Aprimorando o frete e o frete de emergência na cadeia de suprimentos: uma abordagem baseada em dados

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Resumo: Este artigo explora a aplicação da ciência de dados e do Modelo de Processo Espiral no contexto de frete emergencial na cadeia de abastecimento. Ele investiga estratégias baseadas em dados para melhorar a tomada de decisões, a eficiência operacional e a redução de custos em processos de frete emergencial. A pesquisa segue o Modelo de Processo Espiral para planejamento, execução e avaliação. A estrutura de ciência de dados incorpora coleta, pré-processamento, análise e visualização de dados para extrair insights significativos e orientar a tomada de decisões. Os resultados do estudo demonstram benefícios quantificáveis significativos da abordagem baseada em dados. A implementação da tomada de decisões baseada em dados levou a um processo de aprovação de frete aéreo mais ágil, reduzindo a carga de trabalho mensal das partes interessadas em mais de cem horas. Além disso, estratégias baseadas em dados permitiram um controle confiável de custos, medidas proativas para resolver inconsistências e processos aprimorados de reclassificação e estorno. As conclusões também revelaram o potencial substancial de poupanças e ganhos de eficiência. A análise revelou uma redução de 7% nas provisões em comparação com os valores anuais realizados. Além disso, a tomada de decisões baseada em dados melhorou os números transversais, como os relatórios mensais, melhorando a visibilidade operacional geral.

Palavras-chave: Análise de dados, tomada de decisão baseada em dados, frete de emergência, cadeia de suprimentos.

Enhancing Freight and Emergency Freight in the Supply Chain: A Data-Driven Approach

Abstract: This paper explores the application of data science and the Spiral Process Model in the context of emergency freight within the supply chain. It investigates data-driven strategies to enhance decision-making, operational efficiency, and cost reduction in emergency freight processes. The research follows the Spiral Process Model for planning, execution, and evaluation. The data science framework incorporates data collection, preprocessing, analysis, and visualization to extract meaningful insights and guide decision-making. The study's results demonstrate significant quantifiable benefits of the data-driven approach. Implementing data-driven decision-making led to a more agile air freight approval process, reducing stakeholders' monthly workload by over a hundred hours. Additionally, data-driven strategies enabled reliable cost control, proactive measures to address inconsistencies, and improved reclassification and chargeback processes. The findings also revealed the substantial potential for savings and efficiency gains. The analysis uncovered a 7% reduction in provisions compared to realized yearly values. Moreover, data-driven decision-making improved transversal figures such as monthly reports, enhancing overall operational visibility.

Keywords: Data analysis, data-driven decision making, emergency freight, supply chain.

1. Introduction

Supply chain management, freight transportation, data science, and data-driven decision-making are essential to modern business operations. In today's global marketplace, businesses rely on effective supply chain management to remain competitive and meet customer demands. This involves various stages: sourcing, manufacturing, warehousing, and product delivery. Efficient supply chain management can reduce costs, increase productivity, improve quality, and enhance customer satisfaction.

Freight transportation plays a crucial role in supply chain management, enabling the movement of goods and materials to meet consumer and business demands. Emergency freight focuses on transporting urgently needed goods that cannot wait for regular shipping schedules. It requires specialized methods and coordination between multiple parties to ensure timely and efficient delivery.

Data collection, preprocessing, analysis, and visualization are vital steps in data science. Data-driven decision-making (DDDM) leverages these insights to make informed and objective decisions, minimizing guesswork and subjectivity. This paper utilizes the Spiral Process Model to address the challenges and optimize supply chain operations. This risk-driven software development methodology enables iterative planning, execution, and evaluation, ensuring continuous improvement and risk management. By integrating big data analytics, DDDM, and the Spiral Process Model, organizations can enhance decision-making, optimize emergency freight processes, and improve overall supply chain performance. Exploring how data-driven strategies can improve decision-making, operational efficiency, cost reduction, and customer satisfaction. The findings highlight the potential benefits of embracing these concepts in the dynamic and competitive supply chain landscape. By leveraging data-driven approaches, businesses can stay ahead and drive success in their supply chain operations.

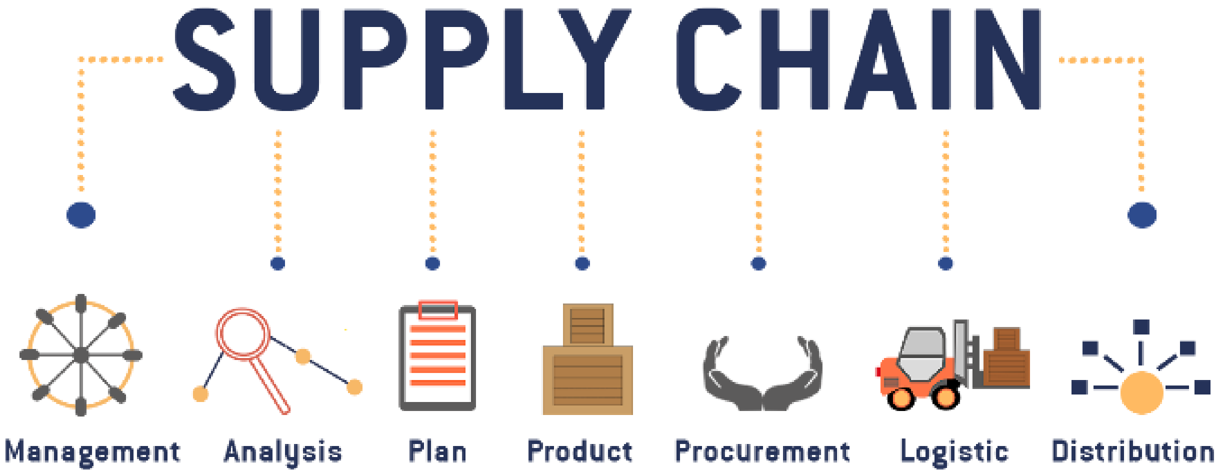
2. THEORETICAL BACKGROUND

Following, we have the core concepts to be used throughout the development of this paper.

2.1 Supply Chain

A supply chain consists of all stages directly or indirectly in fulfilling a customer request. The supply chain includes the manufacturer, suppliers, transporters, warehouses, retailers, and customers (Chopra et al., 2015). It involves various stages, starting with sourcing raw materials or components. The manufacturing or assembly of the product, followed by warehousing and inventory management, and finally, the delivery of the finished product to the customer. The key activities in supply chain management include management, procurement, analysis, planning, production, logistics and distribution, and customer service.

Figure 1 – Supply chain key activities



Procurement includes sourcing, purchasing and contracting, and supplier management. This is where the raw materials or components needed for production are acquired. The production provides design, planning, making and assembling, and quality control. This is where the product is manufactured or produced. Logistics and distribution include transportation, warehousing, and inventory management. This is where the finished products are stored and then transported to customers. Customer service provides order fulfillment, returns, and complaints handling. This is where the customers' needs are met, and their satisfaction is ensured (Hofman, D, 2004); Efficient supply chain management is crucial for businesses to remain competitive in today's global market. It can help to reduce costs, increase productivity, improve quality, and enhance customer satisfaction. Companies can achieve these goals by implementing effective strategies for managing their supply chain, such as implementing just-in-time inventory management, utilizing technology for better visibility and control, and building solid relationships with suppliers and customers (Copacino, w.c, 2019).

2.2 Freight and Emergency Freight

Freight refers to transporting goods, raw materials, or merchandise from one place to another, typically by truck, train, ship, or airplane, being the physical process of transporting commodities and merchandise goods and cargo (McLeod & Curtis, 2020). It can also be defined as the goods and materials that are transported. Freight can be classified into several categories, such as full truckload (FTL), less-than-truckload (LTL), air freight, ocean freight, and many others, depending on the mode of transportation and the shipment size. The cost of freight is usually determined by the weight or volume of the goods, the distance they are transported, and the mode of transportation used. Freight transportation is a critical aspect of supply chain management and global trade as it enables the movement of goods and materials to meet the demands of consumers and businesses around the world; the benefits of good transportation are enormous, increasing the value of goods by moving them to locations where they worth more and encourages competition and production by extending the spatial boundaries of commodity and labor markets (USDOT FHWA 2020).

Emergency freight refers to transporting urgently needed goods that cannot wait for regular shipping schedules. This type of freight is typically used when a delivery delay would result in significant consequences, such as loss of revenue or even harm to human life. Emergency freight services usually involve using specialized transportation methods, such as charter flights or expedited ground delivery, to ensure that the goods reach their destination quickly.

2.3 Data Science

Data science combines math and statistics, specialized programming, advanced analytics, artificial intelligence (AI), and machine learning with specific subject matter expertise to uncover actionable insights hidden in an organization’s data (IBM, 2022). We can sort data science into a vast amount of core concepts, some of them being:

Data collection: Data science starts with collecting data from various sources, such as databases, web APIs, sensors, or user-generated content. Ensuring that the data is reliable, relevant, and comprehensive is crucial.

Data preprocessing: Raw data often needs to be processed to remove noise, handle missing values, and transform it into a format suitable for analysis. Data preprocessing may involve techniques such as data cleaning, data integration, and feature engineering.

Data analysis: Involves applying statistical and machine learning algorithms to the processed data to uncover patterns, trends, and relationships. Data analysts may use techniques such as regression analysis, clustering, classification, and visualization to extract insights from the data, besides playing a role in making decisions more scientific and helping businesses operate more effectively (Xia, B; Gong, P; Selena, P, 2014).

Data visualization: A critical aspect of data science, enabling analysts to communicate their findings effectively. Visualizations may include charts, graphs, maps, or interactive dashboards that help users explore and understand the data: model building and evaluation. Unlike static data visualization, interactive data visualization allows users to specify the format used in displaying data (Sadiku, M. et al. 2016).

2.4 Data-driven decision making

Data-driven decision-making (DDDM) is a process of using data and analytics to inform and guide decision-making. It involves collecting and analyzing data to identify patterns and insights and then using them to make informed decisions. DDDM aims to minimize guesswork and subjectivity in decision-making by basing decisions on empirical evidence and objective analysis. Among many kinds of decision-making, the data-driven relies on data analytics and machine learning algorithms. Data science is all about using data to drive decision-making (Alexandros et al., 2021). Insights and recommendations derived from data analysis are used to inform business strategy, improve operations, or guide policy decisions. Relying on such, organizations can make more accurate, efficient, and practical decisions, leading to better outcomes. The DDDM process typically involves several steps:

- Define the problem: The first step in DDDM is to define the problem or decision that needs to be made. This may involve identifying key performance indicators (KPIs) that will be used to measure the success of the decision.
- Collect and prepare data: The next step is to collect relevant data that can be used to inform the decision. This may involve collecting data from various sources and cleaning and preparing the data for analysis.
- Analyze the data: Once the data is collected and prepared, it can be analyzed using various analytical techniques such as statistical analysis, machine learning, or data mining. The goal of the analysis is to identify patterns and insights that can be used to inform the decision.

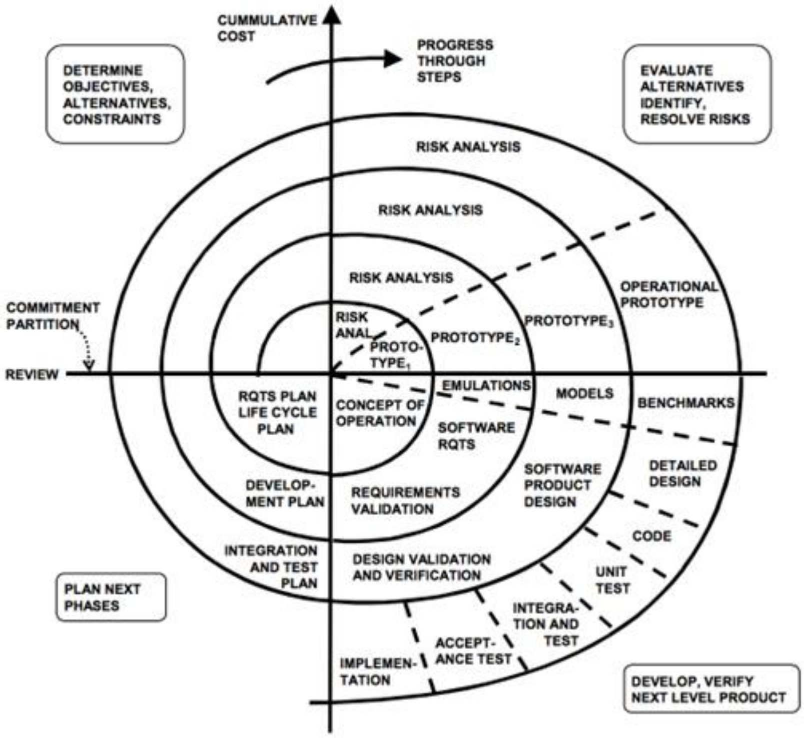
- Draw insights and make recommendations: Based on the analysis, insights can be drawn that can help inform the decision. These insights may be used to make recommendations or guide the best action.
- Implement the decision: The decision is implemented, and the results are monitored to assess the effectiveness of the decision. This may involve collecting new data and repeating the DDDM process to refine the decision over time.

DDDM can be applied to various decision-making contexts, from business strategy and marketing to healthcare and public policy.

3. SPIRAL PROCCES MODEL

The Spiral Process Model for Case Studies is a software development methodology that can be used for case studies. It is a risk-driven model that involves a cyclic process of planning, executing, and evaluating the development process. The model is designed to help developers identify and manage risks throughout the development process and ensure the project remains on track (Boehm, 1988).

Figure 2 – The original spiral model diagram (Boehm, 1988)



The Spiral Process Model is based on four main phases, which are repeated cyclically:

Determine objectives, alternatives, and constraints: Here, the project's objectives will be defined, and requirements and conditions that may be impactful for the project are also identified and noted.

Evaluate alternatives; Identify and resolve risks: In the second main phase of the Spiral model, the identified risks are analyzed, and alternative solutions are evaluated. After these risks are treated and considered, a prototype may be developed to test the solutions created to see if they are helpful.

Develop, verify, and next-level product: At the third phase of the Spiral model, the project is designed, developed, and tested. The project is built in small increments, which are tested and evaluated before moving on to the next increment.

Evaluation / Plan subsequent phases: In the last step of the Spiral model, the project is evaluated to determine its effectiveness and identify any improvement areas. This information is used to refine the project requirements and plan for the next cycle.

The Spiral Process Model is a flexible methodology that can be adapted to suit the needs of different projects. The model emphasizes the importance of risk management, which helps to ensure that the project stays on track and that any problems are identified and addressed early in the development process (Boehm, 1988). By following the Spiral Process Model, developers can create a reliable, practical project that meets the needs of the end-users or goals.

4. Development and Results

The first step of the development was creating the spiral model to be followed throughout the work.

Table 1 – Spiral Cycles

#	Goal(s)	Scope Type	Alternative Evaluation / Development	Next Phase
1	Data analysis and selection	Exploratory	Understanding the current situation, see what could be used to enable DDDM.	Obtaining and preparing the relevant data by doing any wrangling or data modeling necessary.
2	Data Acquisition	Exploratory	Obtaining the data to be used in creating visualizations and analysis.	Creating dashboards and visualizations to enable DDDM.
3	Dashboard Creation / Data visualization	Exploratory	Creation of the dashboards and adapting the previously cruse data into new visualizations for a new and better	See if the dashboards created and the visualizations enable DDDM and help see things that previously could not be seen or analyzed.
4	Validation	Explanatory	Verifying with the personnel that will use the said dashboards and visualizations if it fits the needs and enables better understanding	Use DDDM for future works and obtain a far better performance in the freight processes.

Faced with the vast diversity and complexity of the central control and analysis processes linked to emergency freight – Déppanage with inconsistencies of information, the need for data integration and unification, aiming to obtain a robust, standardized, and independent source, providing more excellent quality in communication, reduction of error margins, deductions of costs and gain in time for in-depth analysis. Visible benefits for the project include a more agile air freight approval process, the inconsistencies in taking proactive measures possible, a higher chargeback rate, and providing good transversal figures, such as monthly reports.

Figure 3 – Incomplete Replica of the database obtained in the acquisition

2	Part Number	Supplier Code	Quantity Origin	Piece Price	Impacted
3	42847284	AILN	450,00	0,00	U91
4	32224332	CAL	5,00	0,00	XVB
5	904249EF	CONTIN ELAS	1080,00	0,00	LSZ
6	492882F2	CAL	16000,00	0,00	T85
7	82170021	CONTIN ELAS	120,00	0,00	TR8
8	42236TY2	AILN	120,00	0,00	GJK
9	29284311	AILN	126,00	0,00	GJK
10	82107032	CONTIN ELAS	288,00	0,00	EWA
11	9843KA92	CAL	8400,00	0,00	OLQ

These databases previously on Excel were treated, and several minor adjustments were made when imported within Spotfire. Once the data was imported, several views were created before each final version of the pictures. Besides the central idea in the middle of the visualizations, several filters were included in each view. Although the data table was provided, out of the 69 columns available less than half of them were considered relevant for the views to be created; also, some of these 69 columns were deemed obsolete by the team from the company the data origins from; however, even though obsolete, they still are there due to system complications.

Once the data was cleaned, four views were created to fulfill the team's needs, save time performing the same tasks they did previously, and also see things that once either they couldn't or that would take a massive amount of time on Excel.

The first view was "Status of References," this view was created to see the status of any specific part number the team wanted information on, the rank of the most popular part numbers, and how much they amount compared to others; Also including filters of what was used mainly by the team, such as country, part number, and status. The second view was "total volume per reference" This view shows us the total volume per reference, in m^3, with filters for quality and countries, also ranking the top 20 references with the most significant volume. The third view was "Weight per reference," showing the total weight per reference number in KG, using the same filters from view two but on a new filtering scheme. The fourth view was "Freight value EUR per reference," showing the total freight cost per part number or reference wanted, with the filters like view one but on another filtering scheme. Following the dashboards can be seen in the blurred for confidentiality Figures 5, 6, 7, and 8 at the annex.

The results of these views are immediate, reducing the time for approval processes of air freights, making them agile, the reduction more than 100 hours from the stakeholders, amounting to thousands of Reais in savings per year, having a reliable cost-controlling air freight visibility, being able to use the information to see actual cost and chargeback statuses, see inconsistencies easily to take proactive measures, having a higher rate of chargeback and challenges which implies in the reduction of EUR/vehicle, the potential recovery of over 1 million euros also reducing the euro cost per vehicle, and like with all of these, being able to use DDDM.

5. Conclusion

This paper underscores the significance of integrating big data analytics, supply chain management, emergency freights, data-driven decision-making (DDDM), and the Spiral Process Model. By leveraging big data analytics, organizations can gain valuable insights that optimize supply chain processes, while DDDM enables them to make informed decisions based on empirical evidence and objective analysis. The Spiral Process Model provides a structured framework for project management, emphasizing risk mitigation and continuous improvement. Integrating these concepts and methodologies offers several benefits, including enhanced operational efficiency, cost reduction, improved decision-making, and increased customer satisfaction. It provides a foundation for future research and practical implementation, enabling organizations to leverage data-driven insights, optimize emergency freight processes, and improve overall supply chain performance.

In today's competitive market, integrating big data analytics, supply chain management, emergency freights, DDDM, and the Spiral Process Model is essential for organizations to thrive. By embracing these concepts, organizations can achieve greater efficiency, resilience, and competitiveness in emergency freight management practices. The ability to proactively address disruptions, make data-driven decisions, and continuously improve processes gives organizations a significant advantage. The work here not only reduced more than 100 hours from the stakeholders, but also had the potential reduction of thousands of Reais per year; As technology advances and data availability increases, organizations that embrace these methodologies will be well-positioned to adapt and succeed in the complex and rapidly evolving world of supply chain operations. This integration is critical for organizations seeking to optimize their supply chains and achieve sustainable success.

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ANNEX

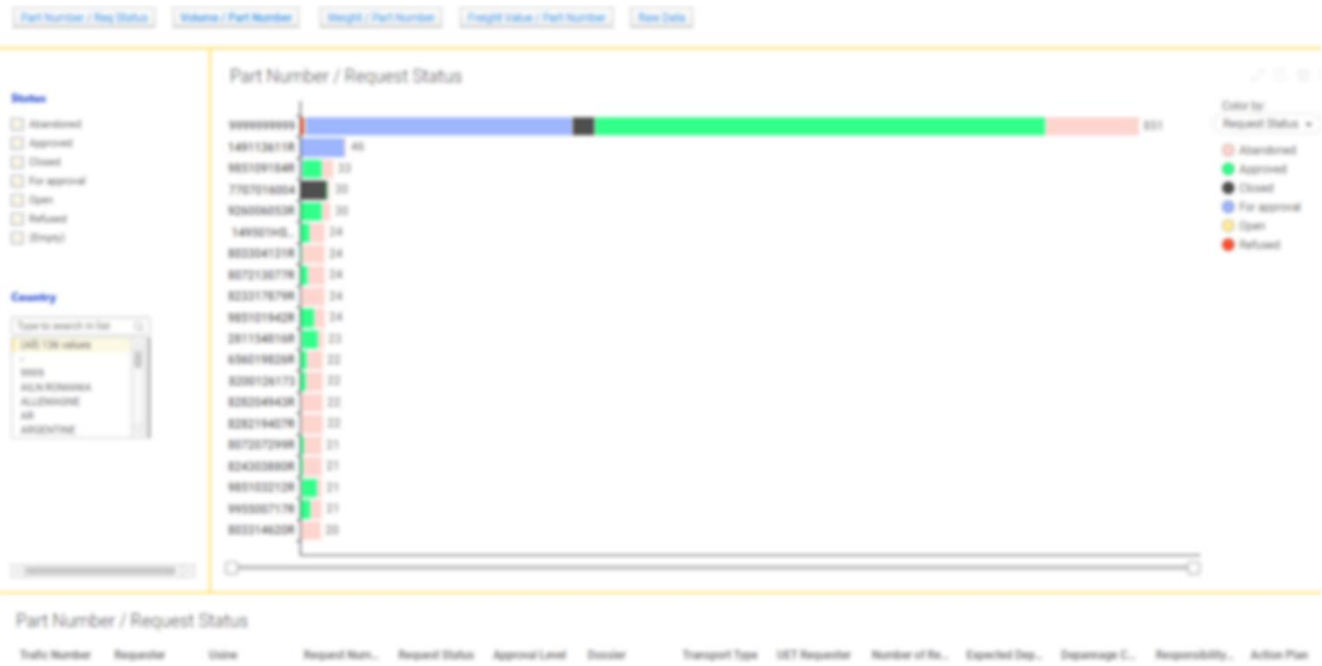

Figure 5 – Blurred snapshot of the first created.

Figure 6 – Blurred snapshot of the second visualization created.

Figure 7 – Blurred snapshot of the third visualization created.

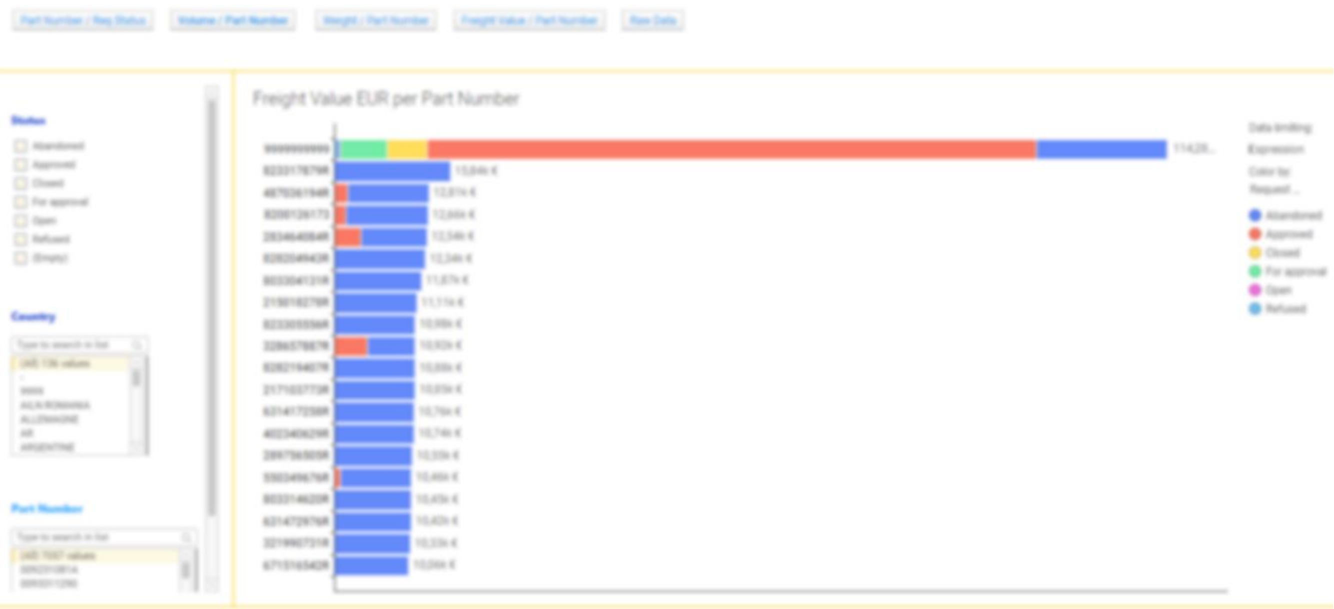

Figure 8 – Blurred snapshot of the fourth visualization created.