Stakeholder: *Head of ESG at the World Trade Organization*

Executive Summary

The e-commerce industry's rapid growth, particularly accelerated by the COVID-19 pandemic, has significantly increased carbon emissions, especially in last-mile logistics, which accounts for up to 50% of supply chain emissions. This segment is particularly challenging due to fragmented logistics networks, inefficient delivery systems, and urban congestion, which increase fuel consumption and emissions. The rise of small, frequent deliveries and the slow adoption of electric vehicles (EVs) further exacerbate the issue. Despite public commitments to sustainability, the industry's environmental impact is still high, with key contributors including transportation, warehousing, packaging waste, and returns. Addressing last-mile logistics through improved efficiency, cleaner technologies, and policy interventions is crucial to reducing the e-commerce sector's carbon footprint.

Background

The e-commerce industry has seen exponential growth, particularly accelerated by the COVID-19 pandemic. According to a report by Statista, global e-commerce sales reached 5.7 trillion in 2022 were projected to grow to 6.3 trillion by 2024 (Statista, 2023). In 2023, around 356 billion packages were shipped across the globe and this number is projected to reach 498 billion by 2028 (World Trade Organization, 2023). This rapid growth of the e-commerce industry has significantly increased energy consumption and carbon emissions across its supply chain, from manufacturing and packaging to warehousing and last-mile delivery. The “Last Mile Delivery” part of the supply chain poses a unique challenge as it is the most complex, time-consuming, and expensive step in the entire shipping process. Last-mile logistics contribute up to 50% of total supply chain emissions and despite companies’ big claims for green fleets and moves towards electric vehicles (EVs), very few are practicing what they preach on sustainability and climate change. In fact, due to fragmented logistics networks, lack of standardized data collection practices amongst subcontractors, and the sheer number of small individual deliveries involved in the final leg of the supply chain, it is a challenge to even source publicly available data to try and address this problem.

We want to understand the scope of possible policy implementations that could systematically try and limit the carbon footprint and environmental impact of this industry. To understand this segment, we begin by exploring specific facets of the supply chain industry and identifying the extent of this problem within the industry.

How pertinent of a problem has carbon emissions in the e-commerce industry been over the past few years?

A study by the World Economic Forum (WEF) estimates that e-commerce-related emissions could increase by 32% by 2030 if no mitigation strategies are implemented (WEF, 2020). The last-mile delivery segment, which involves the transportation of goods from a distribution center to the final consumer, is particularly problematic. It is estimated that last-mile delivery accounts for up to 50% of total supply chain emissions (McKinsey & Company, 2020).

Last-mile delivery is the most carbon-intensive part of the e-commerce supply chain due to several factors:

- Fragmented Logistics Networks: The reliance on multiple subcontractors and third-party logistics providers often leads to inefficiencies and redundant routes, increasing fuel consumption and emissions (World Trade Organization, 2023).

- Increased Delivery Frequency: The rise of same-day and next-day delivery options has led to more frequent trips, often with partially filled vehicles, further exacerbating emissions (International Transport Forum, 2024).

- Urban Congestion: Last-mile delivery often occurs in densely populated urban areas, where traffic congestion leads to longer idling times and higher emissions per delivery (European Environment Agency, 2022).

While many e-commerce companies have made public commitments to reduce their carbon footprints, the actual implementation of these initiatives has been inconsistent. For example, Amazon, one of the largest e-commerce players, has pledged to achieve net-zero carbon emissions by 2040 through its "Climate Pledge" (Amazon, 2023). However, a report by the New Climate Institute found that Amazon's actual progress toward this goal has been limited, with only a 2% reduction in emissions from 2019 to 2021 (New Climate Institute, 2022).

Similarly, the adoption of electric vehicles (EVs) for last-mile delivery has been slower than anticipated. A study by the International Council on Clean Transportation (ICCT) found that EVs accounted for less than 1% of the global delivery fleet in 2022, despite the potential for significant emissions reductions (ICCT, 2022). Barriers to adoption include high upfront costs, limited charging infrastructure, and a lack of standardized data collection practices among subcontractors, which makes it difficult to measure and manage emissions effectively (World Trade Organization, 2023).

What are the most energy-intensive stages of the e-commerce supply chain and how do they contribute to the overall environmental impact?

The e-commerce supply chain involves several stages, each with varying levels of energy consumption and environmental impact. According to research and industry reports the most energy-intensive stages typically include:

- **Transportation**

One of the phases of the e-commerce supply chain that uses the most energy is transportation. It includes the movement of goods from manufacturers to warehouses, between warehouses, and finally to customers. This stage involves various modes of transport, including trucks, planes, ships, and delivery vans, all of which consume large amounts of fuel. Last-mile delivery is the final link in the supply chain from retailer/supplier to the consumer and considered to be the most energy and carbon-intensive segment [12]. It may involve delivery fleets of fossil fuel-powered trucks and vans that generate relatively high CO2 emissions [13]. However, the adoption of alternative vehicles, such as electric vans, could dramatically reduce emissions and contribute to a more sustainable e-commerce supply chain.

- **Warehousing and Storage**

Warehousing is a key component of the e-commerce supply chain, involving the storage of goods before shipment. These facilities consume significant energy for lighting, heating, and cooling, with inefficiencies in space utilization and inventory management increasing energy use. The trend toward larger, centralized warehouses to meet fast shipping demands further drives energy consumption. Construction and maintenance also impact the environment through land use changes. While warehouse buildings are becoming more energy-efficient, the complexity of the order-and-delivery process, including increased packaging and individualized deliveries, can offset these gains, making the overall system less energy-efficient.

- **Product packaging**

Packaging is part of the order picking and assembly phase, where items are sorted and placed directly in the packaging used for deliveries to limit damages during transport, returns, and re-deliveries. An analysis of the quantitative impact of e-commerce on packaging waste in Korea found that e-commerce generated 4.8 times more packaging waste than goods sold in traditional retail sales stores, with implications for GHG emissions [14]. In particular, e-commerce significantly contributes to environmental waste and carbon pollutants through the use of cardboard boxes, with the issue being exacerbated when increased packaging and hard-to-recycle materials such as printed return forms and sticky labels are used for online returns.

- **Returns**

Returns are part of the post-sale phase. Activities linked to the return of a purchased item have environmental impacts that are affected by the use and choice of return packaging and labeling, reconditioning, storing, order picking, repackaging and new deliveries. The growth of e-commerce has been accompanied by a rise in product returns, the rates of which tend to

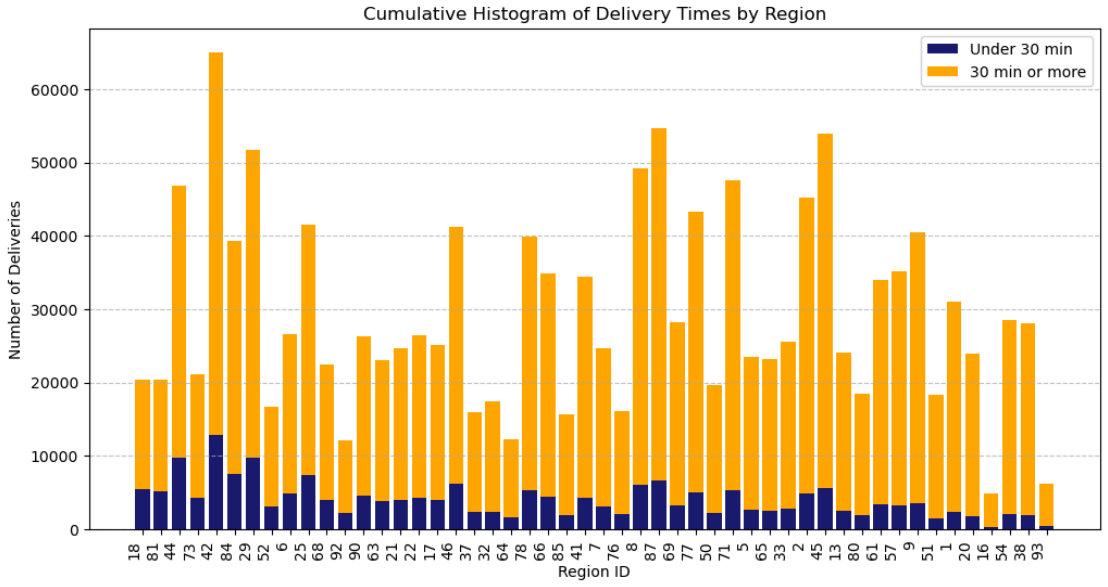
be much higher for online shopping than for in-store purchases. Returns can result in increased transportation emissions due to additional trips for product collection, sorting and redistribution, especially if return centers are far away from the customer's location. Additionally, returned items need to be inspected, restocked, or refurbished, which requires extra energy for processing and storage. Many returned products require repackaging, often leading to additional plastic, cardboard, and filler materials being used even though those items are not resold in most cases and may end up in landfills, further exacerbating waste issues.

Together, these stages highlight the complex and energy-intensive nature of the e-commerce supply chain. Different amounts of energy consumption and waste generation will result from a variety of factors, including the location of warehouses, the kind of packaging materials used, the effectiveness of transportation vehicles, and the volume of returns. Therefore, the environmental impact of the full e-commerce supply chain cannot be captured by a single number or one-size-fits-all approach.

How long does it currently take for a package to get delivered to the final consumer?

In the 50 regions of Shanghai, China that we looked into, between pickup from the last warehouse and delivery to the final customer, only ~14% of packages on average were able to be delivered under the 30-minute benchmark, and a significant majority of the deliveries happen between 30 - 300 minutes of pickup from the warehouse. Only four regions in Shanghai crossed the benchmark of having over 20% of the last mile deliveries under 30 minutes. This could be due to these regions being subdistricts in Shanghai with a reasonably fast-growing population size; it currently has the perfect population density to ensure that deliveries are possible in under 30 minutes.

[Delivery Time Distribution by Regions in Shanghai (Cumulative)]

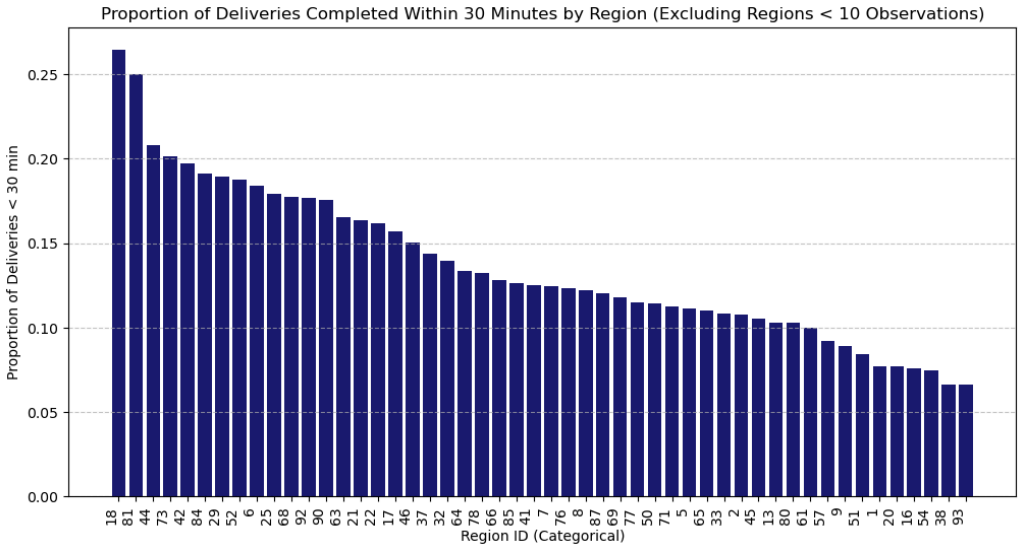


Appendix

The data used was sourced from "LaDe: The First Comprehensive Last-mile Delivery Dataset from Industry". Due to the difficulty in finding public last-mile data in the United States, we chose to analyze data from 50 districts in Shanghai aggregated over a 6-month time period spanning late 2022 and early 2023, comprising 1.4 million delivery orders to answer our research question.

We cleaned the data by only including the lower 99 percentile of the data to remove any skewness and outliers from the data. We also included only regions with more than 10 observations available to ensure completeness of the data we were working with. The % of total deliveries that happen under 30 minutes for each region has been aggregated and displayed in the graph below.

[Last-Mile Delivery by region in Shanghai:Proportion of delivery less than 30 minutes]



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