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Improving visibility to foster more informed decision making: The case of containers Reverse Logistics at Volkswagen AutoEuropa

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RESUMO

No complexo panorama das cadeias de abastecimento modernas, a busca pela visibilidade da informação emerge como um desafio crítico, impactando a eficiência operacional e a tomada de decisão estratégica. O estado da arte na gestão da cadeia de abastecimento (SCM) reflete uma paisagem dinâmica e em constante evolução, moldada pelos avanços tecnológicos, globalização e uma ênfase acrescida na eficiência e resposta. Este projeto interno, enraizado na metodologia de Pesquisa de Design de Ação (ADR), navega este desafio num gigante automóvel, a Volkswagen AutoEuropa (VWAE), situada em Palmela, Portugal. Inspirado pelos princípios de fornecimento lean, a iniciativa visa construir um painel de desempenho operacional para monitorizar e controlar a logística reversa de contentores do departamento de manuseamento de materiais para ajudar no processo de tomada de decisão com o objetivo de erradicar o desperdício e desbloquear valor, abordando a falta de ferramentas visíveis que impedem o alinhamento estratégico com indicadores chave de desempenho (KPIs). No coração da Logística Operacional da VWAE, o projeto foca-se na gestão de pedidos de contentores, um processo crucial frequentemente afetado por insights relacionados com custos que passam despercebidos devido à sua baixa taxa de apresentação à gestão de topo. O caminho para enfrentar este desafio gira em torno da pesquisa de ferramentas previamente aplicadas que abordam a visibilidade em empresas da cadeia de abastecimento, utilizando-as como uma força transformadora de forma colaborativa e específica ao projeto. O painel atua como uma ferramenta de solução para empoderar os tomadores de decisão com dados em tempo real, fomentando a colaboração e permitindo escolhas baseadas em dados. Conforme o projeto se desenrola, torna-se um farol de eficiência, não apenas resolvendo gargalos de visibilidade, mas também oferecendo uma vantagem estratégica que alinha os processos operacionais da VWAE com objetivos mais amplos da cadeia de abastecimento.

Palavras-chave: Visibilidade da Informação; Gestão da Cadeia de Abastecimento; AutoEuropa; Controlo de Contentores; Tomada de Decisão; Dashboard

Classificação JEL: L62 – Estudos industriais, Indústria automóvel; C8 – Recolha de dados

ABSTRACT

Amid the complex landscape of modern supply chains, the quest for information visibility emerges as a critical challenge, impacting operational efficiency and strategic decision-making. The state of the art in supply chain management (SCM) reflects a dynamic and ever-evolving landscape shaped by technological advancements, globalization, and a heightened emphasis on efficiency and responsiveness. This in-company project, rooted in the Action Design Research (ADR) methodology, navigates this challenge in an automotive giant, Volkswagen AutoEuropa (VWAE), situated in Palmela, Portugal. Inspired by lean supply principles, the initiative aims to build an operational performance dashboard to monitor and control the container reverse logistics of the material handling department to help the decision-making process in hopes of eradicating waste and unlock value by addressing the lack of visible tools hindering strategic alignment with key performance indicators (KPIs). At the heart of VWAE's Operational Logistics, the project zooms in on container request management, a pivotal process often plagued by unnoticed cost-related insights due to its low portrayal rate to upper management. The path to tackle this challenge revolves around research of previously applied tools that address visibility in supply chain companies, utilizing them as a transformative force in a collaborative, project-specific manner. The dashboard acts as a solution tool to empower decision-makers with real-time data, fostering collaboration, and enable data-driven choices. As the project unfolds, it becomes a beacon of efficiency, not merely resolving visibility bottlenecks but also offering a strategic advantage that aligns VWAE's operational processes with broader supply chain goals.

Keywords: Information Visibility; Supply Chain Management; AutoEuropa; Container Control; Decision-making; Dashboard

JEL Classification: L62 – Industry studies, Automobiles; C8 – Data collection

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Glossary

ADR – Action Design Research

BI – Business Intelligence

VWAE – Volkswagen AutoEuropa

KPIs – Key Performance Indicators

SC – Supply Chain

SCM – Supply Chain Management

SCT - Supply Chain transparency

SCV – Supply Chain Visibility

CC – Container control

ETL – Extract transform load

POC – Proof-of-concept

POV – Proof-of-value

POU – Proof-of-use

QS - Qlick sense

1. INTRODUCTION

1.1. General framing

In contemporary supply chain management (SCM), the notion of visibility has gained significant traction among researchers and practitioners, as highlighted by Catalayud et al. (2019). This trend is further exacerbated by the significant changes happening with the adoption of digital technologies (Capgemini, 2016; DHL, 2016; Wu et al., 2016; Haddud et al., 2017). Instances like the Covid-19 pandemic have brought to light the vulnerabilities that companies encounter due to limited visibility (Sharma et al., 2020). The constrained visibility upstream to suppliers and downstream to customers has left companies with little control beyond what is directly observable (Carter et al., 2015). Non-premium suppliers, often less visible and potentially unknown to focal firms, further exacerbate the challenge (Choi et al., 2021). Consequently, companies grapple with disruptions in material supply, deliveries, productivity, and revenue, impacting overall business performance (Caridi et al., 2014; Yu and Goh, 2014; Swift et al., 2019). Beyond the immediate business consequences, reduced visibility hampers the ability to build supply chain resilience. Consequently, the management of supply chain (SC) disruptions within a network of global suppliers, operations, and markets has underscored the significance of Supply Chain Visibility (SCV) to achieve sustainable and competitive business performance (Kalaiarasan et al., 2022). In fact, visibility stands out as a paramount concern voiced by manufacturing companies (Sodhi and Tang, 2019). Insufficient visibility with stakeholders has fueled skepticism, eroding trust and confidence in organizations' adherence to social, ethical, and environmental standards (Hein, 2002). The continuous advancement in communication technology empowers both external and internal stakeholders, fostering an environment where everyone is "always-on, always connected" (Paris et al., 2016). Even in tightly interconnected supplier-buyer relationships, opaque communication can lead to dysfunctional dynamics, resulting in moral dilemmas (Roloff and Aßländer, 2010). Westbrook, (2004) observed that it may introduce the risk of waste in the form of sunk opportunities not shared among stakeholders, contradicting the principles of lean management. When a company discloses information to stakeholders, it signifies a commitment to an unrestricted flow of information (DeKinder and Kohli, 2008). However, a crucial consideration is that the information must be perceived as valuable and relevant to stakeholders. This lack of visibility poses challenges for supply chains, potentially leading to disruptions in material supply, deliveries, productivity, and revenue (Caridi et al., 2014; Yu and Goh, 2014; Swift et al., 2019). Visibility is thus a key element of SCM integration and a driver of process adaptability, according to prior research (Morgan et al., 2018; Christopher and Towill, 2000). Stakeholders in SC interactions strategically use visibility to solve certain concerns, emphasising value enhancement through involvement and communication (Lamming et al., 2001; Morgan et al., 2018; Carter and Easton, 2011). A thorough definition of SCV was given by Williams et al. (2013), who also emphasised the importance of accurate, timely, complete, and usable information. Integrating components of previous definitions, SCV is defined as the extent to which participants in a supply chain have visual access to timely and accurate supply and demand information that they consider necessary or advantageous for their supply chain operations.

Numerous authors assert that Supply Chain Visibility (SCV) brings about enhanced capabilities and contributes to overall performance improvement. For instance, demand visibility facilitates dynamic responses to changing customer demands, while supply visibility enables the analysis and adaptation to trends within supply networks, enhancing agility and flexibility (Barratt and Barratt, 2011; Handfield et al., 2019). SCV not only leads to the flexibility of supply chains and organizations but also enhances the effectiveness of decision-making through increased visibility in general (Sarker et al., 2016; De Giovanni, 2020).

Visibility is posited as a transformative approach in the supply chain, involving collaborative information sharing applied on a project-by-project basis. This approach seeks to transcend traditional managerial practices within supply interfaces, significantly aiding decision-making by providing accessible and real-time information, fostering collaboration, and enabling data-driven, responsive, and risk-aware choices. This empowerment allows decision-makers to optimize processes, manage risks, enhance collaboration, and continuously improve supply chain performance, leading to increased efficiency and effectiveness. As a catalyst for gaining a competitive advantage, visibility's intrinsic value lies in creating, nurturing, and delivering value for the benefit and sustained existence of all involved parties in the supply chain (Lamming et al., 2001).

In the pursuit of SCV, production alliances, intricate economic partnerships involving multiple enterprises across diverse geographical locations, necessitate various logistical activities (Kalaiarasan et al., 2022; Paris, D.L. et al., 2016; Khan et al., 2022). These alliances require substantial communication, as stakeholders collaborate to add value and facilitate the smooth flow of resources across procurement, production, distribution, and transportation processes. Within this complex network, logistic service providers play a pivotal role, offering a spectrum of value-added services, including transportation coordination.

1.2. Problem Statement at Volkswagen AutoEuropa

Information made visible is a bottleneck from a bottom-up and cross-departments perspective at Volkswagen AutoEuropa (VWAE). The development of this project encompasses building a Dashboard with the purpose of follow up of container request management inside the Operation Logistics business unit at VWAE factory plant in Palmela, Portugal. The idea appeared when, conducting factory daily operational internal processes, analysts started seeing that some valuable cost-related information goes by “unnoticed”, not because there is lack of concern to address them, but rather because it is not displayed to upper management in a way that is suggestive that strategic KPI’s should be aligned to reduce costs, time and waste. In other words, more transparent and streamlined information tools. Furthermore, when asking the Operational logistics manager, what was the exact quantity of container inventory being lost and the cost of investing in optimal quantities of containers, he didn’t have a tool to help him provide a quick answer. Data such as the cost of having deficit of durable packaging in closed-loop circuits between the factory and its suppliers, is an example of information that is not properly portrait to upper management, making it harder for the decision-making process to take place, adding another layer to the problem. To first arrive at the conclusion that there is indeed a deficit or excess of packaging in the circuit, there must be a thorough analysis of the reverse logistics process. This analysis also requires a specialist to perform the task at hand. Hence a corresponding salary package and everything that comes with new employment (even if outsourced). Therefore, there is a whole new set of direct and indirect costs that come with not having proficient tools to assist in data-driven decision-making. This is also a challenge because there is some dispersion of information across several files. Montazemi & Wang (1988) delve into the question of how various methods of presenting information can shape human behavior in terms of receiving, processing, and reacting to information within a decision-making environment. It stresses that when a problem is neither obvious nor well portrayed, it is difficult for organizations to see the full scope of its effects. This highlights the pivotal role that information visualization technologies play in facilitating a comprehensive understanding of complex issues (Kalaiarasan et al., 2022). Adding to this, there is not a standardized ground rules for processing data and organizing information for display, meaning that when practitioners utilize digital resources for the daily business activities, very rarely they contemplate a standard display format that is well perceived by all. This can sometimes blur the lines and leave information unclear to others that need to use the same resource. The daily business activities are linked to the empirical analysis required for the normal course of operations, and digital resources facilitate them. The oversight of these challenges is further exacerbated by the fact that they occur within the context of the reverse logistics process. In the broader scope of operations, the primary focus of the plant is automobile manufacturing. The reverse logistics function is intricately linked to this core operation, ensuring that key performance indicators (KPIs) related to parts-to-car production are consistently met. This has proven to be a key challenge currently faced by the Operational Logistics department at VWAE. The argument that is made explicit throughout this project is that the pursuit of visibility at VWAE, including the investment in operational activities and shared resource interfaces, yields economic value through the enhancement of operational decisions (Akerlof & Shiller, 2016). With increased visibility, there is the possibility to rely more on the internal processes at VWAE logistics. As the progression of crucial information moves forward, it is possible to know the exact situation of inventory management and understand exactly what works and what doesn’t. The mere existence of enormous amounts of safety stock acts as a prevention measure of scenarios where management of inventory fails to deliver. Things such as Inventory loss and schedule changes, production volume increases are some of the reasons that make up this prevention measures. If there is a more visible communication of information it is possible to create a record of historical data about process issues and create prevention models to predict inventory setbacks which leads to less need for inventory safety nets such as large safety stock, and hence less unnecessary costs. VWAE, being a manufacturing company, is included in the industry group that sees visibility as one of the most highlighted concerns. This happens to be due to the management and supply of global networks increased interest in attaining sustainable and competitive business performance (Suh and Lee, 2018). What motivated this research was the focused observation on specific indicators that were expressed by practitioners (manager, coordinator and specialists) as pains felt at container control (CC). The complaints were about the values in-system of deficit of available containers for part suppliers were not matching reality. In some cases, there was a lack of containers in the system, but no deficit reported, in others there were deficits in the system but no supplier's reported complaint. This gap between the estimates and reality has been culminating in department costs that were mentioned above, hindering the entire department's overall performance. Through methodology's diagnosis stages displayed in chapter 3 and presented in chapter 4, these pains were narrowed down into three indicators that presented low performance. Communication, dispersion of multiple files throughout the data sources and the low maturity of the data reviewed. After a dashboard solution has been implemented, the methodology's evolution presents a survey, which is answered in the results chapter, to assess specific questions related to the performance of the dashboard itself, but also to clarify whether the communication, dispersion of files and data maturity indicators have in fact improved.

1.3. Importance of the project

From a practical standpoint, the research is appealing for the everyday processes that manage container availability and supplier requests which require large datasets to work with. Therefore, developing a specialized tool that processes that information and turns it into perceivable metrics about the business performance, creates space for innovative solutions, better tracking, and potential new ways to look at data to take place. From the scientific perspective, this study operates at the intersection of multiple disciplines - logistics, behaviour theory, data analytics, and management - tackling the complexity of systems through data analysis and modelling to enhance decision-making and practical applications. Despite the broad spectrum of research, a notable gap persists in the literature regarding the translation of theoretical dashboard building methods into actionable solutions that significantly contribute to decision-making processes at VWAE. This project specifically targets this deficiency by focusing on improving the visibility of KPIs that demand rigorous analysis, through the development of a user-friendly tool. By applying this method at VWAE, the project not only fills a critical gap in existing literature but also introduces a proven concept through an innovative lens. The intention is to extend the academic discourse by offering a tangible solution that others might expand upon, fostering new methodologies and deeper comprehension of visibility challenges in operational contexts. This endeavour aims to serve as a cornerstone for future research, bridging the separation between theoretical constructs and their practical application, thereby enriching the scientific landscape with valuable insights into overcoming visibility bottlenecks.

1.4. Research questions and objectives

As the project moves forward in search of paths to address the inefficiencies identified, it was inquired about how the challenges were going to be surpassed. This concern led to the development of questions. These questions proved to be of great importance as the mere fact of trying to answer them meant the collection, analysis and interpretation of information that helped make more sense of the issue at hand. Questions such as: "What measures should be taken to prevent an information transmission bottleneck? Where are the areas where the pains of low levels of shared data are being felt the most? How can the insights found be converted into actionable measures? What indicators can be used to assess the improvements or setbacks and properly monitor them?" All these questions provided the necessary conditions to build the main research question: "*How can an effective visibility enhancing approach efficiently assist decision-making at VWAE's CC processes?"* From this point forward the research question became the heart of the project, as the path to answer it constituted the subject of the research. In these regards, the main objective of this project's investigation was to find plausible options that monitor, in real time, the performance of container inventory management and provide helpful insights to aid the decision-making process. To build this tool sub-objectives arose:

1. Recognizing how VWAE operates daily in its sector. This objective will allow the building of specific framework structure directed to VWAE logistics, so when information bottlenecks and their solutions are addressed, it is clear where they occur.
2. Identify how other companies have addressed visibility bottlenecks in the past. Although there is a lot of different improvement solutions in companies of the SC business, the logistics structure is very similar (Stock et al., 2000), so it can be especially useful to harness the literature to benefit from others experience in the quest to finding tools to improve transparency and apply them to VWAE.
3. Choose the most suitable tool to answer the challenge of visibility improvement.
4. Reveal how the decision-making process takes place. To reach the objective of execution, understanding how decision-makers process and act on information is pivotal. This will help to incorporate in the "how", a more concise and supported way to present information;

1.5. Methodology

Having properly defined the research question and objectives, it becomes crucial to outline the correct path to achieve a good answer and the completion of the established goals. In addressing the decision-making processes through the improvement of visibility of information regarding the CC management processes at VWAE, the selection of an appropriate research methodology is fundamental. Sein et al. (2011) propose the Action Design

Research (ADR) methodology. A comprehensive framework that integrates the building and evaluating of innovative IT artifacts of design research (DR) with the proactive elements of organizational intervention of action research (AR). This project falls under the category of an in-company project, where the theoretical frameworks and practical application must be aligned, ADR emerges as a fitting approach. The objective of crafting a path to improve the visibility of information about internal processes such as container management in a dynamic environment such as VWAE represents both a design research and empirical observation challenge, requiring a methodology that fosters cross-fertilization between design and use aspects (interaction with the real organizational scenario) (Sein et al., 2011). ADR's cyclical process of design, enactment, and evaluation aligns seamlessly with the iterative nature of creating ensemble artifacts — to be discovered by the appliance of the literature review — ensuring a nuanced exploration of the research question and objectives. Thus, the adoption of Action Design Research proves not only methodologically sound but also strategically aligned with the nuanced demands of the project. Hence allowing to delve into deeper layers of the research both in scientific research and the translation of the theoretical findings on the field. The ADR method comprises four stages, five activities and eight principles (Mullarkey & Hevner, 2018) that can help address both a problem on an organizational setting (VWAE Logistics Business unit) with the means of intervening and evaluating, and building evaluating an artifact that refer to the problem encountered within the context of the company.

1.6. Project structure

This project is structured into six chapters. The first one is the introduction which sets the stage by elucidating the relevance of addressing visibility bottlenecks, both in a general context and specifically within the selected operations of the container reverse logistics management at VWAE. It formulates a research question and sub-objectives. The methodology section delineates the systematic approach adopted, laying the groundwork for robust research execution. In the literature review chapter, the project delves into the theoretical framework, extracting insights from existing research to answer the research question and address sub-objectives. This chapter forms the intellectual backbone of the project, grounding it in established knowledge within the field of SCM and SCV. The third chapter explains the ADR methodology, illustrating how it guides the project through four distinct stages – diagnosis, design, implementation, and evolution. The fourth chapter is where the case study chapter describes the practical application of the ADR methodology, detailing the creation of the artifact that enhances visibility in VWAE's container management processes. This chapter is pivotal in bridging theoretical concepts with real-world implementation, showcasing the tangible results of the project. Result analysis, the fifth chapter, scrutinizes the artifact's impact through qualitative study techniques and Likert scales. The conclusion chapter serves as the project's culmination, presenting key findings, reflecting on the journey, offering a cohesive narrative.

2. LITERATURE REVIEW

This section serves as the conducting backbone that sculpted the theoretical framework for this project. It encompasses the exploration of various scientific research articles that not only paved the way for a better understanding of the challenges felt at VWAE but also contributed to establishing a robust structure for a tool that helps overcome this bottleneck. These articles, each a building block, collectively help to comprehend the surrounding visibility issues in supply chains. By delving into this literature, the project walks through the setbacks and implications of its inadequate application, shedding light on its impacts on organizational processes, as well as the importance in terms of value creation it brings. Crucially, this theoretical exploration sets the stage for a focused examination of the specific case at hand: information made visible at VWAE Operational Logistics. Through this literature review, it is possible to understand how the challenges align with the operational landscape of VWAE, laying the groundwork for a detailed analysis of the setbacks and opportunities it poses to SCM. The research used a diverse array of research platforms, including sources such as Google Scholar, Emerald, JSTOR, Elsevier and b-on to find the necessary information to be analyzed. The method employed was anchored in a tracing of citations, ensuring that each referenced researcher's insights was followed back to their origins. This approach served a dual purpose: The augmentation of interpretation of key concepts by considering the broader context in which they were conceived, and it facilitated a mirror-like reflection of these insights onto the specific arguments and objectives of this project. The citation tracing method acted as a navigational tool, seeking a concise connection between the broader scientific discourse on SCV and the dynamic considerations specific to the challenges faced at VWAE. The criteria to perform the research at the beginning was to filter the articles by the ones as close to the current year as possible. This meant seeking for publications between 2016 and 2023. Furthermore, the criteria ranged only to Automobile industry cases of supply networks that sought to increase transparency levels. The reasoning behind this rationale was that it would provide a set of publications that were already built on previous cases, having been peer-reviewed and having their limitations pointed out, allowing for a more careful examination of transparency bottlenecks, and to have a similar case of Automobile industry such as the one being studied in this project. But by tracing the latter publications concepts back to earlier ones, it enabled the research to have more understanding depth of when this subject started to appear and where. So, the filter criteria were immediately dropped, and the focus shifted to be directed on SCM across the globe, having publications as early as 1988 (Montazemi et al., 1988).

2.1. Visibility

Chasing the achievement of a good grasp of how visibility can help improve the way business is conducted at the company, this section will enable a progressive discovery of the definition of visibility and to understand how it can contribute to a concise approach. This exploration delves into the diverse definitions that have shaped the understanding of SCV, acknowledging the varied lenses through which scholars have addressed this element of supply chain dynamics. The journey to define SCV extends beyond academic curiosity, finding resonance in its practical implications for decision-making, operational efficiency, and resilience within supply chains. As we unravel the layers of SCV definitions, we unveil a concept that not only navigates the complexities of supply chain processes but also plays a pivotal role in shaping contemporary lines of thinking that inform SCM. It emerges as fundamental in social relationship affairs in and out of the business realm, influencing the functioning of operations and SC. SCV ensures that actors within the supply chain have visual access to information that is not only essential but also valuable for their decisions (Kalaiarasan et al., 2022). Ultimately, SCV transcends its conceptual origins to become a practical necessity, shaping how organizations navigate the intricacies of the modern supply chain landscape.

Diverse perspectives on SCV are evident in the literature, with Francis (2008) highlighting the multiplicity of definitions. Williams et al. (2013) contributed another dimension to SCV, emphasizing high-quality information access that encompasses accuracy, timeliness, completeness, and usability of demand and supply factors. Synthesizing insights from prior definitions, our interpretation of SCV is the extent to which actors within a supply chain have visual access to timely and accurate demand and supply information deemed essential or valuable for their operations and supply chains. This has implications in terms of performance within the organizational context, demand in terms of customer management and the effectiveness of decision-making (Kalaiarasan et al., 2022). In inventory management, and particularly interesting in VWAE business case, is the cost dimension that benefits from higher levels of SCV, it can be applied in improved stock levels and reduced uncertainty. For increased visibility, the problems stated can be more well displayed and create room for demonstrating the functional feasibility for a potential solution. (Nunamaker et al., 2015)

2.2. Visibility vs Transparency in SCM

It is worth noting that transparency appeared as a key concept within lean SCM, aiming to eradicate waste and rectify flawed practices (New & Westbrook, 2004). The primary target of this pursuit was the elimination of wasted opportunities within supply relationships. These overlooked opportunities, if leveraged, had the potential to create value for both the customer and supplier. These developments in lean SCM introduced transparency as a novel perspective, challenging the common belief at the time that maintaining high inventory levels was a requisite for agility in responding to market dynamics (New & Westbrook, 2004). Transparency entails providing pertinent information promptly and impartially, without imposing charges, delays, or unfair distinctions (Parris et al., 2016; Khan et al., 2022). It can be defined as the unrestricted flow of information, which is very important in the context of SC operations. It entails the provision of essential and unbiased information promptly and without cost, delays, or discrimination. The concept adheres to the principle of 'what you see is what you get,' emphasizing the alignment between words and actions (Parris et al., 2016).

The dynamic exchange of information serves as a driving force for organizations, propelling them to generate value (Narver and Slater, 1991), elevate performance (Forza, 1995), and fortify their competitive edge (Von Krogh, 1998). Putting transparency and visibility side by side the concepts might come off as very similar or near-synonyms (Montecchi et al., 2021). Numerous organizations encounter the task of enhancing the visibility of their SC to align with regulatory obligations and optimize operational efficiency, while research endeavors have underscored the significance of information sharing in the context of visibility (Montecchi et al., 2021). These studies posit that visibility is either achievable through or is a consequence of sharing information across supply chains (Kaipia and Hartiala, 2006; Barratt and Oke, 2007; Brandon-Jones et al., 2014; Dubey et al., 2018a, 2019, 2020).

In the landscape of SCM, transparency and visibility, although interconnected, play distinctive roles in shaping organizational strategies. Transparency, as posited by Montecchi et al. (2021), is the overarching concept that encompasses deliberate efforts to disclose information strategically. It involves the conscious decisions organizations make to reveal specific aspects of their operations. Visibility, on the other hand, serves as a pivotal component within the broader framework of transparency. It is a dynamic aspect that ensures real-time access to information throughout the SC network. Visibility, along with traceability and other dimensions, acts as a means to achieve transparency (Montecchi et al., 2021). While transparency involves intentional disclosure, visibility is the continuous flow of information, providing stakeholders with timely and accurate data, serving as a conduit within the transparency strategy, facilitating the establishment of an appropriate level of disclosure, increased scrutiny, and enhanced openness perceptions among stakeholders. In essence, visibility is a vital building block contributing to the comprehensive concept of supply chain transparency.

2.3. Supply chain management & the role of Visibility

Supply Chain Management (SCM) has evolved from its historical roots in the physical transportation of goods, such as those during the era of constructing the great pyramids, to a comprehensive and integrative approach that oversees the entire distribution channel flow from suppliers to end customers (Lummus et al., 2001). Defined as a strategic tool by Ellram and Cooper (1993) and further expanded by Giunipero and Brand (1996), SCM aims to enhance customer satisfaction, competitiveness, and profitability by efficiently managing the journey from raw materials to finished products within an integrated system. This system includes a variety of entities like manufacturers, wholesalers, and retailers, focusing on core processes such as handling, storage, packaging, transportation, and trading to preserve product quality (Khan et al., 2022). Visibility within the supply chain is identified as a critical component for optimizing these processes. It entails the extensive sharing of information across all stakeholders, thereby fostering trust, aiding in strategy formulation, and enhancing overall performance (Parris et al., 2016). Despite advancements in technology that have increased transparency levels in business, achieving true transparency in SCM poses significant challenges, emphasizing the need to address information sharing bottlenecks to improve supply chain efficiency (Coello Coello, 1999; Van Der Zee & Van Der Vorst, 2005).

SCM's role extends beyond logistics, serving as a strategic endeavor that focuses on the tactical and operational execution of supply chain activities. The evolution of SCM underscores the importance of a strategic, integrated approach to managing the diverse and complex needs of stakeholders, ensuring product quality, and optimizing costs, with visibility playing a pivotal role in enhancing supply chain performance and achieving strategic objectives (Lummus et al., 2001).

2.4. Tools

Efforts to enhance visibility within organizational processes represent a dynamic and essential facet of contemporary business strategies. These attempts encompass a spectrum of initiatives aimed at fostering openness, accessibility, and clarity in the flow of information. From implementing advanced technologies to redefining communication protocols, organizations engage in multifaceted endeavors to improve transparency. Such initiatives are driven by the recognition that transparent practices not only instill trust among stakeholders but also contribute to informed decision-making and operational efficiency (Khan et al., 2022). The exploration of attempts to improve transparency delves into the diverse strategies employed by organizations across industries, shedding light on innovative practices and valuable lessons that can be harnessed to navigate the landscape of information disclosure.

2.4.1. Business Intelligence (BI)

As the research moves forward, it becomes relevant to provide understanding on where the solution for this challenge might lie. Recent literature expands on the direction of business intelligence (BI) tools (Foley & Guillemette, 2010) as suitable path to address issues like low visibility of information, often linked to transparency and traceability or even disclosure and openness (Montecchi et al., 2021) within an organizational environment to align objectives. In that sense, an attempt to provide a definition of BI in the context most relevant to the project's success is given.

There has not been a consensus in the academic community about the concept of business intelligence (BI) itself as multiple studies have used different connotations for BI to better suit their studies (Foley & Guillemette, 2010) and it has caused some confusion around what BI is and in the interpretation of results. By synthesizing the vast information and different definitions of the BI construct and restructured the working, Foley & Guillemette (2010; pp. 4) suggest the following definition: **"***Business intelligence* (BI) is a combination of processes, policies, culture, and technologies for gathering, manipulating, storing, and analyzing data collected from internal and external sources, in order to communicate information, create knowledge, and inform decision making. BI helps report business performance, uncover new business opportunities, and make better business decisions regarding competitors, suppliers, customers, financial issues, strategic issues, products and services.**"**

2.4.2. The balanced scorecard

The Balanced Scorecard (BSC) serves as a strategic management tool designed to translate an organization's overarching mission and strategy into tangible, measurable goals, actions, and performance indicators. In response to the recognition that a single performance metric falls short in capturing the multifaceted nature of organizational performance (Epstein and Manzoni, 1998), the BSC approach provides a comprehensive framework. This technique can be flexibly applied at various levels, spanning the entire organization, strategic business units, individual operational units, or even to individuals. The essence of the BSC lies in identifying key components of operations, establishing goals for these components, and devising means to measure progress toward their attainment (Evans, 2005; Sandkuhl et al., 2003; Walker, 1996).

In the context of increasing visibility, the Balanced Scorecard becomes instrumental by offering a structured methodology to align strategic objectives with operational activities. By incorporating key performance indicators (KPIs) across different facets of the organization, the BSC ensures that various dimensions of performance are considered, promoting a holistic understanding. Through this systematic approach, organizations can enhance their visibility into critical areas, facilitating a comprehensive assessment of progress and enabling timely adjustments to achieve strategic goals effectively (Assir et al., 2006).

2.4.3. Block-chain based technology

Blockchain technology represents a transformative system for enabling the storage and distribution of data across a network of stakeholders in a manner that actively engages participants in a shared database. Unlike traditional methods, which centralize transaction data and selectively share it with involved parties, blockchain operates on principles of decentralization, security, and smart execution. In this decentralized environment, every participant in the network has immediate access to comprehensive transaction information in real-time. This peer-to-peer network structure ensures that transaction details are accessible sequentially, fostering visibility and collaboration among all participants. This departure from centralized hubs enhances the security, accessibility, and efficiency of transactions within the blockchain network (Park et al., 2021). Numerous supply chains have embraced blockchain technology to enhance traceability, thereby promoting a heightened level of visibility. Within the design considerations of the distribution network, the pivotal factor lies in determining the extent of order visibility. The adoption of blockchain not only addresses the imperative need for traceability but also aligns with the broader goal of fostering visibility in supply chain operations. This technological integration ensures that order visibility becomes a crucial aspect of the overall strategy, emphasizing the interconnectedness of blockchain solutions with the design and optimization of distribution networks (Khan et al., 2022).

Giannakis et al. (2019) highlighted the pivotal role of cloud-based collaborative planning systems in facilitating end-to-end SCV, particularly concerning material movements and the tracking of current and projected inventory levels. The significance of connectivity in achieving SCV is underscored by technological infrastructure, serving as a key antecedent (Brandon-Jones et al., 2014). This emphasis on cloud-based collaborative planning systems and the essential role of connectivity emphasizes the technological underpinnings crucial for comprehensive SCV, as demonstrated by these scholarly contributions.

2.4.4. Radio Frequency Identification (RFID)

RFID brings a new sense of visibility through the movement of goods and services across the supply chain. The adoption of RFID enables real-time tracking and monitoring of goods as they traverse various stages of the supply chain journey (Kalaiarasan et al., 2022; Fosso Wamba et al., 2008; Caridi et al., 2013; Pero and Rossi, 2014) This technology utilizes wireless communication to transmit data between RFID tags attached to products and RFID readers strategically positioned along the supply chain nodes. The data exchanged includes critical information such as product location, movement, and other relevant details. As goods move across geographical zones, RFID facilitates tracking, allowing stakeholders to access real-time information about the physical progress and location of items. This not only enhances operational efficiency but also contributes to the swift identification of potential time bottlenecks or delays. Looking forward, the integration of RFID with emerging technologies such as blockchain holds tremendous potential. Van Hoek's (2019) suggestion of coexistence implies a symbiotic relationship where RFID complements blockchain solutions, contributing to an elevated level of supply chain visibility. As technology continues to evolve, the creative synergy between RFID and other innovations promises to redefine how we perceive, manage, and optimize supply chain processes.

2.4.5. Social Internet of Things (SIoT)

Another technology that tried to assist in the transformation of conventional SC networks the visibility issue is the Social Internet of Things (SIoT) (Khan et al., 2022). Tackling various challenges in areas such as composition, service discovery, connection, and behavioral monitoring and control of objects. Within the SC context, SIoT stands as a catalyst poised to revolutionize performance efficiency and open up new income streams. Unlike these segmented approaches, SIoT ensures comprehensive transparency in the supply chain, offering detailed and previously unattainable information through advanced technology. Thus, SIoT distinctly aims at improving the visibility within the supply chain (Khan et al., 2022), marking a change in basic assumptions from conventional tracking methods.

The ability to monitor and trace a product's trajectory throughout the supply chain is defined as traceability. This encompassing definition comprises three key components: tracking the product both forward and backward (reverse logistics, Dekker et al. 2002), maintaining product history data pertaining to its movement within the supply chain, and facilitating product follow-up in both directions. These data elements play a pivotal role in discerning the extent and location of defective materials introduced into the supply chain at any given point, thus influencing production batches. The integration of recall management and traceability technologies emerges as a strategic solution, to enhance the value within the global SC (Khan et al., 2022). Despite its evident advantages, achieving seamless traceability poses challenges, particularly concerning the efficient integration of these technologies to optimize SC processes (Khan et al., 2022).

2.4.6. Tracking and surveillance technologies

Tracking and surveillance technologies play a pivotal role in automating data collection processes, diminishing reliance on supplier input or interpretation. In the context of enhancing visibility, these technologies, such as those associated with the Internet of Things (IoT), offer real-time tracking of goods across geographical zones. This includes monitoring in-transit environmental conditions for product traceability and safety. Notably, companies like Johnson & Johnson utilize track-and-trace sensors to achieve "end-to-end visibility" by tracking location, departure and arrival times, and identifying potential interferences impacting product quality. Smart pallets, equipped with RFID tags and embedded sensor technologies, contribute to real-time data gathering, encompassing information on location, movement, load type and weight, as well as prevailing temperature and humidity. By utilizing these technologies there is the possibility to have higher levels of traceability.

2.4.7. Audits

Audits serve as a crucial safeguard mechanism, offering stakeholders assurance regarding the integrity of products or services and their adherence to essential regulations or standards. Beyond being perceived as a conventional process, here audits are portrayed as a purposefully designed monitoring system, increasingly intertwined with information technologies (McGrath et al., 2021). In a context like the one of VWAE, audits function as a regular tool to ensure the compliance of production and financial processes with regulatory standards. These audits can be internal, industry-led platforms, independent audit platforms or external certifications. The idea is that by entrusting an unbiased entity with the sole purpose of making sure that internal procedures to optimize efficiency are being met, there will be more sharing of relevant information in the process by providing the necessary information to complete the task. The outcome is to then have more visibility as external audits occur.

2.4.8. Dialog Technologies

Dialogic technologies play a role in advancing transparency practices within supply chains. In contrast to the conventional approach of accumulating vast amounts of supplier data, these technologies focus on fostering dialogue and information sharing across the supply chain to enhance the quality of data flow and supplier engagement. Although these mechanisms may fall outside the traditional definition of technologies, they are purposefully designed systems aimed at promoting communication and collaboration. By creating a platform for dialogue and information exchange, dialogic technologies contribute to improving transparency practices among suppliers, aligning with the evolving needs of companies seeking more effective ways to engage with their supply chain partners (McGrath et al., 2021). To promote these technologies the is a range of activities that usually are performed, such as:

1- Two-way communication systems: This approach allows for early notification of impending regulatory and compliance changes, reducing the likelihood of surprises and providing suppliers with ample time to adjust their data gathering and reporting systems. This proactive engagement through multiple communication channels contributes to a more clear and collaborative relationship between companies and their suppliers.
2- Multiple Stakeholder Initiatives (MSIs) represent a collaborative approach involving various actors within an industry, encompassing multinational corporations (MNCs), suppliers, non-governmental organizations (NGOs), governments, academia, trade unions, and other stakeholders. This horizontal form of collaboration brings together diverse entities to collectively address industry challenges and foster a multi-dimensional engagement that goes beyond traditional business boundaries. By involving a spectrum of stakeholders, MSIs aim to create a more inclusive and comprehensive framework for addressing industry-wide issues, promoting visible communication standards, and achieving collective goals.
3- Company and Industry-Led Forums, akin to MSIs, are initiatives guided by one or multiple companies or overseen by an industry association. While other stakeholders are included, they don't hold primary founding or decision-making roles. These forums provide platforms for companies and industry participants to collaborate, share insights, and collectively address challenges specific to their sector. The leadership from companies or industry associations underscores a proactive approach in driving industry-led discussions and initiatives, contributing to enhanced transparency and cooperation within the sector.

2.4.9. Data Dissemination Technologies

Data Dissemination Technologies play a crucial role in transferring information and knowledge from the central company to its suppliers and a broader network of stakeholders, including shareholders, customers, external regulatory bodies, and interest groups. Supplier feedback is often facilitated through the audit process, supplemented by online or on-site technical support. Some companies utilize supplier newsletters to share best practices, upcoming changes, and improvements. Summary data, often in the form of sustainability reports, are publicly released on the company's website or integrated into annual reports. Notably, QR Codes are frequently used at the customer level, providing a direct link to information through smartphones. Anticipated advancements include integrating QR codes with blockchain technology to offer unprecedented insights into product details, fostering consumer trust by transparently showcasing good business practices.

2.4.10. Dashboards

A dashboard is “organizational magnifying glass” that keeps the focus of organizations on monitoring performance issues in one direction (Eckerson, 2005). Even a big company like VWAE is subject to organizational inertia or entropies caused by the vastly decentralized supply network of suppliers, sub-suppliers and intermediate consolidation points it has. In that sense, decision-makers need appropriate information systems that help them clearly and concisely communicate strategies and targets to all employees on a personal basis every day. In essence, this means that organizations need performance dashboards that can translate their strategies into actionable measures, metrics, initiatives and tasks (Eckerson, 2005) customized to each group in the organization. A performance dashboard functions as a comprehensive performance management system, serving as a communication tool for strategic objectives. It empowers business professionals to quantify, oversee, and oversee the critical activities and processes essential for attaining their objectives (Eckerson, 2005). Dashboards have shown great results in augmenting decision-making within educational contexts by providing visual representations of learning processes (Sedrakyan et al., 2019). These serve as dynamic tools, allowing educators and learners to track the progression of learning initiatives. Through visualizations, they offer insights into areas where learning processes are unfolding as anticipated and highlight potential challenges or issues that may arise. The interactive nature of learning dashboards contributes to a more informed decision-making process, fostering a data-driven approach to education (Sedrakyan et al., 2019). Furthermore, visualizations are often the only reasonable approach to analyze data to gain knowledge about the underlying processes and relations (Lange, Schumann, Müller, & Krömker, 1995). BI visualization dashboards offer consolidated displays comprising various visual components, including charts, all within a single view. This design facilitates a quick and comprehensive monitoring of information with just a glance. These dashboards leverage apt visual representations, incorporating elements like colors, size, and shape. Through interactive exploration features, they go beyond static presentations, actively engaging users to amplify cognitive processes and elevate the overall understanding of information. The combination of diverse visual elements and interactive capabilities enhances human cognition, making complex data more accessible and facilitating more profound insights (Elias & Bezerianos, 2011).

2.4.11. Comparison of tools

All the other previous tools contemplated in the literature review (B*lock-chain based technology; The balanaced scorecard; Social Internet of Things (SIoT); Tracking and surveillance technologies; RFID; Audits; Dialog Technologies; Data Dissemination Technologies*) present particularly good offers to increase visibility bottlenecks. However, regarding the main issue at VWAE, they fail to deliver an answer that consistently explicit the performance of container management in a clear and timely manner. For example, *block-chain technology, SIoT, tracking, surveillance technologies, Audits, Dialog Technologies,* and *Data Dissemination Technologies* present a level of investment that is not justifiable at the scale of one team, rather it makes more sense to restructure the way processes are followed in the larger context of the company. Another impairment is the fact that some of these approaches have already been put in place but act as a short term “band-aid” as opposed to a long term solution, furthermore they mostly focus on the traceability aspect of the items rather than providing a holistic assessment of how to make crucial information about internal container processes clearer, not creating much space for actionable measures to arise. Traceability involves a diverse array of organizational procedures and technological frameworks essential for enhancing the seamless integration of information (Ringsberg, 2014), while visibility is more akin to the efforts made by organizations to gather and iterate information about SC activities, primarily for internal use (Montecchi et al., 2021). Seeing their established difference side by side, it is easier to perceive which path should be followed to meet either traceability or visibility. Bearing in mind that the main purpose is the pursuit of visibility of said internal procedures, a performance dashboard emerges as a potent catalyst for organizational transformation. Dashboards are anticipated to enhance decision-making by leveraging and augmenting human cognitive abilities, capitalizing on the innate capacities of human perception. When strategically implemented, it has the potential to elevate an underperforming organization into a high-performing entity (Yigitbasioglu & Velcu, 2012). Analogous to the magnifying glass reference, a performance dashboard directs the focus of organizations toward pivotal actions necessary for success (Eckerson, 2005). It furnishes executives, managers, and employees with timely and pertinent information, enabling them to quantitatively assess, monitor, and manage their advancements toward crucial strategic objectives. In the context of VWAE, deploying a collaborative dashboard for performance monitoring can notably make information more obvious by providing real-time insights into key operational processes, fostering data-driven decision-making, and aligning strategic goals with less opaque and measurable outcomes. Furthermore, there is empirical evidence suggesting that implementing a performance dashboard leads to better outcomes in terms cashflow performance, namely linked to accounts receivable management (Yigitbasioglu & Velcu, 2012). Companies recognize big data analytics as a transformative force driving competitive advantage and productivity, evident in industry leaders like Amazon.com and Walmart (Yesudas et al., 2014). The strategic shift towards data discovery as the primary BI platform reflects the changing landscape, emphasizing analysis-centric approaches over traditional reporting-centric methods. This transition aligns with projections indicating that over 50% of analytics implementations by 2017 will leverage event-based data streams from instrumented machines, applications, and individuals, further emphasizing the pivotal role of dashboards in navigating the data-driven era (Yesudas et al., 2014).

2.5. Dashboard as a visibility enhancing tool

The inception of dashboards in organizational settings can be traced back to the late 20th century, used as executive information systems (EIS) in the 1980s (Eckerson 2005). These systems faced limited adoption due to their high customization and maintenance costs, as initially their use was mainly to aid executives to have an overview of the company's landscape in a brief way. The concept of dashboards draws its inspiration from vehicle dashboards, which display essential metrics for drivers. Simply put, a driver, by looking at an organized set of measures on a dashboard, can make on-time decisions about the way he/she handles the vehicle taking into consideration speed limit, fuel level and other factors that dictate driving. Similarly, dashboards serve as invaluable tools for managers, offering visual insights into business trends, patterns, and anomalies. Effective visual information design is crucial in this context (Yigitbasioglu & Velcu 2012). Dashboards can serve multiple purposes, including ensuring consistency in measures and measurement procedures across departments, day-to-day monitoring of metrics for prompt corrective actions, facilitating planning through scenarios and what-if analyses for the future, and serving as a communication tool that not only conveys performance to stakeholders but also communicates the values of an organization through the chosen metrics (Pauwels et al., 2009).

The organizational landscape evolved rapidly in the subsequent two decades, witnessing a shift, from client/server systems to the web as the primary platform for applications and information delivery. With a globalized economy coupled with technological advancements and intensifying competition radically changing the working environment in SC (Magnus & Rudra, 2019) organizations sought ways to provide business users with direct and timely access to critical information, giving rise to the field of BI (Eckerson, 2005). The advent of information-sharing platforms and real-time data connectivity has significantly impacted the dynamics of information utilization within SCs. Despite the access to extensive databases, there still exists a necessity for the refinement of software applications and tools. The objective is to augment awareness of critical information within the working environment and enhance user-friendliness (Magnus & Rudra, 2019). This, in turn, empowers personnel for heightened efficiency in the SCM process (Chopra and Meindl, 2013). The contemporary challenge resides in ensuring that information is presented in a manner conducive to the users providing them with a summarized overview of available resources (Records and Shimbo, 2010). In SC this challenge is very present as the daily business activities require a great deal of agents to share information that allows products and services to be exchanged and moved across the chain, and with a globalized and decentralized economy the degree of reliability on each agent is vastly greater. Resorting to literature for answers as to how this challenge can be tackled, it is found that the potential for enhancing supply chain operations such as inventory management and logistics handling, ca be done by tapping into the potential of making real-time data and IT capabilities more accessible and visible in order to create more dynamic environments with integrated flow of information (Magnus & Rudra, 2019). Operational dashboards have proven to encompass large volumes of structured data to reach integration (Yesudas et al., 2014), as it is a tool that can be shaped to each environment, highlighting the most relevant of KPIs to reach certain objectives.
As per Yigitbasioglu & Velcu (2012), dashboards exhibit two distinct types of design features: functional features and visual features. Functional features pertain to the capabilities of the dashboard, describing its potential actions and functionalities. On the other hand, visual features revolve around the principles guiding data visualization—how information is presented to the user efficiently and effectively. The alignment of functional features with the intended purpose of the dashboard is crucial, ensuring optimal decision-making cues and

symbols for the user. An inadequate fit may lead to suboptimal decisions, lacking necessary features for specific uses.

2.5.1. Application of dashboards in organizational landscape

The widespread adoption of dashboards is a universal trend transcending industry boundaries and company sizes. This trend is rooted in the human inclination to measure everything, amplified by the capabilities of IT processing tools and the extensive network infrastructure within organizations. The evolution of managing and planning functions has generated an abundance of information, presenting a challenge in assimilation without effective tools like dashboards (Lanotte et al., 2020). Notably, the surge in interest in big data analytics, particularly operational intelligence (OI), has spurred significant research and investment. This sub-chapter aims to provide some of the practical examples of dashboard application in the industry, demonstrating how SCs benefit largely from this lean management tool that works as a proactive initiative to improve logistics performance and quality. The examples used are published research on the Hutchinson group case by Lanotte et al., (2020), and the IBM Sterling Order Management System by Yesudas et al., (2014).

The Hutchinson Group

Having Airbus as one of the main customers, the Hutchinson group is a large multinational company specialized in aeronautical seals manufacturing. Driven primarily by its main customer supply necessities, the group took its first steps in approaching an innovative customer-oriented dashboard that allowed the monitoring of the most relevant metrics that dictated the success of the supply operations of products and services for the aerospace manufacturer during the A350 aircrafts program. The executive dashboard offered a comprehensive overview by condensing diverse data into weekly and monthly indicators, providing insightful analysis of delay causes, accompanied by a forward-looking perspective on service rates and "offering nevertheless a real and useful visibility to the customer, which is a source of a real competitive advantage". The implementation of the dashboard as a strategic lean management tool allowed the giant supplier to achieve an unprecedented level of proactivity in its operational activities (Lanotte et al. 2020).

IBM Sterling Order Management System (OMS)

The IBM Sterling OMS case, demonstrated by Yesudas et al., (2014) examines existing research on OI, leveraging streaming data, and puts forward a methodology for building intelligent operational dashboards within SCM systems. The process involves streaming data from a relational database management system (RDBMS) to a big data database, facilitating the application of correlation principles and the development of an intelligent data model. Ultimately the OI dashboard derived from big data aided in giving answers to various stakeholders, and by utilizing statistical correlation methods and industry expertise, the examination of unstructured data yields a universal data model, facilitating the conversion of raw data into insightful information.

2.5.2. Data Visualization

Visualization involves transforming data into a visual representation (Latham, 1995). The sense of sight is incredibly powerful, surpassing all other senses combined in terms of the information it provides. Visualizations play a small but vital and increasingly significant role in how the mind works. When it comes to communication between computers and humans, visual displays offer the fastest and most information-rich pathway. The human brain, which contains around 20 billion neurons dedicated to processing visual data, excels at recognizing patterns. This ability to identify patterns is a fundamental part of many cognitive processes (Ware, 2004). Enhancing cognitive systems often involves strengthening the connections between individuals, computer-based tools, and other people, creating a more seamless and efficient flow of information and understanding. In the past, when we talked about "visualization," it referred to creating mental images in our minds. However, the meaning of visualization has evolved over time. Today, it's more about creating graphical representations of data or ideas. So, instead of something we imagine internally, visualization has transformed into an external tool that helps us make decisions (Ware, 2004). Therefore, what was once a mental construct has transformed into an external tool that enhances the decision-making process. Additionally, even with a functional fit, poor visual design elements such as excessive use of colors or a low data-to-ink ratio can create confusion and distraction for the user.

Visualization offers a powerful capability to make sense of vast quantities of data. It allows decision-makers to quickly access and grasp crucial information from datasets that may consist of over a million measurements (Ware, 2004). This visual representation not only condenses complex data but also simplifies it in a way that decision-makers can readily comprehend. Instead of sifting through overwhelming numbers and figures, they are presented with clear and meaningful visuals that facilitate a more informed and efficient decision-making process. This ability to distill and present extensive data at a glance significantly aids decision-makers in making sense of immense information to arrive at well-informed decisions.

2.5.3. Visualizations influence on decision-making behavior

There is a prevailing trend in dashboard design being predominantly data-centric rather than being informed by principles from cognitive psychology (Presthus and Canales, 2015). Interestingly, there is a noticeable lack of attention among designers toward factors associated with visual perception and eye-tracking patterns when users engage with dashboards (Magnus & Rudra, 2019). Dashboards and visualizations are essential tools for decision-making, they are based on the principles of visual perception, namely Gestalt psychology (Yigitbasioglu & Velcu 2012). This psychological viewpoint places a strong emphasis on considering components as more than the sum of their parts, a notion that is easily translated into dashboard design. Gestalt concepts including proximity, resemblance, continuity, figure-ground, symmetry, and closure are used by these visual aids to depict complex material in a way that is coherent and easy to understand. Dashboards are information visualization devices that use a two-step encoding and decoding technique. While the decoding process depends on the viewer's capacity to precisely detect data quantities and relationships, the encoding phase involves the strategic use of visual features such shape, location, color, and textual elements. For visualization to be effective, the decoding process must be successful for the information displayed to correspond with the data. Additionally, visualization efficiency is reached when the greatest amount of data is accessed in the shortest amount of time (Yigitbasioglu & Velcu 2012).

Dashboards are used to aid in decision-making and are judged on how well they can balance the need for information with aesthetic sophistication (Yigitbasioglu & Velcu 2012). It is necessary to balance the overarching objective of promoting informed decision-making with visual complexity, which is characterized as the challenge of verbally describing an image. In this pursuit, symmetry, consistency, and simplicity become fundamental principles that guarantee that data visualizations not only communicate structural representations of the data but also improve the conceptual comprehension of the information displayed. As we pursue this research, the complex dance between visually appealing and usefulness develops, leading us to a more sophisticated comprehension of the function dashboards serve in directing decision-making procedures.

Every day, humans engage in decision-making, often without consciously recognizing these situations. Behind the scenes, our brains operate as intricate machinery responsible for crafting these decisions. This cognitive system continually evolves as we encounter new experiences and situations. However, it is not infallible. It is susceptible to biases, illusions, and a tendency to seek comfort (Korhonen, 2015). Human beings often deviate from the principles of classical economic theories when it comes to economic transactions. They do not typically construct utility functions and relentlessly pursue economic goals with unwavering consistency (Kahneman, 2011). Administrative decision-making is often characterized as a rational process. In this context, decision-makers are expected to operate under conditions of certainty, implying that they are well-acquainted with their available options, potential outcomes, decision criteria, and possess the capability to choose the most favorable option and successfully execute it (Towler, 2010). According to the rational model (Schoenfeld, 2011), the decision-making process can be dissected into six specific steps.

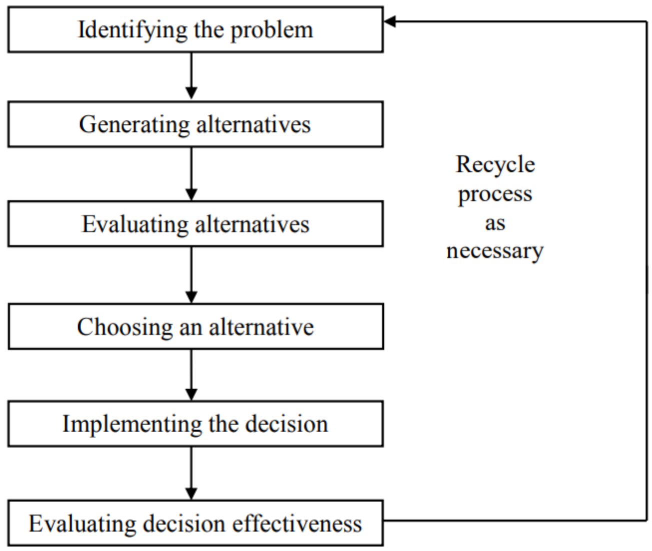

Figure 1 - The decision-making process. (Lunenburg, 2010)

Once a problem is recognized, the next step involves generating a range of alternative solutions. These alternatives are subject to a thorough evaluation process, leading to the selection of the most suitable option for implementation. Subsequently, the chosen alternative is continually assessed over time to ensure its immediate and sustained effectiveness. If any challenges or issues arise at any point in this process, recycling or revisiting of earlier stages may be necessary. In essence, decision-making follows a logical sequence of activities, where in problem identification precedes alternative generation, and so forth. Moreover, decision-making is not a one-time event but rather an iterative and ongoing process (Lunenburg, 2010). Thinking does not just happen silently in our heads. It involves using various tools like pens, paper, calculators, and now, computers. We do not usually think all alone, it often involves working with others and using these tools together. Throughout the history of science, scientists have used things like drawings, math symbols, and writing to understand things better. Today, we have powerful computer programs like MATLAB, Maple, Mathematica, and S-PLUS, along with large databases. Fields like genomics and proteomics (fields of molecular biology and biotechnology) rely heavily on these computer tools and data storage for their research. So, thinking and problem-solving often happen with the help of tools and sometimes with the collaboration of others (Hutchins 1995). Our opinions are shaped by the information we have access to. However, when the information we receive changes and leads to a shift in our opinions, it can replace the old perspective with a new one. This can pose challenges in decision-making scenarios because it becomes challenging to recall the rationale behind the previous opinion, resulting in an imbalance of information (Kahneman, 2011).

To enhance decision-making, organizations must focus on improving transparency in their processes and data. Within this context, two vital areas require attention. First, organizations should work on acquiring, filtering, and verifying the data necessary for decision-makers. Second, they should gain a deeper understanding of how human beings integrate into the decision-making process (Nespeca & Chiucchi, 2018). Many organizations have already adopted Business Intelligence tools and other information systems to address the first issue. However, the future evolution of the decision-making process remains a topic of exploration in numerous organizations (Korhonen, 2015). Furthermore, it's important to recognize that various cognitive and visual factors influence the decision-making process for humans. These factors include communication between cognitive systems, visual cues, cognitive mapping, context, available information, risk perception, and more. This list could be extended to include challenges arising from group decision-making dynamics, social interactions, cultural backgrounds, and so forth (Korhonen, 2015).

2.6. Benefits vs shortcomings of dashboard

Performance dashboards have been heralded as powerful tools that can revolutionize organizational decision-making and strategy execution. The benefits associated with their implementation are multifaceted. By communicating and refining strategy, these dashboards align organizational objectives, creating a unified vision among stakeholders. The enhanced visibility they offer allows for increased coordination and a consistent view of business operations, contributing to more informed and strategic decision-making. The streamlined presentation of key performance indicators (KPIs) aids in achieving lean performances, leading to reduced costs, redundancy, and time inefficiencies. Empowering users with actionable information, dashboards become catalysts for organizational empowerment and efficiency. However, these benefits should be carefully considered considering potential drawbacks that emerge in literature.

Despite their transformative potential, performance dashboards are not without their challenges. Ensuring data quality for accurate representation demands a thorough analysis, and any shortcomings in this area can compromise the reliability of dashboard insights. One significant concern is the tunnel vision that dashboard users may develop, focusing solely on the measured KPIs and potentially neglecting other critical aspects of organizational performance. Additionally, the effectiveness of dashboards diminishes when dealing with small datasets and rare events, as the increased variability in KPIs can render trending unreliable. This poses a challenge for smaller organizations that may not benefit from dashboards to the same extent as their larger counterparts. Thus, while performance dashboards offer substantial advantages, a better understanding of their potential limitations is essential for their successful implementation.

Table 1 - Benefits and shortcomings of using dashboards

Benefits	References
Communicate Strategy	(Buttigieg, Pace, & Rathert, 2017); (Eckerson, 2005); (Wilbanks et al., 2014)
Refine Strategy	(Eckerson, 2005)
Increase Visibility	(Eckerson, 2005); (Wilbanks et al., 2014)
Increase Coordination	(Eckerson, 2005); (Lousa, Pedrosa, & Bernardino, 2019); (Wilbanks et al., 2014)
Give a consistent view of the business at hand	(Eckerson, 2005); (Lousa, Pedrosa, & Bernardino, 2019)
Reduce costs, redundancy and time (Achieving Lean performances)	(Eckerson, 2005)
Empowers users	(Eckerson, 2005)
Deliver actionable information	(Eckerson, 2005)
Shortcomings	**References**
Requires a thorough analysis to ensure data quality.	(Buttigieg, Pace, & Rathert, 2017)
Tunnel vision by dashboard users as they tend to discard the need to address other challenges not being measured.	(Buttigieg, Pace, & Rathert, 2017); (Dowding et al., 2015)
Hard to measure small data sets and rare events because of the increased variability in KPIs accounts for unreliable trending purposes (Small organizations would not benefit from dashboards as much as large ones).	(Wilbanks et al., 2014)

2.6.1. Key Performance Indicators (KPIs) Selection

KPIs are typically described as measurements that have a significant impact on the organization and aid in tracking progress toward organizational objectives (McKinney, 2012). In performance management and organizational efficiency, the careful selection of KPIs holds immense importance. KPIs serve as metrics that encapsulate critical aspects of an organization's performance, providing a focused lens through which to gauge success and identify areas for improvement. Following the identification and selection of the KPIs to be included in a dashboard, it is very important to benchmark against other companies in the same industry. As per Buttigieg et al., (2017) there are three types of dashboards: Strategic, Tactical and operational. Each one corresponds to top management, departmental management and operational management respectively. This project aims at the operational dashboard type, aligning the internal processes decision-making with higher management outcomes (tactical and strategic). Benchmarking is fundamental to understanding the trends and variations in the market and replicate them by integrating them in the dashboard build (Buttigieg et al., 2017; Bakos et al., 2012; Donaldson et al., 2005). In the sections ahead the specific criteria to choose the correct KPIs for VWAE container management dashboard solution will use these concepts as primary foundation, but also utilizing further qualitative data such as semi-structured interviews where there are prepared questions but also the adjustment of the interview according to the answers received, allowing for a more in-depth grasp of the performance indicators to be included while also having the scientific backup in the structure of the question set.

2.7. Conclusion

The literature review chapter allowed for an in-depth understanding of the context in which visibility has appeared and how it was framed in SCM. The gradual evolution and applications of technology brought advanced tools that are shaping our day and age. In order to make a compelling argument around increasing the transmission of information with visibility enhancing tools, it was pivotal to harvest these concepts that were scientifically conceived and applied. This chapter provided the necessary structure for the real work at the company to begin. The real-world context poses a lot of volatility that sometimes cannot simply be explained by theoretical models, especially when dealing with the operational layer, where the contact between agents in the supply network in very strong. This is also because competitive markets are moving to light-speed where the main goal is not just to be able to deliver goods and services in an effective way, but to do it as fast as possible. This contributes to the atomization of SCs (Xu et al., 2016) where instead of companies having 20 warehouses (as it was the case 40 years ago), they now have 45 smaller warehouses increasingly closer to the point of consumption. This poses transportation challenges (among others, lead times) to SCs and therefore more opportunities for optimization. According to the concepts addressed in the literature it was possible to see that real efforts have been made both from academia but also from organizations trying to create more value. A lot of what was looked for was found and gladly the main criteria to create a proper theoretical foundation was able to be met. However there seemed to be a small gap between the studies found in the scientific literature and the application of those concepts in real world scenarios. As stated, to fulfill the car orders of production the logistics of VWAE deals with a wide range of suppliers in its daily business activities, and to maintain a continuous cycle of products and services exchange, both parties' benefit from closed-loop circuits where forward and reverse logistics (Ding et al., 2023) take place. This is a very nuanced event to have a visibility bottleneck associated to, and regarding the main thesis objective of increasing visibility in Operational Logistics' CC, very little was found in the literature that could be applied in the company's context to help cope with this challenge. With the completion of the project, it is intended to not only provide a way to help bridge this gap but also contribute with and optimization for the company that can later pave the way for new improvements in procedures of this new SC fast paced markets era.

3. RESEARCH METHODOLOGY

As previously mentioned in the introductory chapter, the research methodology chosen for this project is Mullarkey & Hevner (2018) Action Design Research (ADR). ADR bridges the gap between scientific research and practice and provides a strong foundation for undertaking research. ADR is a methodology that emphasizes the iterative nature of the research process while also allowing for methodical formulation and implementation of solutions, making it especially helpful in the context of a practical application project. In Mullarkey & Hevner (2018) it identifies a four-stage process model. It complements the already established ADR methodology developed by Sein at al., (2011) of four stages and seven principles, with an 8^{th} principle - Abstraction. In Sein et al. (2021) the four stages are (I) Problem Formulating, (ii) Building, Intervention and Evaluation (BIE), (iii) Reflection and Learning, (iv) Formulation of Learning. The first three stages form a cycle of sequencing with the learned results and culminate into the final stage (Mullarkey & Hevner, 2018). However, the BIE cycle found in Sein et al. (2011) is left to open interpretation for the researcher, and as suggested by Mullarkey & Hevner (2018), practitioners could better relate to an explicit ADR Cycle. In the Cycles articulated at VWAE, it was important to have explicit communication of what was required throughout the interactions with practitioners, thus the latter ADR cycle was chosen.

3.1. Action Design Research (ADR)

ADR methodology allows the researcher and practitioners to co-create and intervene directly in the research methodology cycles. In this case the researcher-practitioner is an intern, and the practitioners are the employees at VWAE. There are four stages – diagnosis, design, implementation, evolution - with five activities each and eight principles (Mullarkey & Hevner, 2018). The iterations between these stages, activities and principles happen in a back and forward movement that enriches the research as it progresses. Once a stage has gone through all the activities, a cycle is complete. The cycle repeats until the artifact reaches the desired form. Furthermore, the authors predict the multiple entry points of ADR as a very effective way for researchers to visualize and communicate goals and execution steps. Each of these four stages has a distinct set of objectives, techniques, set of artefacts, and results that can be useful in the practical application domain. In other words, the researcher-practitioner can benefit from the research to optimize its practice. The first activity is the Problem formulating/planning (P), which encompasses 2 principles: practice-inspired (1) and Theory Ingrained (2). The second activity is the Artifact creation stage (A) that has abstraction (8) as the only principle. The third activity is the evaluation (E) which comprises the principles of authentic & concurrent evaluation (5) and mutually influential roles (4). The fourth activity is reflection (R) that encompasses the sixth principle, guided emergence (6). The fifth activity is learning formulating (L) having the generalized outcomes principle (7). The third principle (3) is the reciprocal shaping applied between the Learning (L) and Problem formulation (P) activities. This project used the ADR problem centered approach as seen in figure 2.

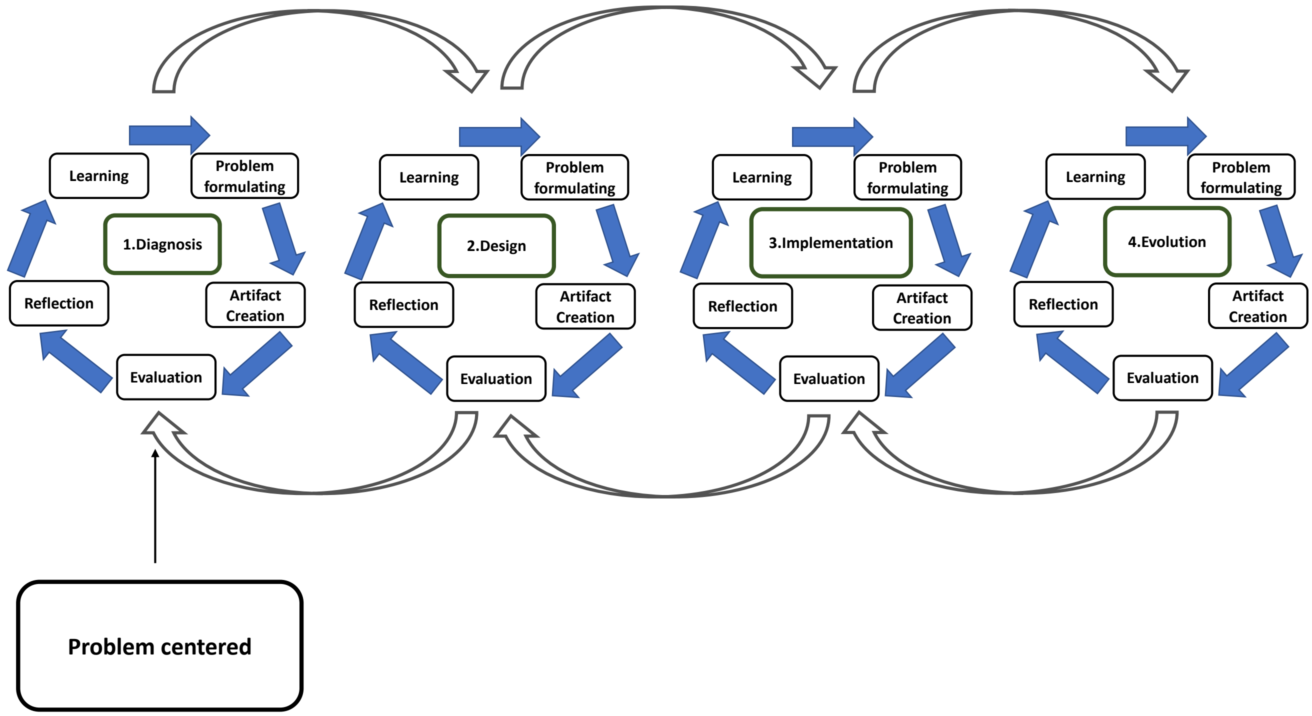

Figure 2 – ADR Cycle, adapted from Mullarkey & Hevner (2018)

3.1.1. Diagnosis

As stated by Mullarkey & Hevner (2018), the first ADR stage is the diagnosis, and it has the purpose of analyzing the underlying root-cause of a problem in its domain and identifying the artifact that will evolve into the solution. To diagnose the pains felt in this domain, two major stages will be considered. Firstly, the process mapping is developed. This stage will allow to build the structure and map the path used by practitioners and provide visual clues of which steps of the daily process need optimizations and how will it affect the outcome of the process itself. The mapping of the container request allocation process will then be established referring to reverse logistics. A flow chart is expected in the results chapter to represent the operational procedure that analysts tasked with opening container requests and allocating them to part suppliers must endure daily. For the process mapping flowchart, the research will use Microsoft PowerPoint and Microsoft Visio software for the visualizations. The data gathering process will encompass direct and participatory observation as the researcher is also a practitioner, focus groups, semi-structured interviews, MS Word, MS Excel, MS PowerPoint, PDF documents review and internal Volkswagen Group Software. These data gathering procedures will be established with the collaboration of CC specialists, the manager, CC coordinator and Press, body & paint coordinator. With their collaboration the second stage will be developed - The “5 whys” technique. It is a simple but powerful way to troubleshoot problems by exploring cause-and-effect relationships (Serrat, 2017). It serves as a straightforward yet potent approach, encouraging profound problem-solving through a sequence of iterative questioning. This method involves questioning the answer five times, fostering in-depth analysis and quick adaptability for a wide range of problems. The technique's effectiveness is contingent on adherence to three crucial elements: (i) articulating problems accurately and comprehensively, (ii) responding to the questions with complete honesty, and (iii) maintaining a resolute commitment to uncovering the root causes and resolving issues. There are a few steps to follow with this technique:

1. Within the department environment, develop the problem statement.
2. Ask the first why and record the first answer obtained.
3. Ask four more successive “whys”, repeating the recording of the answers. When asking “why” yields no further useful information, the root-cause is identified.
4. In the middle of the statements provided, identify systemic causes of the problem. A systemic cause is understood as a cause that comes from a broader organizational problem but has impacts on local and focalized processes.
5. When the most probable root cause is settled, and the diagnosis is complete, proceed to the next ADR stage.

The inefficiency challenge will be regarded from two perspectives: Excessive employee workload and high operational costs and waste. For this reason, the technique will be adapted and have three questions for each perspective, making six questions instead of five. The artifact creation activity in this stage refers to the solution ideation of the inefficiency challenge that the problem formulation will identify with the technique from Serrat et al. (2017).

3.1.2. Design & implementation

The Design stage and implementation stage are expected to be performed in loop sequences in a back and forward movement. This means the first design implemented receives feedback, which will require further re-design and so on until the dashboard reaches its final form. The reasoning behind this sequence is the fact that it isn’t known what the outcome should look like, therefore, this iteration of the ADR enables the artifact to become more robust as each cycle takes place. Using the Miro.com application the conceptual model will be built to provide the structural format of the database. The tool chosen to perform these operations will be Qlik Sense. This tool was already being used at VWAE to enhance operational logistics within VWAE Material Handling operations, focusing on key performance indicators. It highlights three main metrics: handling unit, delivery, and warehousing, offering a detailed view of efficiency across the VWAE network. Integrated with SAP (Systems, Applications, and Products in Data Processing) for daily updates, it allows for real-time data analysis without manual effort. The platform supports dynamic evaluation, showcasing trends and operational insights through numeric and visual representations. The design stage will focus on the identification and conceptualization of the proposed solution artifact design, which in this case, will require a solution that addresses the problem formulated using practical and available resources. As stated by Mullarkey et al., (2018) a design artifact may be a model, method, or set of design principles, which assists in establishing a structure for the designed solution. As seen in the literature review, several tools to address the visibility bottleneck were presented. Due to the nature of the challenge and the organizational environment, the dashboard seemed sounder in this setting. Using Qlick sense, the design stage was divided into six layers to build the artifact that is referred in this stage as "Mockup version" of the dashboard which corresponds to the dashboard zero. The layers will correspond to the CRISP-DM framework (Jaggia et al., 2020; Chapman et al., 2000; Schröer et al., 2021) for designing and execution of the dashboard structure: (1) business understanding, (2) data understanding, (3) data preparation, (4) modeling, (5) evaluation, and (6) deployment (Chapman et al., 2000). In parallel with the CRISP-DM framework, the ADR methodology cycles are expected to foster the reflective and adaptive approach to the dashboard's development. The combined use of CRISP-DM for ETL and modeling, along with ADR for improvement cycles, will constitute a comprehensive strategy for the artifact's development. Literature will be used to find clues for KPI selection. Combined with focus groups, direct feedback, direct and participatory observation, document review, KPIs will be selected to meet the challenge's requirements.

Table 2 - CRISP-DM phases and corresponding project learning objectives

CRISP-DM Phases	Project Learning Objectives
Business Understanding	Formulation of questions to grasp the business strategies or actions
Data Understanding	Describe the data in terms of the business context.
Data Preparation	Perform data wrangling to prepare the data for subsequent analyses.
Modeling	Develop predictive model(s) to inform decision making.
Evaluation	Evaluate model performance and select the best predictive model(s).
Deployment	Communicate key findings through storytelling

3.1.3. Evolution

After implementation, the artifact in the evolution stage will be a dashboard that has all the technical elements established. During this stage, the dashboard will use focused group blocks to help reassess the advantages and shortcomings and improve. This is very analogous to a compass needing to be calibrated to give the exact directions. This problem means that more assessment measures will be taken to bridge this gap and calibrate the dashboard accordingly. There are some keys questions that aided the assessment and recalibration of the tool. Furthermore, the research will have a survey to assess the effectiveness of the dashboard from the practitioner's perspective. The questions range from multiple choice questions to Likert scale (Likert, 1934) questions. The dashboard survey is meant to be divided into two blocks of questioning. The main goal for this process is to obtain practical feedback from the practitioners, and in the first block the questions will assess the practitioner's perspective about the dashboard's visual organization, whether the fields are easy to locate, the overall attractiveness, the colors and charts, and the ability of the dashboard to present comprehensive information.

Table 3 – Survey's question block 1 and assessment objectives

Question block 1	Likert scale				
	1.Completely disagree	2.Partially disagree	3. Neither agree nor disagree	4.Partially agree	5. Completely agree
	Assessment objective				
1.1. In terms of the visual presentation of the dashboard, the dashboard design is suitable for identifying all displayed fields.	Understand effectiveness of the visual aspect of the dashboard regarding the user's perspective.				
1.2. The visual organization of the dashboard clearly separates financial indicators from inventory level indicators.	Understand effectiveness of the dashboard on proving the user with the visual clues be able to separate the financial indicators from inventory level indicators.				
1.3. Overall, the dashboard's attractiveness makes the analysis experience less tiring.	Assess the user's perspective on the attractiveness of the dashboard. This factor will play a key role when the analysis' period is longer, and the screen time can increase fatigue and quality of the analysis.				
1.4. The colors used are consistent and appealing throughout the entire dashboard and yet do not distract the user from the focus.	This question aims to ensure that the dashboard's design facilitates an intuitive and user-friendly interface that aids in information analysis without visual overload.				
1.5. The graphs used, in visual terms, allow for a concrete idea of the intended information.	This question seeks to validate that the dashboard's visual graphs are not only aesthetically pleasing but also functional in delivering precise and actionable insights to the user.				

The block 1 final question aims to assess the user's ability to understand the information portrait in the dashboard by the way it is presented visually. This uses a multiple-choice type of question to allow the surveyed user to express whether they need the help of external resources to grasp the information.

Table 4 – Survey's question block 1 final question

1.6. The way the data is presented allows for a clear understanding of what information it pertains to.			
A. I can perceive it without difficulty.	B. I can perceive it with some difficulty.	C. I can perceive it after a second analysis and/or additional research.	D. I cannot perceive it.

Furthermore, the second questioning block will try to get a grasp on the practitioners' perspective about the user-friendliness of the interface, the performance or loading speed, the relevance and customization of the presented information and the overall effectiveness of the support documents and procedures. During the results chapter it will be expected to have answers to these questions and draw conclusions about the impacts of the implemented dashboard. It starts with an initial multiple-choice question followed by six Likert scale type of questions. The multiple-choice question aims to assess the ability of the users to navigate the tool by themselves allowing them to choose an option that enables the understanding of the degree of difficulty they witness while utilizing the tool.

Table 5 – Survey's question block 2 initial question

2.1. Regarding the intuitiveness/user friendliness of the tool, which of these statements do you consider more accurate in terms of user experience?			
1. I can navigate through the tool without difficulties.	2. I have some difficulty navigating through the tool.	3. I can navigate through the tool with great difficulty.	4. I cannot navigate the tool.

Table 6 – Survey's question block 2 and assessment objectives

Question block 2	**Likert scale**				
	1.Completely disagree	**2.Partially disagree**	**3. Neither agree nor disagree**	**4.Partially agree**	**5. Completely agree**
	Assessment objective				
2.2. With the tool, it is possible to easily find critical information.	To determine the dashboard's efficiency in allowing users to locate and access essential information with minimal effort.				
2.3. The dashboard manages to upload and update quickly, remaining stable when handling data volumes.	To evaluate the dashboard's technical performance in terms of data processing speed, update frequency, and stability under various data loads.				
2.4. Overall, I consider the dashboard experience to be very "user-friendly".	To assess the overall user experience, specifically the ease of use, intuitiveness, and accessibility of the dashboard interface.				
2.5. I can easily customize the dashboard to my liking.	To understand the level of personalization and customization the dashboard allows, enabling users to tailor it to their preferences and needs.				
2.6. The technical support provided by the research intern helps to learn how to navigate the dashboard.	To evaluate the effectiveness of the support provided by the researcher in facilitating user understanding and navigation of the dashboard.				
2.7. Text support in digital format (instruction manual) is sufficient for manipulating the tool.	To determine if the digital documentation provided is adequate for users to effectively operate and utilize the dashboard without additional assistance.				

4. CASE STUDY

4.1. Company Introduction

Volkswagen AutoEuropa, situated in Palmela near Lisbon, Portugal, is a key automotive manufacturing facility inaugurated by Volkswagen in 1995, following its establishment in 1991. As Portugal's largest foreign industrial venture, this plant has significantly contributed to the local economy. Initially gaining attention for securing the production of the Volkswagen Eos convertible/coupé in late 2005—with a production count of nearly 79,896 for the Eos and its original models—the facility expanded its portfolio in 2008 by beginning the manufacture of the third-generation Volkswagen Scirocco. Currently, the plant boasts approximately 3,000 onsite employees, supports 2,350 jobs at the supplier level in the industrial park, and creates an additional 3,750 supplier-related positions across Portugal. Volkswagen Autoeuropa is celebrated for its production of notable models like the T-Roc, Sharan, and the SEAT Alhambra. In 2023, the facility was honored with the prestigious Automotive Lean Production Award in the OEM category, marking a milestone in its commitment to excellence in the automotive manufacturing sector. The plant plays a crucial role in the supply chain management, overseeing the entire process from the procurement of raw materials to the distribution of finished vehicles, ensuring the efficient movement and storage of materials, timely delivery to production lines, and swift dispatch of completed vehicles to customers.

4.2. Diagnosis

Problem formulating is the first activity of the cycle and the process of accurately identifying the problem makes the path to a prominent solution much clearer. Therefore, the diagnosis consisted in mapping the process and afterwards performing the "5 whys" technique. This approach allowed to understand where the diagnosis was operating, and why the challenges were occurring.

4.2.1. Process mapping

The first thing to do in this stage was to locate the exact point where this analysis took place. The researcher accomplished this by mapping the process where the desired solution for inefficiencies occurred. The information was obtained through review of internal file sources and software databases. - The container allocation process seen in figure 3 goes as follows. In the beginning of the process, the analyst must understand whether there is excess or lack of containers. This is possible to see in the system and its exported MS Excel files. If the difference between the demand for containers and the available stock is negative, there is a lack of containers and usually the supplier formalizes a complaint. In this case the process follows the "down" course. The analyst then tries to understand if the complaint makes sense by rechecking the available stock against the supplier's demand level of containers. If the complaint doesn't make sense, it means a truck is late and will arrive at his warehouse shortly. If there is indeed a lack of containers, the supplier is authorized to use alternative cardboard containers. This is a sub-optimal solution considering the waste reduction goals. If the number of available containers is superior to the demand level, there is excess. In this case the goal is to reduce stock costs, therefore, the analyst looks for unattended requests of packaging in the "limbo" or virtual factory. These are requests that didn't arrive in time and the system allocated them to a separate place. If there are requests in the factory, the analyst pulls them into the main frame and allocates the excess to them. If there aren't any in the virtual factory, the analyst makes one last effort to outbound the excess by contacting the supplier directly to check if he submitted a request that didn't go through in the system. If he did then the analyst pulls that request and allocates the excess container to it, ending the process.

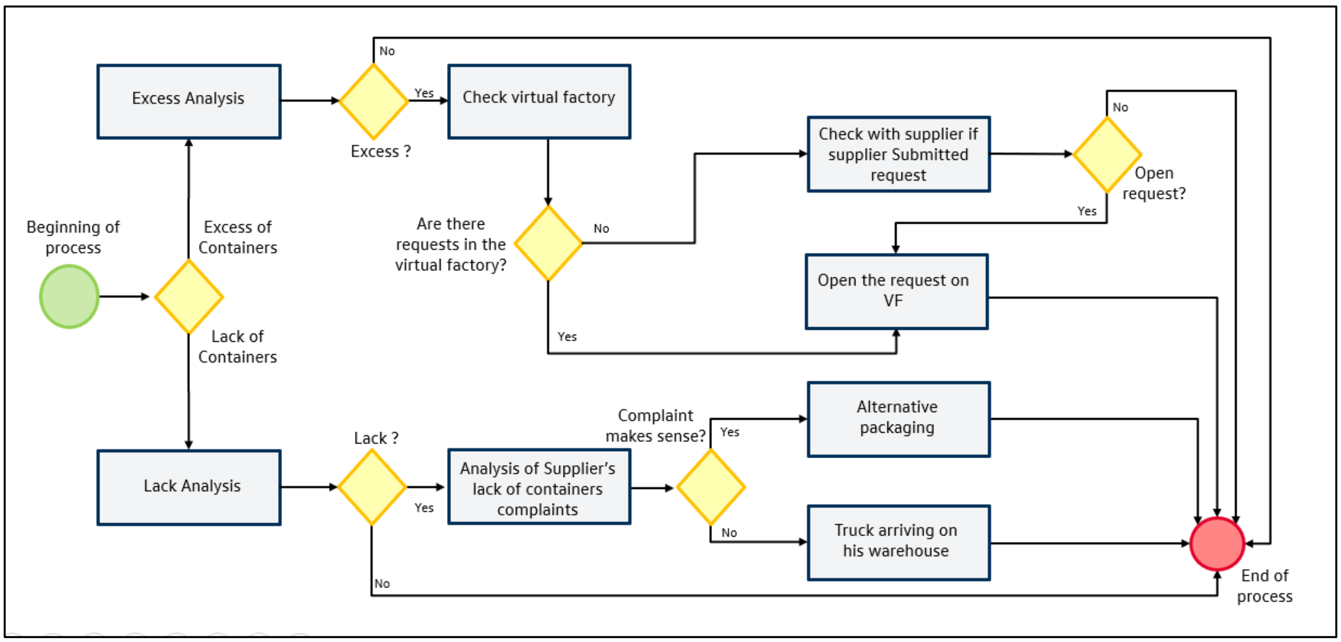

Figure 3 - Flowchart of Container Request allocation process at VWAE

4.2.2. The "5 whys" technique

As seen in the introduction, the challenge happens in the container request and allocation process of the CC team in the material handling department of the operational logistics unit at VWAE. Usually, when cars are scheduled to be made a planned quantity of parts is required from the parts suppliers, that in turn will request container/packaging to carry those parts back to the factory. The defined and agreed problem in the CC team is inefficiency of the container request process. A set of inquiries to understand the root cause of inefficiency took place. These questions were systematically answered by 2 container control specialists and the Body shop, Press and Paint coordinator. Figure 5 demonstrates the "5 whys" framework adapted from Serrat (2017). The original technique assesses the root cause using five questions. On this adaptation the researcher subdivided the inefficiencies into two layers and performed the questioning separately. This can be narrowed down to excessive employee workload and high operational costs and waste as inefficiencies being caused by communication bottlenecks. This means some of the challenges being faced weren't visible in a holistic manner, rather, analysts had to manually dissect the causes to provide managers with the information so they could make decisions. This process of understanding the underlying root causes aided the research in finding the direction followed to build the dashboard.

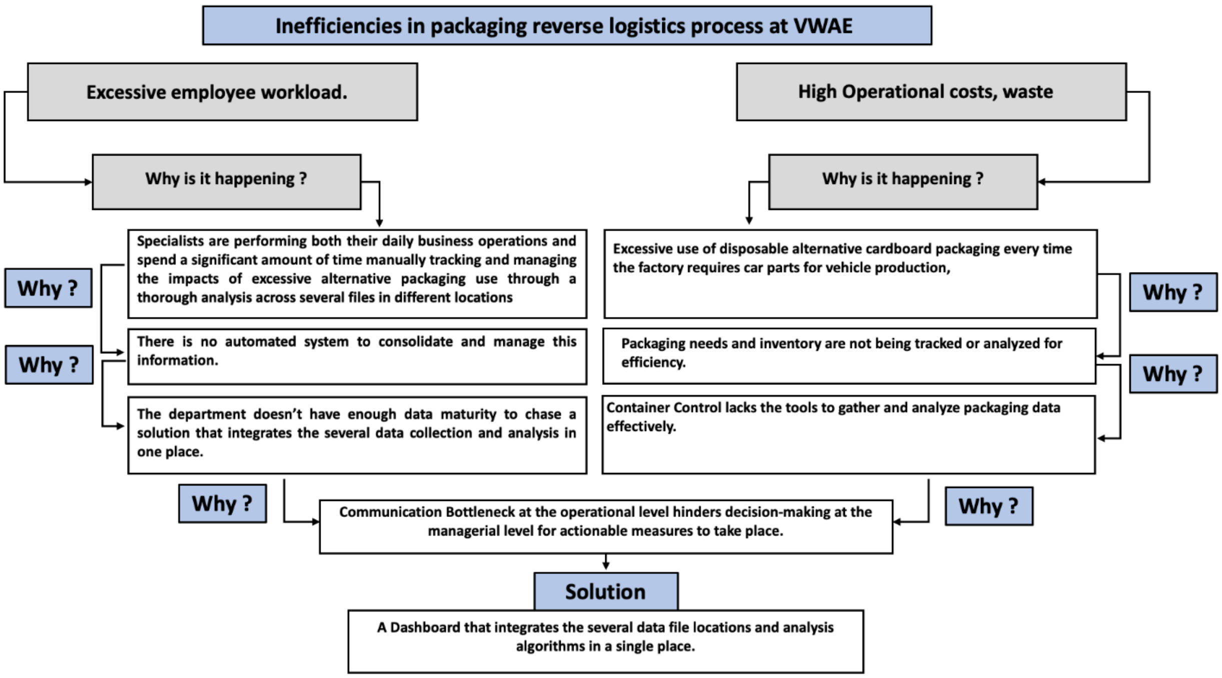

Figure 4 - five whys framework, adapted from Serrat (2017)

4.3. Design stage & implementation.

During the process of designing the data structure, the CRISP-DM method for data collection and preparation was followed (Wirth & Hipp, 2000), resulting in a consistent and robust data source. This equally contributed to the reduced duplication of data and low redundance level that proved its importance when building the dashboard and obtaining accurate values for the KPIs. Literature suggests cost, profit excess inventory, stock-out, resource measure as performance metrics in supply chain for the decision-making process (Anand & Grover, 2015).

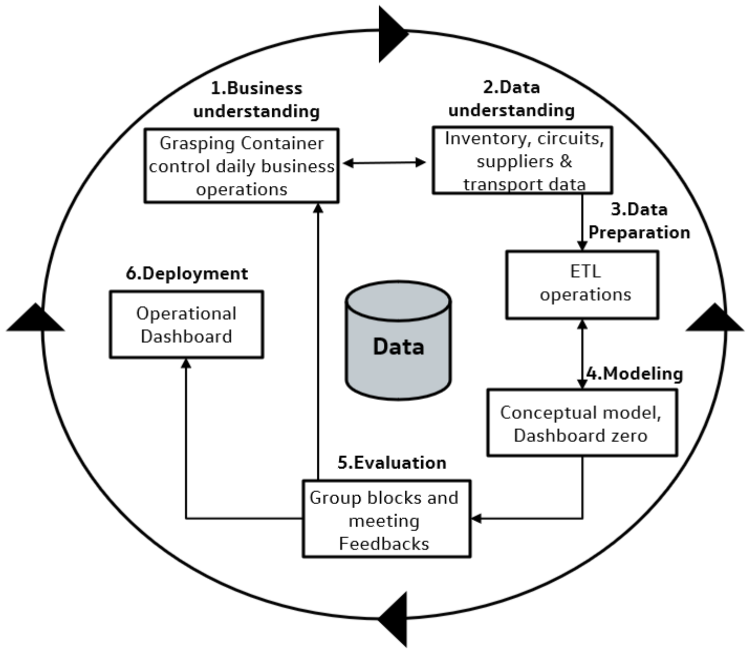

Figure 5 - CRISP-DM life cycle in Container Control Volkswagen AutoEuropa, adapted from Wirth & Hipp (2000).

Business understanding is to understand the project's objectives and requirements from a business perspective and converging this knowledge into a data mining problem (Jaggia et al., 2020). The goal was to find metrics that supported the decision-making process regarding the management of reverse logistics packaging. Daily business at CC translates to maintaining the stock level of these packaging as close as possible to their demand through management actions. From this point the direction pursuit should be in terms of converging the container management daily business into mining data specifically related to container inventories and supplier needs.

The data understanding and data preparation phase enabled the researcher to identify some issues with the way data was structured, therefore a thorough extraction, transform and load (ETL) process had to be performed to clean the data and reduce it to the most relevant information. This encompassed going through the internal file locations and analyzing a vast repertoire of information on the formats like Microsoft Excel, PDF, Microsoft PowerPoint, Microsoft Word, as well as internal Volkswagen software(Behältermanagement LISON), where real-time data about supplier needs are displayed. The modeling started with rudimentary ideation of the conceptual model of what the data structure should look like.

The Conceptual model was elaborated – Appendix A. This allowed for a visual roadmap to what the backend source of the dashboard should look like. The ETL process was done by using Microsoft Excel to clean and structure the data in tables. Each excel sheet is supposed to be a table. After the preparation is done, the Excel file is then uploaded into Qlick sense. This way it is possible to process a lot of information and manipulate the tables as they were variables. The evaluation and deployment happened after the ELT process occurred, having received the first feedback on the mockup version of the dashboard – Appendix B. The first stages of the mockup benefited from constructive appreciation and bridging the gap between the presented artifact mockup and the expectations in the organizational setting. With both managerial and technical support, the learning activity contributed to the consolidation of the artifact. Another procedure that assisted in enriching the data source was finding B2B durable packaging suppliers' prices that impacted the business case regarding investment costs. Prices were not updated in the data sources used as the values varied with external factors such as inflation that put a burden on operational and transportation costs. The suppliers' origin ranged from Nacional to foreign. The researcher-practitioner established direct contact with the suppliers' representatives and added the updated values to the data source, firstly in MS Excel and then in the Qlick sense application.

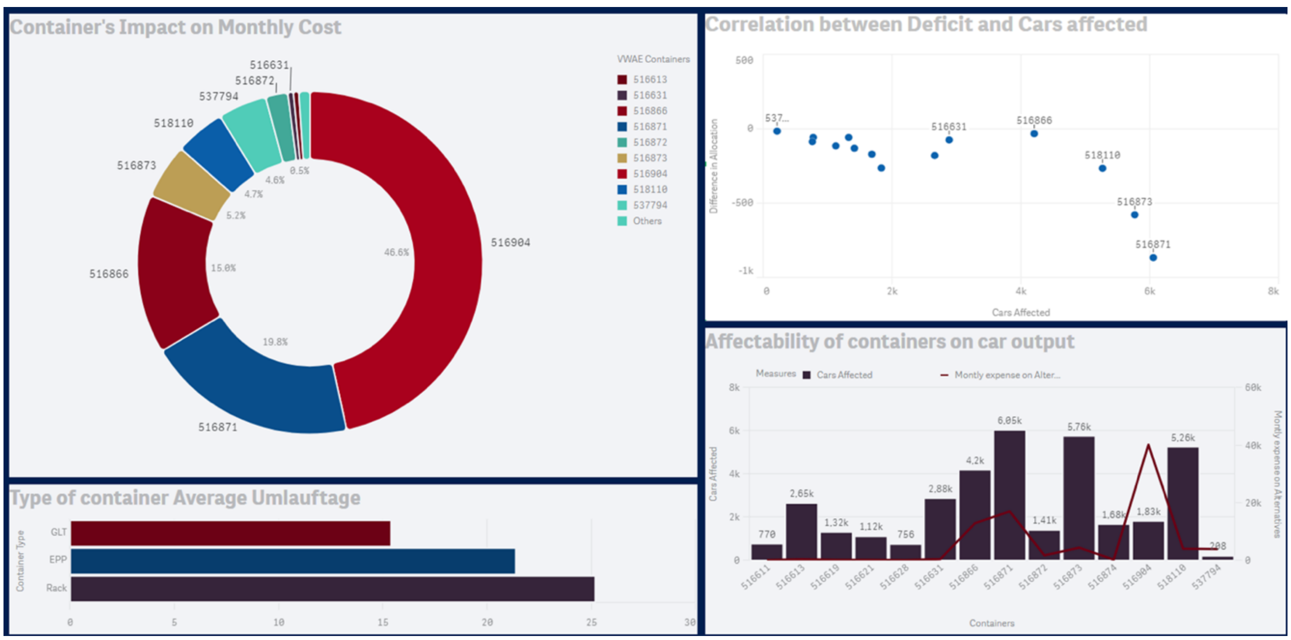

Figure 6 – Dashboard "zero"

As per the literature, the dashboard in figure 6 presents costs as a KPI and splits it up into different inventory items responsible for the portion of total cost illustrated in the second quadrant of the dashboard. Furthermore, there is the affectability of each container on the weekly car output as the KPI in the fourth quadrant, the type of container average days' worth of stock needed in the close-loop circuits and a scatter graph with the correlation between the deficit of each container and the number of cars they affect.

Table 7 – KPI selection from semi-structed interviews

Practitioner	Semi-structured Interview Outcome	KPI selected
Operational Logistics manager. CC specialists	Financial Outline must consider operational costs to make decisions about the availability of current container stock. If the costs are higher than the investment, a business case to invest leads to operational costs mitigation.	Operational costs; Investment Cost; Cost avoidance
Press, body & paint coordinator	Constantly review Safety stocks needs according to lean inventory management. Continuous improvement philosophy entails to always question the actual necessity of having a safety net, which burdens the days' worth of stock needed	Production volume (UPD); Delta between Demand and available stock;

These inputs were very insightful to help develop the dashboard's KPIs and even to break them down into a subset of information to provide more details for the decision-makers. The dashboard after this ADR implementation cycles shifted to the one seen in figure 7.

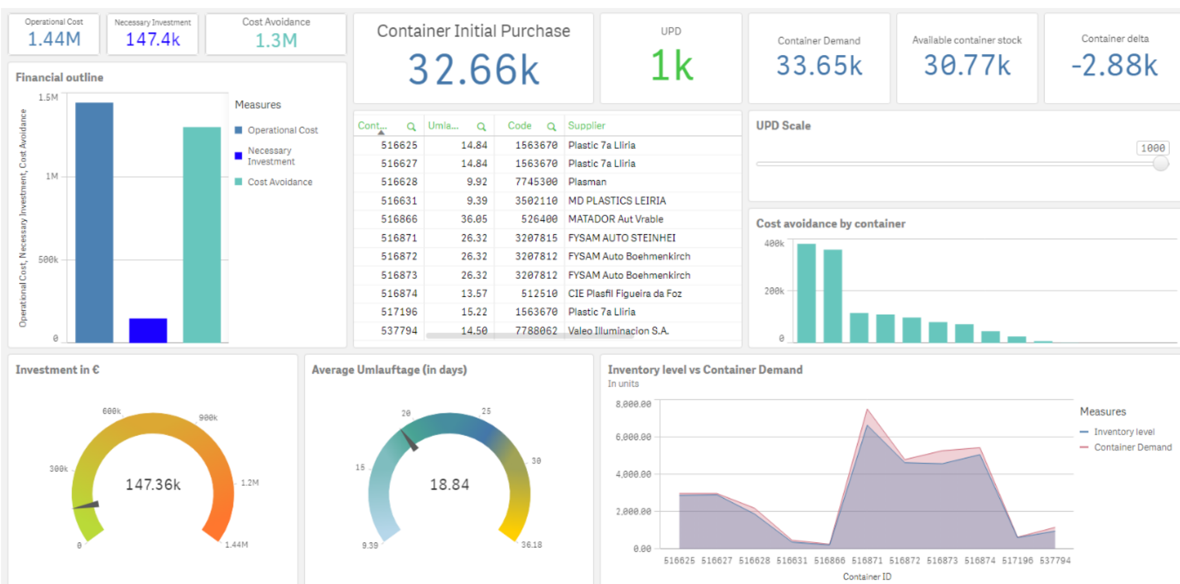

Figure 7 – Dashboard 1.0

To input data in the source of the dashboard it took some research on multiple internal files and confirmation with the coordinator of Press, body & paint to arrive at the correct data and transform it into the same business logic applied in the dashboard KPIs. This shows how the span of the routine for obtaining the relevant data for this analysis is inefficient in terms of time and cost in case a specific analyst was to be hired for this task. The dashboard made the analysis way more efficient in terms of time saving and the number of resources applied to gather results, as one specialist is now capable of having information about financial and inventory KPIs by consulting the dashboard rather than having to perform a complex analysis that requires multiple data files to calculate the results seen in figure 7.

The implementation walkthrough process in figure 8 goes as follows: The researcher sat down with each CC specialist and explained how to navigate the tool. After that he proceeded to distinguish different streams of work inside the platform and to duplicate an application from a public stream into a personal stream so the application can be worked on without changing the public one. If the action is understood they move to the next action if not repeat the previous. The researcher walked the specialist through the data preparation action and how to map the QS drive file to the application. Then he walked the specialist through loading the data and the automatic script insertion. After that the researcher explained the data structure model and how the CC logic translated into the algorithmic logic step by step. When these actions were understood and they were able to perform them on their own, the next action was to interact with the dashboard figures and extract the necessary information.

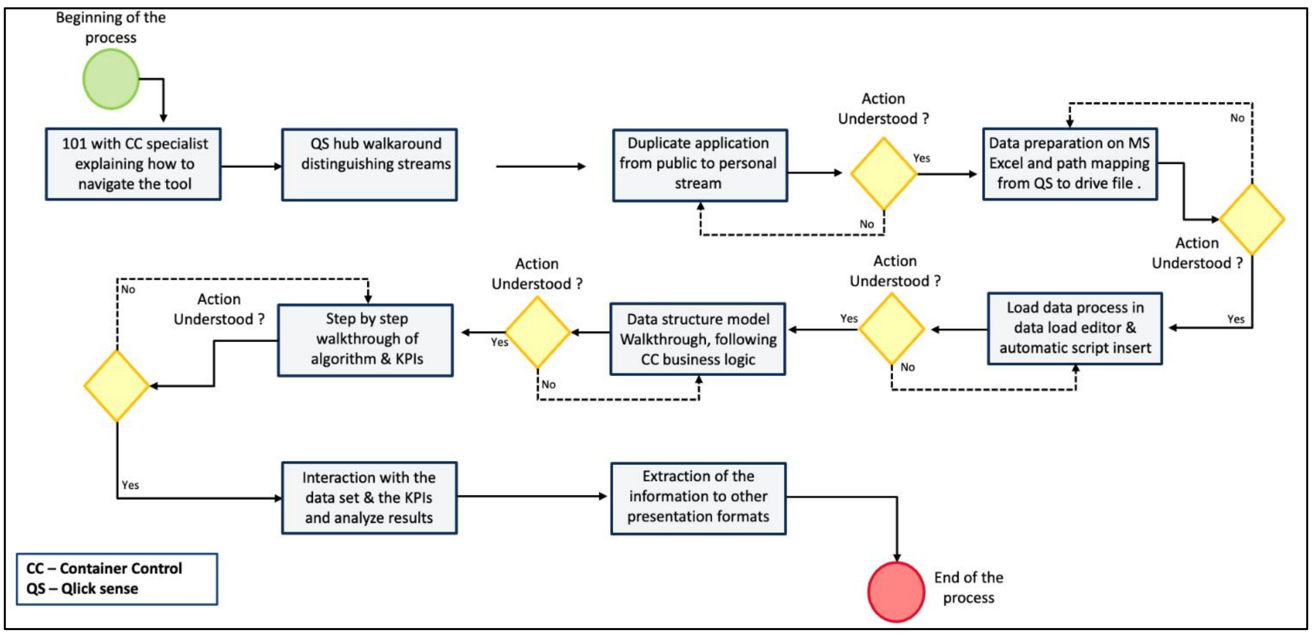

Figure 8 – Implementation walkthrough process between researcher and practitioner.

4.6. Evolution stage ADR and survey results

In addressing the challenge of low visibility, after implementing the dashboard, it underwent an evaluation process, drawing on stages outlined by Nunamaker et al. (2015). This process was pivotal in validating the dashboard's effectiveness, employing a structured feedback mechanism through focus groups. These sessions facilitated direct engagement with the end-users—employees who interacted with the dashboard daily. Through follow-up statements designed to probe the dashboard's proof-of-concept (POC), proof-of-use (POU), and proof-of-value (POV), the researcher was able to gather invaluable insights from the employees' perspectives. This feedback loop proved instrumental in refining the dashboard, ensuring it met employees' expectations in terms of functionality and decision-making support – Appendix E. Consequently, the evolution of the dashboard since its inception reflects a significant advancement towards achieving operational excellence, underscored by the tangible improvements in data-driven decision-making processes among users.

4.6.1. Final dashboard version

In addressing the challenge of low visibility, after implementing the dashboard, it underwent an evaluation process. With this, the dashboard changed in terms of layout organization, colors used and the KPIs were divided into further metrics, allowing portrait measures more accurately. It is possible to see in figure 8 that the financial indicators are now placed on the left side of the sheet, and the inventory ones, on the right side. The red color is used to display both negative values and values above the actual stock, indicating that those metrics might require more attention. There are now two gauge charts for weekly and monthly operational costs and one gauge for the necessary investment for that equivalent level of deficit in inventory. The graph on the bottom right represents the inventory level against the demand for that same inventory.

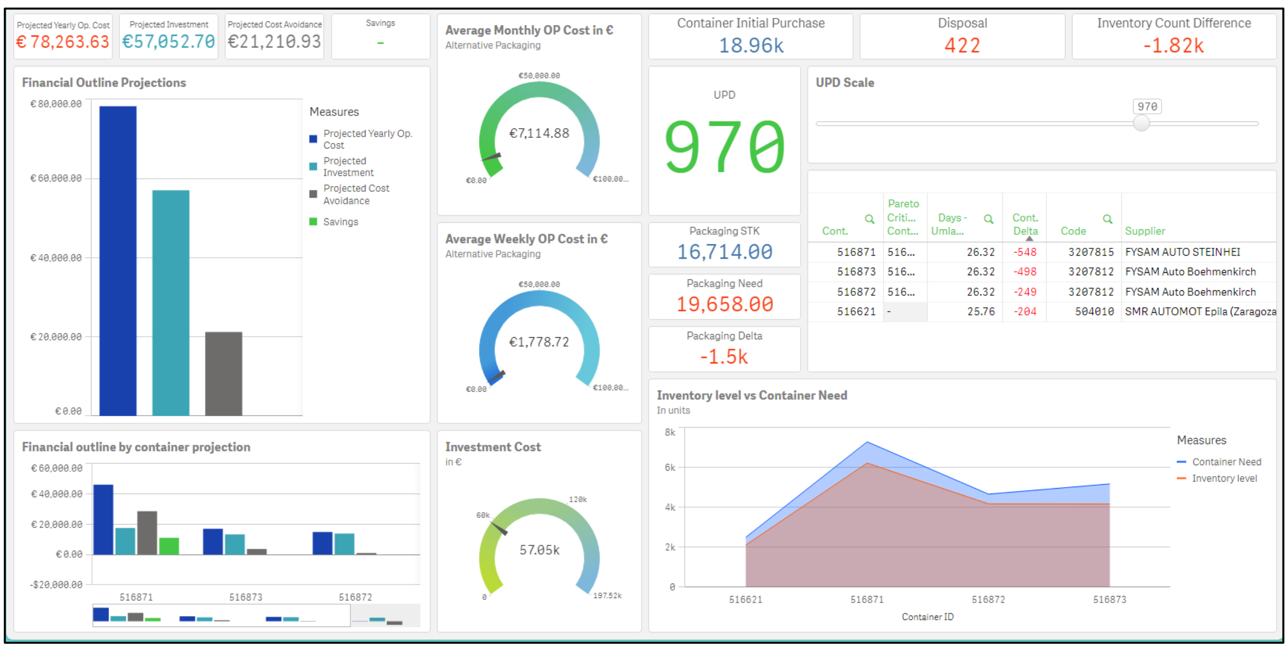

Figure 9 – Dashboard final version

4.6.2. Final evaluation

In terms of the visual presentation of the dashboard, all practitioners agreed that the dashboard design was suitable to identify all the displayed fields. As seen in table 7.1. When trying to assess the ease with which people could locate and identify the fields, the answers were 100% unanimous.

Table 7.1 - Analysis of Question 1.1. answers

Q 1.1				
n = 4				
Scale	Numerical value	Responses	Total	%
1.Completely disagree	1	0	0	0%
2.Partially disagree	2	0	0	0%
3. Neither agree nor disagree	3	0	0	0%
4.Partially agree	4	0	0	0%
5. Completely agree	5	4	20	100%
AVG	**5**			
Std dev.	**0**			

Regarding the visual organization's ability to enable the separation of financial indicators from inventory level indicators, practitioners' answers on average expressed a value of 4.75 which indicates that they completely agreed on this point as seen in table 7.2. below. The standard deviation of 0.5 tells us that the answers don't differ too much from each other.

Table 7.2 - Analysis of Question 1.2. answers

Q 1.2				
n = 4				
Scale	Numerical value	Responses	Total	%
1.Completely disagree	1	0	0	0%
2.Partially disagree	2	0	0	0%
3. Neither agree nor disagree	3	0	0	0%
4.Partially agree	4	1	4	25%
5. Completely agree	5	3	15	75%
AVG	**4.75**			
Std dev.	0.5			

When it came to the fatigue, practitioners on average completely agreed that the attractiveness of the dashboard allows for a less tiring experience, especially when analysts must spend more of their time reviewing values. - Figure 7.3.

Table 7.3 - Analysis of Question 1.3. answers

Q 1.3				
n = 4				
Scale	Numerical value	Responses	Total	%
1.Completely disagree	1	0	0	0%
2.Partially disagree	2	0	0	0%
3. Neither agree nor disagree	3	0	0	0%
4.Partially agree	4	1	4	25%
5. Completely agree	5	3	15	75%
AVG	**4.75**			
Std dev.	**0.5**			

Regarding the color used, the practitioners on average agreed that they are appealing and don't distract the user from the KPI assessment. The standard deviation of 0.96 means that there was some dispersion among answers as 25% of respondents had a null opinion about this question, but as seen in figure 7.4. they remained within the agreeability scope.

Table 7.4 - Analysis of Question 1.4. answers

Q 1.4				
n = 4				
Scale	Numerical value	Responses	Total	%
1.Completely disagree	1	0	0	0%
2.Partially disagree	2	0	0	0%
3. Neither agree nor disagree	3	1	3	25%
4.Partially agree	4	1	4	25%
5. Completely agree	5	2	10	50%
AVG	**4.25**			
Std dev.	**0.96**			

When asked if the graphs used enabled users to have a good idea of the information intended to be transmitted, only 25% had a null agreement sentiment, the remaining 75% completely agreed. This leaves a standard deviation of 1 which implies that while there is some consensus among the respondents, there is also a differing view within the level of agreement.

Table 7.5. Analysis of Question 1.5. answers

Q 1.5				
n = 4				
Scale	Numerical value	Responses	Total	%
1.Completely disagree	1	0	0	0%
2.Partially disagree	2	0	0	0%
3. Neither agree nor disagree	3	1	3	25%
4.Partially agree	4	0	0	0%
5. Completely agree	5	3	15	75%
AVG	**4.5**			
Std dev.	**1**			

In table 7.6, it is possible to see that 50% of respondents can perceive what information the dashboard relates to just by the way the data is presented, 25% can perceive it with some difficulty and the other 25% can perceive it after additional research.

Table 7.6 - Analysis of Question 1.6. answers

Q 1.6			
n = 4			
Option		ANSWERS	%
I can perceive it without difficulty.	A	2	50%
I can perceive it with some difficulty.	B	1	25%
I can perceive it after a second analysis and/or additional research.	C	1	25%
I cannot perceive it.	D	0	0%
Mode	**Option A**		

The overall responses to the first question block are positive, with the general average of the five Likert scale questions equal to 4.65, meaning that the dashboard visual design aspects were successful from the user perspective. Furthermore, this checks out with the POC demonstrating the functional feasibility of the solution, and POV (Nunamaker et al., 2015) as CC users can create value by using the tool to predict scenarios of production volume increase to make decisions.

4.6.3. Dashboard's Interface user-friendliness analysis

Moving to the second question block where the researcher tried to assess intuitiveness and user-friendliness of the tool. As seen on table 7.7, 100% of respondents said they can navigate the tool without difficulty (option A), which meets the criteria for POU where users can self-sustain practice by using the implemented solution (Nunamaker et al., 2015).

Table 7.7. Analysis of Question 2.1. answers

Q 2.1			
n = 4			
Option		ANSWERS	%
1. I can navigate through the tool without difficulties.	A	4	100%
2. I have some difficulty navigating through the tool.	B	0	0%
3. I can navigate through the tool with great difficulty.	C	0	0%
4. I cannot navigate the tool.	D	0	0%
Mode	**Option A**		

When asked about finding critical information within the tool, 75% of respondents completely agreed that it is easy and intuitive, while 25% partially agreed. This leaves a standard deviation on 0.5, meaning that the answers don't differ much from everyone.

Table 7.8. Analysis of Question 2.2. answers

Q 2.2				
n = 4				
Scale	Numerical value	Responses	Total	%
1.Completely disagree	1	0	0	0%
2.Partially disagree	2	0	0	0%
3. Neither agree nor disagree	3	0	0	0%
4.Partially agree	4	1	4	25%
5. Completely agree	5	3	15	75%
AVG	**4.75**			
Std dev.	**0.50**			

Regarding the ability of the dashboard to load information quickly, the respondents agreed that the application remains stable. Specifically, 50% completely agreed and 50% partially agreed. This indicates that the application can withstand vast amounts of data while operating without crashing down, which is one of the reasons to use these types of BI tools as a complement to MS Excel to extend practitioners analytical capabilities.

Table 7.9. Analysis of Question 2.3. answers

Q 2.3				
n = 4				
Scale	Numerical value	Responses	Total	%
1.Completely disagree	1	0	0	0%
2.Partially disagree	2	0	0	0%
3. Neither agree nor disagree	3	0	0	0%
4.Partially agree	4	2	8	50%
5. Completely agree	5	2	10	50%
AVG	**4.5**			
Std dev.	**0.50**			

When asked if the dashboard overall performance is "user-friendly", 75% of respondents said they completely agreed that it was as seen in table 7.10. This response meets one of the requirements posed by the manager at the beginning of the challenge.

Table 7.10. Analysis of Question 2.4. answers

Q 2.4				
n = 4				
Scale	Numerical value	Responses	Total	%
1.Completely disagree	1	0	0	0%
2.Partially disagree	2	0	0	0%
3. Neither agree nor disagree	3	0	0	0%
4.Partially agree	4	1	4	25%
5. Completely agree	5	3	15	75%
AVG	**4.75**			
Std dev.	**0.50**			

The questions also tried to assess the dashboard's customizable characteristics, and as seen in table 7.11, 50% of respondents completely agreed that it is easy to customize, while the remaining respondents' sentiment was split between partially agreed and a null sentiment. This leaves a total average of 4, which is a positive outcome as they agreed with the statement.

Table 7.11. Analysis of Question 2.5. answers

Q 2.5				
n = 4				
Scale	Numerical value	Responses	Total	%
1.Completely disagree	1	0	0	0%
2.Partially disagree	2	0	0	0%
3. Neither agree nor disagree	3	1	3	25%
4.Partially agree	4	2	8	50%
5. Completely agree	5	1	5	25%
AVG	**4**			
Std dev.	**0.82**			

When asking the participants of the survey what their opinion on the researcher technical support was while implementing the tool and explaining its functionalities, the total average was 4.5. This enables us to infer that the support given was helpful to properly understand and use the tool.

Table 7.12. Analysis of Question 2.6. answers

Q 2.6				
n = 4				
Scale	Numerical value	Responses	Total	%
1.Completely disagree	1	0	0	0%
2.Partially disagree	2	0	0	0%
3. Neither agree nor disagree	3	0	0	0%
4.Partially agree	4	2	8	50%
5. Completely agree	5	2	10	50%
AVG	**4.5**			
Std dev.	**0.58**			

The same conclusion can be taken in question 2.7, as the instruction manual also had a positive reinforcement on providing the necessary support to manipulate the dashboard. The answers ranged from 3 to 5 in the Likert scale, having 50% of complete agreement, 25% in partial agreement and 25% with a null sentiment, implying that the digital support was sufficient to aid users manipulating the tool.

Table 7.13. Analysis of Question 2.7. answers

Q 2.7				
n = 4				
Scale	Numerical value	Responses	Total	%
1.Completely disagree	1	0	0	0%
2.Partially disagree	2	0	0	0%
3. Neither agree nor disagree	3	1	3	25%
4.Partially agree	4	1	4	25%
5. Completely agree	5	2	10	50%
AVG	**4.25**			
Std dev.	**0.58**			

The survey's answers enriched the research in terms of getting measurable feedback from the dashboard's diagnosis, design, implementation and evolution. The overall response was very positive (total averages were above 4) considering the goal established at the beginning of the journey. The problem of communication, dispersion of files and data maturity as indicators expressed in the beginning of the project, was addressed and improved as the responses clarified that now CC employees could visualize information that required analysis and ways to collect the necessary data and transform it into perceivable insights. Although this is true for this specific project, the data maturity issue for BI tools is still a challenge for most teams in the material handling department, suggesting that a future work could be successfully developed to increase data maturity.

5. CONCLUSION

In the beginning VWAE stated a clear problem relating to high costs due to the inefficiencies felt in the container allocation process to its suppliers. The company was spending a lot on alternative packaging solutions because the amount of durable packaging wasn't enough to supply the circuit between factory and suppliers. At first glance, the problem seemed to require a simple logistical optimization solution relating to container inventory organization, truck loading methods or redesigning routes. As the research started diagnosing the root causes of the cost problem, underlying challenges started to come to light. To assess these difficulties the CC department agreed to have different stages of their container allocation operation analyzed in closer detail, including the mapping of the entire process to pinpoint where these issues laid. The research undertaken funneled the challenge into an information visibility bottleneck within the CC department. The origin of this project was rooted in the realization that crucial cost-related information was not being effectively communicated cross-departments and to upper management, leading to strategic misalignments and inefficiencies in cost, time, and waste reduction efforts.

To address the issue, the project was developed using action design research methodology to answer the formulated research question and objectives: "*How can an effective visibility enhancing approach efficiently assist decision-making at VWAE's CC processes?*". Various data collection methods were used such as direct and participatory observation, surveys, focus groups, group block and semi-structured interviews to gather the necessary information to diagnose, design, implement and evolve the solution. In the first stage, the diagnosis, the mapping played an important part in establishing the main areas where the challenges originated and understanding the business logic. Using literature, precedented solutions were reviewed to find one that could be reshaped into the specific challenges at VWAE. The main solution was focused on visualization methods, specifically the dashboard for monitoring and control which had very strong scientific support and practical application, making it a very robust candidate for the issue at hand. Using the CRISP-DM methodology, the data collection helped understand the level of maturity of the data and how it should be processed to fit the dashboard loading requirements and most notably, to design the solution dashboard. To implement the solution some technical actions were taken, including designing an implementation process that consisted of side-by-side explanations of how the tool worked with follow-up support material in digital format. During this implementation, feedback was collected and used to re-design the dashboard appearance to match specialist's and coordinator's technical expectation, going backwards and forward in the methodology stages completing a learning cycle. Surveys allowed the research to evolve as the questions went along with scientific validation methods used by Nunamaker et al. (2015) that provided valuable insights in redefining the dashboard's final version.

This project was carried out at the crossroads of various fields, such as logistics, behavioral theory, data analytics, and management. It highlights how integrating diverse areas of knowledge significantly enriches research, demonstrating the value of interdisciplinary approaches in enhancing the study's depth. In exploring dashboard applications within the automobile industry, numerous examples emerge. However, delving into niche sectors like the reverse logistics of containers in supplier circuits reveals a scant presence of literature advocating for dashboards as effective management tools. Most studies focus on operational field projects instead of proposing dashboard-based solutions for forecasting production volume changes. Additionally, there's a notable gap in literature regarding the practical implementation of such solutions, which is crucial for generating tangible value in a company setting. This project aimed to shed some light and address this gap, offering a practical approach that not only enriches scientific literature but also provides a clear direction for researcher-practitioners. By bridging the gap between theory and practice, it intends to make it easier for professionals to apply well-founded methodologies to solve real-world problems, specifically within the context of dashboard applications for managing logistics and supply chain challenges.

This project provided VWAE with a BI tool for their employees to work with and streamline decision-making processes by offering real-time insights into container management and logistics operations, thereby enhancing operational efficiency and strategic planning capabilities. As seen in the results chapter, the employees' perspective on the Likert scale had an average of 4.65 on the first block of questions and 4.46 on the second block of questions, where all the statements were portrait to have 1 as a negative outlook and 5 as a positive one, meaning a successful implementation of the solution dashboard. Furthermore, a navigation manual for the dashboard application was provided to allow users a knowledge base to seek from when consulting the tool – Appendix G.

In conclusion, the discovery of low data maturity within the CC department highlights a significant challenge in utilizing BI tools effectively. This limitation suggests that future work could focus on increasing data maturity, involving enhanced data governance, improved collection and processing techniques, and staff training in data literacy. Such initiatives can create room for cost and waste reduction optimization projects to take place for a better logistics at VWAE and for society.

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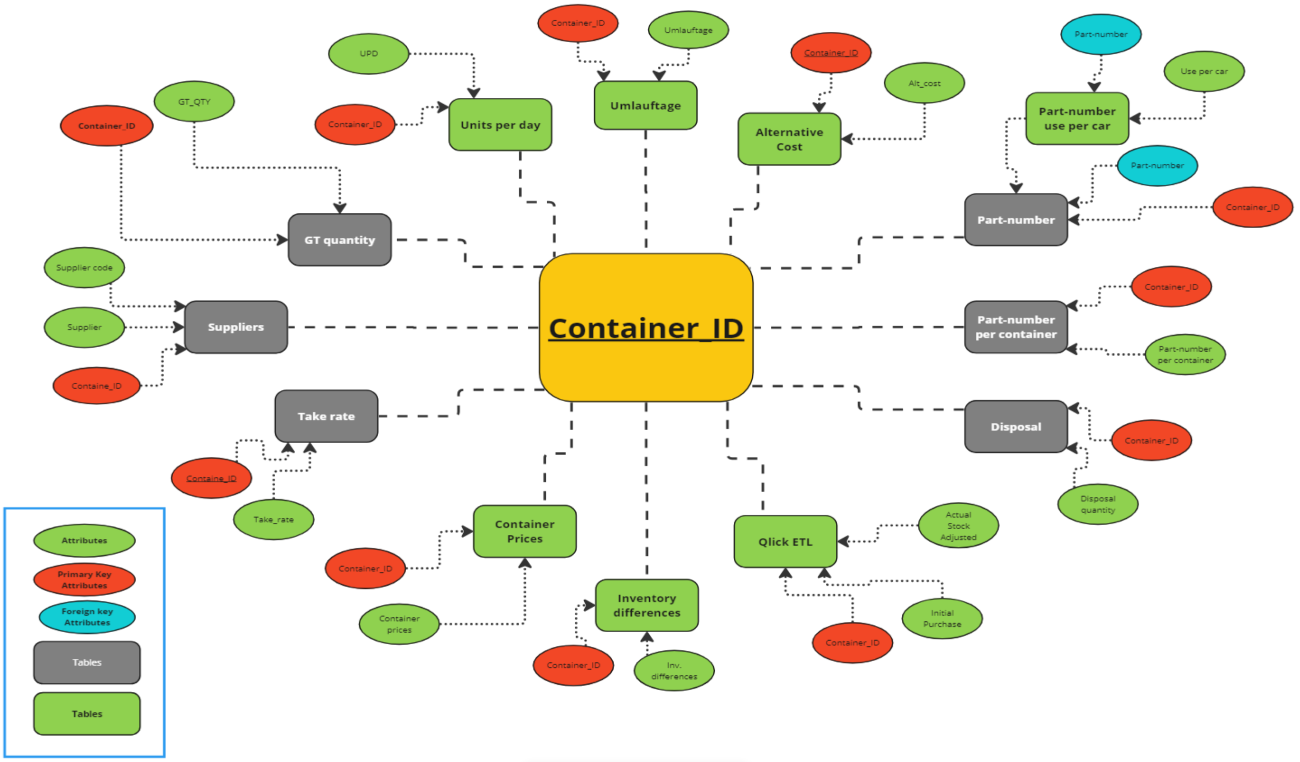
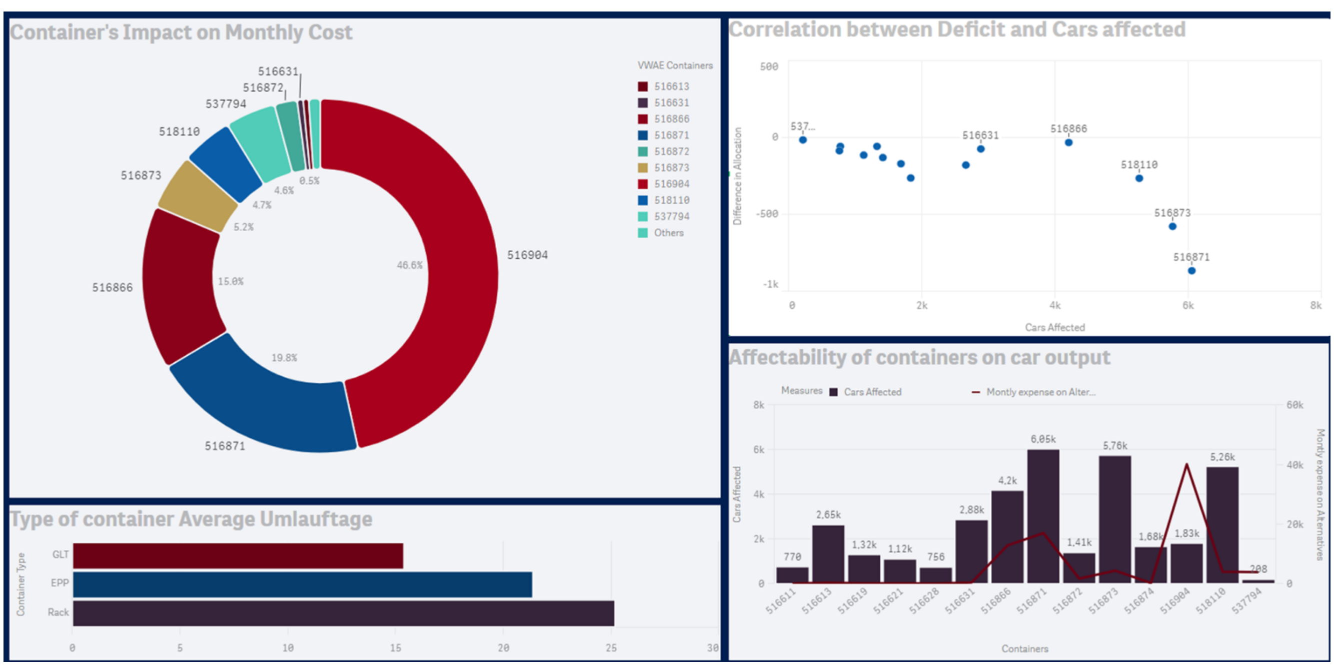
APPENDIX

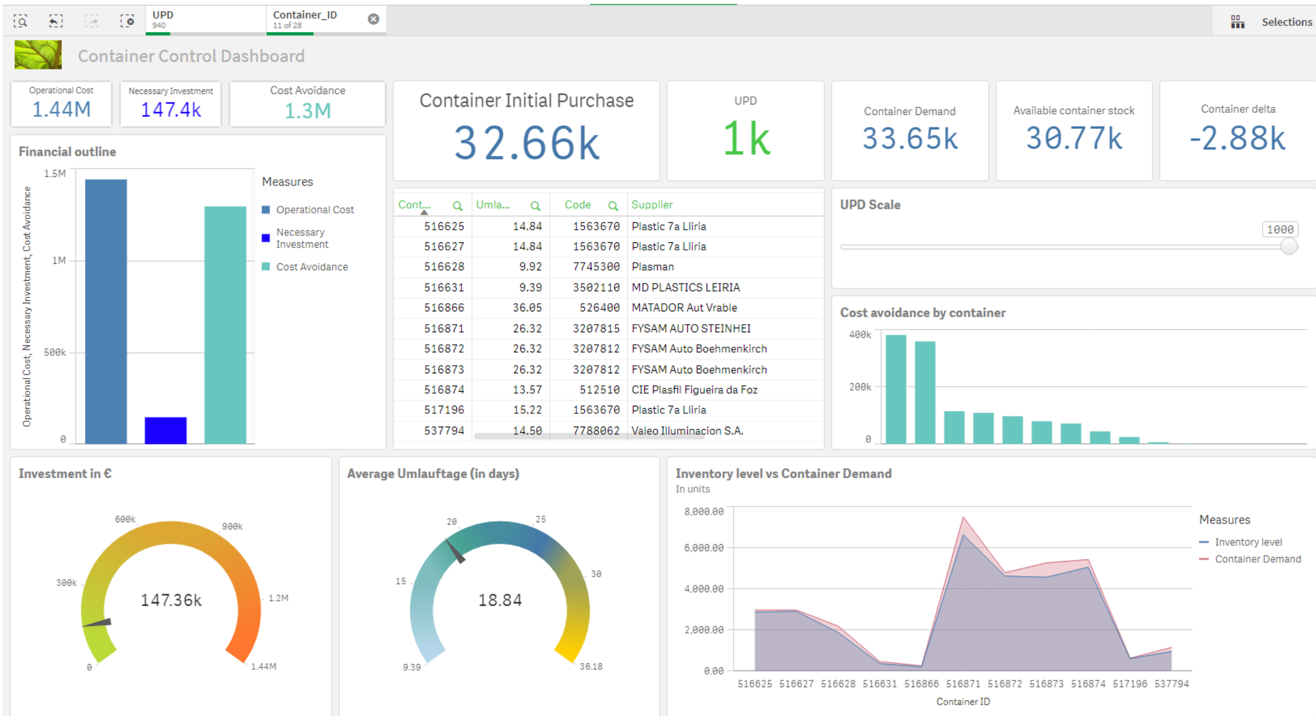
APPENDIX A – Conceptual model of the data structure design



APPENDIX B – Dashboard zero

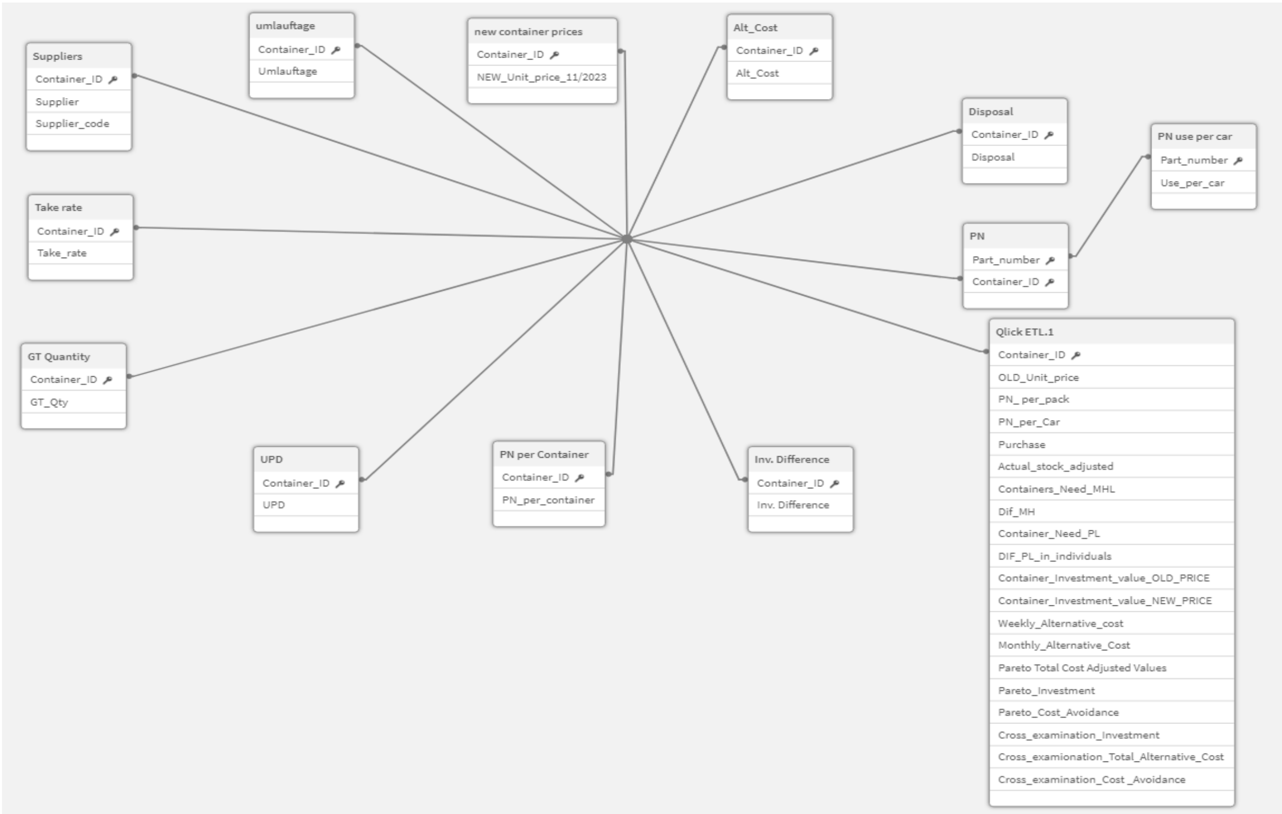


APPENDIX C – Dashboard version 2.0 that resulted in several feedback iterations.

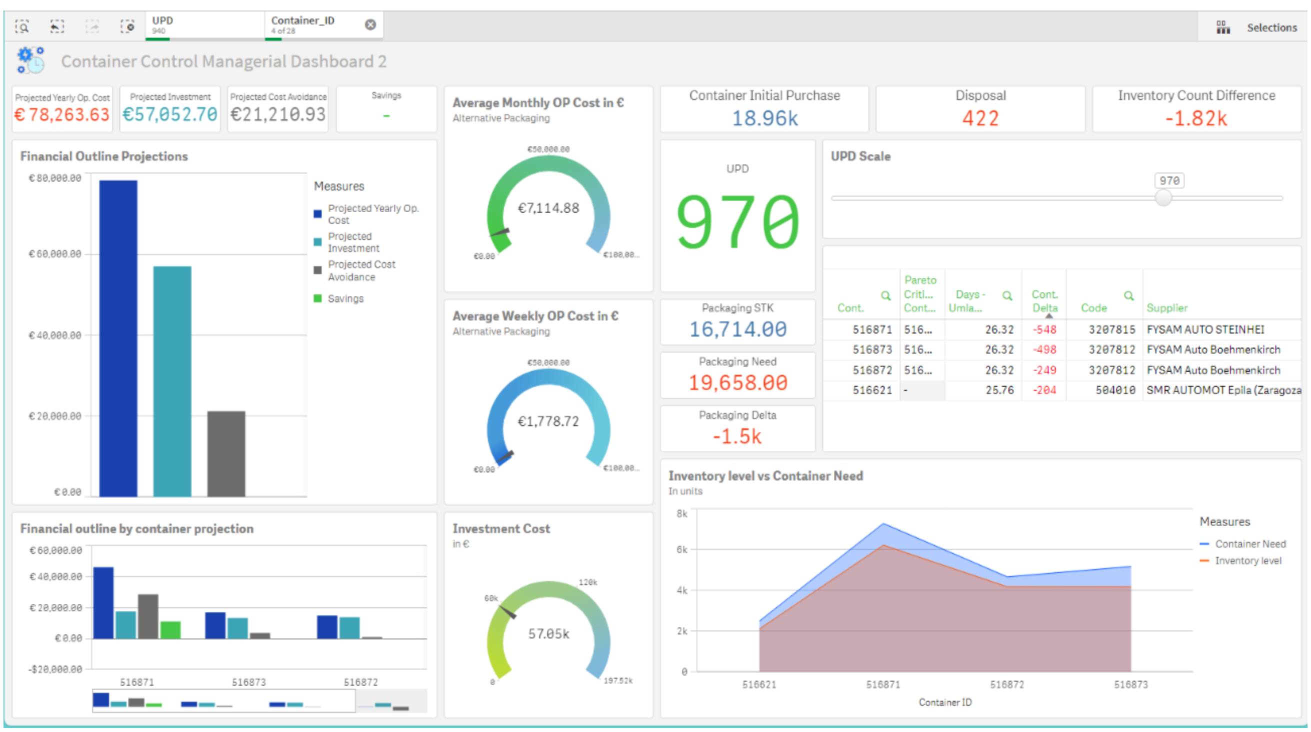


Cont...	Umla...	Code	Supplier
516625	14.84	1563670	Plastic 7a Liria
516627	14.84	1563670	Plastic 7a Liria
516628	9.92	7745300	Plasman
516631	9.39	3502110	MD PLASTICS LEIRIA
516866	36.05	526400	MATADOR Aut Vrable
516871	26.32	3207815	FYSAM AUTO STEINHEI
516872	26.32	3207812	FYSAM Auto Boehmenkirch
516873	26.32	3207812	FYSAM Auto Boehmenkirch
516874	13.57	512510	CIE Plasfil Figueira da Foz
517196	15.22	1563670	Plastic 7a Liria
537794	14.50	7788062	Valeo Iluminacion S.A.

APPENDIX D – Physical model or data model viewer of the data structure in Qlick sense



APPENDIX E – Final Dashboard version



APPENDIX F – ADR Methodology guide structure

<table>
<tr><th></th><th></th><th colspan="4">ADR Stages</th></tr>
<tr><th>Activities</th><th>Principles</th><th>Diagnosis</th><th>Design</th><th>Implementation</th><th>Evolution</th></tr>
<tr><td rowspan="3">Problem Formulation</td><td>P1:Practice inspired</td><td>The study was born when empirical observation of the reverse logistics processes that took place in the work environment showed ineffiencies.</td><td>A practical solution for the visibility bottleneck is the operational performance dashboard. Having the main KPIs for container control in one spot, allows for practical use and informed decision-making</td><td>Describing KPIs, connecting the data sources, and using the Qlicksense dashboard. This includes data preparation (ETL), dashboard development, and deployment.</td><td>The dashboard not giving the desired answers to make decisions about identified inefficiencies</td></tr>
<tr><td>P2: Theory-ingrained</td><td>Literature informed the diagnosis of the pains felt at the AutoEuropa through precedents the same type of inneficiencies throughout supply chains. Using "the 5 whys" approach (Serrat et al., 2017).</td><td>The design of a dashboard solution appeared using the CRISP-DM framework (Jaggia et al., 2020; Chapman et al., 2000; Schröer et al., 2021) to outline how a data minig process can retireve important unnoticed information and transform it into a decision-making tool.</td><td>CRISP-DM Data understanding that relates to the "cleanness" and relevance of the data (Jaggia et al., 2020; Chapman et al., 2000; Schröer et al., 2021) posed a challenge during implementation.</td><td>CRISP-DM data preparation step (Jaggia et al., 2020; Chapman et al., 2000; Schröer et al., 2021) in which new set of data was re-simulated using different premisses to input in the artifact algorithm.</td></tr>
<tr><td>P3:Reciprocal Shaping</td><td>Daily exchanges between the researcher and practitioners allowed to pinpoint an accurate diagnosis that could produce actionable measures.</td><td>Daily and weekly interactions with practitioners guided this stage to find a practice-inspired design that would be understandable and make sense to their daily use, both visually and functionally</td><td>The business understanding goes beyond a linear path as it is described in process map. Practitioners practice special actions that make parameters vary which tamper with the conciseness of the data. Thus "special adjustment" was required.</td><td>The data preparation benefited from the collaboration of logistics planning, operational logistics department and the researcher to gather the rectified data and input it back in the algorithm.</td></tr>
<tr><td>Artifact Creation</td><td>P8: Abstraction</td><td>The researcher dettached from the environment and look for a clear and achieveble definition of the diagnosis that explained problem formulated - Information transparency bottleneck hinders decision-making</td><td>ETL (extract, transform and load) process for company Data, necessary to build the first visualization mockup version.</td><td>"Dashboard Zero" with Operational and financial KPIs already in place: Containers initial purchase, Container demand, inventory loss, avalability. Operational costs correlated with production volume increase.</td><td>The new and improved dashboard with the adjustments from practitioners observations regarding their utilization needs (After surveys)</td></tr>
<tr><td rowspan="2">Evaluation</td><td>P4: Mutually Influential Roles</td><td>Both the researcher and the practioners form the ADR team, combinig practical, technical and theoretical perspectives to evaluate the artifact created.</td><td colspan="2">Bringing the theory regarding ways to build dashboard using Qlicksense, accompanied by practitioners know-how of data visualizations and experience on what works and what doesn't</td><td rowspan="3">Focus Group Blocks were used to validate the KPIs and the way that the dashboard aggreggated the data. This resulted in some small changes in the algorithm and finally reaching the final form of the dashboard.</td></tr>
<tr><td>P5: Authentic Concurrent Evaluation</td><td colspan="3">For validation, the concept as the artifact underwent the last research mile approach: Proof-of-concept, proof-of-value, proof-of-use (Nunamaker et al., 2015).</td></tr>
<tr><td>Reflection</td><td>P6: Guided Emergence</td><td>This reflects the changes suffered by the concept as the artifact presented by the researcher and shaped by organizational use and by practicality needs.</td><td>The first stages of the mockup visualization benefited from constructive appreciation in to order to shorten the gap between the presented artifact and the expected artifact.</td><td>The first stages of "dashboard zero" recieved constructive appreciation in to order to shorten the gap between the presented artifact and the expected artifact.</td></tr>
<tr><td rowspan="2">Learning</td><td>P7: Generalized outcomes</td><td>Benefiting from the previous stage, the outcome was adjusting the diagnosis from transparency to visibility bottleneck.</td><td rowspan="2">An iterative feedback loop was established with the operational logistics manager and other stakeholders to refine and validate assumptions, ensured that the learning process remained dynamic and the mockup resulted in a more robust version of the dashboard with metrics that allowed for some decisions to be taken.</td><td rowspan="2">Co-creation sessions were facilitated where practitioners actively contributed to the design and ideation of "Dashboard Zero." Ideas, preferences, and expectations were encouraged to ensure a solution that resonated with end-users.</td><td rowspan="2">Both the researcher and the practitioners learned a lot about new ways to make the algorithm and how to optimize it as a function of the specific needs of the practitioners. The outputs were accurate considering the calculations, and the tool was abvle to forecast values for different levels of production volume.</td></tr>
<tr><td>P3: Reciprocal Shaping</td><td>A new concept was articulated as the result of the principles use and repositioned the Diagnosis to meet a more feasible solution.</td></tr>
</table>

APPENDIX G – Qlick sense dashboard application navigation manual


iscte

Manual de navegação no *Container Control Dashboard* na aplicação Qlick sense

Qlik Sense™

Departamento de Material Handling

Volkswagen AutoEuropa

Janeiro de 2024

Estagiário: Rafael Santana

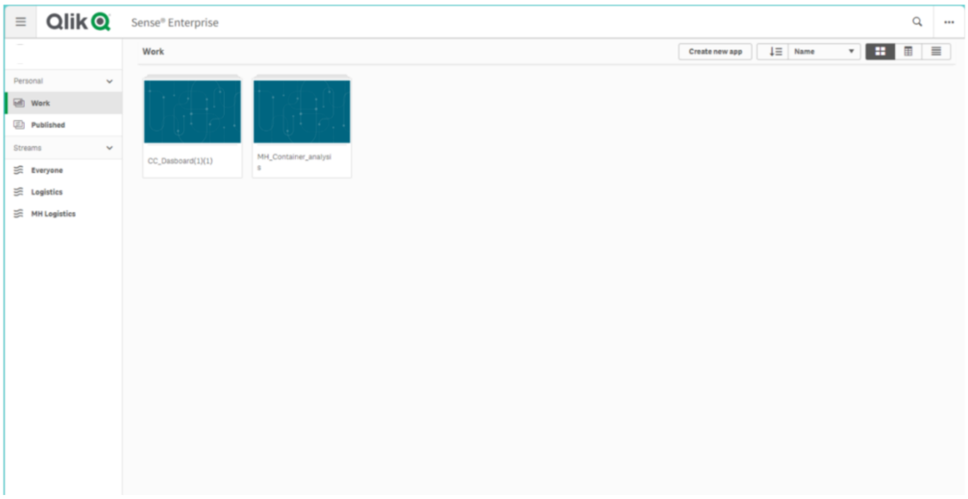
CSD-Class: Internal

Responsible department for filing: AGLH

APPENDIX H – Qlick sense stream introduction.

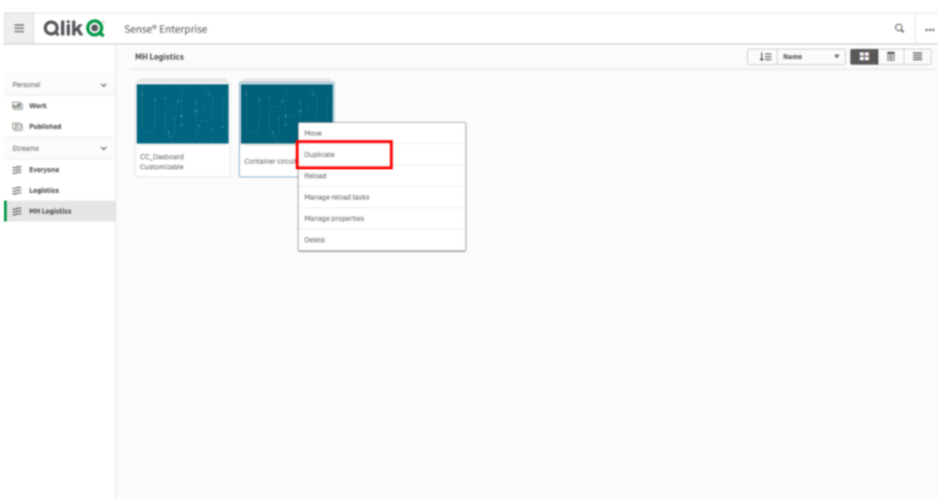
2. Qlick sense hub

Esta secção do Qlick sense é onde se encontram as "streams" onde estão as aplicações desenvolvidas.



APPENDIX I – Instruction of how to duplicate application from public to personal stream.

2.1. Fazer **rightclick** na aplicação "Container circuit" e duplicar a aplicação. Rightclick>Duplicate. Isto vai fazer com que a aplicação apareça na stream pessoal designada "Work" no canto superior esquerdo da tela. Estando na stream pessoal do utilizador será possível editar a aplicação uma vez que se trata agora de uma cópia pessoal e não de uma aplicação publicada.



APPENDIX J – Introduction of data load editor.

3.1. Data load editor

Esta subsecção é onde se faz preparação, upload e modelização da estrutura dos dados que vão alimentar o dashboard. Para esta ferramenta em específico só vamos necessitar de dois campos (delimitados a vermelho), *Data load editor* e *Data model viewer*.