Fast Fashion Transition Risk and Carbon Cost Exposure

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December 2025

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1 Introduction

The fast fashion industry is responsible for a significant share of global greenhouse gas emissions, mainly due to practices such as producing large volumes, having short lifetimes for products, and operating supply chains spread over several regions. In response to that, regulators gradually become more stringent, prices for carbon emissions increase, and investors and consumers keep a closer eye on environmental impacts, all leading to considerable transition risks for fast fashion companies.

Transition risk in this case means the financial and strategic risks that a company faces when societies and economies are changing to low-carbon models. The risks stem from climate policies, ways of implementing carbon pricing, technological innovations, and changes in market expectations. Fast fashion companies whose manufacturing processes are energy-intensive and carry the risk of being done in regions with a lot of carbon emissions, these events may imply a significant increase in costs and quite a few strategic challenges for them.

This project is an attempt to do that by measuring fast fashion sector transition risk through the lens of carbon pricing scenarios. We have collected data for the multi, country, multi, year dataset, which covers the major fast fashion brands. We are looking at how emissions intensity changes from one firm to another or from one geography to another and determine how big their exposure to carbon pricing could be.

The principal aim of this analysis transcends mere quantification, as it seeks to underpin sustainability-oriented decision-making. The study, through the integration of emissions data with financial outcomes, establishes a baseline for mapping the decarbonization levers and thus facilitating the delivery of strategic recommendations that simultaneously contribute to the mitigation of environmental impact and financial risk.

2 Methodology

2.1 Data and Emissions Calculation

This analysis depends on a fast fashion sustainability dataset that captures major international brands across different countries and years. The dataset comprises production, related indicators such as monthly production volumes, release cycles, and pricing variables, along with environmental metrics, including carbon emissions expressed in CO_2 equivalents.

2.1.1 Data Cleaning and Preprocessing

The raw data set was standardized before any analysis to ensure that the results are robust and can be repeated. The column names were harmonized so that the variables were consistent. Observations that lacked brand, country, or year identifiers were dropped because they could not be assigned to a level of aggregation in a reliable way.

In the case of numerical variables, the missing values were imputed with the median in a conservative manner. This treatment makes results less sensitive to extreme values and is very common in sustainability and ESG analytics. Carbon emissions were recast in metric tons of CO_2 equivalent (tCO_2e) following the carbon pricing standards. If by any chance the emissions were originally in kilograms, they were converted accordingly.

The extreme outliers in the emissions values were located and removed using the interquartile range (IQR) method, thus the step of getting rid of atypical observations that drastically affect the aggregated results, yet preserving the overall distributional characteristics of the data is taken.

2.1.2 Emissions Aggregation

After preprocessing, total annual carbon emissions were calculated at the brand, country, year level. This level of aggregation represents the appropriate decision, making scale for evaluating transition risk exposure, as regulatory constraints, carbon pricing mechanisms, and supply chain characteristics differ across jurisdictions and change over time.

2.1.3 Carbon Cost Scenarios

Three carbon pricing scenarios served as the basis for evaluating the financial risk of emissions exposure. These featured a low scenario (€50 per tCO_2e), a central scenario (€100 per tCO_2e), and a high scenario (€150 per tCO_2e). The figures align with both ongoing policy debates and anticipatory climate stress testing exercises.

In each scenario, annual carbon costs were calculated as the product of total emissions and the respective carbon price. The figures thus derived represent a first-level quantification of the potential exposure of fast fashion brands to transition risk as a result of the implementation of progressively stringent climate policies.

3 Results and Interpretation

3.1 Brand-Level Transition Risk Exposure

Brand-level benchmarking reveals that fast fashion companies vary greatly in their exposure to transition risks and emissions intensity. Some of the companies in question could have to pay more than six and a half million euros per year in carbon costs, based on an assumed price of 100 euros per ton of CO2. This indicates a significant risk that these companies will be subject to climate regulations in the future. Figure 1 illustrates the distribution of the annual exposure to carbon costs between the main fast fashion brands under the central carbon pricing scenario.

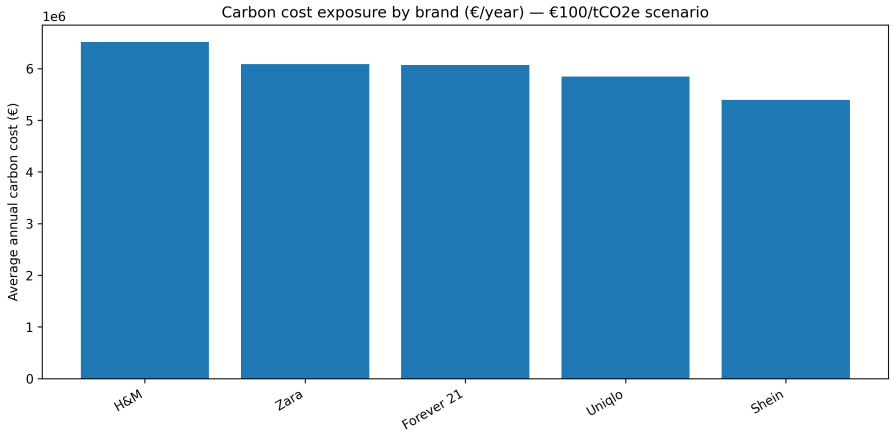

Figure 1: Annual carbon cost exposure by brand under a €100/tCO_2e carbon pricing scenario (€/year).

H&M stands out as the company that is financially the most at risk due to its carbon emissions. It has the highest average carbon emissions and the highest exposure to carbon costs. Compared to its peers, H&M's large production scale, which is combined with only moderate carbon efficiency, indicates that the company has a limited capacity to absorb future regulatory tightening without putting pressure on its operating margins.

Zara shows a very different picture as it has the most carbon-efficient profile of the evidence. Zara is the most carbon-efficient brand in the sample with an average of 20. 24 tCO_2e per $1 million of GDP generated. Such a low carbon emissions-to-GDP ratio puts the company in a pretty good position under carbon pricing systems and possible carbon border adjustment policies, even if the company has a high absolute emissions level.

Shein shows a very inefficient profile and leads in the emissions-to-GDP ratio with 24. 19 tCO_2e per $1 million of GDP. Despite the fact that its absolute carbon costs are still lower than those of H&M or Zara, the brand's low economic return per unit of emissions means that carbon pricing would be a disproportionately negative factor for profitability. Besides that, the company is more exposed to the regulations due to relatively lower transparency scores as stricter ESG disclosure requirements may lead to higher compliance costs.

These results, in large part, indicate that the key factor leading to a transition risk is carbon efficiency and not only absolute emissions. Companies that merge low emissions intensity with high transparency have a structural advantage of being able to resist future climate regulations.

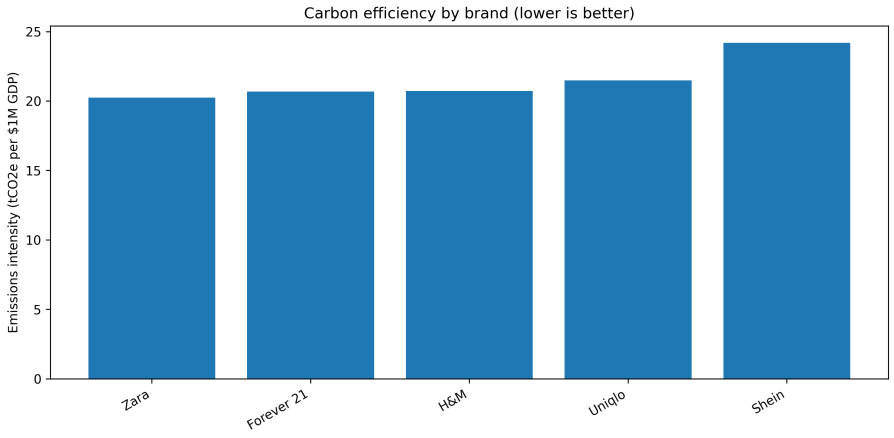

Figure 2: Carbon efficiency by brand (tCO_2e per $1M GDP). Lower values indicate higher efficiency.

4 Decarbonization Levers and Strategic Implications

From a sustainability consulting perspective, tightening climate policy frameworks are progressively transforming carbon emissions into a direct financial cost rather than a purely reputational concern. In this context, Shein faces particularly high transition risk, driven by its high emissions-to-GDP ratio and lower transparency.

In the short term (12-24 months), exposure can be reduced through operational measures requiring limited capital expenditure. These include reducing the number of production cycles to lower overall output volumes, improving ESG disclosure and standardizing sustainability metrics to mitigate compliance risk, and reducing return rates through enhanced sizing accuracy and quality control, which would decrease landfill waste and associated costs.

In the medium term, more structural actions are required. These include partial reconfiguration of supply chains toward regions with lower environmental and social risk, as well as investment in cleaner production technologies powered by renewable energy sources.

Complementary initiatives, such as take-back schemes and recycling programs, would further reduce waste intensity and emissions. Taken together, these measures illustrate

how decarbonization can function as a strategic enabler rather than a constraint, strengthening resilience to transition risk while supporting long-term value creation.