# STATE OF SUPPLY CHAIN SUSTAINABILITY 2024

MIT Center for Transportation & Logistics

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STATE OF

# SUPPLY CHAIN SUSTAINABILITY

2024

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The MIT Center for Transportation & Logistics (MIT CTL) is a leading research and educational center within the Massachusetts Institute of Technology with more than 50 years of supply chain expertise. More than a decade ago, supply chain sustainability emerged as a key research area at the center. The center has responded with research, education, and outreach to address the continuing growth of supply chain sustainability as a business imperative fueled by the demands and requirements of consumers, governments, and investors. Supply chain sustainability research at the center is focused on enabling research and collaboration on the social and environmental sustainability of supply chain business processes. **ctl.mit.edu**

### About the Council of Supply Chain Management Professionals

Since 1963, the Council of Supply Chain Management Professionals (CSCMP) has been the leading worldwide professional association dedicated to education, research, and the advancement of the supply chain management profession. With more than 9,000 members globally, representing business, government, and academia from 62 countries, CSCMP members are the leading practitioners and authorities in the fields of logistics and supply chain management. **cscmp.org**




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### Suggested citation:

Velázquez Martínez, J.C., and Arnold, V. “State of Supply Chain Sustainability 2024” (Cambridge, Mass. and Lombard, Ill.: MIT Center for Transportation & Logistics and Council of Supply Chain Management Professionals, September 2024).

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# EXECUTIVE SUMMARY

Sustainability is impacting the way companies operate in every industry across the globe. In 2015, the United Nations created the 17 Sustainable Development Goals, which 191 countries agreed to meet by 2030; many of those countries have put in place regulations for organizations to start reporting on their progress and emissions in order to be held accountable for ensuring that governments can meet the pledges they have signed. Yet the understanding of supply chain sustainability and its impact on organizations is limited. The State of Supply Chain Sustainability Study aims to address the lack of information and provide insights into the potential direction of supply chain sustainability in the future. The report was founded on two fundamental levels. First, the report is an annual research project aimed at chronicling the evolution of supply chain sustainability over time. Second, a three-pronged analytical approach and comprehensive coverage are pioneering in the supply chain sustainability domain. The report shares an unbiased statement of what has been happening in the supply chain concerning environmental and social sustainability.

- In this year's State of Supply Chain Sustainability, we are reflecting on the findings of the past four reports to better direct our future. There are four main takeaways that we have learned since 2019, when the first survey was shared.
- First of all, the world has gone through rapid change and instability during this time, and we can evaluate how each of the main crises has affected the work on making sustainable changes to the supply chain, and how those changes were different depending on the organization's size.
- Secondly, organizations are not financially backing their stated goals, causing companies to not be set up to meet sustainable objectives.
- The third lesson we expand on is the source of pressure that compels organizations to implement sustainable changes.
- The final conclusion drawn from prior research relates to Scope 3 carbon emissions, which include indirect emissions resulting from a company's value chain and suppliers. Estimates suggest that Scope 3 emissions account for an average of 75% of a company's overall emissions,[1] yet they remain challenging to track due to the intricate web of supplier and customer relationships and their extended business workstreams. Companies rely on estimation platforms that may not provide the most accurate data.

This report also discusses the MIT Sustainable Supply Chain Lab's efforts to precisely measure and monitor Scope 3 emissions. This focus is a direct outcome of previous research conducted on the State of Supply Chain Sustainability studies. This aspect is crucial to determining the future trajectory of the report. The current prevailing approach for tracking Scope 3 emissions is the Spend-Based method, which uses economic activity to allocate carbon intensity factors. Unfortunately, this approach discourages companies from implementing sustainable changes if it increases costs. Due to its widespread use, the urgency of this research stems from its significant impact on global supply chains, the strong interest of the world's largest companies, and the implementation of regulations by the European Union and the state of California, which require companies operating in these regions to start reporting on their Scope 3 emissions very soon.

While this year's report is unique from past reports, in the future, the State of Supply Chain Sustainability study will continue to develop and improve. It will not only present impartial findings on environmental and social sustainability in the supply chain but also offer explicit recommendations and suggestions for organizations to make more sustainable decisions. This will include showcasing successful case studies and placing a strong emphasis on addressing Scope 3 emissions. We have already witnessed achievements in circular supply chain initiatives, sustainable packaging innovations, and carbon accounting efforts. However, we still have a significant amount of work ahead of us.

# INTRODUCTION

"This is a must-read for anyone in supply chain. Global supply chains are in a unique position to have a positive effect on society. Businesses and consumers alike are putting pressure on us to source and supply products to live up to their social and environmental standards. The State of Supply Chain Sustainability 2024 provides a thorough analysis of our current understanding along with valuable insights on how to improve our Scope 3 emissions accounting to have a greater impact on lowering our emissions. CSCMP and MIT are excited to present you with the fifth edition of the most valuable tool that will help you benchmark your supply chain sustainability progress."

**—Mark Baxa**
President and CEO, Council of Supply Chain Management Professionals (CSCMP)

The MIT Center for Transportation & Logistics and the Council of Supply Chain Management Professionals together produce the annual State of Supply Chain Sustainability study. As we launch the fifth annual report, it is hard to overlook the enormous events that have reshaped global commerce in the last several years. The Covid-19 pandemic and recent regional wars have presented supply chain networks with significant hurdles that impact trade routes, resource availability, and humanitarian needs. As a result, supply chains are navigating a turbulent landscape. How does the notion of sustainable supply chains align with the current challenging circumstances?

A sustainable supply chain is a supply chain that considers the environmental and social impact of a product's journey through the whole supply chain, from raw materials to final delivery.[2] The goal is to minimize environmental harm while positively impacting the people and communities involved. However, this objective is dynamic, meaning that there cannot currently exist a completely "sustainable" supply chain, as we are unaware of what elements will be deemed essential for sustainability in the future. A sustainable supply chain is characterized by its ability to effectively identify and address both present and future environmental and social impacts, employing strategies to minimize their effects.[3] The World Economic Forum states that supply chain sustainability is critical to achieving climate goals globally, with eight supply chains across major industries that account for more than 50% of global greenhouse gas emissions.[4] In addition, the United Nations has made a clear statement that the opportunity to avoid a climate disaster is hastily closing. The actions we take over the next few years, or fail to take, will have profound consequences for thousands of years to come.[5] We, as leaders in supply chain management, have a responsibility to act.

There is a growing trend of climate regulations being passed globally to help countries meet their climate pledges.[6] Organizations are facing enormous pressures to make sustainable changes, yet they seem to be falling behind. The State of Supply Chain Sustainability Study aims to provide companies with unbiased information regarding ongoing sustainable initiatives. This will enable organizations to adapt their strategies in order to align with the expectations and objectives of both consumers and investors. What knowledge have we acquired over time that can assist us in attaining our sustainability objectives and promoting ongoing development? The fifth annual report aims to provide a comprehensive overview of the advancements made and a detailed analysis of the changes in sustainability observed during the study. The report's findings provide professionals with a clear understanding of our current situation and serve as a roadmap for making future decisions that prioritize sustainability.

In this report, we address four key questions. First, **what impact have crises had on sustainability initiatives in the supply chain?** The rapid pace of global transformation has prompted us to inquire about the impact of crises on sustainability initiatives within supply chains, and whether this impact varies based on company size. The response of companies to a crisis varies depending on their specific circumstances and resources. **Second, what are the sources of pressure on companies to implement sustainable changes?** Although regulations are subject to constant revisions and modifications, it seems that investors and customers are exerting pressure on businesses to adopt these changes. The extent to which this occurs depends greatly on the organization's origins. Specifically, American companies are more inclined to respond to economic factors, whereas European companies are more influenced by regulations and policies. Third, **do companies have the necessary resources to achieve their sustainable goals on time?** According to the data we have collected, it seems unlikely that the majority will be able to accomplish their goals within the specified timeframes. And lastly, **to what extent do companies effectively monitor and calculate their carbon footprint, particularly concerning the Scope 3 category, which encompasses indirect emissions from the supply chain?** Although most companies are adept at measuring Scope 1 and Scope 2 emissions categories, they face challenges in measuring Scope 3 emissions due to the lack of direct control over the information and the process. Consequently, it is becoming increasingly difficult for companies to gather the necessary information to comply with regulatory bodies that

now demand this data. Due to the difficulty in measuring Scope 3 emissions, organizations depend on estimation platforms that may not offer the most precise data. In order to successfully accomplish the climate goals of the organization, it is crucial to acquire more accurate data on Scope 3 emissions, as they account for approximately 75% of a company's overall emissions1. For this reason, a section of this report covers Scope 3 emissions and the pressing need for further research in this field.

This annual report offers professionals a comprehensive overview of the aforementioned topics, aiming to assist organizations in making sustainable decisions in the current context. Our objective is to advance our discussions on sustainable efforts by incorporating research findings on supply chain sustainability and gathering insights from practitioners. The aim is to collectively shape the future of this field and create together a more sustainable future for the world.

The remainder of the report is structured as follows. The Methodology section of our study focuses on the research approach and provides descriptive information about the data collected over the past four years. The section titled Lessons from Previous Studies on Supply Chain Sustainability examines the impact of crises, the drivers of sustainability, the difficulty of achieving sustainability objectives, and the challenges associated with accounting for and tracking Scope 3 emissions. Finally, in the section titled Scope 3 Emissions Research Agenda and The Future of the State of the Supply Chain Sustainability, we provide a thorough examination that addresses the emphasis on enhancing Scope 3 carbon emissions accounting, the challenges associated with the use of aggregate methods (such as Spend-based), and the emerging patterns of utilizing technology to enhance adjustments, monitoring, and accuracy. We then present the findings and implications of this report in the Conclusions section.

# METHODOLOGY

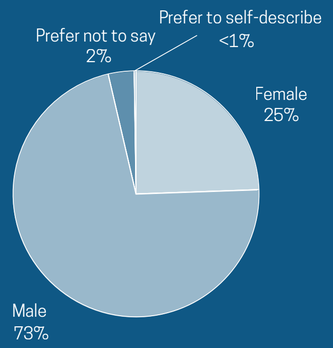
The study's broad objectives are to ascertain the impact of organizational characteristics on sustainability goals and efforts, the key factors that drive organizations to invest in sustainability initiatives, and their existing social and environmental sustainability practices. To meet these objectives, we have embarked on a multi-year empirical study that involves data collection through a survey of supply chain professionals from different industries and business functions. Our goal is to collect longitudinal data to help organizations understand the changing landscape in the sustainability domain among companies and industry sectors. We chose the survey methodology because it is suitable for collecting data from a large number of respondents. It allows us to gather quantitative information on diverse topics, including demographic information, organizational characteristics, knowledge and awareness of specific issues, the amount of effort and initiatives dedicated to a particular function in an organization, as well as future and current organizational objectives. It is also employed in longitudinal studies to track changes over time by surveying the same target segment at different points in time. In the survey, we asked a series of questions using the Likert scale, which is a rating system used in research to measure people's attitudes, opinions, and perceptions. It is a type of question that is often used in surveys and questionnaires. In a Likert scale question, respondents choose from a range of answers to express their level of agreement or disagreement with a statement. We often used a scale between 1–5 to gauge organizations level of priority regarding their sustainablity efforts.

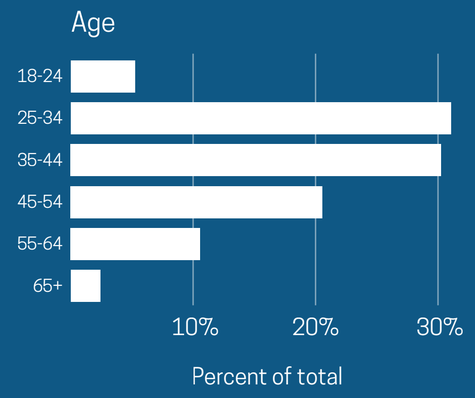
In addition to capturing the demographics of the respondents, their business functions, the extent of their involvement in sustainability initiatives, and the geographical locations of their companies, the survey questions revolved around the following three major themes:

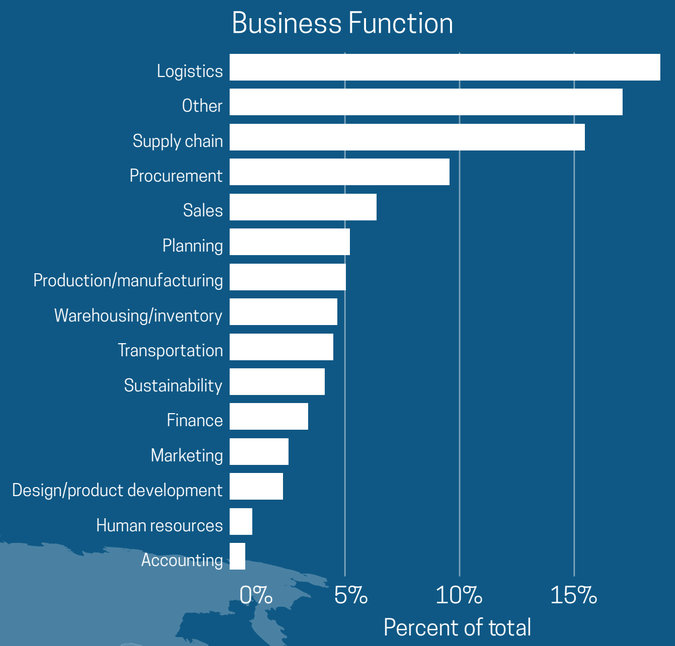
- Organizations' readiness to meet sustainability goals
- Internal and external factors influencing organizations to invest in sustainability initiatives
- Organizations' ability to measure and reduce Scope 1, Scope 2, and Scope 3 emissions

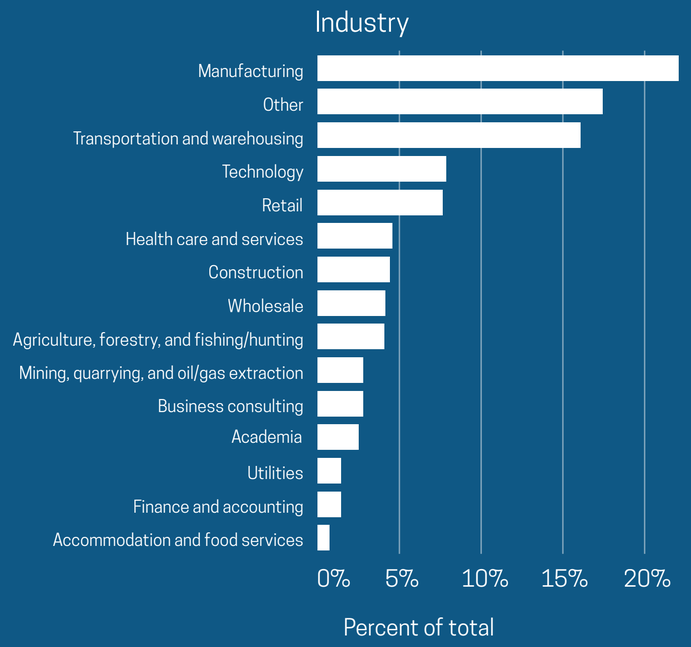
Over the course of the study's history, we have collected more than 7,000 valid responses from approximately 80 countries. shows some demographic and descriptive numbers for the survey data. The survey had an average length of approximately 45 questions and was available in up to five different languages.

# Respondents





7,000+ Survey Respondents

5 Languages

80+ Countries

*Figure 1: Historical respondents' age, gender, industry, and business function*

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# INSIGHTS FROM THE PAST 4 YEARS OF THE STATE OF SUPPLY CHAIN SUSTAINABILITY

In this section, we outline the significant discoveries derived from the study's historical analysis. These findings encompass how companies react to sustainable initiatives during times of crisis, the unpreparedness of organizations to achieve their sustainable objectives, the sources of pressure for companies to implement sustainable changes, and the challenges faced in accounting for Scope 3 emissions.

# How Companies Respond to Sustainability Efforts

Supply chain management is planning, it is a job that requires anticipation and careful coordination between suppliers and customers all across the world. However, even the best-laid plans are susceptible to unforeseen setbacks.

## In Times of Crisis

Four years of observation have enabled us to witness various global-scale supply chain disruptions and their impact on companies' commitments to supply chain sustainability. What we have discovered is that the crisis's nature has a significant impact on commitment to supply chain sustainability. We have detected that if there is an acute disruption, sustainable efforts will either remain constant or increase. For several years, we have dedicated our efforts to studying and researching this unexpected phenomenon. When companies are compelled to revise their supply chains due to circumstances, they often prioritize resilience and sustainability.

The pandemic has elevated the importance of supply chain management, specifically in terms of supply chain transparency and resilience, to a level that has not been seen before. Due to the global disruption caused by the pandemic, businesses were compelled to adapt quickly and make necessary adjustments, allowing them to approach these changes from a sustainable standpoint. As Hong Mo Yang, Senior Vice President for Industry Strategy at Blue Yonder stated in 2022, "In the face of constant disruptions, leading companies worldwide are urgently redesigning their supply networks and ecosystems to not only address business continuity and resilience but also to improve their supply chain for sustainability, which is a very high priority for internal and external stakeholders alike."[7]

Figure 2 shows the comparison between the differences in how organizations reacted to different types of crises. Our study shows that during the two years of the Covid-19 pandemic, 80% of respondents reported that their companies' sustainable efforts only increased or stayed the same, and Russia's invasion of Ukraine had a similar effect. These findings indicate that despite the disruption to the supply chain network due to global circumstances, organizations not only continue to prioritize sustainability issues, but they also appear to intensify their efforts and interest in this area. This aligns with data obtained from the World Economic Forum and other valid sources. Given the significant risks associated with inaction, sustainability continues to be a central priority.

## By Organization Size

Another relevant factor related to the companies' efforts on sustainability initiatives seems to be the size of the company. An outlying trend did start to appear, as shown in Figure 3. When examining the companies that reduced their efforts during the pandemic years, it is evident that the majority of them are small companies with less than 100 employees. This suggests that larger corporations have the ability to endure disruptions and fulfill their obligations, unlike smaller companies that may lack the financial resources to navigate through significant crises. When assessing the impact of global concerns regarding a possible economic downturn on a company's sustainable initiatives, it is evident that the majority of businesses ultimately decrease their efforts in sustainability. While certain sustainability initiatives can lead to cost savings over time, during periods of expected economic instability, supply chains that are anxious tend to prioritize short-term concerns over long-term goals. Many companies' supply chain sustainability initiatives in 2023 were adversely affected by this. Whether companies are actively implementing sustainable practices or reducing their investments, there is genuine pressure to make these changes. We assess these pressures in the following subsection.

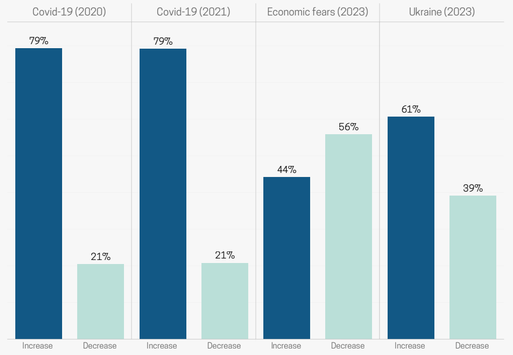


*Figure 2: When commitment to supply chain sustainability changes during crisis*

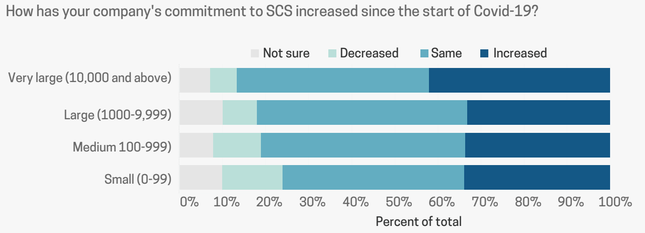


*Figure 3: Commitment to supply chain sustainability by firm size*

# Pressure for Organizational Change

Why do businesses prioritize supply chain sustainability in the first place? After four years of data collection, we discovered persistent trends in replies to questions about companies' perceived demands to enhance supply chain sustainability.

Organizations have reported feeling pressure to make their supply chains more sustainable, and this pressure appears to be increasing over time from each of the ten major sources examined. Notably, none of the pressure sources exhibited any significant decline over time, each of the ten different types of pressure appeared to have increased during the duration of four years of observations. Pressures appear to have plateaued in 2023 at the 2022 level but have not decreased (see Figure 4). Christian Piller, Vice president for Research and Sustainability at project44, stated in 2022, *"Customer demand is a major driver of supply chain sustainability initiatives. Firms we work with are looking for ways to reduce supply chain emissions and adopt more sustainable practices in response to that customer demand. This is the case even in markets where regulatory pressures are not as ambitious."*[8]

Figure 4 also reveals that investors are the fastest-growing source of pressure, with an average response score that increased by 25% over the duration of the study. Investors lead in terms of growth, followed by corporate buyers, who have had their average pressure ranking rise by 15%. Over the last five years, we have repeatedly noticed a vast and expanding role for investor pressure. In today's world, commercial interests, whether access to financing from sustainability-minded investors or sales prospects from sustainability-minded procurement teams, are the fastest-growing source of pressure on supply chain managers to promote supply chain sustainability. In the next sub-section, we assess whether companies are ready to make the necessary changes within their planned timelines, considering the existing pressure on them to do so.

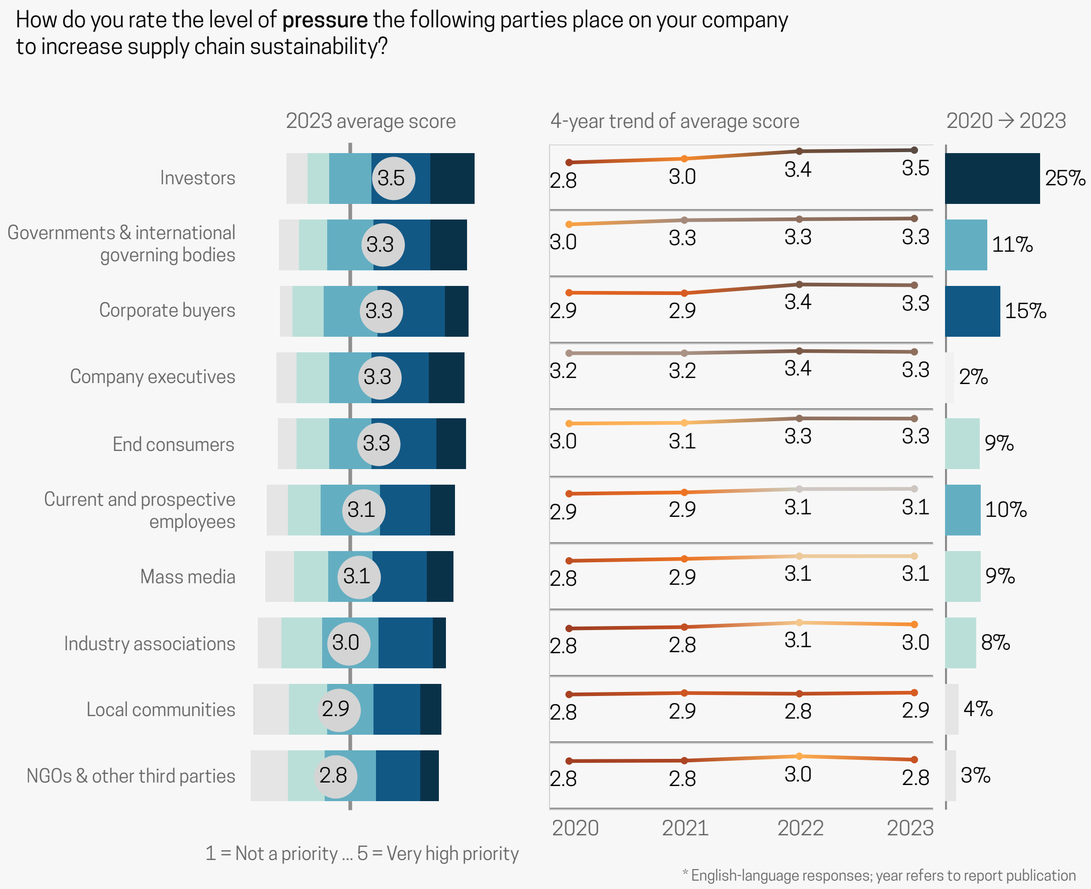


*Figure 4: Level of pressure from top 2023 sources year over year*

# Organizations Do Not Seem Ready to Meet Their Sustainability Goals

This growing pressure to invest in supply chain sustainability manifests itself in organizations' goals and investments among the many focal areas within the umbrella term of supply chain sustainability. For our report, we identify 10 issue areas (five environmental and five social). We evaluated the potential discrepancy between respondents' evaluations of their companies' supply chain sustainability goals and their assessments of the investments made to achieve those goals. Respondents were asked to rate their organizations' investments in the same ten sustainability dimensions using a 1–5 Likert scale.

In Figure 5, we compare the average answers across each dimension. It is both expected and discouraging that goals are prioritized more highly than investments in all aspects. This has been the case in every previous report. Actual investment, after all, is more expensive than goal setting. According to Figure 5, the closer the number is to zero, and closer to a light yellow, the more in line the goal and investment are.

Figure 6 compares the average difference each year between all respondents' goals and investments grouped into environmental and social issues. It shows a more subtle signal: the difference between goals and investment is greater on social dimensions than on environmental dimensions, which is consistent with all reports. However, we have observed progress in decreasing the sustainability investment gap in recent years, particularly in human rights protection. Figure 6 shows a positive score along the y-axis that would indicate that the respondents' aggregated self-reported investment of sustainable goals exceeds their self-reported goal estimates for that topic. Conversely, negative scores along the y-axis of Figure 6 indicate that self-reported goals exceed self-reported investments. In all issues, goals exceed investment. In the early years of our survey, the gap between goals and investments was wider for social issues than environmental issues. That difference appears to have narrowed to a similar magnitude over the last four years.

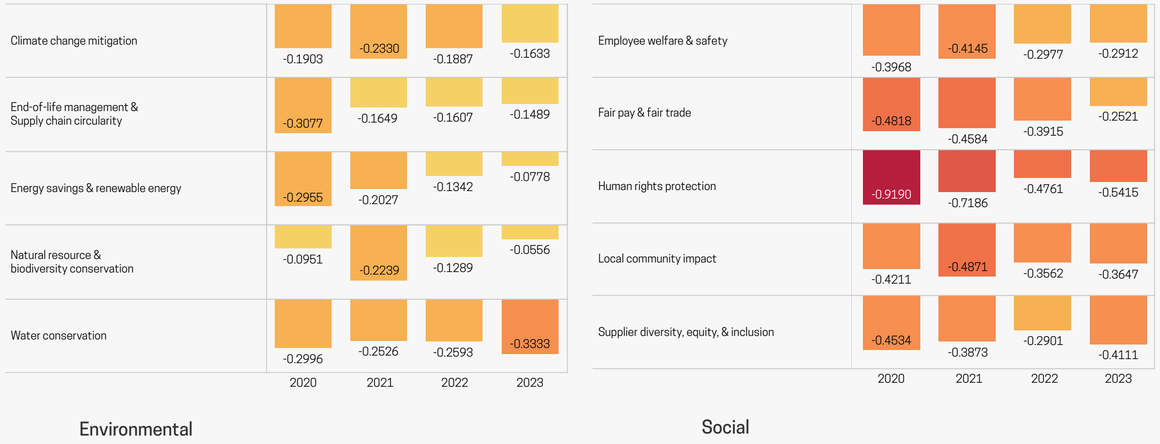


*Figure 5: Gap between stated goals and investments. The darker the color, the farther firms' investments are lagging their goals.*

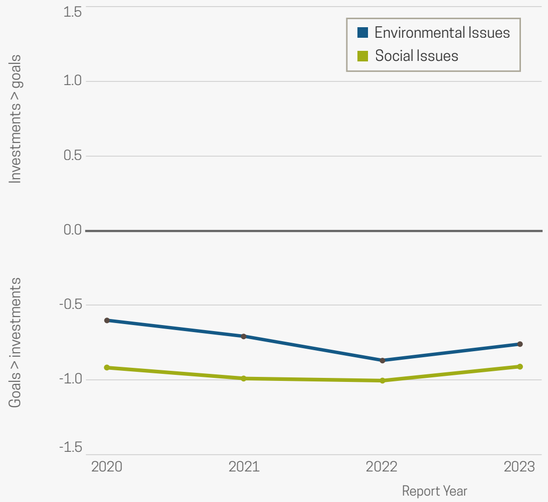


*Figure 6: Supply chain sustainability goals versus investments, 2020–2023*

# Scope 3 Emissions: Challenges, Risk, and the Future

Companies have become proficient at calculating direct emissions (Scope 1) and those from purchased utilities (Scope 2). However, Scope 3 emissions, which include indirect emissions from a company's value chain and suppliers, continue to be challenging due to the complex web of supplier relations and their extended business workstreams. In 2023 Katie Martin, Principal Lead, Sustainability & ESG at Avetta stated "Scope 3 continues to be elusive at scale because of still evolving definitional boundaries that vary by region and vertical, as well as the sheer complexity of managing and monitoring the supply chain where much of Scope 3 lies. Many businesses are forced to use estimations, which open risk to green-washing, or set their own scope [guidelines], which opens risk to shifting metrics year over year."[9]

Scope 3 emissions are estimated to be the largest scope category. The Carbon Disclosure Project (CDP) estimates that it accounts for on average 75% of a company's overall emissions, and over 80% of companies report that quantifying their Scope 3 emissions is difficult.[10] Figure 7 showcases each category of scope emissions by sector.

When evaluating whether organizations have a net zero goal, 67% indicated that they did not. Looking at Figure 8, when asked if a company has an initiative to reduce Scope 1, Scope 2, or Scope 3 emissions, we notice that Scope 3 has the least amount of initiatives in place currently, and has the highest number of companies that do not have a plan at all, and do not anticipate to have one in the near future. This data may reflect the challenges of measuring and reducing Scope 3 emissions. A current lack of clarity around methods for the measurement of these emissions, policy requirements that are changing rapidly, and how to incentivize supply chain partners to share greenhouse gas emissions data may all be slowing down greater adoption of net-zero goals and Scope 3 emissions reduction targets around the world.

Recently, the European Union (EU) passed the Corporate Sustainability Reporting Directive (CSRD) which requires companies to start reporting all of their emissions data including Scope 3 in 2025, for 2024 emissions. The regulation uses a phased approach based on the company size, with the last phase rolling out in 2029; this includes both EU and non-EU entities. The European Commission: Corporate Sustainability Reporting estimates that over 50,000 companies will have to comply with this new regulation.[11]

In the US, while the Securities and Exchange Commission (SEC) has rolled back the Scope 3 emissions at this time, it is expected to come back to vote once more clear outlines have been put in place. California has taken a step further and passed into law in October 2023, the Climate Corporate Data Accountability Act–California SB 253, which mandates Scope 3 reporting for both public and private companies operating in the state with more than $1 billion in annual revenue, with reporting starting in 2027. This includes any company that has a location in California, has any financial transactions for profit, or is paying any payroll, sales, or property tax in the state.

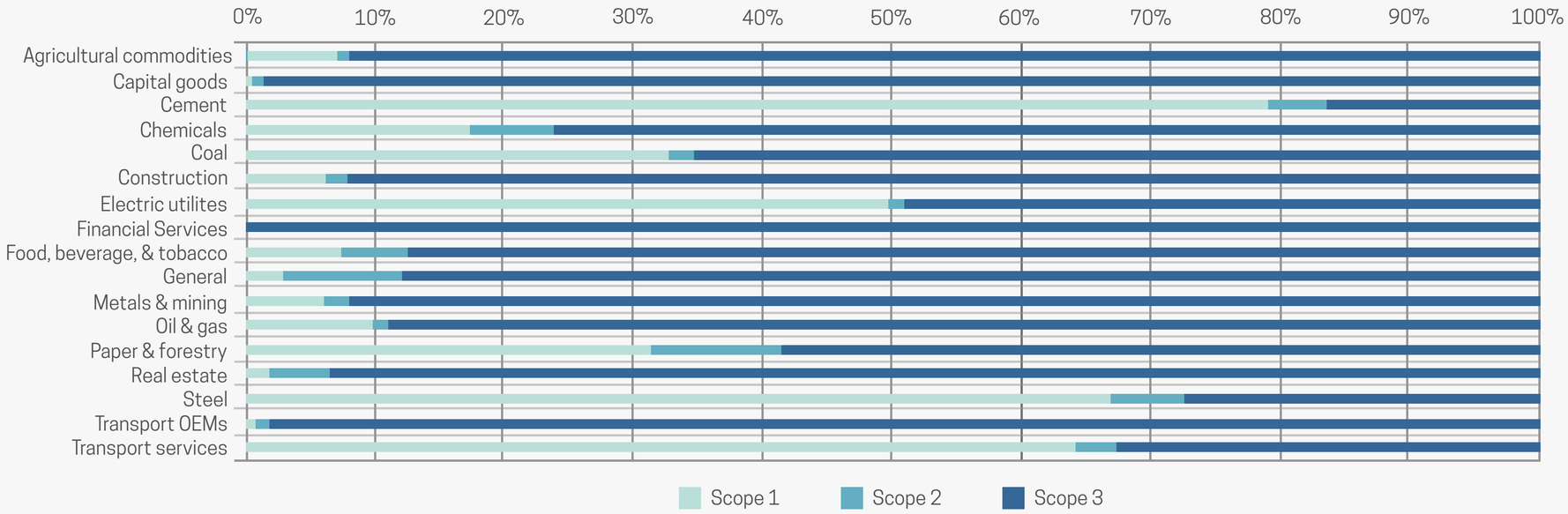


*Figure 7: Scope emissions by sector (adapted from CDP)[13]*

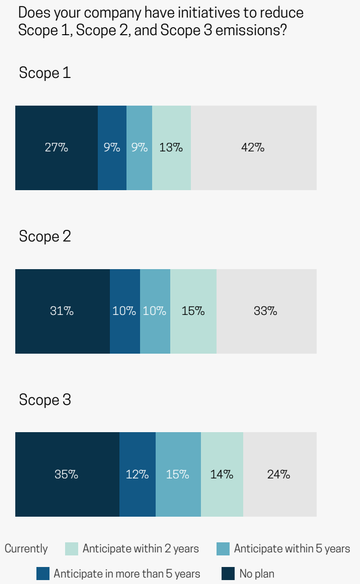


*Figure 8: Companies' emissions-reduction initiative by scope level*

This affects both companies that are US-based as well as international. While there are currently about 1,000 companies that have their headquarters in CA that are generating revenue of over $1B, PwC estimates that this will affect over 10,000 companies.[12]

# SCOPE 3 EMISSIONS RESEACH AGENDA AND THE FUTURE OF THE STATE OF SUPPLY CHAIN SUSTAINABILITY STUDY

In this section, we outline the Scope 3 emissions problems and the research that is taking place at MIT Sustainable Supply Chain Lab. It also covers the future of the State of Supply Chain Sustainability Study.

# Effectively and Accurately Identify Data Outliers

The Greenhouse Gas Protocol categorizes a company's emissions by three different scopes. Scope 1 is direct emissions that a company emits, Scope 2 is all purchased energy from utility companies, and finally, Scope 3, has 15 different categories that make up the whole section (see Figure 9). The largest categories are usually in the purchase of goods and services (i.e., Category 1), and inbound and outbound transportation (i.e. Categories 4 and 9).[14] When analyzing Scope 3 emissions from an organization's suppliers, it is critical to ensure that no errors or anomalies exist. In a supply chain, the reporting of emissions by suppliers impacts the precision and reliability of the organization's carbon emissions reporting, and it has consequences for the overall emissions targets that the organization sets. When companies are conducting their Scope 3 accounting, they face two core challenges, the different sources of the data and how they get that emissions information if each supplier uses different carbon tracking methodologies. Because of these complexities, outliers and inaccuracies can occur. Outliers can drastically skew results, resulting in incorrect reporting of emissions data. If a supplier provides information that is significantly different from the prior year, then there needs to be a means of identifying this information so that additional inspections can be performed. Outlier detection is a critical part of data analysis that is currently not being performed automatically

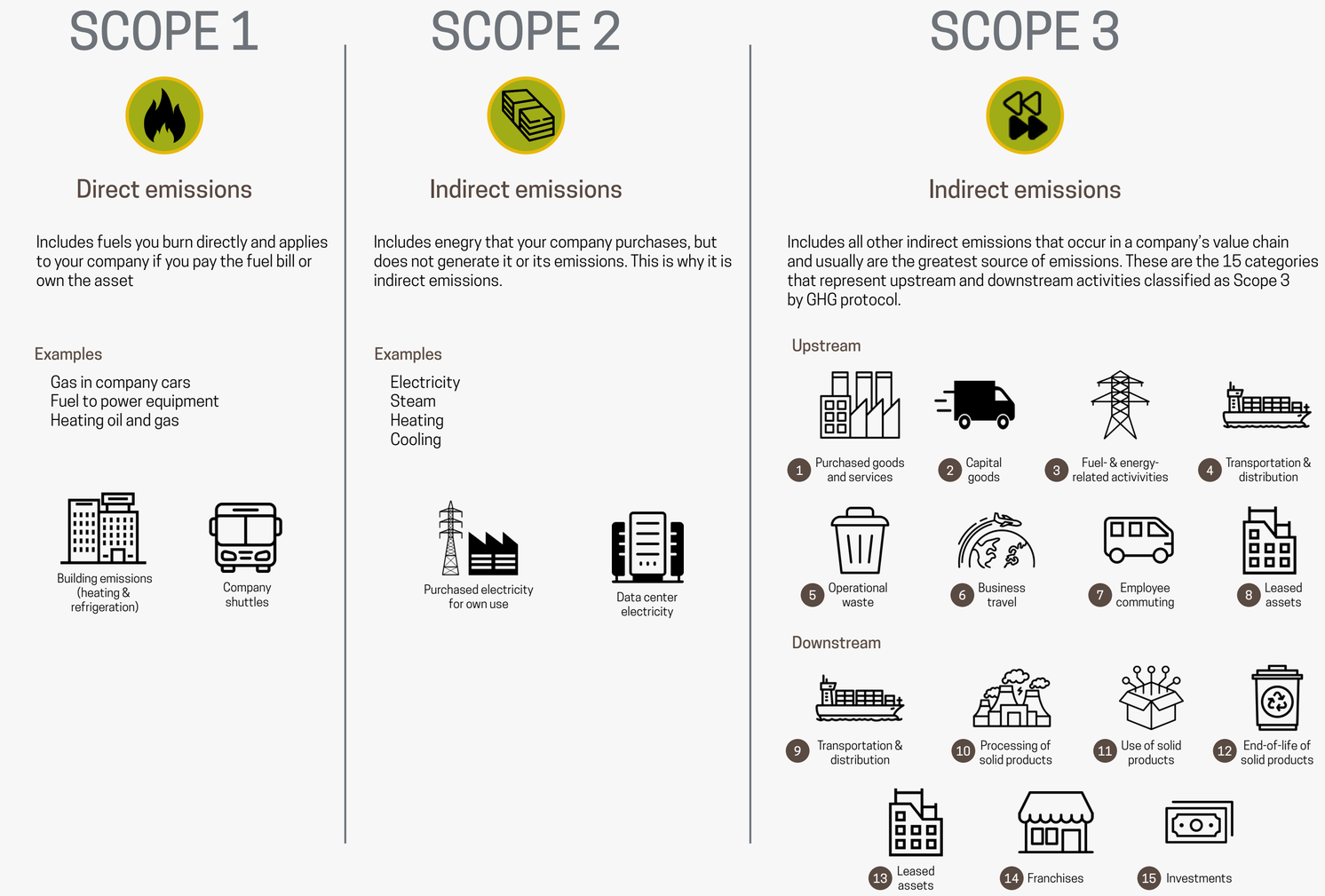


*Figure 9: Emissions breakout by scope*[15]

For example, a company reporting on Scope 3 Category 4 emissions, specifically related to upstream transportation and distribution, may encounter difficulties obtaining precise emissions data if they rely on multiple suppliers who employ different methods of tracking their emissions. It is possible that the company has one supplier employing a hybrid approach to estimate their emissions, while another supplier uses the spend-based method. Despite traveling the same distance or using the same routes, the emissions data from these suppliers could vary significantly. The hybrid data would provide a more precise representation, but it could reveal significantly divergent emissions levels compared to other suppliers, potentially reducing the customer's inclination to engage with them. Despite the spend-based method's greater traceability and widespread popularity, it poses certain complications that we discuss in the following section.

An MIT study recently proposed a preliminary solution in a thesis project titled "Supply Chain Emission Hotspot and Allocation Method Analysis". The project suggests an effective and accurate outlier detection algorithm, which is crucial for precisely reporting and evaluating an organization's Scope 3 emissions data. The thesis project employs a boxplot method to identify outliers, which offers a graphical representation of the data, facilitating the identification of potential outliers. This allows for further investigation to determine the accuracy of this type of information.[18] Further research is required in this field to develop a definitive and practical algorithm that can be made accessible to the general public.

Ideally, the allocated emissions of the acquired products and services should be equivalent to their actual emissions. However, current emission allocation methods use a variety of attributes including cost to determine the allocated emission.

## Improvements to Spend-Based and Average Accounting Methods

Companies today face increasing pressure from investors, customers, and regulatory bodies, to track and disclose their emissions data accurately. Understanding and monitoring their carbon footprint is essential for several reasons, including allowing companies to identify areas where they can reduce greenhouse gas emissions. However, the accuracy and reliability of emissions accounting are paramount, like any analytical process, the quality of its output is only as accurate as the data inputted into it. Therefore, careful data collection, comprehensive reporting, and standardized methodologies are essential to ensure the integrity and usefulness of emissions accounting. Emissions tracking is not just a regulatory requirement but also a strategic imperative for companies looking to thrive in a sustainable future.

Businesses have gradually become adept at calculating direct emissions (Scope 1) and those from purchased utilities (Scope 2). However, Scope 3 emissions, which encompass indirect emissions from a company's value chain and suppliers, remain problematic due to the intricate web of supplier relationships and their extended business activities. One of the most popular approaches to address the complexity of Scope 3 emissions reporting in corporate supply chains is the spend-based method for calculating the carbon footprint when direct emissions data from suppliers is unavailable. The spend-based method estimates emissions by utilizing economic value data of purchased goods or services multiplied by industry-average emission factors related to their monetary value.[19]

As shown in Figure 11, if a company accounts for 10% of a supplier's total sales, it is assigned 10% of that supplier's emissions.[20]

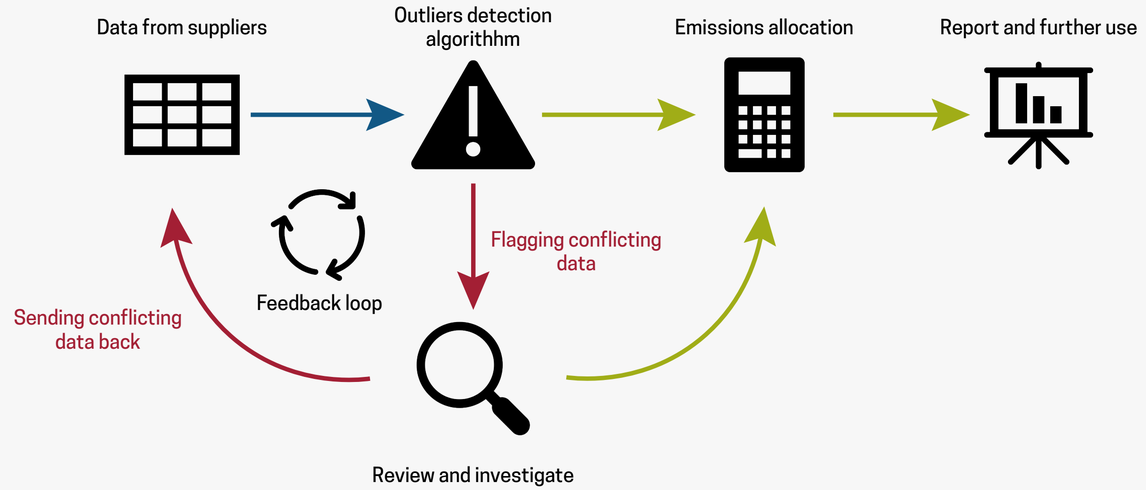


*Figure 10: Path to flag outliers*[16]

To illustrate the effect of using this widely used method for carbon emissions allocation, consider the following example. If a company were to encourage a supplier to adopt carbon capture technology for the products it is purchasing, the supplier may choose to only install this technology for the items that are being supplied to that specific customer, in order to reduce expenses, while keeping other processes unchanged. This selective implementation can reduce emissions only for certain products but not for others, minimizing the overall impact. Moreover, to recover the costs of installing these technologies, the supplier may increase the prices of the products specifically for the company that insisted on carbon reduction. Consequently, the company's allocated emissions could paradoxically increase because its spending on these higher-cost products now represents a larger share of the supplier's total revenue.[21]

The issue is that if businesses begin to make more sustainable decisions and select materials that have a lower $CO_2$ emission but incur higher costs for those investments, their apparent $CO_2$ emissions reflect an *increase* in the company's carbon accountability due to the cost of the product rising. Currently, **the spend-based methodology rewards a cost decrease of the product more than an emissions decrease.** Over time, it is possible to implement enduring modifications that promote sustainability. However, if the price of the product remains unchanged or increases, these alterations will not be accurately reflected. Consequently, the historical emissions data that a company is using for comparison will be rendered inaccurate.

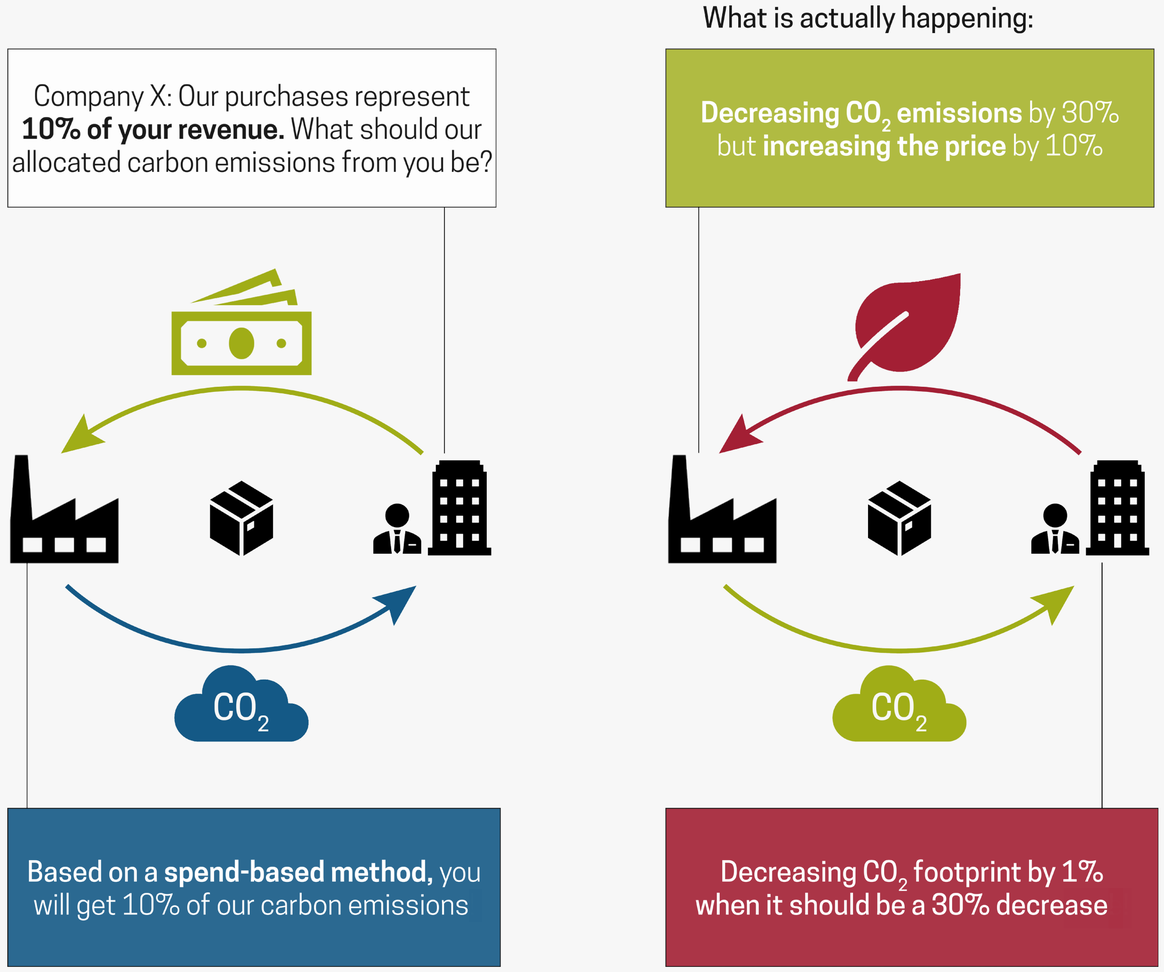


*Figure 11: Relationship between expected emissions changes versus what is actually happening*

Figure 12 illustrates the margin of error generated by the current spend-based approach. This figure is derived from a single product that accounts for 10% of a company's revenue.[22] For example, if the emissions of the product decrease by 25% (indicated by the red dotted line), the emissions accounting using the spend-based method actually shows a decrease of only 3%, which is inaccurate. This indicates that the method is causing an error of 22% in the emissions calculation. On the other hand, when the price of the product increases by 25% (indicated by the blue line), there is a corresponding increase of 25% in the allocation of $CO_2$ emissions to that product. Conversely, if the price decreases, the allocation of $CO_2$ emissions decreases as well. This shows that the spend-based method is mainly sensitive to the cost of the product vs the actual emissions. The significant margin of error discourages companies from making additional sustainable investments. By solely relying on the current methodology for tracking, it is difficult to achieve the goal of reducing Scope 3 emissions and meeting climate expectations.

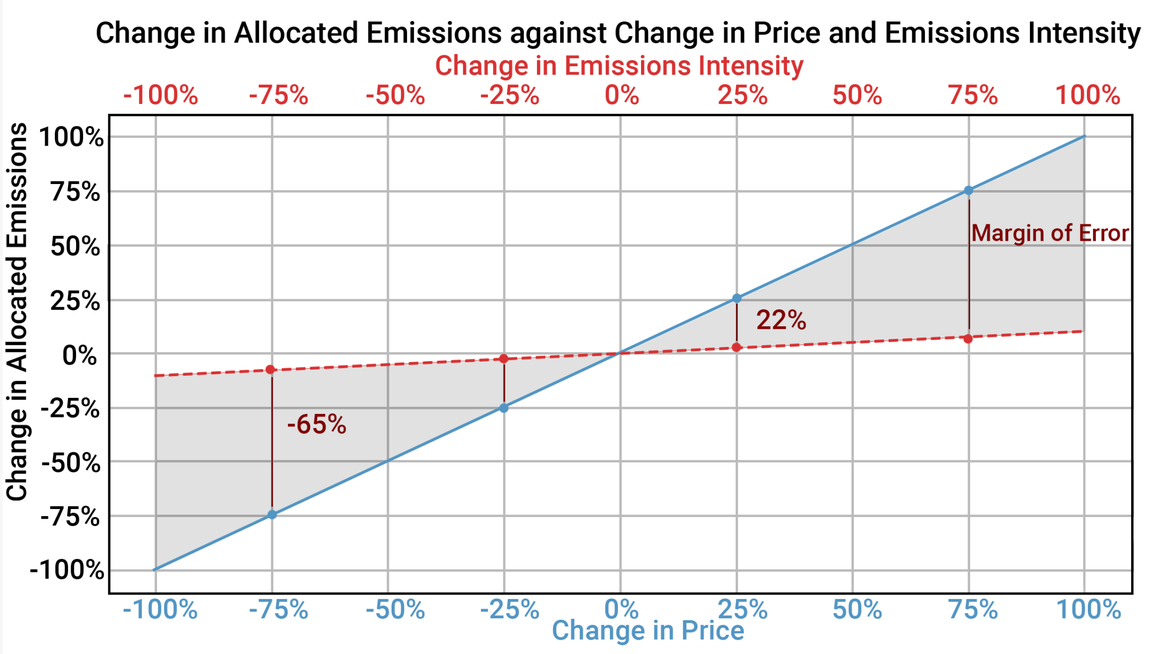


*Figure 12: Margin of error in the spend-based model of a product that is 10% of a company's revenue*

Due to the passing of the EU, Corporate Sustainability Reporting Directive (CSRD) and California's Climate Corporate Data Accountability Act, these changes to the methodology are needed urgently to make sure that the data that is being provided to these regulatory bodies is accurate and can reward corporations for making sustainable choices and not negatively impact them.

## Standardization of Scope 3 Emissions Reporting

Figure 7 (page 6) lists each business sector and its emissions, as you can see each sector's emissions are unique to its own industry. Each sector has very different needs to tackle Scope 3 emissions. Scopes 1 and 2 for the transportation sector correspond to Scope 3 for all of their clients. This means that each business sector requires its own method of tracking Scope 3 emissions and sharing that information with customers in a way that does not violate any of their privacy concerns. However, each sector must utilize the same standardizations and establish a clear baseline for what constitutes Scope 3 emissions. This needs to be a global standard that is communicated and agreed upon so that if a corporation shares its Scope 3 emissions with the EU, California, or any future entity that implements regulations, it is the same required data that is being requested.

Without these principles, enterprises lack a clear understanding of what is required for all Scope 3 emissions accounting, which means that for each regulation, they must re-evaluate the emissions data to meet and share the requirements of that regulation. This is extremely labor intensive and will only increase over time unless clear guidelines are established for every sector. The MIT Sustainable Supply Chain Lab is striving to develop a clear guideline to have a global impact on Scope 3 emission standards.

# Simplify Strategies for Lifecycle Emissions Reporting

Although the spend-based method is most often used to track Scope 3 emissions, there are more accurate reporting approaches available, i.e. Average Data, Hybrid, Carbon Modeling, and Life Cycle. However, these approaches are challenging to implement as they require tracking a larger amount of information. Additionally, sharing this detailed information publicly poses problems due to concerns about company privacy and disclosure.

The Average Data method, which calculates emissions by gathering relevant data and multiplying it by the industry average life cycle assessment, provides a standardized measure of emissions that is straightforward to apply. However, it does not take into account any supplier-specific emissions information or any efforts made by the supplier to adopt more sustainable practices.[23] The Hybrid method estimates emissions by collecting supplier's activity data and applies assumptions whenever the supplier-specific data is not available. This approach provides more precise emissions data by utilizing actual supplier information, which offers valuable insights into emissions-intensive areas. However, there are limitations in data collection when collaborating with suppliers in a manner that ensures their privacy concerns.[24] The Embodied Carbon Modeling uses advanced modeling techniques of product manufacturing, incorporating supplier-specific data whenever it is available. This is a complex modeling process that still needs a lot of information from suppliers to do accurately.

Finally, the Life cycle emissions data is the most accurate approach for calculating Scope 3 emissions, although it is also the most complex and costly. Obtaining accurate emission data is currently a highly demanding and nearly impossible task. The emissions are calculated by collecting all data provided by suppliers and heavily rely on suppliers' investment and collaboration with customers. This assessment of each component of the product is required from the extraction stage and continues until the final use.

In order to make the transition towards life cycle emissions reporting possible, companies need to make advancements in emissions tracking technologies and devices. Effectively calculating a company's Scope 3 emissions should not be a challenging or time-consuming process. The research agenda of the MIT Sustainable Supply Chain Lab focuses on enhancing the accessibility and accuracy of emissions-tracking devices. The objective is to enhance the accessibility of life cycle emissions methods, enabling enterprises to modify their current data collection practices and utilize real and accurate emissions data.

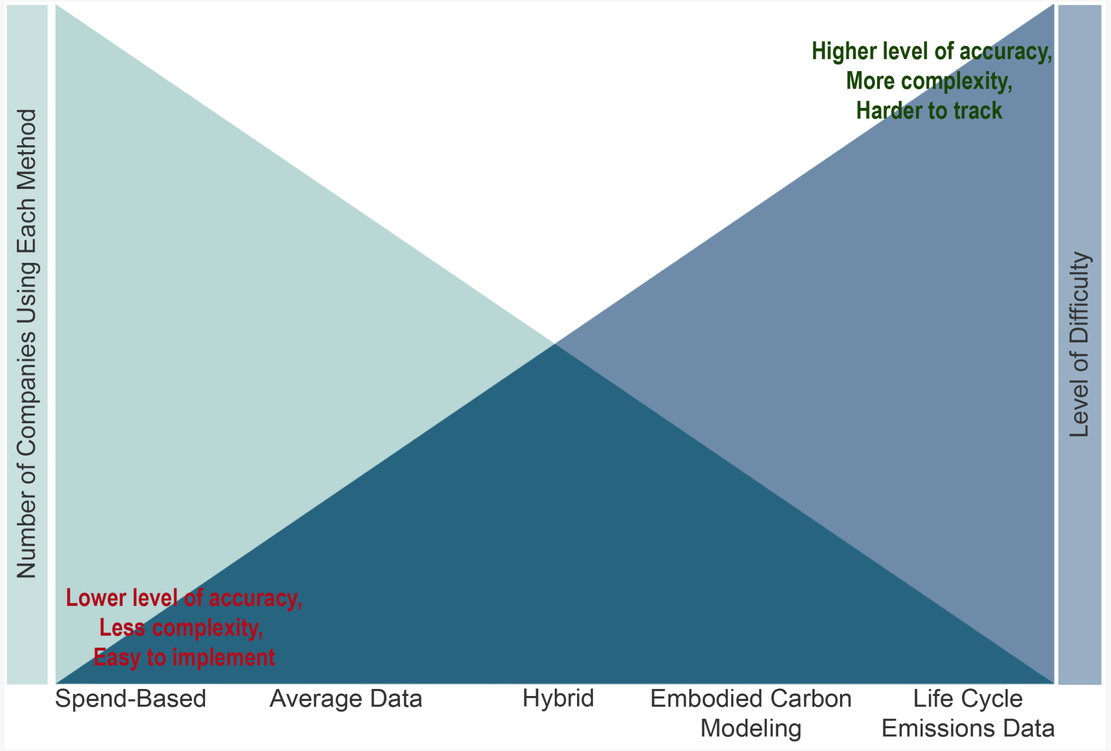


*Figure 13: Showcasing the level of difficulty with the number of companies using that method*

# Real Data Improvements with Machine Learning Tracking Process

Machine learning techniques are driving real data improvements that will transform the global tracking and management of greenhouse gas emissions. Traditional emissions tracking methods frequently rely on recurring reporting and estimates, which are often out-of-date and inaccurate. With the advancements in emissions trackers, however, machine learning algorithms can process massive amounts of real-time data. Machine learning algorithms are able to identify pollution sources and patterns in emissions and provide almost real-time updates on emission levels through the analysis of various data streams. This capability not only enhances the accuracy and reliability of emissions inventories but also enables timely interventions to mitigate environmental impacts.

Additionally, machine learning algorithms are particularly good at revealing complex relationships in data that conventional analytic techniques could miss. They can find connections between different elements that affect emission levels, such as weather patterns, industrial activity, and topographical characteristics. This deeper understanding allows for more targeted and effective strategies for reducing emissions and optimizing resource use. Throughout the development of this process, we will be partnering with collaborators to use Green AI concepts16 to make sure that the machine learning algorithm is built in the most sustainable way possible. This will ensure that while using the algorithm to reduce a company's emissions, it is not adding to the total emissions in another area.

The integration of machine learning with real-time data streams facilitates continuous monitoring and adaptive management of greenhouse gas emissions. By providing companies with up-to-date insights into emission hotspots and trends, decision-makers can make informed choices and interventions. This approach not only helps support compliance with regulatory standards but also encourages innovation in emission reduction practices. Ultimately, the combination of real data tracker improvements and machine learning represents a powerful tool in the global effort to combat climate change and achieve sustainability goals.

# Conclusions and Next Steps

Reflecting on the findings of this report on the State of Supply Chain Sustainability, it is clear that the past years have been a vessel for understanding how organizations respond to crises and integrate sustainable practices into their operations. The Covid-19 pandemic and persistent geopolitical tensions and economic instability have highlighted the resilience and adaptability required of supply chains in order to effectively navigate worldwide upheavals. While larger organizations often have more resources and infrastructure to weather these storms, smaller enterprises can struggle to keep some of their goals due to insufficient support or access to sustainable technologies.

Many companies are having a difficult time achieving their sustainable goals, even in the face of growing awareness and commitment to sustainability. Companies are under increasing pressure from investors and customers to not only establish ambitious sustainability targets but also to show quantifiable progress toward reaching them. Organizations have not supported their initiatives enough to achieve their goals with the expected level of money. In an increasingly interconnected global marketplace, the shift towards sustainability is not just a corporate obligation but also a strategic necessity for preserving competitiveness and ensuring long-term viability.

One of the most daunting challenges identified is the tracking and reduction of Scope 3 emissions. These indirect greenhouse gas emissions, originating from sources outside a company's direct control but associated with its activities, pose complex measurement and mitigation challenges. Addressing Scope 3 emissions has become a critical area of attention for companies as they work to meet their emissions targets and comply with global climate goals. This requires cooperative efforts across industries and supply chains. The MIT Sustainable Supply Chain Lab's research addresses these issues by focusing on developing research aimed at making methodological adjustments and implementing machine learning technology utilizing Green AI for Scope 3 emissions tracking.

The State of Supply Chain Sustainability Study in the future will continue to provide an unbiased status of where Sustainability is in the Supply Chain field. But we will also begin to incorporate successful case studies and research findings, starting with Scope 3 emissions tracking, to provide readers with a more comprehensive picture of their alternatives for a more sustainable future. Global reporting and tracking of Scope 3 emissions will change significantly as a result of the research being conducted by the MIT Sustainable Supply Chain Lab. The path toward a Sustainable Supply Chain is complex and multifaceted. Building a sustainable future for generations to come requires

leadership, tenacity, and collaboration to overcome obstacles and effect real change. The insights and suggestions from real-world successes and this research and subsequent publications will continue to offer a roadmap for organizations to move toward a more sustainable future, create more robust supply chains, and contribute positively to global sustainability goals as we keep navigating the uncertainties and complexities of our ever-evolving world.

# APPENDICES

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**This project is made possible by the generous efforts of a large group of dedicated contributors and collaborators.**

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