Emission Analytics Report

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Executive Summary

This report analyzes emissions data from a company's supply chain processes to identify opportunities to reduce carbon footprint and optimize operations for sustainability. Process mining techniques from the Celonis software platform were used to gain insights from raw datasets capturing 2000 orders over time.

Key findings include:

- Air transportation generates the highest emissions per shipment at 1866kg CO2 on average, while sea transportation produces the lowest at 288kg CO2. However, sea also takes 15 days on average compared to just 2 days for air.
- Road transportation produces moderate emissions of 325kg CO2 per shipment on average and takes 3 days. It is best suited for domestic deliveries where distances are shorter.
- Vendor analysis shows ColorPlus Manufacturing currently has the highest overall emissions at over 14 million kg CO2, while Pioneer Packaging produces the least at over 4 million kg CO2. However, Pioneer Packaging also has the lowest emissions efficiency per order.
- Undesired activities like canceled orders, returned packages, and customs denials contribute significant excess emissions of over 2000kg CO2 per case on average. Addressing the root causes could yield substantial sustainability improvements.
- Emissions fluctuate seasonally, with the first half of 2021 showing consistently high volumes. Understanding driving factors could help proactively manage variations.

Based on these insights, the report recommends optimizing transportation mode selection with a preference for sea and road where applicable, prioritizing efficient vendors, reducing canceled orders, and enhancing monitoring during peak seasons. Collaboration opportunities are also identified to help high-emission vendors improve efficiency.

Introduction

In today's world, companies face many challenges such as maintaining profitability, staying competitive in the marketplace, and advocating sustainability. Companies need to address some of these challenges to continue and thrive by implementing effective strategies and following a desired path. One of the challenges that companies face is managing emissions to achieve environmental sustainability. Emissions can have a significant impact on the environment and public health. In this paper, by analyzing data using Celonis, a process mining tool, the findings of our analysis will help reduce throughput time, emissions, and wasted resources in our supply chain to help companies address these issues among others by drilling down on related aspects (*What is sustainability in business? the process, returns, Kpis and everything you need to know*).

- We will compare the modes of transportation (air, vehicle, sea) with emissions. We will determine which mode produces the highest and lowest emissions. Additionally, we will investigate what happens when there is a change in the mode of transportation and how this relates to emissions. We will also pivot to see which mode was started with and what was the corresponding emissions level.
- We will look at average throughput times within the process explorer and determine the relationship between average throughput time and mode of transportation. We will also investigate how this relationship relates to emissions. This information can help companies optimize their transportation system by identifying bottlenecks or areas for improvement in specific modes of transportation.
- We will look at vendors within this dataset and determine which are producing the most and least emissions. We will also analyze the emissions levels for these vendors chosen. By identifying vendors that produce high levels of emissions, companies can take steps towards reducing their carbon footprint by working with more sustainable suppliers or implementing measures such as carbon offsetting programs.
- We will investigate seasonality within this dataset by analyzing if there is a specific month or season in which emissions are at a high or low point. Furthermore, we will look at all canceled orders within our dataset and determine where any associated emissions are coming from within an order cycle if they exist.

Using Celonis data analysis, companies can tackle their emissions challenge and learn how to lower their carbon footprint. This report examines our emissions from transportation and vendors and suggests green and economical solutions as well as choosing the optimal path.

Data Description

We have built our analyses using four various datasets which and the most informative are activity_table_2, case_8.

activity_table_2

Column	Description
Sorting	A numerical identifier is used for ordering or sorting entries.
caseID	Unique identifier for each case or scenario in the dataset.
Activity Name	Name or title of the activity being recorded.
Timestamp	Date and time when the activity occurred or was recorded.
Emissions (kg CO2)	Amount of CO2 emissions associated with the activity, measured in kilograms.

case_8

Column	Description
Sorting	A numerical identifier is used for ordering or sorting entries.
caseID	Unique identifier for each case or scenario in the dataset.
Material Code	Unique code is assigned to each material for identification.
Material	Name or type of the material.
Vendor	Name of the vendor or supplier of the material.
Amount Ordered	Quantity of material ordered.
Price	Price of the material or the cost of the order.
Emissions from Manufacturing	CO2 emissions resulting from the manufacturing of the material.

Problem-Solving Steps & Framework

The problem-solving steps will serve as a roadmap to overcoming challenges, discovering ideas, and ultimately achieving success. These steps include defining the problem at hand, setting clear objectives, understanding the data, conducting in-depth analysis, and developing concrete solutions.

- **Defining the Problem:** High emissions from logistics operations and other types of activities.
- **Setting Objectives:** To identify and implement lower-emission transportation methods, and engage with vendors to reduce emissions.
- **Integration:** Import the relevant datasets, including activity logs and emissions records, into Celonis.
- **Process Mining:** Celonis employs process mining algorithms to reconstruct and visualize the end-to-end process flow. This includes understanding the sequence of activities, their dependencies, and variations in the processes.
- **Activity Analysis, Ideal, and Undesired Path**: This involves looking at different stages, such as order creation, transportation, and delivery, to understand the sequence and duration of each activity.
- **Emissions mapping:** This helps correlate activities and associated emissions, providing insight into which stages of the supply chain contribute the most to carbon emissions.
- **Performance Metrics:** Use Celonis to calculate and visualize performance metrics such as processing times, bottlenecks, and deviations from optimal processes.
- **Visualization:** Present results through Celonis visualizations, which can include process flowcharts and performance dashboards. This allows stakeholders to better understand the complexities of the supply chain and its environmental impact.
- **Solution Development:** Recommendations for emissions reduction based on data-driven insights.

Data Exploration & Processes General Overview

We found that the process flowchart outlines the journey of 2000 orders in a supply chain, concluding with 1227 packages received at the store and 773 lost due to various reasons. The process flows as follows:

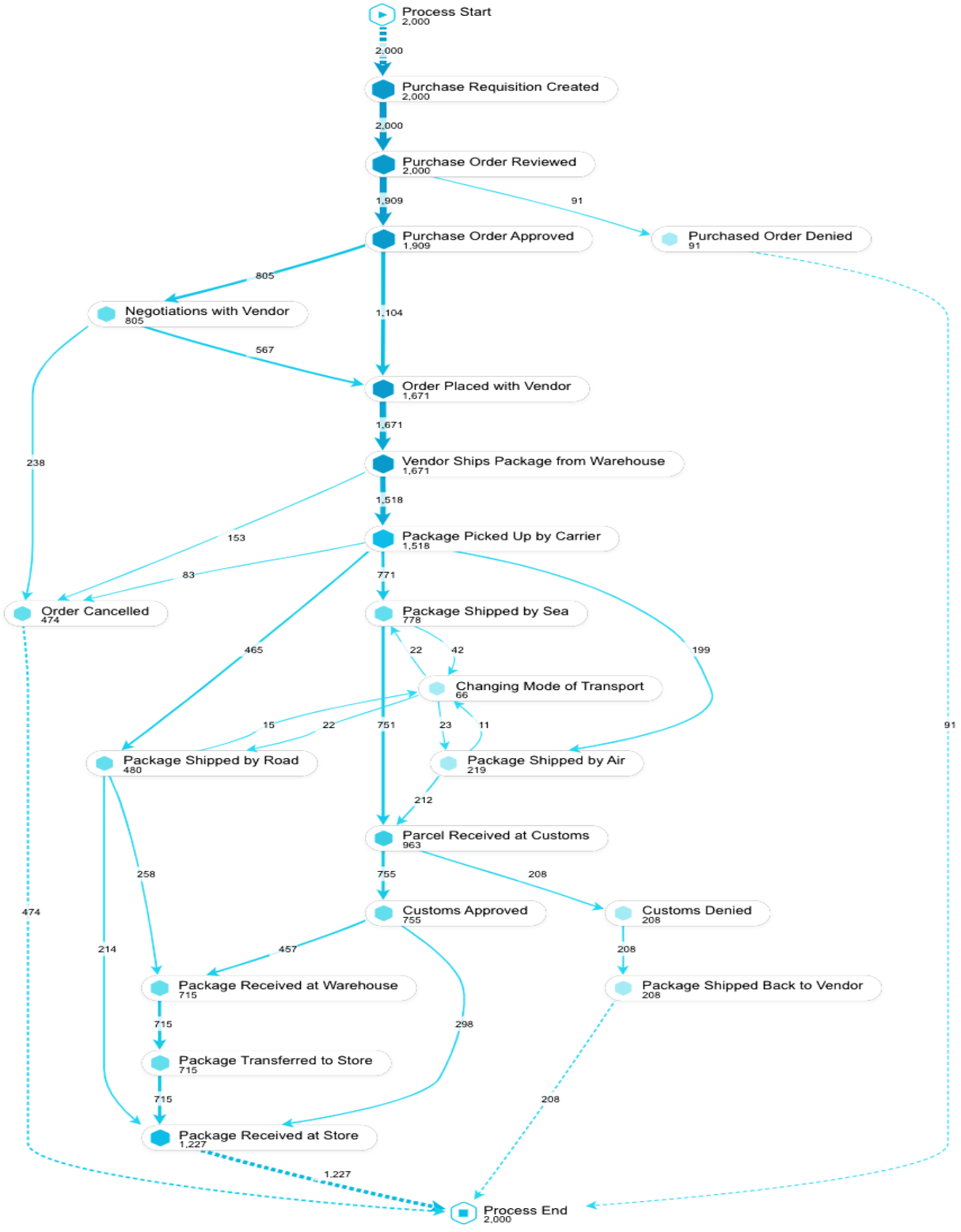
- **Process Start:** The process begins with 2000 orders.
- **Review and Approval:** All orders are reviewed; 1909 are approved, and 91 are denied.
- **Negotiations and Cancellations:** Of the approved, 805 entered negotiations, leading to 238 failures and 567 successes. The rest (1104) proceed without negotiation.

- **Order Placement and Shipping:** 1671 orders are placed with vendors and shipped from the warehouse.
- **Cancellations and Shipping Modes:** Post-shipping, 153 orders are canceled, leaving 1518. Pre-shipping cancellations account for another 83. The remaining orders are shipped by sea (771), air (199), and road (465).
- **Mode Change and Customs:** 66 orders changed their transport mode, affecting the counts (751 seas, 212 air, 480 roads (Note: we found out that road is 472 not 480). At customs, 963 packages (air and sea) are processed; 755 are approved, 208 are denied and sent back.
- **Final Delivery**: Approved packages are either received directly at the store (512) or via warehouse transfer (715). In total, 1227 packages were successfully received at the store.

As we observed throughout this process, factors like negotiations, cancellations, transport mode changes, and customs regulations led to the loss of 773 packages. This illustrates the complexities and challenges of supply chain management and the difference between 2000 and 1227.

See Figure.2

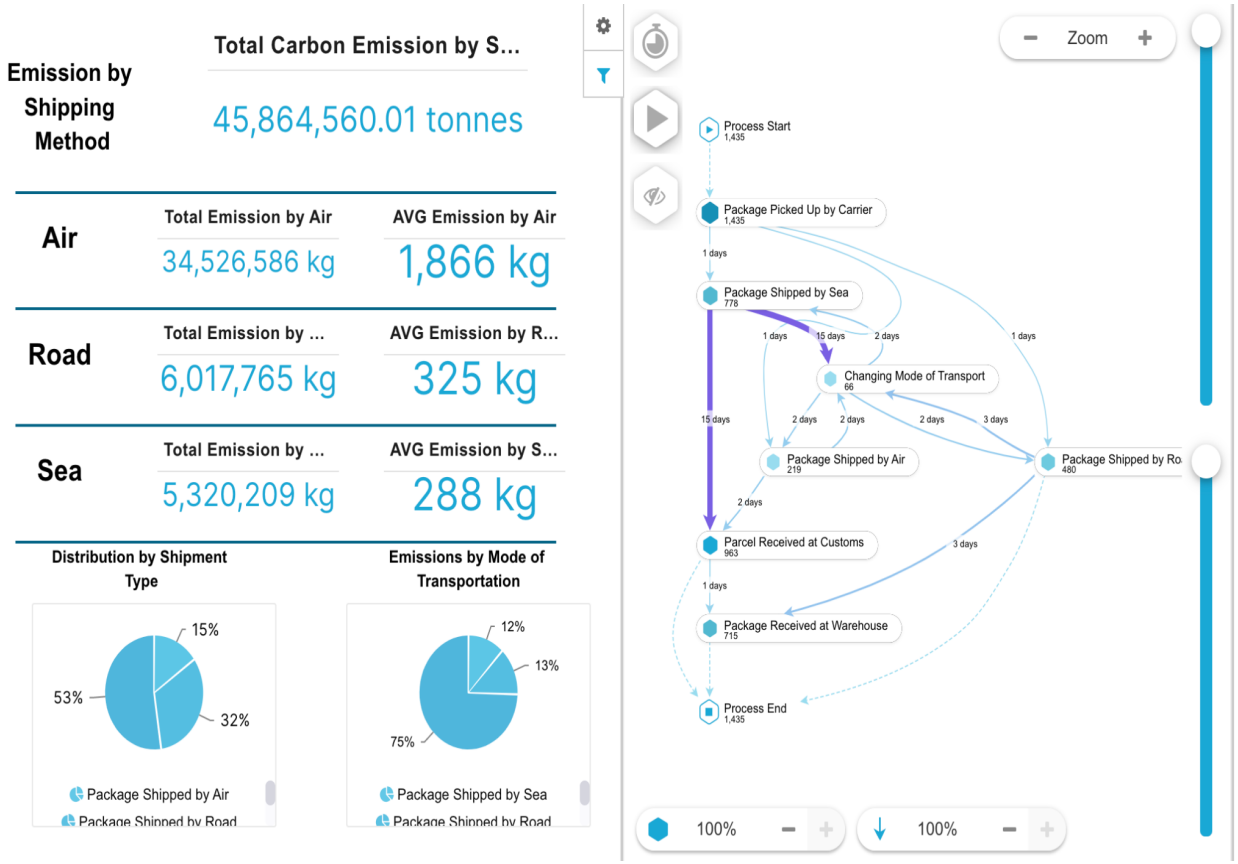
Figure.2


Process Start
2,000
2,000
Purchase Requisition Created
2,000
2,000
Purchase Order Reviewed
2,000
1,909
91
Purchase Order Approved
1,909
Purchased Order Denied
91
805
Negotiations with Vendor
805
1,104
567
Order Placed with Vendor
1,671
1,671
238
Vendor Ships Package from Warehouse
1,671
1,518
153
Package Picked Up by Carrier
1,518
83
771
Order Cancelled
474
Package Shipped by Sea
778
465
22
42
199
Changing Mode of Transport
66
15
22
751
23
11
91
Package Shipped by Road
480
Package Shipped by Air
219
212
Parcel Received at Customs
963
258
755
208
474
Customs Approved
755
Customs Denied
208
214
457
208
Package Received at Warehouse
715
Package Shipped Back to Vendor
208
715
298
Package Transferred to Store
715
715
208
Package Received at Store
1,227
1,227
Process End
2,000

Comparison of Emissions between Transportation Modes

We evaluated three transport modes: sea, air, and land. Sea shipments were the greenest (**288 KG CO2**) but the slowest (**15 days**). Air was the fastest (**2 days**) but the most harmful(**1866 KG CO2**). Land was only for domestic deliveries, and it was moderate in emissions (**325 KG CO2**) and speed (**3 days**).

Air transportation is the most polluting mode of transportation among the three modes due to the large amount of fuel required to power aircraft in addition to its high cost per package. Land vehicles come in a close second as they also require fuel for their engines but are constrained with domestic deliveries only. On the other hand, sea transportation has the lowest emissions because it uses less fuel than other modes per package, produces fewer greenhouse gases per passenger-mile of service, and is cheaper than air shipments. However, it lacks speed in delivery.



Switching the mode of transportation can affect the emissions levels greatly, with an average of (**1123 KG CO2** per shipment), and adding (**2 days**) to the throughput time. The mode of transport can change from sea, air, or land shipments to either sea, air, or land again.

The relationship between average throughput time and mode of transportation is inversely proportional. This means that the faster the mode of transportation, the shorter the average throughput time, and vice versa. For example, air transportation has the shortest average throughput time (**2 days**) but the highest emissions (**1866 KG CO2**), while sea transportation has the longest average throughput time (**15 days**) but the lowest emissions (**288 KG CO2**).

Comparison of Vendor in Terms of Emission

We found that ColorPlus Manufacturing tops the list for the most emissions with a total of (**14,776,478 KG CO2**) as shown in the Table below. We also noted that Pioneer Packaging produces the least emissions with a total of (**4,008,323 KG CO2**).

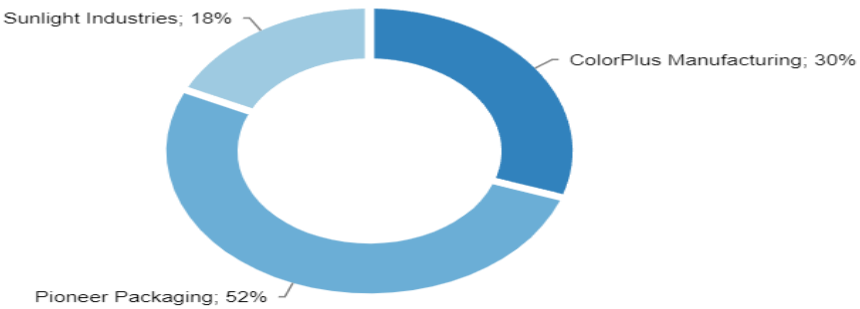
Total Vendor Emissions From Manufacturing

VENDOR	Emission from manufacturing
ColorPlus Manufacturing	14,776,478
Sunlight Industries	8,158,629
Pioneer Packaging	4,008,323

The "EFM By Order Ratio" donut chart below, shows the ratio of emissions from manufacturing by order and it explains the efficiency of each vendor in terms of emissions per order showing the following:

- Sunlight Industries is the most efficient, with the lowest EFM ratio at (**18%).** This implies that for each order, Sunlight Industries emits less CO2 compared to the other vendors.
- ColorPlus Manufacturing is the second most efficient with a (**30% EFM ratio**).
- Pioneer Packaging, despite having the lowest total emissions, has the highest EFM ratio at (**52%**), suggesting it is the least efficient in terms of emissions per order.

EFM By Order Ratio



Based on the above, Sunlight Industries is the most efficient vendor in terms of emissions per order, ColorPlus Manufacturing is in the middle, and Pioneer Packaging, while emitting the least overall, is the least efficient when considering emissions per unit of output (amount ordered). It is important to remember that each vendor is producing certain materials that are not produced by other vendors, we would need to drill down to understand what is the root cause of the emissions.

Emission Analysis Based on Activity

We observed, after a previous discussion about the mode of transport, that undecided activities such as:

- Packages shipped back to vendors
- Changing mode of transport
- Customs denied have high amounts of emissions that could have been avoided.

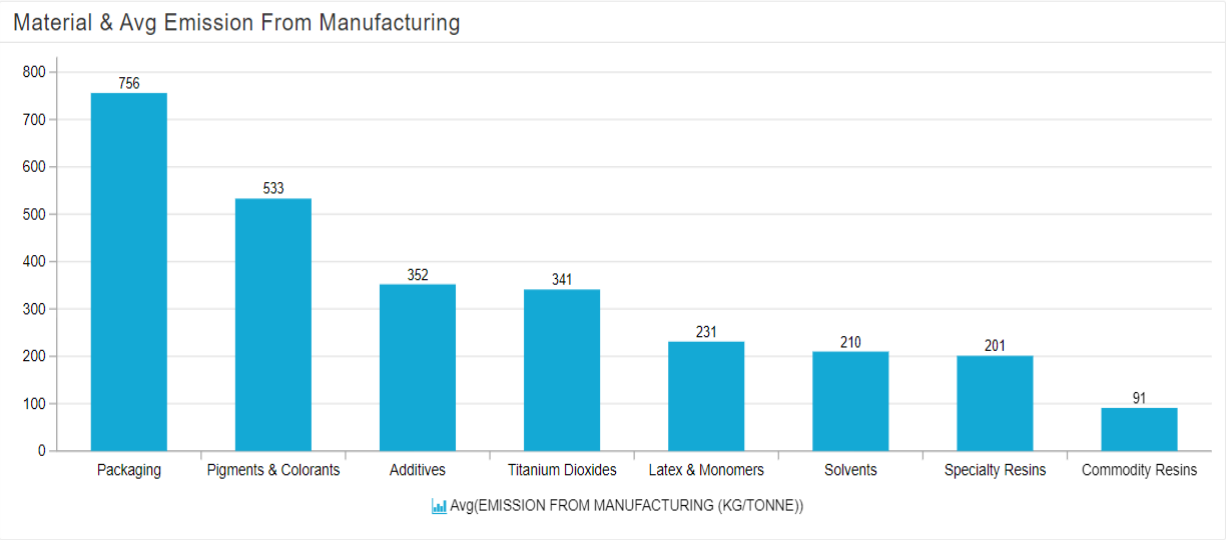
ACTIVITY NAME	Sum(EMISSIONS (KG CO2))
Package Shipped by Air	34,526,586.00
Package Shipped by Road	6,017,764.83
Package Shipped by Sea	5,320,209.18
Package Shipped Back to Vendor	1,291,820.20
Vendor Ships Package from Warehouse	1,181,393.17
Package Transferred to Store	448,542.64
Package Received at Store	132,299.26
Changing Mode of Transport	77,531.18
Package Received at Warehouse	51,262.02
Package Picked Up by Carrier	26,978.85
Order Placed with Vendor	23,627.86
Customs Denied	17,457.03
Parcel Received at Customs	17,225.30
Negotiations with Vendor	14,629.52
Customs Approved	13,733.89
Purchase Order Reviewed	7,088.17
Purchase Requisition Created	7,088.17
Purchase Order Approved	6,784.66
Order Cancelled	3,352.81
Purchased Order Denied	303.50

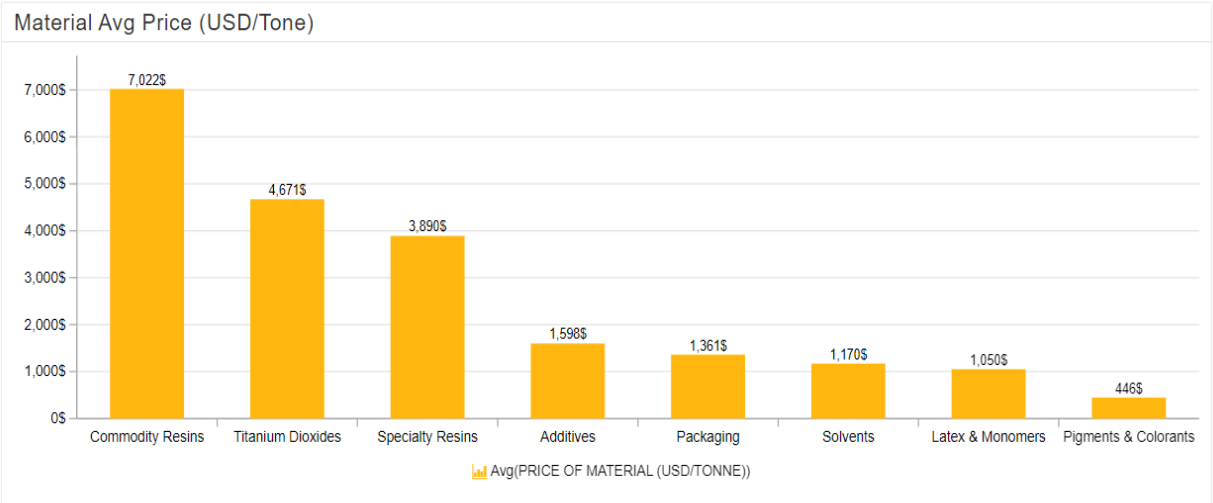
Emission Analysis Based on Material, Vendor, and Price

We observed that each vendor is associated with a specific material. See table below

We observed that packaging material has the highest average emission from manufacturing, whereas, commodity resins have the least emission. Interestingly enough, we found that most likely the higher the price the less the emission such in the case of commodity resins and specialty resins. See tables below.

VENDOR	MATERIAL	Count(MATERIAL)
ColorPlus Manufacturing	Specialty Resins	275
ColorPlus Manufacturing	Titanium Dioxides	272
Sunlight Industries	Commodity Resins	272
Sunlight Industries	Solvents	270
Pioneer Packaging	Packaging	268
ColorPlus Manufacturing	Pigments & Colorants	257
Sunlight Industries	Additives	241
Sunlight Industries	Latex & Monomers	145





Emission Analysis Based on Seasonality

The charts illustrate the seasonality of emissions in the dataset, looking at average monthly emissions (**KG CO2**) for the years 2020 and 2021. The results show distinct trends that can be categorized into four types of variations: seasons with high emissions, with constant emissions, decreasing emissions, and fluctuations.

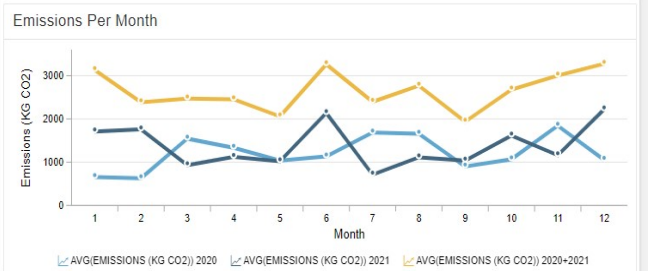
The first notable season of high emissions occurs in January 2021, reaching (**3,487.40 KG CO2**), and persists until June 2021, with emissions remaining relatively high at (**2,126.90 KG CO2**) and (**4,181.46 KG CO2**), respectively. This suggests a continued trend of high emissions during the first half of 2021. The second type, a period of constant emissions, is observed from March to May 2020, where the volume of emissions is high but remains stable throughout this period. The

third type reflects a significant reduction in emissions, starting in February 2020, marking a notable drop to (**1,260.20 KG CO2**), and in March 2021. This indicates a conscious effort or external factors leading to a reduction in emissions during this period.

The last type involves fluctuating emission levels, characterized by uncertain periods of increasing and decreasing emission volumes. These fluctuations are observed in August 2020, November 2020, and August 2021. Despite the increases, emission levels remain lower than during the first season of high emissions, suggesting a cyclical trend with varying intensities. Overall, these variations in emissions volumes across seasons can be attributed to factors such as excessive or non-excessive use of certain modes of transportation, materials used by specific manufacturers, and fluctuations in all Commercial activities. See figure below.

Emissions Per Month

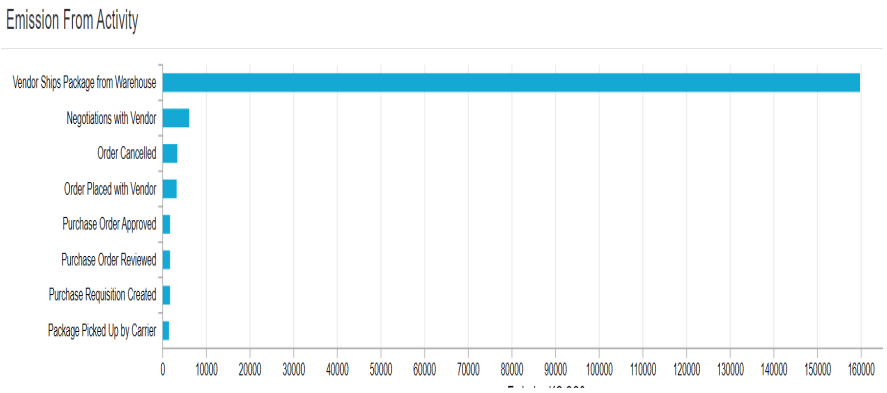
Month(TIMESTAMP)	AVG(EMISSIONS (...	AVG(EMISSIONS (...	AVG(EMISSIONS (...	Count(ACTIVITY N...
2020-01	1,736.56	0.00	1,736.56	632
2020-02	1,260.20	0.00	1,260.20	673
2020-03	3,003.95	0.00	3,003.95	776
2020-04	2,575.18	0.00	2,575.18	813
2020-05	1,997.66	0.00	1,997.66	830
2020-06	2,312.08	0.00	2,312.08	670
2020-07	2,894.62	0.00	2,894.62	876
2020-08	3,279.14	0.00	3,279.14	870
2020-09	1,735.48	0.00	1,735.48	769
2020-10	1,949.42	0.00	1,949.42	863
2020-11	3,266.04	0.00	3,266.04	825
2020-12	2,351.96	0.00	2,351.96	754
2021-01	0.00	3,487.40	3,487.40	821
2021-02	0.00	3,505.02	3,505.02	676
2021-03	0.00	1,911.64	1,911.64	734
2021-04	0.00	2,325.37	2,325.37	758
2021-05	0.00	2,126.90	2,126.90	766
2021-06	0.00	4,181.46	4,181.46	699
2021-07	0.00	1,703.17	1,703.17	629
2021-08	0.00	2,246.28	2,246.28	852
2021-09	0.00	2,153.28	2,153.28	714
2021-10	0.00	3,562.35	3,562.35	716
2021-11	0.00	2,662.13	2,662.13	638
2021-12	0.00	4,024.35	4,024.35	928
2022-01	0.00	0.00	5,783.92	221

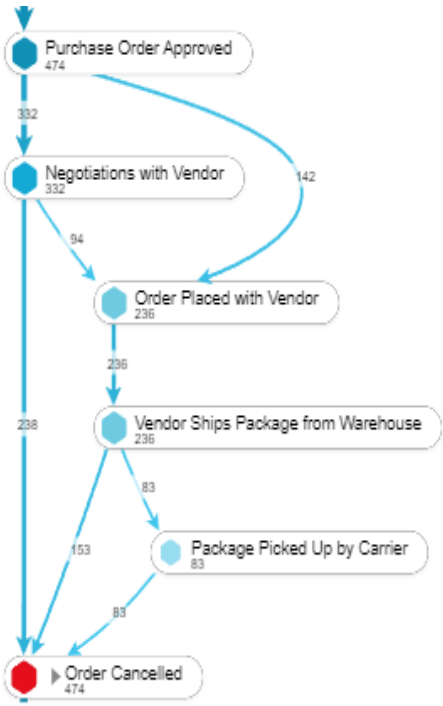


Exploring canceled orders

From the filtered process below, we can see the number of cases that ended up with canceled orders is 474 cases. We also can see from the bar chart below that when the order is canceled there is emission from several activities such as negotiations with vendors, vendor ships

orders from the warehouse, etc. The activity that produces the highest emission when the order is canceled is when the vendor ships packages from the warehouse.





Ideal Path Determination

Using Celonis, we analyzed our supply chain process to find the most efficient path. We defined an ideal process that reduces throughput time, emissions, and wasted resources. We avoided undesired activities that cause waste, such as:

- Canceled orders
- Packages shipped back to the vendor
- Denied customs
- Denied purchase orders
- Unnecessary changes in modes of transport

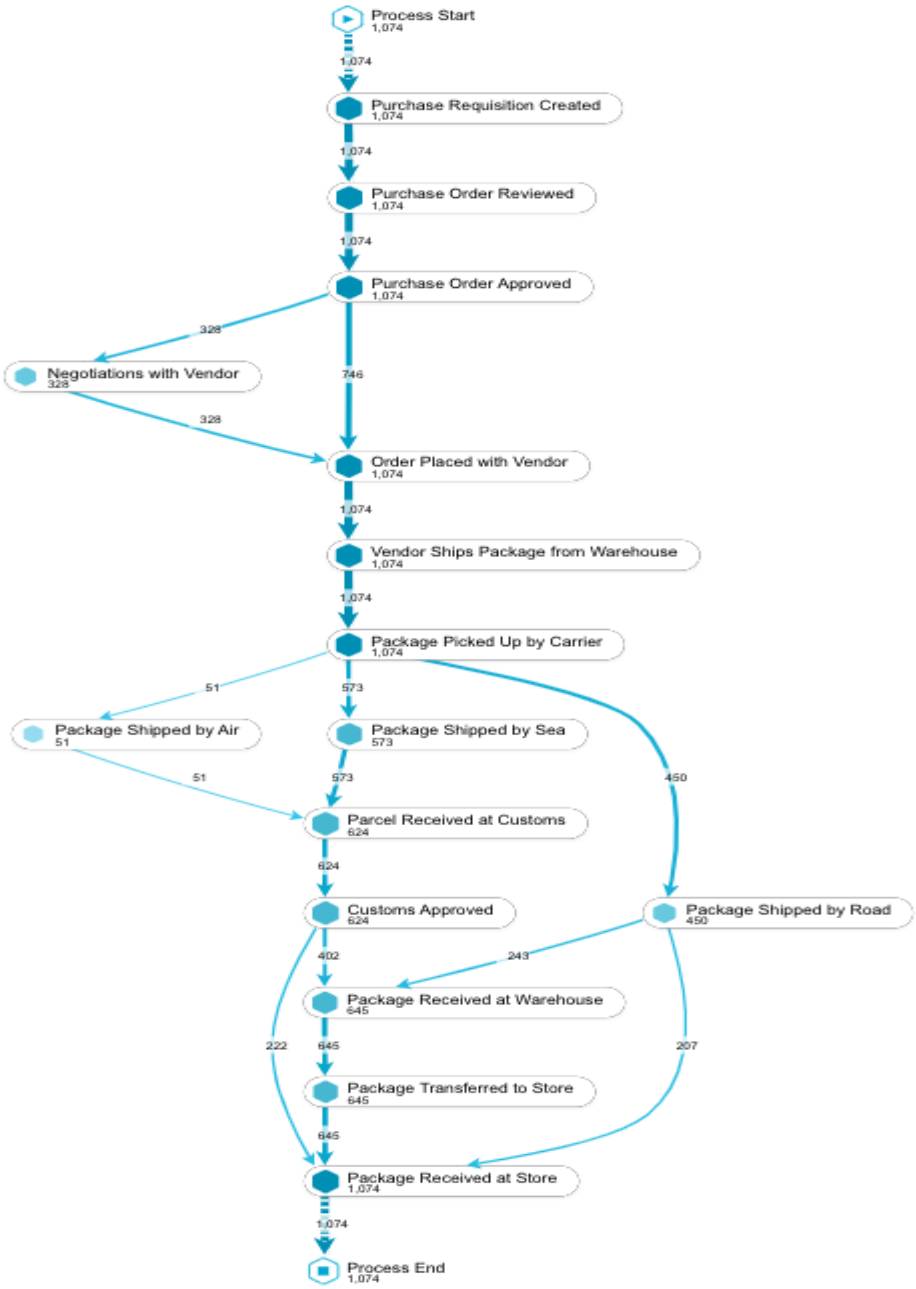
These activities hurt our profit, sustainability, and customer satisfaction. We also looked for bottlenecks and improvement areas in each supply chain activity. We ensured that each step was valuable.

We wanted to choose the best transport mode for each delivery. We used Celonis to analyze data and improve our efficiency and environmental impact. We found out that only **60%** of our deliveries had the best route and time (**18.9 days**).

We also considered the limitations of each mode, such as the distance and the destination. Our analysis helped us make smarter decisions for our supply chain optimization.

We implemented optimizations like changing transport modes or vendors based on emissions or selecting more efficient suppliers. We reduced time, emissions, and resources.

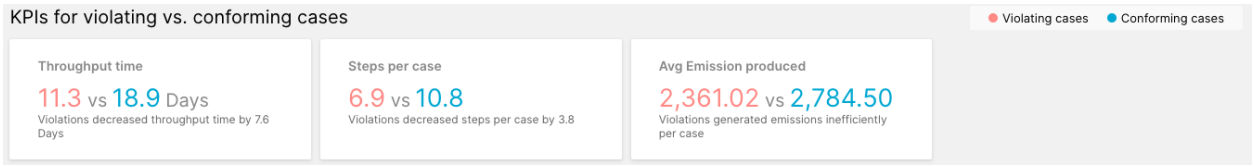
Overall, our analysis has given us valuable insights into optimizing our supply chain processes using Celonis process mining tool. We have modeled an ideal supply chain process that minimizes throughput time, emissions, and wasted resources while identifying areas for improvement within each key activity within the supply chain.



Undesired Activity Calculation

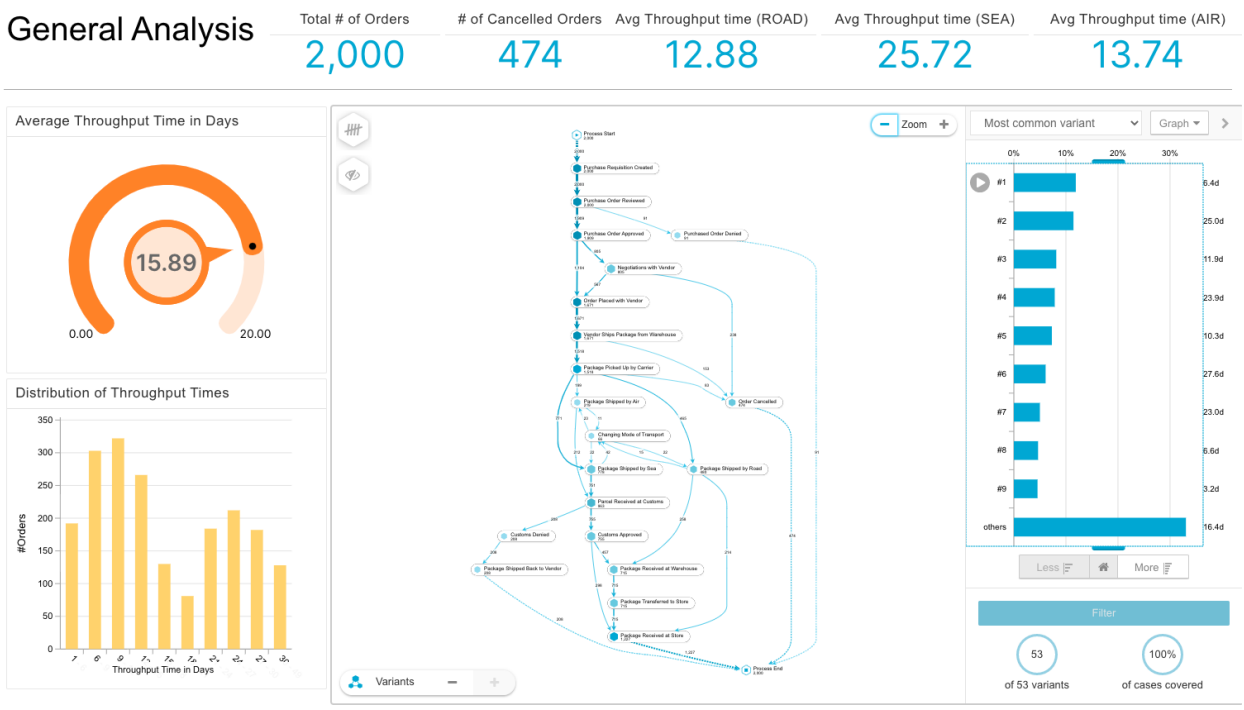
The undesired activities resulted in a waste of **(11.3 days)** and effort spent on **(7 steps)** per failed order. Additionally, an average of **(2,361.02 KG CO2)** emissions were generated inefficiently per case. However, by removing the steps causing inefficiency, such as canceled orders, packages shipped back to the vendor, denied customs, denied purchase orders, and

unnecessary changes in the mode of transport, we can achieve higher environmental sustainability, increased profit, and higher customer satisfaction.



To mitigate unnecessary carbon emissions, it is critical to address businesses experiencing a high rate of order cancellations. Identifying and correcting the root causes of these cancellations can significantly contribute to a more sustainable supply chain.

Dashboard Examples



Dashboard visuals are used to illustrate the high emission levels associated with all modes of transport and their average throughput time.

Recommendations

To reduce the carbon footprint when selecting a mode of transportation the company should consider the following recommendations:

- Use sea transportation for international deliveries, unless urgent or time-sensitive. It has the lowest emissions and cost, but the longest time. (Highly recommend)
- Use land transportation for domestic deliveries, unless they are too long or difficult. It has moderate emissions and speed and can cover most routes. (Recommend)
- Use air transportation only as a last resort, or when the customer pays extra. It has the highest emissions and cost, but the shortest time. (Consider)
- Use hybrid modes of transportation, such as sea and air or sea and land, to balance emissions, cost, and time. (Recommend)
- Use more efficient vehicles, such as electric or hybrid cars, trucks, buses, or aircraft, to reduce fuel consumption and emissions. (Highly recommend)
- Optimize routes and loads to match forecast and minimize travel distance and fuel demand. (Highly recommend)

Example: Amazon is committed to decarbonizing its delivery fleet and has rolled out more than 10,000 custom electric delivery vans across the U.S.(*Amazon now has over 10,000 custom electric vans delivering to customers across the U.S.* 2023).

To reduce carbon footprint when ordering from these vendors the company should consider the following recommendations:

- Prioritize Efficiency: Choose Sunlight Industries for orders when possible, as they have demonstrated the highest efficiency with the lowest emissions per order ratio (**18%**). By doing so, the company would be minimizing the emissions footprint per unit of output received. (Highly recommend)
- Evaluate Total Emissions Impact: If the order size is large, ColorPlus Manufacturing, despite having the highest overall emissions, still has a relatively low emissions-per-order ratio (**30%**). Large orders from ColorPlus might not significantly alter the emissions per unit of output, making them a viable option for bulk orders. (Recommend)
- Engage with ColorPlus Manufacturing and other high-emission vendors to discuss sustainability improvements. (Recommend)
- Negotiate with Vendors: Engage with Pioneer Packaging to discuss ways to improve their efficiency since they have the highest emissions per order ratio (**52%**). They produce the

least total emissions, which indicates potential for improvement in efficiency. The company could explore opportunities for joint initiatives to lower emissions, such as investing in carbon reduction technologies or improving process efficiencies. (Consider)

To reduce carbon footprint in terms of canceled orders and seasonality we recommend the following:

- Implementing a policy where orders cannot be canceled after the vendor has shipped the package from the warehouse. As it is the step with the highest carbon emissions when the order is canceled. (Highly recommend)
- Replicate Success, Analyze the factors contributing to reduced emissions in February 2020 and replicate successful strategies in other months. (Recommend)
- Flexibility in Operation, Develop strategies to adapt operations based on identified factors, promoting flexibility in response to changing circumstances. (Consider)
- Enhanced Monitoring, Implement real-time monitoring during peak months to identify specific activities or processes leading to high emissions.

Conclusion

This Emission Analytics Report, conducted using Celonis software, has provided in-depth insights into the emissions generated from a company's supply chain processes. Our analysis encompassed a diverse range of factors, including transportation modes, vendor emissions, and seasonal variability, across 2000 orders.

Key findings highlight the substantial emission disparities between transportation modes, with air transport being the most emission-intensive and sea transport the least. Vendor analysis revealed significant differences in emissions, pinpointing opportunities for strategic partnerships and efficiency improvements. The seasonal analysis underscored the fluctuating nature of emissions, suggesting potential for targeted emission reduction strategies during high-emission periods. Our report uncovered the considerable impact of undesired activities like canceled orders and customs denials, contributing to excess emissions. These findings underscore the necessity for more efficient supply chain management to enhance sustainability.

Our analysis suggests a multi-faceted approach to reducing emissions.

This includes:

- Optimizing transportation mode selection
- Prioritizing efficient vendors
- Reducing undesired activities
- Enhance monitoring during peak seasons.

Implementing these recommendations could lead to substantial improvements in sustainability, demonstrating the power of data-driven analysis in guiding environmental strategy in business operations.

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What is sustainability in business? the process, returns, Kpis and everything you need to know. Celonis. (n.d.). https://www.celonis.com/blog/what-is-sustainability-in-business-the-process-returns-kpis-and-everything-you-need-to-know/