words rather than utilizing quantitative data measure for performing the analysis (Creswell, 2014). Additionally, there are three stages to the research process for this thesis. They are: Data collection, conducting literature review and finally conducting qualitative data analysis.

3.1.1 Literature Review

The literature review in this thesis is a key foundation for understanding the topic subject and identifying existing research gaps. In order to give readers a thorough grasp of the topic, a narrative review methodology referred to as the narrative review is used, with a focus on KPIs in logistics and warehousing. It enables a thorough investigation of the subject, offering a wide comprehension of important ideas and contextual insights. According to Bryman and Bell (2015a), this method of doing a literature review is especially well-suited for qualitative and inductive research since it allows for a thorough examination of relevant topics. The evaluation ensures the authenticity and dependability of the data acquired by drawing from a broad range of peer-reviewed sources.

According to Seuring et al. (2005) the literature review serves as the fundamental basis for every research endeavour, as it establishes a fundamental definition and understanding of the concepts and contents of the case under investigation.

An exploratory stage was undertaken before the literature review to acquire a thorough grasp of the corpus of work pertinent to the subject. Using a focused selection of keywords and key phrases, journal articles and books from online bibliographic databases such as Chalmers Library, Google Scholar and Scopus were collected. The search was not exhaustive rather it concentrated on the sources that were thought to be most relevant to the research goals, even though it attempted to cover a broad spectrum of applicable literature. The fact that a large number of the sources had undergone peer review before publication added to the materials credibility. To find relevant material search terms like KPIs, 3PL warehouse, supply chain, 3PL, logistics, pallets in and out, performance assess-

ment, warehouse efficiency and full-time equivalent were used.

Used Sources	Keywords Searched
Chalmers Library, Emerald Insight, Scopus	KPIs, 3PL warehouse, supply chain, 3PL evaluation, warehouse efficiency fulltime equivalent, KPI formulation, logistic performance, performance metrics productivity, quality, operational efficiency, inventory management, throughput analysis labour productivity

Table 3.1: Literature Sources & Keywords

As a result of the findings from the initial searches, the keywords further developed through a snowball effect, which is typical according to (Bryman & Bell, 2015b). The available selection at Chalmers Library served as a good guide for selecting printed books for some external referencing in addition to internet resources. This was very helpful in bridging the gap in the current research as these observations and findings from the literature review were then used to validate and support the points in the analytical section.

3.2 Data Collection

The steps and processes related to the data collection are described in this section. This comprises secondary data, questionnaires, observations and interviews.

3.2.1 Questionnaire

In the initial phase of data collection for this thesis, questionnaires were utilized as the primary tool to gather numerical data on warehouse operational dynamics, specifically focusing on KPIs relevant to the study. The decision to use questionnaires was driven by the need to collect structured, quantitative information efficiently from a diverse group of respondents, which aligns with the study's emphasis on operational metrics and performance evaluation.

The questionnaires were meticulously crafted around five major themes that have significant effects on warehouse operations. Their development was supported by key literature insights. The themes include **Material handling efficiency** (Tompkins et al., 2010); **Employee engagement and efficiency** (Gimenez & Ventura, 2005); **Current KPI measurement** (Huang et al., 2003); **Warehouse layout and space utilization** (Gu et al., 2007) and **Safety and well-being** (Gimenez & Ventura, 2005). Based on its proven impact on warehouse efficiency and effectiveness, each theme was chosen.

The chosen themes are derived from significant literature supporting their demonstrated effects on warehouse effectiveness and efficiency. While there are other viable themes, these five were chosen because they encompass a wide range of key aspects that drive warehouse operations. The category of themes were chosen to offer a thorough understanding of operational possibilities and problems, guaranteeing that the questionnaire covers important topics that can result in gaining information about the warehouse performance. We made sure that our questionnaire addressed all the important facets of warehouse operations by including these insights from the literature, which put it in line with best practices and

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established research.

By grounding our questions in these well-established themes, we ensured that the data collected would be relevant and aligned with the study's objectives. Although thematic analysis was performed later in the research process, these themes were predetermined based on their significance in the literature, allowing us to create targeted questions that would provide a comprehensive understanding of the warehouse environment.

The respondents included a range of key organizational stakeholders: CEOs, production managers, logistics developers, lead engineers and warehouse managers. These individuals were selected for their expertise and direct involvement in the operational aspects of the warehouse, making their insights crucial for understanding the various performance metrics and operational dynamics being studied.

Following the recommendations of Bryman and Bell (2015a), the questionnaire was designed to be brief and targeted, primarily using closed-ended questions. This approach facilitated coherent and clear responses, simplifying data administration and analysis. Despite the inherent limitations of questionnaires, such as the limited capacity to obtain in-depth qualitative insights, this method was deemed appropriate given the study's focus on qualitative operational data.

The content of the questionnaire aimed to extract significant information on regular business operations, including inventory management, throughput, productivity, labor productivity and equipment utilization. These metrics provided valuable insights into warehouse productivity and effectiveness, highlighting current issues and potential areas for improvement.

Overall, the use of questionnaires was well-suited to the study's objectives, allowing for organized and efficient data collection from key stakeholders. This methodological choice effectively supported the initial data gathering, setting the stage for further analysis and interpretation. Detailed questions posed to the respondents are included in the Appendix.

3.2.2 Interviews

During the qualitative data collection phase of the study, interviews played a pivotal role in gathering in-depth insights and contextual understanding of warehouse operations (Bryman & Bell, 2015a). The interviews were systematically structured into two distinct phases to address the research objectives effectively.

Initial Phase - Unstructured Interviews:- The first phase involved unstructured interviews designed to explore broad topics related to the current state of warehouse operations. The purpose of these interviews was to uncover preliminary insights into existing operational challenges and contextual factors affecting warehouse management. By engaging in open-ended discussions, we aimed to identify key issues and themes that would inform the focus of subsequent phases.

Second Phase - Semi-Structured Interviews:-Building on the insights gained from the initial phase, the second phase adopted a semi-structured interview format. This phase aimed to achieve a more detailed understanding of warehouse operations by engaging with a diverse group of stakeholders, including key position holders and floor workers. The semi-structured approach allowed for a combination of predetermined questions and flexible, open-ended inquiries. This flexibility enabled us to delve deeper into specific issues, explore emergent themes and gather comprehensive perspectives on the roles and responsibilities within the organization.

The both phase of interviews were instrumental in providing a nuanced understanding of the complexities underlying warehouse operations, highlighting specific challenges and areas for improvement. Insights from the initial unstructured interviews helped refine the focus and formulation of targeted questions for the semi-structured phase, ensuring that the interviews addressed relevant issues in greater depth. By including a diverse range of stakeholders, the interviews facilitated a holistic examination of operational dynamics, capturing varied perspectives on warehouse management practices.

The responses from the interviews were systematically analyzed to identify key operational issues and contextual factors. Unique codes and themes were assigned to each stakeholder's input, aiding in the data triangulation process. This approach ensured a robust analysis by combining qualitative insights with other data sources, which will be elaborated upon in the upcoming chapter.

Name	Role in the company	Duration of the Interview	Code used for Analysis
Mathias Olsson	CEO	75 minutes	A1
Oscar Hjerpe	Operations Manager	120 minutes	A2
Adam Trawber	Logistic Developer	60 minutes	A3
Linda Lindberg	Business Developer	45 minutes	A4
Simon Gustaffson	Operational Leader	45 minutes	A5
Nathalie Olit	Production Leader	60 minutes	A6

Table 3.2: Summary of Interview Participants & Details

3.2.3 Observations

Since open observation allowed interaction with warehouse staff during observations, it was deemed ethically and technically feasible, as suggested by (Christensen et al., 2019). This methodological choice enabled the investigation of contextual elements impacting operational effectiveness in addition to offering options for real-time data collecting.

Direct observations were made at the warehouse site on a regular basis (twice per week) because the case study requires direct interaction in the current warehouse. From official evaluations of inventory procedures to casual observations of daily workflow dynamics,

these observations covered both qualitative and quantitative data gathering operations. KPIs including inventory turnover rates, order processing efficiency, and equipment utilization were all firsthand knowledge acquired by the researchers through physical immersion in the warehouse environment. A solid basis for in-depth case study analysis and KPI evaluation was laid by this practical method, which was crucial in obtaining information and assessing the state of warehouse operations at the time.

3.2.4 Secondary data

Secondary data includes information gathered from internal sources of the company. These data sources provide insightful information on the warehouse's operating environment, facilitating a thorough comprehension of current procedures and performance indicators. Secondary data was essential to understand the warehouse's operational environment in the early stages of the study. Internal systems like XR's Warehouse Management System (WMS) and pre-existing process documentation are the sources of this secondary data. The main goal was to use pre-existing data and established operations to improve understanding of the present warehouse scenario.

A thorough examination of the process routines that were recorded in XR's systems was part of the investigation. Before making direct inspections, we became acquainted with operational procedures thanks to this preventive review. We successfully formulated follow-up questions during observations and increased the depth of data acquired by having a prior awareness of these practices.

In conclusion, the WMS and process documentation, two internal sources of secondary data offered insightful contextual information that was crucial for comprehending the warehouse's operational environment. Although the primary purpose of the data required careful interpretation, this secondary data was a fundamental component that shaped further research efforts and analysis.

3.2.5 Gemba Walks

Gemba walks are an essential method for triangulating data, particularly in qualitative research. Using this approach, managers and leaders can directly comprehend procedures and difficulties by immersing themselves in the real work environment (Suárez-Barraza et al., 2012). Through direct observation and interaction with the operational environment, leaders can obtain crucial qualitative insights necessary for efficient problem-solving and decision-making (Imai, 2007).

Gemba walks offer a practical viewpoint that enhances other data sources including focus groups, interviews and document analysis in qualitative data triangulation. Real-time data collecting and a sophisticated comprehension of operational realities are made possible by this direct observation. According to Suárez-Barraza et al. (2012), leaders can get a better understanding of the workplace and identify the underlying reasons of inefficiency by observing problems firsthand and communicating with staff members.

The Gemba walk method focuses on useful, doable discoveries, which is in line with Kaizen, the ideals of continual development. By guaranteeing that observations are based on the real circumstances in which issues arise, it facilitates a thorough qualitative study. By improving the validity and richness of qualitative data, this approach produces more long-lasting and efficient solutions.

All things considered, adding Gemba walks to the triangulation of qualitative data enhances the analysis by offering a more profound, culturally grounded viewpoint, which helps make more meaningful and informed decisions.

3.2.6 Workshop

A workshop was held with key stakeholders from XR Solutions to address current gaps in their performance evaluation system and examine the theoretical classification of KPIs based on cost, time, quality and productivity. This 90-minute program intended to improve knowledge exchange, increase cross functional collaboration and develop a high-performance culture. The KPI classification mentioned here is based on initial stakeholder interviews and a thorough literature review.

The workshop's goal was to adjust the focus within the four criteria to ensure that the proposed KPIs correspond with XR Solutions strategic goals for performance assessment in their warehouse operations.

Production planners, logistics developers, business development managers, material handling leaders, the CEO and operational managers were some of the key stakeholders who took part in this workshop program. The Gemba technique which involves direct observation and discussion of actual procedures, was used to discover and successfully address performance gaps. The workshop used Gemba technique to help participants gain a better understanding of practical challenges and collaborate on refining KPIs, ensuring that these metrics were closely aligned with the organization's strategic goals and improving performance measurement methods (Tyagi et al., 2015); (Romero et al., 2018).

The As-Is situation of warehouse operations was elaborated in detail to these stakeholders followed by several discussion topics. The workshop's goal was to navigate the identification of most aligning KPI criterion's that measures the operational performance by aligning with their organisational objectives.

Therefore, the following steps were followed to perform this workshop:

- **As-Is Situation:** Presentation of current gaps with existing KPIs was presented to the stakeholders to understand the as-is situation of current warehouse operations and understand the issues with their current performance evaluation method. This step discusses in detail the limitations with respect to full-time equivalent and pallets in and out indicators.

- **Literature Review:** A thorough literature assessment was presented to offer a theoretical framework for the proposed KPI categories. Drawing on a variety of case studies and academic sources, the review provided insights into how KPIs could be properly categorised and implemented in the context of XR Solutions. This theoretical foundation ensured that the workshop's results were backed up by proven research and best practices
- **Strategic Alignment:** A collaborative discussion has been held with the stakeholders to understand their business goals and strategic objectives that XR solutions would like to achieve through improving their performance indicators.

3.3 Data Analysis

In qualitative research, data analysis is the process of analyzing non-numerical data such as text, audio in order to identify trends, themes, and insights (Creswell, 2014). The method is flexible and iterative, with an emphasis on comprehending meaning and arriving at a output addressing the required parameters.

A rundown of the steps as suggested by Creswell (2014) has been implemented for the qualitative data analysis carried out in this thesis is mentioned below.

Data collection:- The first step is the data collection which was gathered by methods like interviews, physical visit, observation and understanding of secondary data documents. The data collection consisted of transcripts and notes which were obtained from the interviews.

Data Familiarization:- Next the researchers immerse themselves in the data, reading the transcripts, findings from the interview to gain a thorough understanding of the contents. This familiarization of data paves the way for gap analysis, which highlights difference between the current state and the desired future state. This process helps companies identify inefficiencies, areas for improvement and opportunities for achieving better performance in their processes.

Data Coding:- Coding is the process of labelling the pieces of data (sentences, paragraphs) based on the content. These coding represent the key concepts or ideas. The codes are then grouped into categories or themes establishing relationships between them.

Theme Generation:- Once the data is coded, the researchers identify broader patterns and organizes codes into themes. These themes represent the main ideas or recurring topics that emerge from the data, helping to answer the research questions. The theme are then reviewed in relation to the data to ensure they accurately reflect the content.

Data Linkage:- The researchers look beyond the surface-level content to make sense of the findings. This involves considering the context, linking the themes to the theoretical framework such as literature's, books and articles and correlating it to find deeper meanings, patterns.

Data Triangulation:- Triangulation involves gathering data from different sources, such as interviews, surveys, observations and literature documents to corroborate findings. This triangulation ensures cross verifying data, ensuring that the findings are not the result of a single source or method but are supported by consistent evidence of various research scholars and their works.

Presenting the findings:- The final stage involves presenting the results, the themes are illustrated with quotes or examples from the data, and the findings are connected to the research questions and literature review.

The above steps will be explained in a very detailed manner in the next upcoming chapter Analysis.

3.4 Research Quality

The quality of the research might be affected by a number of factors. According to Yin (2017), validity and reliability are the two criteria that can be used to evaluate the fineness of a qualitative study. A thoroughly documented approach is necessary to ensure that the study can be duplicated or whether another researcher can use the same methods and reasoning and get to the same conclusions. Conversely, validity pertains to whether the study evaluates, notes or identifies what it is intended to (Bryman & Bell, 2015b).

The external validity and the internal validity are the two view points on this. The degree of generalizability of the data is known as external validity, while the degree of agreement between the observations and the theoretical concepts is known as internal validity. It is crucial to take into account potential casualties and competing theories in order to address these problems (Yin, 2017).

Since these elements can have a significant impact on the calibre of the research, meticulous documentation of the research procedure, the use of various sources and the consideration of competing theories have all been taken into account throughout the thesis work to ensure trustworthiness.

4. ANALYSIS

This chapter provides an in-depth exploration of the qualitative analysis conducted during the study. The focus here is on interpreting and understanding the rich, non-numeric data collected, aiming to uncover significant patterns, themes and insights. Employing techniques such as thematic, content, and narrative analysis, we seek to reveal the complex experiences and viewpoints of the participants. This section describes the methodical approach used to examine the data, highlights the primary themes identified and discusses how these findings address the research questions. By thoroughly analyzing the qualitative data, we aim to offer valuable insights that contribute to a deeper comprehension of the study's goals and provide meaningful implications for both practical applications and theoretical development.

4.1 Interview Analysis

In this section, we delve into the analysis of interview data collected from various stakeholders focusing on the five themes "**Warehouse layout and space utilization; Current KPI measurement, Material handling efficiency, Employee engagement and productivity**" which was also discussed earlier in subsection 3.2.1.

This analysis is intended to pinpoint significant concerns and highlight the most frequently mentioned issues within each theme as reported by stakeholders. Additionally, a detailed thematic analysis was carried out to match the data with specific codes, a process that is explained more elaborately in the following sections.

4.1.1 Interview Analysis - CEO(A1)

The A1 emphasized that the layout of the warehouse which is mostly determined by the kind of items received, has not been optimized and is still stagnant. The outdated floor material and rigid structure limit handling flexibility and space efficiency, making it difficult to handle complex and irregular pallets. In order to make better use of the available space and accommodate new operational demands, A1 underlined the necessity for a redesign.

A1 has also stated that there is no systematic strategy to KPI measurement and that it has been inconsistent. It is challenging to pinpoint performance problems and efficiently monitor improvements in the absence of precise and consistent data. This inconsistency makes it difficult to promote operational improvements and make well-informed judgments.

A1 also pointed out that the outmoded infrastructure and layout of the facility makes goods handling difficult. The handling of complicated and irregular pallets is complicated by problems including small aisles, uneven floors and obstructive pillars, which can lead to inefficiency and possible damage. Productivity and employee engagement are important

issues, especially when it comes to handling demand variations.

A1 stressed upon the difficulties related to managing costs associated with damage of the products, operating lower volumes of good and irregular varying demand. Volume reductions have an impact on labor expenses and overall productivity, thus cost optimization and workforce management strategies must be adaptive. Costs associated with insurance are rising due to product damage rates. So, new performance measures must be suggested in order to control costs and boost profitability.

4.1.2 Interview Analysis - Operations Manager(A2)

A2 draws attention to how inefficient space usage results from a lack of structure and organization on the warehouse floor. There are underutilized and floating areas in the current design, which causes operational bottlenecks particularly during peak hours. To reduce congestion, it's also necessary to strategically arrange commodities and optimize traffic flow.

A2 also states that the present KPI measurement is simplistic and mainly compares the amount of products moved between shifts vs the number of Full-Time Employees. The organization's dependence on basic bench-marking and comparisons fails to adequately address operational inefficiencies or performance problems. A lack of defined handling procedures, erratic workflows and sporadic goods delivery are among the concerns.

The warehouse's dependence on client systems creates inefficiencies and complicates material management, especially when it comes to scheduling and resource allocation. A2 also makes the argument that prior management setups, in which a single production leader oversaw big teams weakened operational efficacy and diluted focus. He highlights the significance of goal-setting, improved team management and transparent communication as tactics to raise productivity and improve employee engagement.

4.1.3 Interview Analysis - Logistic Developer(A3)

A3 states that his team took into account of forklift dimensions, pallet sizes and standard measures when designing the warehouse. Nevertheless, considering that every square meter is currently sold out, optimizing the warehouse space is a substantial difficulty. Going forward he emphasizes on making the most of the current space rather than physically expanding, particularly given the increasing demand for more warehouse space.

Operational efficiency is also impacted by the placement of the commodities, especially slow pace vs high-volume products. The current arrangement finds it difficult to maximize space use while maintaining accessibility. A3 also explains how the current KPI's assess turnover is by comparing it to worked hours. Although it gives a broad picture, this is not very good at capturing specific operational performance.

Currently, the material handling lacks the precision and efficient procedures required to reduce mistakes and delays. According to him, new KPIs are required as they must monitor accuracy and efficiency in addition to production.

4.1.4 Interview Analysis - Business Developer (A4)

The old and ineffective warehouse arrangement is one of the major problems the business developer brought up. She points out that the warehouse was originally intended to be a factory, which created a number of structural issues like pillars, sloping floors and small spaces. These design restrictions make it more difficult to transport things smoothly and reduce the amount of space that can be used for effective storage. Furthermore, the arrangement wastes potential for storage by not making the most of vertical space.

A4 also stated that while employee ideas are solicited through meetings and other means, there is no standard procedure for calculating important indicators like equipment efficiency, productivity or space usage. The lack of KPI's makes it challenging to spot inefficiencies and monitor progress.

Another issue explained by A4 related to equipment utilization and material handling was due to narrow aisles and antiquated infrastructure that is not suited to contemporary warehouse operations. A4 also emphasized in particular that uneven flooring and pillars that impede forklift operations cause damage and slow down operations.

4.1.5 Interview Analysis - Operational Leader (A5)

A5 lists many challenges associated with warehouse design and space use highlighting important problems such as overuse of forklifts, traffic and outdated layout. Forklifts are supposed to be utilized for three main tasks: loading, sorting and unloading. However, in actual use the forklift usage is more than the suggested limit which causes inefficiencies and bottlenecks. Many trucks parked close to important locations cause congestion, which impedes operational flow. In addition, the warehouse's outdated factory layout is unfit for modern requirements, leading to ineffective space use and prolonged handling times.

A5 also highlights the shallow and basic nature of the existing KPI measurement method. The current KPIs mostly concentrate on simple benchmarks, such as the amount of products moved in; measurement of workload of the employees, but they don't offer a complete picture of performance or highlight underlying inefficiencies. More thorough KPI tracking that appropriately reflects actual operational circumstances and problems is of vital importance.

Regarding material handling, A5 highlights the difficulties arising from irregular processes and dependence on systems tailored to each client. Efficiency is regularly disrupted by unplanned handling procedures and unplanned arrivals and handling is made more difficult and operational flexibility is decreased.

4.1.6 Interview Analysis - Production Leader(A6)

A6 stated that accurate inventory levels are maintained through continuous WMS and physical inventory checks. The production lead also showed interest in increasing the space utilization due to demand the warehouse holds amidst their customers.

A6 efficiently manages labor resources by modifying workforce levels in response to variations in demand. It also seen that quality has been placed as a important criteria so that they reduce damaged goods and the cost associated with them.

4.2 Gap Analysis

This gap analysis was performed based on outcomes obtained from the interview analysis of various stakeholders which provided insights into the limitations and shortcomings of the current Key Performance Indicators used by the company.

The analysis revealed that the FTE KPI, while useful for evaluating overall employee workload and optimizing staffing levels, does not offer detailed insights into shift-level labor allocation or workload distribution. This limitation was highlighted by A2, who noted that FTE fails to address which shifts require additional staffing leaving a significant gap in workforce management. Additionally, the FTE overlooks qualitative factors such as employee satisfaction, which are crucial for maintaining sustained productivity and morale. These deficiencies emphasize the need for a more holistic performance measurement approach that incorporates real-time data and considers employee-centric metrics.

Similarly, the Pallets In and Out KPIs crucial for inventory control and assessing the efficiency of receiving and shipping procedures, were found to be insufficient in evaluating the precision and quality of handling processes. As noted by stakeholders A1 and A3, these KPIs focus solely on the volume of pallets handled, neglecting critical aspects such as packing and picking quality. Furthermore, as lagging indicators, they provide historical data without actionable insights for immediate operational improvements. This narrow focus underscores the need for additional KPIs that offer thorough process analysis, quality control and operational flexibility to provide a more complete picture of warehouse performance.

4.3 Coding & Thematic Analysis

The procedure for creating codes and connecting them to themes in qualitative analysis is described in this section. **Codes** are initially generated as short labels that summarize important ideas or concepts found in the data. These codes act as the fundamentals, dividing the data into discrete, understandable sections. Then, **thematic analysis** combines these codes into larger more thorough themes. These themes stand for important trends or revelations found in the data. The triangulation of data that answers the research question is made possible by this coding and thematic analysis.

4.3.1 Generation of Codes

We have used a thematic analysis approach to carefully evaluate the findings from the stakeholder interviews. As mentioned earlier in section 3.2.1 we have used 5 themes namely: **Warehouse layout and space utilisation; Material handling efficiency; Current KPI measurement; Employee engagement and efficiency; Safety and well being** and the codes were generated from the interview analysis of the key stakeholders under these themes.

The resulting codes offer a comprehensive framework for comprehending the opportunities and difficulties in the warehouse environment by reflecting particular aspects of these themes. Since every code is consistent with the main themes, the analysis is both structured and in line with the principal areas of concern discerned from the interviews.

4.3.2 Representation of themes & Codes associated with them

1. Warehouse Layout & Infrastructure

Code 1.1: Inefficient Space Utilization

Code 1.2: Outdated and Rigid Infrastructure

Code 1.3: Obstructive Physical Structures (Pillars, Narrow Aisles)

Code 1.4: Inadequate Floor Material and Structure

Code 1.5: Poor Traffic Flow and Congestion

2. Material Handling & Equipment Utilization

Code 2.1: Difficulty Handling Complex/Irregular Pallets

Code 2.2: Overuse of Forklifts

Code 2.3: Damage due to Inefficient Handling

Code 2.4: Dependence on Client Systems Leading to Inefficiencies

Code 2.5: Irregular and Unplanned Handling Procedures

3. Key Performance Indicators (KPI)

Code 3.1: Lack of Systematic KPI Measurement

Code 3.2: Simplistic Benchmarking Methods

Code 3.3: Need for More Comprehensive KPIs

Code 3.4: Inconsistent Data and Performance Tracking

4. Operational Efficiency & Productivity

Code 4.1: Bottlenecks in Operations (Especially During Peak Hours)

Code 4.2: Impact of Volume Reductions on Productivity

Code 4.3: Cost Management and Optimization

Code 4.4: Challenges in Workforce Management

5. Space Optimization

Code 5.1: Maximizing Existing Space vs. Physical Expansion

Code 5.2: Vertical Space Utilization

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Code 5.3: Strategic Commodity Placement

6. Employee Engagement & Communication

Code 6.1: Need for Improved Team Management and Goal-Setting

Code 6.2: Employee Feedback Mechanisms

Code 6.3: Enhancing Employee Productivity and Engagement

7. Cost and Damage Management

Code 7.1: Costs Associated with Product Damage

Code 7.2: Rising Insurance Costs

Code 7.3: Strategies for Reducing Damage and Associated Costs

8. Adaptation to Operational Demands

Code 8.1: Flexibility in Managing Demand Variations

Code 8.2: Adaptation of Workforce and Resources to Operational Needs

4.3.3 Mapping Codes to Key Performance Indicators

The **table** presented below indicates the relation of how the codes derived from the interview analysis classified under five themes(Refer Section 3.2.1)is linked to four direct performance indicators(Refer Section 2.2).This mapping offers insights into how different elements of the warehouse’s design, material handling procedures, KPIs, operational effectiveness, space optimization, staff involvement, cost control and flexibility in response to changing needs affect the warehouse’s overall performance.Through the coding of these KPIs, the table identifies the critical areas that may be improved upon to improve operational results.

Themes	Codes Generated	Relevant KPI's	Explanation relating to the KPI
Warehouse Layout & Infrastructure	1.1: Inefficient Space Utilization	Time, Productivity	Inefficient layout increases handling time and reduces productivity due to congestion and poor space utilization.
	1.2: Outdated and Rigid Infrastructure	Cost, Quality	Outdated infrastructure leads to higher maintenance costs and impacts the quality of handling, causing product damage.
	1.3: Obstructive Physical Structures	Time, Productivity, Quality	Physical obstructions slow down operations, reducing productivity and potentially leading to damage (quality).
<i>Continued on next page</i>			

Themes	Codes Generated	Relevant KPI's	Explanation relating to the KPI
	1.4: Inadequate Floor Material and Structure	Cost, Quality	Poor floor conditions increase the risk of product damage, leading to higher costs and lower quality.
	1.5: Poor Traffic Flow and Congestion	Time, Productivity	Traffic congestion within the warehouse delays processes, reducing overall productivity.
Material Handling & Equipment Utilization	2.1: Difficulty Handling Complex/Irregular Pallets	Time, Quality	Complex handling increases time spent on operations and raises the likelihood of damage, affecting quality.
	2.2: Overuse of Forklifts	Cost, Productivity	Excessive forklift use leads to higher operational costs and reduces overall productivity due to inefficiencies.
	2.3: Damage due to Inefficient Handling	Cost, Quality	Inefficient handling practices increase product damage rates, leading to higher costs and compromised quality.
	2.4: Dependence on Client Systems	Time, Productivity	Dependence on external systems can cause delays and inefficiencies, impacting time and productivity.
	2.5: Irregular and Unplanned Handling	Time, Cost, Productivity	Unplanned handling disrupts workflow, increases time, raises costs, and decreases productivity.
Key Performance Indicators (KPI)	3.1: Lack of Systematic KPI Measurement	Productivity, Quality	Without systematic KPIs, it's challenging to identify and improve operational inefficiencies and quality issues.
	3.2: Simplistic Benchmarking Methods	Productivity	Basic benchmarking fails to capture true productivity levels, leading to inaccurate assessments of efficiency.
	3.3: Need for More Comprehensive KPIs	Productivity, Quality	More detailed KPIs are needed to better measure and enhance productivity and quality.
	3.4: Inconsistent Data and Performance Tracking	Productivity, Quality	Inconsistent tracking hinders the ability to monitor and improve productivity and quality consistently.

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Themes	Codes Generated	Relevant KPI's	Explanation relating to the KPI
Operational Efficiency & Productivity	4.1: Bottlenecks in Operations	Time, Productivity	Operational bottlenecks increase the time required to complete tasks and reduce overall productivity.
	4.2: Impact of Volume Reductions on Productivity	Productivity, Cost	Lower volumes lead to underutilized labor and higher per-unit costs, reducing overall productivity.
	4.3: Cost Management and Optimization	Cost, Productivity	Effective cost management directly impacts productivity by ensuring optimal resource use.
	4.4: Challenges in Workforce Management	Productivity, Cost	Inefficient workforce management leads to higher costs and reduced productivity.
Space Optimization	5.1: Maximizing Existing Space	Cost, Productivity	Better space optimization reduces costs and increases productivity by making the best use of available space.
	5.2: Vertical Space Utilization	Cost, Productivity	Using vertical space effectively can reduce costs associated with storage and increase productivity.
	5.3: Strategic Commodity Placement	Time, Productivity	Strategic placement of goods reduces handling time and increases operational efficiency.
Employee Engagement & Communication	6.1: Need for Improved Team Management	Productivity, Quality	Better team management enhances productivity and quality by fostering a more engaged and efficient workforce.
	6.2: Employee Feedback Mechanisms	Productivity, Quality	Regular feedback can lead to process improvements, boosting both productivity and quality.
	6.3: Enhancing Employee Productivity and Engagement	Productivity, Quality	Engaged employees are more productive and likely to produce higher quality work.
Cost and Damage Management	7.1: Costs Associated with Product Damage	Cost, Quality	Product damage increases costs and impacts the overall quality of goods.
	7.2: Rising Insurance Costs	Cost	Higher product damage rates lead to increased insurance costs.

Continued on next page

Themes	Codes Generated	Relevant KPI's	Explanation relating to the KPI
	7.3: Strategies for Reducing Damage	Cost, Quality	Implementing damage reduction strategies improves quality and reduces associated costs.
Adaptation to Operational Demands	8.1: Flexibility in Managing Demand Variations	Time, Productivity	Flexibility in operations ensures timely responses to demand changes, enhancing productivity.
	8.2: Adaptation of Workforce and Resources	Time, Productivity, Cost	Adaptive resource management ensures efficient use of time, enhances productivity, and controls costs.

Table 4.2: Relating themes, codes to the KPI's

4.4 Workshop Outcomes

The session with key warehouse personnel helped to validate the preliminary gap analysis and match the recommended KPIs with XR Solutions strategic goals. The workshop provided for a practical approach to developing KPIs that better represent the warehouse's situations by incorporating individuals who work in daily operations directly.

The workshop began with a presentation of the preliminary gap analysis results, which identified areas where current KPIs were ineffective in capturing operational success and were misaligned with XR Solutions strategic goals. Involving key employees of the warehouse in the discussion ensured that the examination was grounded in real-world experiences. This also helped to link the suggested KPIs with the company's strategic goals, ensuring that the measures promoted improvements in crucial areas.

A crucial component of the program was allowing warehouse employees to extensively evaluate the present KPIs. This hands-on approach allowed employees to evaluate how valuable existing measurements were in their everyday work. Throughout the process, participants were encouraged to propose alternative KPIs that could provide more relevant insights into operational performance. His open communication enabled that employee feedback was directly applied to the formulation of more relevant and effective KPIs.

The initiative also covered critical performance dimensions such as time, cost, quality, and productivity based on a literature review. The emphasis on time and cost helped identify inefficiencies, although quality and productivity were critical in determining the overall efficacy of warehouse operations. As the workshop progressed, the discussion switched to indicators focusing on quality and productivity. Participants felt that these two characteristics were the most important for XR Solutions.

The workshop was critical in verifying the early gap analysis and refining the proposed

KPIs to better align with XR Solutions strategic goals. By emphasising practical study and collaborative exploration of KPI possibilities, the workshop guaranteed that the chosen KPIs were relevant and realistic for the company's operational goals. The emphasis on quality and productivity paves down for improving performance in critical areas, allowing XR Solutions to achieve their objectives.

4.5 Data Triangulation Analysis for suggesting KPI's

Data triangulation is a technique used by researchers to make sure their findings appropriately address the primary challenges while creating an appropriate and relevant performance indicator (Bans-Akutey & Tiimub, 2021); (Carter et al., 2014). This approach entails combining data from several sources to create a thorough picture of the issue and identify feasible solutions (Velimirović et al., 2011).

A review of the thematic analysis, which offers crucial insights into current challenges and contextual elements, kicks off the process. In addition, literature reviews provide a more comprehensive academic viewpoint, firmly establishing the indicator in accepted theories and methodologies. Workshops cut down the emphasis by adding useful insights from stakeholders, further refining a plan of action.

By combining these various inputs, Through the use of theme analysis, literature reviews and workshop results, researchers create a performance indicator that is reliable and in line with the actual challenges observed.

4.5.1 Analysis of Quality related KPI

Quality performance indicators are essential for assessing the efficacy and efficiency of operations in a warehouse context. These metrics assess a number of performance-related factors, including as precision, dependability, and standard compliance. Warehouses can improve client satisfaction, cut expenses related to errors and rework, and increase operational efficiency by putting a strong emphasis on quality performance.

Product damage has a direct impact on customer satisfaction and warehouse operational costs, making it a critical quality performance indicator. Elevated percentages of product damage signify ineffective material handling procedures and inadequate quality assurance, resulting in higher expenses from returns, replacements, and disgruntled customers. Warehouses can improve overall quality performance and operational efficiency by concentrating on minimizing product damage.

Laosirihongthong et al. (2018) states that ineffective material handling procedures, inappropriate storage or insufficient training are frequently the causes of damaged items. Damaged items in warehouses are a sign of improper material handling and can result in greater operating expenses from returns, replacements and even service level agreement problems. It is possible to determine the underlying causes of damage and quantify it over various time periods by monitoring product damage rates.

On the other hand, product damage was mentioned as a significant issue affecting warehouse operations during interviews with important stakeholders, including the (A1) and A2. The A2 highlighted that, particularly with high-value clients, repeated damages impair consumer trust and also raise insurance costs. As part of the present strategy, damaged goods are thoroughly investigated, the sources of damage are determined, and damage counts are tracked on a monthly basis. It was underlined that in order to preserve high customer satisfaction and prevent financial losses, damage must be reduced to almost nil levels.

The literature supports the importance of tracking product damage rates as a KPI. Studies by Gallmann and Belvedere (2011) indicate that high product damage rates are indicating inefficient material handling processes and poor quality control. By measuring and addressing damage rates, warehouses can enhance operational quality, reduce costs, and improve customer satisfaction.

Another essential KPI for evaluating the quality of warehouse operations is **Inventory accuracy**. Precise inventory levels minimise interruptions and improve operational effectiveness by guaranteeing that data entered into the WMS corresponds to the actual stock on hand. Ramaa et al. (2012) state that inventory accuracy is essential for minimising holding costs, avoiding the bullwhip effect, and optimising storage space. The body of research highlights how crucial correct inventory is to preserving efficient operations, guaranteeing client happiness and cutting down on wasteful spending.

According to A5 surveyed, substantial space restrictions and operational bottlenecks have resulted from inventory mistakes. According to A2, incomplete inventory records have led to bottlenecks that have decreased profitability and prevented the warehouse from accepting new clients. Operational efficiency has been hampered by the absence of a trustworthy inventory management system, which has made the use of KPIs to track inventory correctness necessary.

The significance of inventory accuracy as a KPI is emphasised further in literature studies. The percentage of accurate inventory records relative to all records is one way to quantify inventory accuracy, according to (Chen et al., 2017). For best use of available space and to reduce errors that can jeopardise the quality and operating efficiency of the warehouse, maintaining high inventory accuracy is essential.

Order delivery accuracy is a critical key performance indicator (KPI) that shows how well a warehouse can accurately and timely process customer orders. According to Caputo and Pelagagge (2006) and Laosirihongthong et al. (2018), order delivery accuracy has a direct impact on long-term business success, operational efficiency and customer happiness. Good delivery accuracy lowers expenses related to order problems, refunds, and replacements and is a sign of efficient order processing.

Issues with order delivery accuracy were brought into focus during interviews with A2 and A3. These issues included processing speed, inadequate quality checks and order

prioritisation. The operations head saw a sharp rise in returned goods over the previous year as a result of quality and delivery mistakes, which had an adverse effect on customer satisfaction. Insufficient delivery precision has resulted in elevated operating expenses and strained client connections, highlighting the necessity of an effective KPI system to oversee and enhance delivery excellence.

These findings are supported by literature, which indicates that maintaining excellent service quality requires tracking order delivery accuracy. Chen et al. (2017) state that the percentage of correctly delivered orders relative to the total number of orders can be used to determine the accuracy of order delivery. Reduced operational waste, customer loyalty and operational excellence are all impacted by accurate order delivery.

4.5.2 Analysis of Productivity related KPI

One of the key factors in a warehouse is **Productivity**, which provides information on labor and resource use, overall business performance and operational efficiency. To improve the warehouse and raise both its efficiency and profit margin, it is imperative to identify effective performance indicators for productivity dimensions.

A key component of warehouse management is **Storage space utilization**, which measures how well the available space is utilized. Making optimum use of storage space ensures that the warehouse can handle and process items in an efficient manner by maximizing inventory capacity and minimizing waste. Maintaining operational efficacy, attracting new clients and generating new business prospects all depend on accurate measurement and oversight of this component.

A2 emphasizes that a major problem in the warehouse is inefficient space usage. Congestion, particularly during peak hours and unoccupied areas are the results of a lack of organization and structure. Productivity is negatively impacted by operational bottlenecks and delays brought on by this instability. Similar to this, the interviews with A5 emphasize the challenges of managing short-term projects and the necessity of optimizing space to welcome new clients. If the warehouse can respond to these requests rapidly, its productivity can increase significantly. A4 also cites operating delays and traffic flow issues on outdated infrastructure, such as uneven flooring and small aisles. These defects in design limit the efficient use of available space and impede the smooth delivery of items.

These interview insights are corroborated and strengthened by the literature. Aronovich et al. (2010) state that efficient warehouse management depends on tracking storage capacity and utilization. When managers use storage space utilization as a performance metric, they can spot inefficiencies and take the appropriate action. According to Aronovich et al. (2010), clearing out outdated or expired goods on a regular basis can increase storage capacity by creating more room and enhancing the effectiveness of storage facilities. Rearranging systems and storage layouts to better suit the demands of the existing inventory helps to maximize the amount of space that is available.

According to Bragg (2011), effective use of storage space improves the flow of items through the warehouse overall by minimizing bottlenecks and congestion, which directly leads to quicker order processing times. Efficient space management makes selection, packing, and shipping easier by making products more accessible. Bragg (2011) also emphasizes how important it is to have flexible and orderly storage spaces so that they can adjust to sporadic demand surges and seasonal variations, keeping operations running smoothly even in times of fluctuating demand.

In warehouse operations, **forklifts are essential equipment** for shifting, loading, unloading, and stacking products. Maintaining operational efficiency and cutting costs require the efficient usage of these equipment.

A2 highlights that the warehouse's disorder and lack of structure results in inefficient space usage, congestion and bottlenecks, particularly during peak hours. This results to an overuse of forklifts to navigate through crowded spaces and move goods more frequently than is required. A3 adds that despite careful design regarding pallet sizes and forklift dimensions, the warehouse's full occupancy presents difficulties for accessibility and space optimization. This spatial inefficiency directly leads to the overuse of forklifts. Forklifts are compelled to operate in less than ideal conditions in densely populated areas, which increases maintenance expenses, wear and tear, and operational speed.

A5 explicitly identifies forklift overuse as a major issue, noting that forklifts are being used beyond their intended purposes of loading, sorting and unloading. This excessive utilization highlights the shortcomings in the current warehouse layout and contributes to traffic congestion inside the warehouse, especially when several forklifts are operating in close proximity to each other. Forklift operations are made more difficult by narrow aisles and poorly designed traffic flows, which raises the possibility of bottlenecks.

By using the theoretical solutions put forth by academic experts, the highlighted issues can be successfully resolved. Theoretical insights from Hirunwat et al. (2017), who stress the significance of regular maintenance and careful planning while using equipment. They contend that equipment that is properly scheduled and maintained lowers operating costs and boosts output. The authors emphasize that preventive maintenance is necessary for overused equipment, like forklifts in this instance, in order to keep efficiency and prevent breakdowns. To monitor and enhance equipment efficiency, they advise computing important parameters like active time, idle time, workload movement and equipment lifetime.

Furthermore, the operational and economical advantages of effective equipment use are stated by (Laosirihongthong et al., 2018). They emphasize how managers can optimize resource use and cut costs by allocating equipment where it is most required by adhering to optimal utilization patterns. Effective equipment management, which includes preventative maintenance guarantees a safer working environment, lowers downtime and increases output overall from a safety standpoint. Additionally Makaci et al. (2017), gives an alternative viewpoint saying that capacity and utilization are combined to determine equipment efficiency. In order to make informed decisions about maintenance and

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distribution, they suggest that it is important to comprehend the quantity of equipment utilized as well as the degree of its capacity usage.

A vital component of warehouse operations that has an enormous effect on customer satisfaction, productivity, and operational efficiency is **Order picking**. This process's effectiveness depends on a number of variables, including the management of workers, workflow structure and utilization of space.

According to the A2, operational bottlenecks especially during peak hours are mostly caused by improper space usage and disarray on the warehouse floor. These factors interrupt order picking by resulting in delays and decreased productivity. A3 state that the warehouse area is not well planned, even at full occupancy, which makes it difficult to maintain accessibility and lengthens the time employees spend finding products, exacerbates this problem. Even when the workload lessens, inefficiencies continue, which results in uneven productivity. The antiquated layout, with its constrained aisles and structural flaws, further complicates operations and makes employees spend more time order picking, according to A4.

The problems identified in the warehouse operations can be effectively addressed using theoretical solutions proposed by academic scholars. High picking productivity depends on effective inventory control, according to Ghaouta et al. (2018); Kusrini and Helia (2018), they contend that ineffective inventory control makes pickers seek for things for longer periods of time, which lowers productivity. On the other hand, an inventory that is well-organized makes sure that things are readily available, which speeds up the picking process and improves productivity overall.

This viewpoint is further supported by Ghaouta et al. (2018), who point out that a streamlined picking procedure shortens order fulfillment times, which is necessary to maintain high throughput and satisfy delivery obligations. Efficient order choosing increases accuracy and shortens processing times, which boosts output overall. Meeting key performance indicators for on-time delivery depends heavily on this.

Order picking productivity is mostly determined by labor productivity and picking times, as noted by (Kusrini & Helia, 2018). They state that since advancements in an area frequently have a favorable impact on another, it is critical to combine efforts in labor training with process optimization. Consistent productivity gains can be attained by improving workforce productivity through focused training, which can result in more effective order selecting. Lastly, Laosirihongthong et al. (2018) advise adding adjustments to productivity evaluations that improve precision and effectiveness. This all-encompassing method guarantees that accuracy and speed are taken into account when assessing order picking performance, offering a full picture that aids managers in pinpointing problem areas and maintaining high performance levels.

4.6 Summary of the KPI's

Our data triangulation analysis obtained six KPIs that are critical to improving warehouse operations productivity and quality: **Storage Space Utilization, Equipment Utilization, Order Picking Productivity, Product Damage Rate, Order Delivery Accuracy, and Inventory Accuracy.** These KPIs, which address key operational concerns, were developed from stakeholder interviews and supported by scholarly research.

While effective **Storage Space Utilization** maximizes capacity and minimizes congestion, **Equipment Utilization** makes certain that forklifts and other resources are used as efficiently as possible to reduce expenses and downtime. The goal of **Order Picking Productivity** is to increase labor productivity and expedite order fulfillment procedures. **Order Delivery Accuracy** is crucial for preserving **Product Damage Rate**, which in turn helps save expenses and improve customer satisfaction by eliminating inefficiencies in material handling.

Regarding quality, by resolving inefficiencies in material handling, lowering the **Product Damage Rate** contributes to cost savings and improved customer satisfaction. **Inventory Accuracy** eliminates operational bottlenecks by ensuring stock levels are accurately recorded in warehouse systems and **Order Delivery Accuracy** is essential for upholding customer trust by guaranteeing timely, error-free deliveries. When combined, these KPIs provide a thorough foundation for raising warehouse quality and operational efficiency. In the next section, we will talk about the benefits and the formula for calculating each of the KPIs.

5. RESULTS

The results that address the two main research questions mentioned in this study are presented in this chapter. A detailed analysis of the suggested solutions is conducted, emphasizing how they directly address the study questions. Furthermore, additional details are added to the recommended KPIs offering a clearer picture of their applicability and significance. Every KPI is thoroughly explained and includes exact formulas, guaranteeing that the measurements are clear and useful for real-world application.

RQ1: What are the most suitable KPIs for evaluating internal warehouse operations that align with the company's key problems and organizational goals?

Finding the best Key Performance Indicators (KPIs) for warehouse operations is the main goal of this study, particularly for the productivity and quality categories. From section 4.6, it is seen that the chosen KPIs "**Product Damage Rate, Order Delivery Accuracy, Inventory Accuracy, Storage Space Utilization, Order Picking Productivity, and Equipment Effective Utilization**" were determined by a thorough examination of academic literature in addition to real-world knowledge gleaned from interviews with companies. These particular KPIs were selected with care to ensure maximum relevance to the company's operational objectives, drawing from both theoretical frameworks and empirical data.

Each KPI will be fully described, along with a detailed discussion of its significance and formula. The formulas have been fetched from literature's which align with our solutions. Formula references have been taken from research articles stated by authors like Putri and Wahyudi (2023); Aronovich et al. (2010); Staudt et al. (2015); Chen et al. (2017)

1. Product Damage Rate

$$\text{Product Damage Rate (\%)} = \left(\frac{\text{Number of Damaged Items}}{\text{Total Number of Handled Items}} \right) \times 100$$

Number of Damaged Items: This is the total number of goods detected as damaged throughout a certain time period. This count should include any items damaged during handling, storage, or transportation within the warehouse.

Total Number of Handled Items: This reflects the total number of items processed or handled by the warehouse over the same period. It includes all items that have entered or exited the warehouse, whether by receiving, storage, picking, packing, or shipment.

Purpose of KPI: One of the most important KPIs in warehouse operations is the Product Damage Rate KPI, which measures the amount of goods that get damaged during handling, storage, and transportation. All sections of the warehouse where products are handled, such as the receiving, storage, picking, packing, and shipping zones, should have

this KPI measured.

2.Inventory Accuracy

$$\text{Inventory Accuracy (\%)} = \left(\frac{\text{Number of Accurate Inventory Records}}{\text{Total Number of Inventory Records}} \right) \times 100$$

Number of Accurate Inventory Records:The number of inventory records that match the actual physical inventory count or the system-estimated inventory count. These records are considered accurate if they reflect the actual quantity and status of products in stock.

Total Number of Inventory Records:The overall number of inventory records in the WMS system, regardless of their accuracy. This includes all entries for in-stock products, whether correct or inaccurate.

Purpose of KPI:This KPI evaluates the degree to which reported inventory levels correspond to actual physical inventory. It facilitates effective inventory management, lowers the expenses related to errors, and helps guarantee ideal stock levels. Order picking productivity, storage space utilization, and order delivery accuracy are just a few of the KPIs that are directly impacted by inventory accuracy. Inaccurate inventory data can cause problems in a number of different domains, resulting in mistakes, inefficiencies, and delays.

3.Order Delivery Accuracy

$$\text{Order Delivery Accuracy (\%)} = \left(\frac{\text{Number of Orders Delivered Accurately}}{\text{Total Number of Orders Delivered}} \right) \times 100$$

Number of Orders Delivered Accurately:The total number of orders delivered to customers without errors.

Total Number of Orders Delivered:The total number of orders delivered, regardless of their accuracy.

Purpose of KPI:an important indicator of how well a warehouse fulfills orders from customers. It measures how well the warehouse performs in terms of accurately and consistently fulfilling orders, and it's a key sign of both operational effectiveness and client satisfaction. This should be measured at the moment of delivery will allow for quick feedback on how well the fulfillment process is working. By doing this, errors are found and fixed quickly, stopping repetition and steadily raising the standard of operation.

4.Storage Space Utilization

$$\text{Storage Space Utilization (\%)} = \left(\frac{\text{Occupied Storage Space}}{\text{Total Available Storage Space}} \right) \times 100$$

Occupied Storage Space:Measured in cubic feet, square feet, or any other relevant unit, the quantity of warehouse space that is presently being utilized to hold goods.

Total Available Storage Space: The total amount of warehouse space that can be used to store inventory.

Purpose of KPI: This KPI calculates the proportion of storage space that is actively used for inventory storage out of all available storage space. The amount of storage space used should be measured throughout the entire warehouse including the floor, shelves, bins and racks.

5. Equipment Utilization

$$\text{Equipment Utilization (\%)} = \left(\frac{\text{Active Time}}{\text{Total Available Time}} \right) \times 100$$

Active Time: The total time the equipment is in use performing its intended functions (e.g.: moving goods, picking orders).

Total Available Time:- The total time the equipment is available for use including both active and idle time.

Purpose of KPI: This KPI keeps track of how well warehouse machinery—such as pallet jacks, conveyor systems, and forklifts—is employed while conducting operations. It seeks to minimize operating expenses and maximize resource use. All of the warehouse's equipment should be measured for this KPI.

6. Equipment Capacity Utilization

$$\text{Equipment Capacity Utilization (\%)} = \left(\frac{\text{Actual Output}}{\text{Maximum Possible Output}} \right) \times 100$$

Actual Output:- The actual amount of work done by the equipment in a given time period.

Maximum Possible Output: The maximum potential work the equipment can perform under ideal conditions in the same time period.

Purpose of KPI: metric that assesses the efficiency with which warehouse equipment is utilized in comparison to its full capacity. Precise information on the use of equipment facilitates improved resource allocation decisions. It assists in determining whether new equipment is required, whether existing equipment needs to be adjusted, or whether procedures need to be reworked to be more efficient.

7. Order Picking Productivity

$$\text{Order Picking Productivity} = \frac{\text{Total Picking Time}}{\text{Total Orders Picked}}$$

Total Orders Picked (TOP): The total number of orders picked during a specific time period.

Total Picking Time (TPT): The total time spent on picking orders, usually measured in hours.

Purpose of KPI: A key performance indicator, or KPI, gauges how rapidly and effectively warehouse staff can select products to complete customer orders. Usually, it is stated as the quantity of orders or things picked in a given hour. The KPI should be precisely measured in the picking regions of the warehouse where order fulfillment activities take place in order to appropriately estimate picking productivity.

8. Order Picking Productivity with Accuracy Factor

$$\text{Order Picking Productivity with Accuracy Factor} = \left(\frac{\text{Correctly Picked Orders Without Error}}{\text{Total Orders Picked}} \right) \times 100$$

Correctly Picked Orders Without Error: The total number of orders picked accurately without any mistakes.

Total Orders Picked (TOP): The total number of orders picked during a specific time period.

Purpose of KPI: This improved metric that takes into account both the accuracy of the picked ordered items and the order picking efficiency. This KPI offers a thorough picture of how fast and accurately warehouse staff can select products to fulfill orders. It provides a more holistic view by evaluating not just how many items or orders are picked per hour, but also how many of those are picked correctly without errors. This indicator should be measured in all picking areas of the warehouse.

RQ2: What are the benefits that the company could attain using the proposed set of KPIs?

The benefits of the recommended KPIs for the case company stem from significant research and insights offered by prominent scholars in logistics and supply chain management. The framework of the suggested KPIs has been greatly influenced by important works by Putri and Wahyudi (2023); Aronovich et al. (2010); Staudt et al. (2015); Chen et al. (2017); Bragg (2011); Hirunwat et al. (2017); Laosirihongthong et al. (2018); Makaci et al. (2017); Ghaouta et al. (2018) and Kusrini and Helia (2018). These researchers gave critical insights into numerous elements of warehouse operations, such as inventory management, order fulfillment, and space optimization, which are directly related to the KPIs proposed in this thesis. Based on their findings, the KPIs were identified and refined to ensure that they cover important aspects such as competitiveness, customer happiness and operational efficiency. The benefits listed in this section clearly show that the suggested KPIs provide a holistic strategy to enhance warehouse performance by embracing the thoughts and conclusions from these specialists.

One of the main KPIs mentioned is the **Product Damage Rate**. Warehouses can detect underlying difficulties in material handling procedures, the root causes of the damaged goods and apply corrective measures to reduce damage by carefully tracking the quantity of damaged goods in relation to the total number of handled items. This not only reduces

the insurance costs associated with damaged items, but it also improves the effectiveness of material handling operations, resulting in smoother workflows and higher operational efficiency.

Inventory Accuracy is another important KPI that assesses the consistency of recorded inventory levels with physical inventory counts. By regularly monitoring this measure, warehouses may assure proper stock levels while reducing inventory errors costs. This is especially important for 3PL warehouses since correct inventory management is required to optimise the warehouse storage space and also maintain optimal stock levels at the warehouse and maintain efficient supply chain operations.

Furthermore, **Order Delivery Accuracy** has emerged as an important KPI for 3PL suppliers, with a direct impact on client satisfaction levels. Warehouses can improve customer satisfaction and operational effectiveness by measuring their capacity to complete client requests accurately and on time. This not only builds existing client connections but also generates new business opportunities through a positive customer perception.

Storage Space Utilisation is another critical KPI that assists warehouses in identifying the most effective use of available storage space. Warehouses may maximise capacity, resulting in cost savings and increased efficiency. This is especially important for 3PL warehouses, as effective space utilisation directly affects profitability and attain competitive advantage.

Furthermore, **Equipment Utilisation and Order Picking Productivity** are essential KPIs that help warehouses optimise resource utilisation and improve order fulfilment procedures. Warehouses can improve their operational effectiveness by tracking equipment usage and order picking efficiency. This not only boosts overall productivity, but also lowers operating expenses and increases customer satisfaction levels.

Ultimately, using the recommended set of KPIs provides several benefits to the company. Warehouses may identify areas for improvement, make calculated decisions and promote ongoing optimisation and growth by tracking and analysing these KPIs on a systematic basis.

Finally, this establishes 3PL warehouses as reliable partners in the logistics business, capable of providing high-quality services while preserving a competitive advantage in the market.

A tabular summary of the suggested benefits for the proposed KPIs are presented below:

5. RESULTS

Proposed Set of KPIs	Benefits
Order Delivery Accuracy	Enhances customer satisfaction, strengthens client relationships, attracts new business opportunities
Order Picking Productivity	Enhances customer satisfaction, reduces operational costs, improves productivity and operational performance
Storage Space Utilization	Maximizes storage capacity, minimizes wastage, improves efficiency and profitability
Equipment Utilization	Optimizes resource utilization, reduces operational costs
Product Damage Rate	Identifies material handling inefficiencies, reduces expenses related to damaged goods
Inventory Accuracy	Ensures optimal stock levels, minimizes expenses related to inventory inaccuracies, enhances supply chain efficiency

Table 5.1: KPIs and their Benefits

6. CONCLUSION

We present a summary of our research on improving warehouse efficiency in a 3PL setting in this chapter, with an emphasis on XR Solutions. The purpose of this study was to suggest new KPIs that would provide a more thorough insight of the company's operational performance and be more in line with its strategic goals. This chapter also outlines the research limits that were encountered and proposes potential research options.

6.1 Summary of the Study

The purpose of the study was to solve the inefficiencies in XR Solutions's current performance evaluation procedures. The existing performance metrics, which predominantly concentrate on quantitative indicators like pallet movements and FTE, were found to be inadequate in offering a thorough comprehension of warehouse operations. The depth required to fully reflect the complex and multidimensional character of warehouse performance.

In order to overcome these limitations, the study used a detailed flow of research methodology that included a review of the literature, data triangulation analysis. Several crucial areas were identified using this method, allowing for the introduction of new KPIs to offer more useful insights. The suggested KPIs were carefully chosen to provide a more thorough and useful assessment of performance, going beyond the constraints of conventional measurements.

6.2 Limitations

Although this study was conducted using a comprehensive methodology, it is important to recognize its limitations: A significant portion of the research's data came from XR Solutions. Conducting a comprehensive examination in specific performance areas was hindered by missing or non-aligned data with the proposed new KPIs in certain cases. The breadth and depth of the conclusions may have been limited by this reliance on the data that was available.

This particular 3PL supplier in Sweden, XR Solutions, was the only subject of this case study. The results may not be directly applicable to all 3PL environments, especially those that operate in various markets or face distinct operational issues, even though they may provide insightful information for similar firms. The case study's specificity restricts how broadly the findings may be applied. Due to the study's time constraints, it was not possible to observe the suggested KPIs long-term consequences. To assess these KPIs long-term efficacy and get a better knowledge of how they affect warehouse efficiency over time, a longer study would be required.

6.3 Further Research

The study's limitations provide numerous directions for future investigation, all of which are intended to improve the relevance and effectiveness of the suggested Key Performance Indicators (KPIs) in raising overall organizational performance and warehouse efficiency.

Quantitative studies may be conducted in the future to evaluate the long-term effects of the recently suggested KPIs on warehouse efficiency. The results of these studies would be extremely helpful in understanding how certain KPIs change over time and maintain effectiveness in various operating settings.

Findings from the study might be more broadly applicable if it were to encompass additional 3PL providers from various industries. Through evaluating these KPIs' performance in diverse operational settings, researchers may obtain more comprehensive understandings of logistics performance assessment. This would make it easier to comprehend how various industry-specific elements affect KPI performance and what adjustments might be needed to adapt them to various situations.

Another interesting topic for future research is examining how cutting-edge technologies like artificial intelligence (AI) and the internet of things (IoT) affect the creation and application of KPIs. These technologies, which offer predictive analytics and real-time insights, have the potential to greatly increase warehouse productivity. Subsequent research endeavors may investigate the ways in which these technologies can be incorporated with the current KPIs to enhance their precision, promptness, and comprehensiveness.

While the primary focus of this study was internal operational efficiency, future research should include key performance indicators (KPIs) that directly monitor other areas such as customer results, logistics viewpoint, and external operations. Future research could create and evaluate KPIs that are customer-centric in order to supplement the current measures that are internal process-oriented.

Because this study was conducted as a single case study, the validity and generalizability of the findings have not been examined in other contexts, which would have greatly enhanced the research's validity. In order to ascertain this KPI framework's wider applicability and identify any necessary improvements, future study should consider applying it to different firms. This would support the KPIs' refinement and guarantee their robustness in a variety of organizational scenarios.

The study's suggested KPIs are recommendations for the company. This idea might be put into practice and evaluated based on what the demands of the business are. As soon as these indicators are put into use, they should be improved to guarantee that they work properly and offer reliable performance evaluations. Even though they work well, more adjustment is required in light of their long-term objectives in order to attain peak efficiency. While it might take several years to perfect the KPIs, future research should concentrate on making these modifications.

The possibility of implementing the suggested KPIs in their other locations should be further investigated. This could entail assessing how well these KPIs adapt to various operating contexts and industries. These studies would be useful in evaluating the KPIs' generalizability and pinpointing any industry-specific adjustments that could be required for their successful application.

6. CONCLUSION

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A. Appendix

The complete list of questions provided to key stakeholders is included in this appendix, along with their complete responses. A brief overview of the key conclusions gleaned from these discussions is given in Section 4.1 in order to maintain readability. By providing all of the stakeholder replies along with the interview questions, the appendix seeks to provide a thorough understanding of the interview process.

A.1 Interview Questions to the Key Stakeholders

A.1.1 Interview Questions to the CEO(A1)

- Can you tell us about the warehouse's history When was it last restructured? Has the current layout evolved significantly since it was first implemented?
- What is your strategic vision for XR's future warehouse layout? How do you see this evolving to maintain a competitive edge?
- Given the operational challenges you've identified, what would you say are the key considerations when narrowing down to a root cause or common issue that impacts warehouse efficiency?
- When evaluating the current layout, what specific pain points do you see in areas like material handling, especially in segments like the Volvo Powertrain and Aurobay warehouses or the customs warehouse?
- What potential challenges do you foresee while restructuring or optimizing the warehouse layout, especially in terms of space utilization and material flow?
- Are there any capacity or resource constraints that must be factored into the optimization process?
- What key metrics or data points do you currently track to evaluate warehouse performance? Which of these have been the most critical in shaping recent decisions?
- What warehouse management systems (WMS) are currently in place, and how well are they integrated into your operations?
- How is inventory managed, and what challenges do you face regarding stock levels, accuracy, and potential issues like stockouts, overstock, or inventory obsolescence?
- Could you describe your order fulfillment process, and what are the main challenges you face in ensuring speed and accuracy, particularly during peak seasons?
- Which key performance indicators (KPIs) do you rely on most to measure warehouse efficiency? Are there specific areas where you believe significant improvements can still be made?
- Can you describe your collaboration with suppliers for coordinating logistics and material flow into the warehouse? What specific strategies, such as VMIs or JIT, are in place with suppliers like Volvo and Aurobay?
- What measures have been implemented to optimize storage and picking processes within the warehouse?
- How do you manage relationships with suppliers and vendors, and what are the main

challenges you face in coordinating the supply chain?

- How do you engage and motivate employees to maintain high productivity levels? Are there specific initiatives in place to improve efficiency and morale among warehouse staff?
- Are there areas where you feel employee productivity is being held back due to layout or process inefficiencies? How do you plan to address these challenges?

A.1.2 Interview Questions to the Operational Manager(A2)

- Can you describe the current layout of the warehouse? How does it support or hinder operational efficiency?
- What criteria were used to design the current layout, and how well do you think they are being met?
- Have you identified any specific areas where space is underutilized or inefficiently used?
- How do you manage the allocation of space for different types of inventory? Are there any adjustments you've made recently?
- What strategies have you implemented to optimize vertical space in the warehouse?
- How do you ensure that space utilization aligns with seasonal fluctuations in inventory?
- What key performance indicators (KPIs) are currently used to measure warehouse efficiency and effectiveness?
- How frequently are these KPIs reviewed and updated?
- Can you provide an example of a recent KPI trend and how it influenced decision-making?
- How do your current KPIs compare to industry standards or benchmarks?
- What methods do you use to analyze KPI data and identify areas for improvement?
- How do you incorporate feedback from KPI results into operational changes?
- What material handling methods are currently in use? How effective do you find these methods in terms of efficiency and accuracy?
- Have you experienced any recurring challenges with material handling? How have you addressed them?
- Have you explored or implemented any new technologies or automation to improve material handling? What results have you seen?
- How do you evaluate the cost-benefit of investing in new material handling equipment or systems?
- How do you measure employee engagement within the warehouse? What recent findings have you had?
- What strategies are in place to address and improve employee engagement and satisfaction?
- How do you track and measure employee productivity in the warehouse?
- Can you provide an example of a time when productivity metrics led to a significant operational change or improvement?
- What training programs are available to employees? How do you determine their effectiveness?
- How do you ensure that employees are continuously developing skills relevant to

their roles?

A.1.3 Interview Questions to the Logistic Developer(A3)

- When designing the current warehouse layout, what key factors were prioritized? How did those decisions influence the overall flow and efficiency?
- How are zones within the warehouse determined? Is the layout based more on demand, turnover rate, or other factors like product size and handling requirements?
- What type of storage systems (e.g., racking, shelving) are currently in use, and are there any challenges you've encountered that impact the material handling process?
- Given the various pain points identified in the current layout, which specific issue do you believe should be prioritized for improvement to maximize efficiency?
- Are there specific storage considerations (like size, weight, or fragility) that play a critical role in how different types of inventory are organized within the warehouse?
- How are orders received, processed, and fulfilled within the warehouse? What processes are in place to ensure speed and accuracy?
- What challenges or limitations have you encountered with the current material handling equipment, and how do they affect overall efficiency?
- How do client requirements and service level agreements (SLAs) shape material handling processes and workflows?
- How does XR Solutions plan to optimize material flow and throughput to reach a targeted per-hour turnover rate, and what strategies are in place to achieve this?
- Are there any plans to integrate new technologies or upgrade current systems in the near future? How do you evaluate the potential benefits and impact of these upgrades on operational performance?
- What is XR Solutions' vision or target for key performance metrics, such as per-hour turnover rate, order accuracy, or fulfillment speed?
- Can you provide examples of how XR Solutions customizes its services to meet different clients' unique needs while maintaining alignment with key KPIs?
- In your view, what are the critical KPIs that need consistent monitoring to ensure optimal warehouse performance? Are there any areas where these metrics suggest room for improvement?
- How do you engage employees in continuous improvement initiatives, especially in areas like material handling efficiency and warehouse organization?
- Are there operational or layout-related challenges that negatively impact employee productivity, and how are these being addressed?

A.1.4 Interview Questions to the Business Developer(A4)

- Can you elaborate on the temporary project "Big Move" related to the Volvo warehouse in Tiburon? What is the main objective of this project, and how is space being utilized during this transition?
- What are the key challenges you face with the current warehouse layout, particularly in the 3PL warehouse and the Modine warehouse?
- Given the narrow space and the presence of pillars, how do you plan to optimize the warehouse layout to improve space utilization? Are there any specific areas where

vertical racking systems could be implemented?

- How do you address the limitations posed by the current warehouse infrastructure, such as the sloping floors and ceiling obstructions, to ensure smooth operations?
- Although you mentioned that you're not directly involved in KPI measurement, what informal indicators or observations do you use to gauge the efficiency and safety of warehouse operations?
- How do you evaluate whether the current warehouse operations are efficient, safe, and minimizing damage, especially given the challenges with space and infrastructure?
- Do you believe there are specific KPIs or metrics that should be introduced to better track and improve warehouse performance, particularly in the context of material handling and space utilization?
- What are the main issues related to material handling in the current warehouse setup? How do the narrow spaces and old factory design affect the loading and unloading processes?
- Can you share an example where a proposed material handling strategy did not work as planned, and how the team adapted the approach to improve efficiency?
- How do you ensure that forklifts and other material handling equipment are used efficiently within the constraints of the existing warehouse layout?
- How do you engage with warehouse staff to address challenges related to layout changes or material handling inefficiencies? What role do team meetings play in this process?
- Could you provide examples of ideas or suggestions from warehouse employees that have led to significant improvements in operations?
- What steps are you taking to improve working conditions in the warehouse, such as addressing lighting issues or ensuring safe traffic flow for forklifts and trucks?
- How do you manage employee productivity in a warehouse environment that is facing structural and logistical challenges? What strategies have been effective in maintaining high morale and engagement?

A.1.5 Interview Questions to the Operational Leader(A5)

- Can you describe how the current warehouse layout impacts operational efficiency and the effectiveness of material handling? Are there specific design aspects that create bottlenecks or inefficiencies?
- You mentioned issues with congestion and the layout affecting forklift performance. What changes or improvements would you recommend to optimize space utilization and streamline operations?
- How do you handle the challenge of managing space when dealing with high volumes of incoming and outgoing goods? Are there specific strategies or tools you use to improve space utilization?
- What key performance indicators (KPIs) are currently used to measure the efficiency of warehouse operations? How are these KPIs tracked and reported?
- You noted that tracking KPI data has been challenging. What steps are being taken to improve KPI measurement and ensure that relevant metrics are effectively monitored?

- How do you evaluate the effectiveness of your current KPI system in providing insights into warehouse performance? Are there any additional metrics you think should be included?
- Given the challenges with forklift usage and the need to adhere to company policies, how do you manage the balance between operational efficiency and adherence to these guidelines?
- What improvements do you see as necessary for optimizing material handling processes, particularly concerning the issues you've faced with excessive forklift usage and layout constraints?
- How do you address the difficulties associated with handling large or bulky items, such as engines? Do you have any suggestions for enhancing material handling efficiency in this regard?
- How do you ensure effective coordination and communication between different warehouse teams, such as forklift drivers, pickers, and supervisors, to maintain high productivity?
- Can you provide examples of how employee engagement and motivation have impacted warehouse performance? What initiatives have been successful in improving team productivity?
- What strategies do you employ to address any productivity issues among staff, and how do you involve employees in the process of continuous improvement?

A.1.6 Interview Questions to the Production Leader(A6)

- Given your role in maintaining accurate inventory levels, how do you ensure consistency and accuracy with systems like WMS and MACS for Volvo PT articles? What key challenges do you encounter in this process, and how do you address them?
- Although you haven't directly implemented inventory tracking systems, how do you collaborate with the team to maintain accuracy and resolve inventory discrepancies?
- While you're not involved in designing warehouse layouts from scratch, how do you contribute to decisions on moving or rearranging goods within ongoing projects? What impact do these decisions have on daily operations?
- From your experience, what are the most significant operational challenges related to the current warehouse layout that you've observed? How do you support addressing these challenges within your role?
- While direct involvement in order processing isn't part of your duties, how do you set goals with your team to improve picking and packing performance? What strategies have worked in motivating your staff to achieve these goals?
- Can you share any specific actions you've taken that contribute indirectly to faster and more accurate order fulfillment, especially in your role as a leader?
- How do you manage labor resources to efficiently meet demand fluctuations? Could you provide examples of how adjusting staffing levels has positively impacted operations during high and low demand periods?
- Even though you haven't implemented automation solutions, where do you think automation could be introduced to enhance efficiency in tasks like picking, packing, or material handling?
- What processes do you have in place to ensure the accuracy and quality of shipments?

How do you address incidents when damage occurs, and how does your team learn from these situations to avoid future issues?

- You mentioned creating a claims process for handling damaged goods—how did this initiative improve overall quality control and client satisfaction?
- You mentioned that your department is still working on establishing formal KPIs. In the meantime, how do you gauge success within your team, and which performance indicators do you think are most critical for measuring warehouse efficiency?
- Can you describe a situation where you identified an area for improvement based on informal performance data or observations, and how you implemented changes based on that insight?

A.2 Interview Responses of the Key Stakeholders

A.2.1 Interview Response of CEO (A1)

The warehouse structure has remained largely consistent over time, primarily dictated by the types of goods received from customers. This consistency has limited our opportunities to optimize space and improve the facility. However, recent changes, such as updating the flooring, have allowed us to handle a wider variety of goods, including engines and large pallets. This flexibility is a significant improvement and highlights the need to optimize warehouse space further.

Our warehouse differentiates itself from competitors by handling irregular and complex pallets. While many warehouses deal with standard pallets, we specialize in irregular items, such as engines and oversized pallets. This capability sets us apart in the market and meets the high demands of clients like Volvo.

Regarding efficiency, we are challenged to meet tight delivery windows. For instance, deliveries must occur within a two-hour window from Gothenburg, regardless of weather conditions. Our ability to meet these deadlines demonstrates our strong logistical capabilities.

Currently, we do not have a specific order fulfillment rate target, but we are open to developing one. We have identified several issues related to material handling and warehouse layout. Our aim is to optimize the layout to improve efficiency and explore automated solutions, possibly starting with prototypes. Additionally, we need to evaluate how forklift operators use their equipment, as operator practices can significantly impact efficiency.

Cost-effectiveness is a priority, as we must remain competitive. Although innovation is important, cost considerations are crucial due to industry pressures. We have not previously focused on optimizing warehouse layouts specifically, but the need for this is now evident, especially with changes like new flooring. Optimizing both internal and external areas of the warehouse is essential.

In terms of space, we must address fluctuating volumes. For example, volumes have recently decreased by approximately 25 percent compared to December, affecting our

costs. We need to be flexible with our workforce and warehouse space to adapt to these changes.

The company is also planning to build a separate warehouse for storing batteries due to their high-risk nature. This new facility will be in the same area but will focus on battery storage exclusively.

Operating costs for our current warehouse are about 500 SEK per square meter, including heating and electricity. This rate is considered normal compared to new buildings, which cost around 600 SEK per square meter. The cost for a new warehouse dedicated to battery storage is significantly higher, around 3500 SEK per square meter.

Regarding efficiency, we are exploring opportunities to reduce costs, particularly in the handling of engines and warehouse space utilization. We aim to attract more customers by optimizing available space and improving operational efficiency.

We do not currently use specific sorting processes such as ABC classification but are considering their implementation. Our performance metrics mainly focus on pallet handling efficiency and hours worked. Future considerations include return on investment and efficiency metrics.

Lastly, we need to address the issue of damage control. Currently, damages lead to increased insurance costs. We are working on reducing damage rates to lower these costs. Damages are processed through insurance claims, which impacts our overall costs.

A.2.2 Interview Responses of Operational Manager (A2)

Current Situation and Challenges:- Our warehouse currently lacks sufficient structure and organization, which affects the efficiency of material handling and overall operations. Previously, one production leader managed 50 employees. To improve, we need to implement better organizational structures and processes.

Bench-marking and Performance Measurement:- We plan to use data from 2022 for benchmarking purposes. This year was selected because 2023 has seen fluctuating customer demands, making 2022 a more stable reference point. We need to acquire the financial data from 2022 to proceed with this analysis.

In 2023, we recorded approximately seven to eight instances of damage involving pallets and motors, resulting in an average damage rate of 4.20 percent. Our goal is to reduce this rate significantly, ideally to zero by the end of 2024. We aim to set realistic targets and measure progress based on pallets in and out, compared to full-time employees (FTEs). This includes tracking the number of motors handled and comparing it with FTEs to analyze trends and efficiency. Initially, the first three months of 2024 will be focused on understanding the current situation before setting specific goals for the latter half of the year.

Operational Efficiency and Staffing:- Currently, three full-time employees handle motors: one for handling the motors in Sweden, one for operating a small truck to move items from trailers, and one for export operations. Each FTE works an 8-hour shift, resulting in 40 hours per week per employee. We are considering whether improving efficiency might allow us to reduce the number of FTEs required.

Trend Analysis and Goals:- To simplify trend analysis, we will compare goods in and out against work hours. This comparison will help us set clear and achievable goals. Our picking system relies on barcode scanning for tracking inventory, which is integrated into the Volvo management system and other customer systems like AuroBay. This system helps in tracking goods efficiently from entry to exit.

Space Utilization and Cost Management:- We manage warehouse space flexibly. Customers rent specific areas, and any extra space can be utilized for other customers. The cost per square meter for our warehouse space is a key consideration, and we need to ensure that we maximize the use of available space to optimize costs.

Fulfillment Rate and Warehouse Layout:-The fulfillment rate at each warehouse is important. Although we get paid for the space regardless of whether it is fully utilized, maintaining a high utilization rate is beneficial. Sometimes, having extra space available for customers can be advantageous.

Planning and Layout Optimization:- Managing the arrival of goods—whether planned or spontaneous—poses a challenge. Delays due to unforeseen circumstances, such as weather conditions, can complicate scheduling.

A.2.3 Interview Responses of Logistic Developer (A3)

Designing of warehouse:- I have a group of people which I go to depending on which area of the warehouse I'm designing so for example here in I will have a few people that I can that I can use and speak to and then we have standard measurements as well which we always have to think about so we have standard pallet measurements we also have standard measurements for our forklifts the area where the forklift drives has to be a specific size as well so that's another key factors.

Current Picking:- At the moment going from a completely manual way of picking to an automated way of picking or ½ half automatic way of picking from Volvo we have to deliver in first in first out fifo as they call it or fifo and that is the way that our system gives us support saying which pallets you should pick you can do it completely automatically we're not quite there yet.

Streamline process in progress(Software):- System knows when it's full rather than the operator because at the moment if you were to go there you would see I can put them here in the system but I can't physically put them here and that's something we don't want to happen because what can happen is that you can put them in the place next door but you

could accidentally put them in that one without the system saying no you can't that one is full you need to put this somewhere else.

Current goal:- His goal dream this year is that continue to implement everything that we can to the system so that we just take away all the what's the best way to describe it all the best human error to take away human error.

Position of goods:- Positioned for example the low volume parts the furthest away from the gate the slow runners furthest away the high runners much closer so you're not driving as far with the truck so the portion is not fixed for each pallet right no and that's something we're also looking at and this is where our system it doesn't really have any boundaries.

Cost:- Per square metre at that particular warehouse out here yeah we've just raised it but last year so 2023 it was 695 per metre squared per year so 695 per metre squared per year.

WMS:- Matthias (CEO) has said to us now that we need to focus on that so it's something which materials are said to our management group that that is the big focus now for the start of the year so he is given that project to Michaela and now we're collecting information from all these three different systems so with the or obey and the Volvo car system that system just runs on all the daily that's all the daily stuff and then once a month we pick the information out of that system we pick it out and we put it into our system because otherwise we would have to run two systems side by side we have trialled that and it just doesn't work it's too much to ask.

KPI:- We've always measured and that is turnover against working worked hours okay so the work hours does mean like the full time AK efficiency FTE is just against turnover so that is extremely large it's a huge run but it's also an interesting one just for trending that we don't really use that for anything more than trending I see okay because if our turn ever goes up the out the man hours should also go up if it's a big change and that's quite a standard one that we use but then we also have on department Kpis as well that is something which we're developing at the moment of one what are we measuring and what can we use to have a statistic which is to do with effectively because that is the hard thing how do you know if someone's affected just you can't always just measure for example how many pallets you've sent in this week against the hours because that's quite a general thing you don't we're discussing at the moment should we break it down into the three shifts that we're running because then you can see okay daytime they're shifting 500 pallets and they work in this many hours but the evening shift they're shifting this many ballots well why is there a difference there why they shifting for example 250 more pallets in the evening and then the night.

Stand out point:- Competitors handle the palaces of 120 into 80 so whereas you handle palaces of 122 into 82 that extra two centimetres for like metres gives you an added advantage. Narrowing down to one problem statement:- for me I'm obviously extremely system driven that's my big interest and something but but I don't see I don't see our system being an issue because it is extremely open and we are allowed to pretty much do whatever we want in there and they take everything and use it I would say that I would say

the biggest problem for me now is the future of we have now sold every square metre in this warehouse and we still have a lot of questions for more warehouse space so how can we optimise the warehouse space we have today without having to build new warehouses so again this also comes in a general theme like optimising the existing thing.

A.2.4 Interview Responses of Business Developer (A4)

Time Constraints:-Our biggest challenge is the lack of time due to staff absences and sick leave. The team struggles to dedicate sufficient time to the project amidst their regular duties.

Space Optimization:-We need to ensure that space is used efficiently, considering factors like forklift operations and material handling. For example, we had initially planned vertical storage but had to adjust due to the size of cardboard boxes and available space. The layout and storage systems need continuous optimization to match our goals.

Operational Efficiency:-The forklift operations and material handling processes are crucial. Issues such as the placement of goods and the ease of access for forklifts need constant monitoring. Changes are often difficult due to varying levels of understanding among staff and the need for continuous communication.

Warehouse Layout:- The existing warehouse has several limitations: The warehouse is narrow with many pillars, which restricts space utilization. The old factory design is not ideal for modern warehousing needs. The ceiling is not suitable for high pallet stacking, limiting storage options. The uneven floor and narrow aisles create challenges for forklift operations and contribute to damage.

Security and Safety:-Ensuring safety is critical, especially in areas with high traffic and narrow spaces. We have implemented measures to mitigate risks, such as reassigning areas for specific equipment and managing traffic flow.

Regarding key performance indicators (KPIs), our primary focus is on efficiency, safety, and damage control. While I personally do not measure KPIs, Miguela, Matthias, and the rest of the team handle this aspect. Our goal is to maintain efficient operations, ensure safety, and prevent damage to goods. The warehouse's old design and the limitations of its infrastructure make it challenging compared to newer facilities.

A.2.5 Interview Responses of Operational Leader(A5)

Policy on Forklift Usage:- We do use forklifts more frequently than our company's policy suggests. This is because, in our line of business, if you are not service-minded and flexible, you risk losing clients quickly. We often have to adjust our practices to meet customer needs, especially since some large companies are not yet established here, and flexibility is crucial.

Improvement in Material Handling:-The layout of the warehouse is a significant concern. The current warehouse is an old factory not designed for modern logistics, which affects forklift efficiency. The layout limits how forklifts can be used, leading to more frequent operations than ideally needed. While we strive to optimize, the current constraints are challenging.

Congestion and Flow Management:-Yes, congestion from multiple trucks parked near the Goods Receiving (GCR) spot is an issue. We aim to streamline the flow by having a more structured system where trucks follow a single-wave flow—drive in, park, and get directed to the office. However, achieving this perfect flow is challenging and costly.

External Logistics and Workflow Efficiency:-I would prefer a more structured approach similar to a one-way street system to reduce errors and improve control. Providing clear paths and eliminating choices for drivers can help in managing the flow and reducing confusion. We are working on improving the system, but it remains a challenge.

Key Performance Indicators (KPIs):- Currently, we track truck in/out and the number of pallets handled. We need to improve our tracking to measure efficiency more accurately. The focus is on truck movements and forklift usage as primary indicators of performance.

Automation in Warehouses:-We see potential for full automation in the 3PL division. If the system is efficient enough, it could automate order processing and picking. This would save time for staff and improve efficiency.

Storage System Challenges:-The repair warehouse division faced challenges due to the lack of a proper FIFO (First In, First Out) system and disorganized storage. We are working on improving it, but it is still a work in progress.

Flexible Storage System:-Implementing a flexible storage system where companies can rent space based on demand could be beneficial. This would allow better accommodation of varying storage needs.

Racking Systems:-For large engines, implementing a racking system that allows stacking would be advantageous. However, this would require vertical forklifts capable of lifting higher loads.

Data on Lead Time:- We typically have a lead time of up to two weeks for goods, with engines taking around two days from collection to shipment. Goods are received daily, with some items stored long-term. Lead times vary depending on the type of goods and their specific handling requirements.

Data Collection and Analysis:-We currently lack detailed data on how long goods stay in each warehouse. However, Volvo's system provides detailed tracking from arrival to departure. Adam might be able to obtain more precise data on this.

A.2.6 Interview Response of Production Leader(A6)

Inventory Management:-To ensure accurate inventory levels in the warehouse, Natalie relies on the warehouse management system (WMS) and ongoing checks. For Volvo PT articles, she uses physical inventory checks, ongoing WMS updates, and MACS. She acknowledges that she has not been directly involved in implementing inventory tracking systems or handling specific challenges related to them.

Warehouse Layout and Design:-Natalie has not been responsible for designing warehouse layouts from scratch, though she has been involved in agreeing on the movement of goods for projects. Her role does not currently include optimizing storage space or designing warehouse layouts, as these responsibilities fall under the logistics developer.

Technology Integration:Natalie has not implemented any warehouse management systems or other technology solutions herself. Her involvement with technology mainly involves using existing systems for real-time inventory tracking.

Order Fulfillment:-Strategies to reduce order processing times and improve order accuracy are not part of Natalie's duties. Her experience with order fulfillment involves setting goals and motivating staff to meet them rather than directly implementing changes in the picking and packing process.

Resource Utilization:-Natalie manages labor resources by bringing in additional staff during peak times and reducing staff numbers during downturns, ensuring cost-effectiveness. She has not implemented automation solutions for improving warehouse efficiency.

Quality Control:-Natalie ensures the accuracy and quality of outgoing shipments by constantly emphasizing the importance of proper handling to her staff. She has established a claims process to manage incidents like damage during loading and works with customers to refine this process. This initiative was a significant improvement in quality control.

Vendor and Supplier Management:-Natalie collaborates with vendors and suppliers to ensure timely and accurate deliveries through established agreements. She has not been involved in optimizing procurement processes or negotiations.

Safety and Compliance:-To maintain a safe working environment, Natalie conducts risk assessments and implements necessary measures based on the outcomes. Compliance with industry regulations is ensured by making them visible to everyone affected.

Performance Metrics:-Currently, Natalie is working on establishing a method for measuring key performance indicators (KPIs) within her departments. She has not yet used performance data to identify areas for improvement or implement changes.

Continuous Improvement:-Natalie fosters a culture of continuous improvement by encouraging staff to share their opinions and suggesting improvements.

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