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A QUANTITATIVE MODEL TO MEASURE A COMPANY'S ENVIRONMENTAL, SOCIAL AND GOVERNANCE (ESG) FOOTPRINT CONSIDERING THE SUPPLY CHAIN AND THE OPERATIONS

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Dissertação de Mestrado apresentada ao Programa de Pós-graduação em Engenharia de Produção, COPPE, da Universidade Federal do Rio de Janeiro, como parte dos requisitos necessários à obtenção do título de Mestre em Engenharia de Produção.

Orientador: Luan dos Santos

Rio de Janeiro

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Resumo da Dissertação apresentada à COPPE/UFRJ como parte dos requisitos necessários para a obtenção do grau de Mestre em Ciências (M.Sc.)

UM MODELO QUANTITATIVO PARA MEDIR A PEGADA AMBIENTAL, SOCIAL E DE GOVERNANÇA (ESG) DE UMA EMPRESA CONSIDERANDO A CADEIA DE SUPRIMENTOS E AS OPERAÇÕES

Antonio Vieira Savi

Dezembro/2022

Orientador: Luan dos Santos

Programa: Engenharia de Produção

Sustentabilidade e os aspectos Ambientais, Sociais e de Governança (ESG) são muito relevantes no mundo corporativo. A Cadeia de Suprimentos (SC) é de responsabilidade do comprador e responde por grande parte de sua pegada ESG. Por isso, as Empresas Âncoras (AC) precisam fazer um processo muito complexo, caro e demorado para avaliar sua SC. O objetivo deste trabalho é desenvolver um modelo de avaliação ESG ponderado para que as empresas recebam uma pontuação quantitativa de suas operações e sua pegada na cadeia de suprimentos. O modelo utiliza uma taxonomia internacional (SASB – *Sustainability Accounting Standards Board*) como referência para os tópicos avaliados e definição de peso com base no setor econômico, e apresenta fórmulas para calcular a pontuação ESG (0-10) para empresas âncora, toda a cadeia de suprimentos e a pontuação consolidada ESG. Por fim, uma análise de cenário é realizada e os resultados mostram que a SC tem um impacto significativo na pontuação ESG final da AC, comprovando que não é possível evoluir em aspectos ESG sem trabalhar em conjunto com a cadeia de suprimentos.

Palavras-Chave: Sustentabilidade; Cadeia de Suprimentos; ESG; Gestão Corporativa; Modelo de avaliação ESG

Abstract of Thesis presented to COPPE/UFRJ as a partial fulfillment of the requirements for the degree of Master of Science (M.Sc.)

A QUANTITATIVE MODEL TO MEASURE A COMPANY'S ENVIRONMENTAL, SOCIAL AND GOVERNANCE (ESG) FOOTPRINT CONSIDERING THE SUPPLY CHAIN AND THE OPERATIONS

Antonio Vieira Savi

December/2022

Advisor: Luan dos Santos

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Sustainability and Environmental, Social and Governance (ESG) aspects are very relevant in the corporate world. The Supply Chain (SC) is the responsibility of the buyer and accounts for a large part of their ESG footprint. Therefore, Anchor Companies (AC) need to go through a complex, expensive, and time-consuming process to assess their SC. The objective of this work is to develop a weighted ESG assessment model for companies to receive a quantitative score of their footprint considering both their operations and the SC. The model uses an international taxonomy (SASB – Sustainability Accounting Standards Board) as a reference for the evaluated topics and definition of weight based on the economic sector and presents formulas to calculate the ESG score (0-10) for AC, the SC and the consolidated ESG score. Finally, a scenario analysis is carried out and the results show that the SC has a significant impact on the final ESG score of the AC, proving that it is not possible to evolve in ESG aspects without working together with the SC.

Keywords: Sustainability; Supply chain; ESG; Corporate Management; Evaluation ESG model; ESG Ratings

SUMMARY

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDIX TABLES

LIST OF SYMBOLS AND ACRONYMS

AA	Access & Affordability
AQ	Air Quality
BE	Business Ethics
BM	Business Model Resilience Business Model Resilience
BS	Basic Suppliers Score
CB	Competitive Behavior
CI	Critical Incident Risk Management
CP	Customer Privacy
CS	Critical Suppliers Score
CW	Customer Welfare
DS	Data Security
EE	Employee Engagement, Diversity & Inclusion
EH	Employee Health & Safety
EI	Ecological Impacts
EM	Energy Management
GE	GHG Emissions
HR	Human Rights & Community Relations
IS	Important Suppliers Score
LP	Labor Practices
ML	Management of the Legal & Regulatory Environment
MS	Materials Sourcing & Efficiency
P	Percentage of the impact of the SC in the company
PD	Product Design & Lifecycle Management
PI	Physical Impacts of Climate Change
PQ	Product Quality & Safety
RS	Relevant Suppliers Score
SM	Supply Chain Management
SP	Selling Practices & Product Labeling
SR	Systemic Risk Management
WE	Weight of environmental aspects
WG	Weight of governance aspects

WH	Waste & Hazardous Materials Management
WS	Weight of social aspects
WT	Total weight for industry
WW	Water & Wastewater Management
BS_{GT}	Average of GTI of all suppliers' matrixes in the Basic Suppliers group
BS_{HD}	Average of HDI of all suppliers' matrixes in the Basic Suppliers group
CS_{GT}	Average of GTI of all suppliers' matrixes in the Critical Suppliers group
CS_{HD}	Average of HDI of all suppliers' matrixes in the Critical Suppliers group
GT_{AC}	GTI of the Anchor Company based on the location of the matrix
GT_{SC}	GTI of the SC based on the location of the matrix of the supplier
HD_{AC}	HDI of the Anchor Company based on the location of the matrix
HD_{SC}	HDI and the of the SC based on the location of the matrix of the supplier
IS_{GT}	Average of GTI of all suppliers' matrixes in the Important Suppliers group
IS_{HD}	Average of HDI of all suppliers' matrixes in the Important Suppliers group
P_E	Percentage of environmental impact of the SC in the company
P_G	Percentage of governance impact of the SC in the company
P_S	Percentage of social impact of the SC in the company
RS_{GT}	Average of GTI of all suppliers' matrixes in the Relevant Suppliers group
RS_{HD}	Average of HDI of all suppliers' matrixes in the Relevant Suppliers group
S_{AC}	ESG score of the Anchor Company
S_{ESG}	Aggregated score of the AC after considering the SC score
S_{SC}	ESG score of the Supply Chain
α_E	Environment company score
α_G	Governance company score
α_S	Social company score
β_E	Environment SC score

β_G	Governance SC score
β_S	Social SC score

ABBREVIATIONS

AC	Anchor Company
BSR	Business for Social Responsibility
CDP	Carbon Disclosure Project
EPA	Environmental Protection Agency
ESG	Environmental, Social, and Governance
Fintech	Financial Technology
GHG	Greenhouse Gases
GHG Protocol	Greenhouse Gases Protocol
GRI	Global Reporting Initiative
GTI	Governance Transparency Index
HDI	Human Development Index
IPCC	Intergovernmental Panel on Climate Change
ISSB	International Sustainability Standards Board
NDCs	Nationally Determined Contributions
OCC	Office of the Comptroller of the Currency
RF	Reverse Factoring
S2CF	Sustainable Supply Chain Finance
SASB	Sustainability Accounting Standards Board
SBTi	Science Based Targets
SC	Supply Chain
SCF	Supply Chain Finance
SDGs	Sustainable Development Goals
SMEs	Small and Medium sized Enterprises
SSC	Sustainable Supply Chain
SSCM	Sustainable Supply Chain Management
TBT	Triple Bottom Line
TCFD	Task Force on Climate Related Financial Disclosures
UN	United Nations

1 INTRODUCTION

There is a clear stakeholders demand for sustainable products and business models in a way that no harm is made to the world, and everyone has equal opportunities. Because of that, companies are on the run to develop solutions that fits this new concept. The motivation is to fulfill the market pain and provide a valid ESG evaluation method for companies to evaluate themselves and their partners and potentially integrate that with financial solutions to incentivize partners and move forward in the agenda. This introduction presents the context and justification, as well as the motivation and main objectives of this work.

1.1 Context and Justification

A lot has been discussed regarding the impacts that are made on both our planet and society. Everybody is paying more attention on the well-being and understanding how we can live in a better and harmonic way. Sustainability is defined as something that meets our own needs without compromising the ability of future generations to meet their own needs (Brundtland, 1987). It is gaining a lot of traction in academia, private sectors, and public institutions. Following that movement, due to stakeholders' pressure, *Environmental, Social and Governance (ESG)* aspects are being a key factor to evaluate companies and institutions, gaining momentum for economic decisions and strategic future planning. ESG is becoming an emblematic symbol of the modern era since it is a high priority for business as they must comply with requirements of sustainability standards and be focused on more than just profit (Tsalis et al., 2020).

In this regard, there is an emerging demand for information about how companies incorporate social responsibility in their operations which has been responded by specialized agencies assessing corporate social responsibility profiles, which includes environmental actions (Bergskaug, 2019). We can see that the market is changing a lot, industries and services enterprises are looking for greener operations and it has gained a firm foothold within financial institution and products to address ESG topics (Bergskaug, 2019).

To achieve net zero emissions commitments and goals, countries are experiencing several regulatory changes in the past few years and a lot more to come in order to incentivize ESG actions. The objectives of these changes are to incentivize and force private and public companies to be more sustainable by reducing their environmental impacts and improving their social responsibility. The tendency is that corporations will have to be more transparent with their ESG footprint and risk, offering something back to the community and stakeholders other than money and profit. China, Denmark, Malaysia, and South Africa are the early adopters where the disclosure of ESG information is mandatory, being expected to happen in every country in a fast pace (Ioannou & Serafeim 2017).

The "E" for environmental is an urgent aspect because the climate change is a threat to future generations (Sanson et al., 2019). On the other hand, firms and governments are also responsible for meeting their "S" and "G" (Social and Governance) obligations. Social is related to all internal and external activities of the corporation, being translated as the practices related to employees and employment, such as wages, laws, safety, training, opportunity and inclusion of minorities, no discrimination, health care, and the impact it causes on the community. By being socially responsible, firms can gain improved brand awareness, a favorable corporate reputation, increased sales, observed firm growth and enhanced customer loyalty (Fernando et al., 2022). Governance is the system by which companies are managed and controlled, which are associated with the rules, practice, and process, and the ability to balance the various interests of the firm (Elston, 2019).

The lack of governance may result in corruption while the lack of social might result in less opportunities for minorities and several other losses to the company and the society itself. These have been significant factors for stakeholders when evaluating the business and deciding to get involved or not. Moreover, an analysis in the Central and Eastern Europe companies by Zumente and Lace (2021) showed the importance of ESG rating for both investors and companies since there is a significant difference in the trading.

Moreover, financial institutions and investors are held responsible for what people are doing with the money that has been borrowed, which causes a huge increase in the interest in green and sustainable assets and bonds. Figure 1 shows the volumes of

sustainable debt surpassed $1.6 trillion in 2021 alone, more than doubling 2020's end of year value (BloombergNEF, 2022).

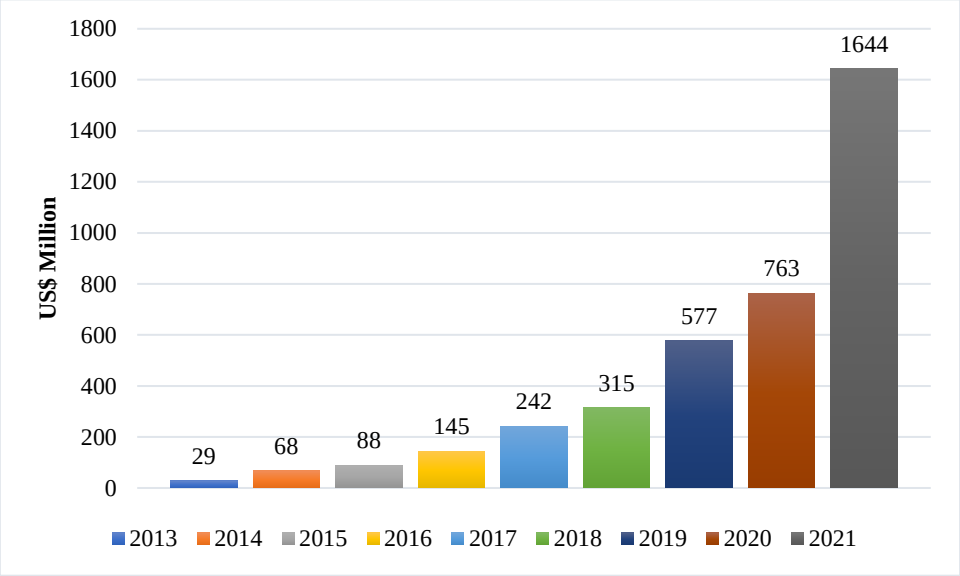

Figure 1 - Annual sustainable debt issuance 2013-2021 (U$ Millions)
Source: adapted from BloombergNEF, Bloomberg L.P.

This exponential increase is happening because those that does not have ESG policies and assess the risks are not going to be competitive in the future. There is a clear stakeholders' pressure for caring about more aspects than just profit. Orsagh (2020) showed that three out of four senior level say it is very important to have a definitive view on climate change to effectively manage investments. Only 13% of them said that having such a view is not important. Nevertheless, only about 40% are currently incorporating climate change into the investment process. Moreover, to affect the strength of the virtuous cycle between environmental and financial performance, firms need to have a two-pronged approach.

Notably, the stronger the explorative logistic orientation in a firm, the more enhanced the link between their environmental and financial performances. Financial resources and environmental investments are necessary conditions but not sufficient for performance improvements in themselves; they need to be coupled with a desire to seek new, innovative solutions rather than just exploit existing practices. The combination of logistics exploitative and explorative orientations helps businesses to meet contrasting stakeholder expectations and interpret their resources into performance (Rintala et al., 2022). The environmental logistic should be organized to support organizational

performance through an active search for new solutions as well as investments to develop both existing and new practices (Rintala et al., 2022).

Manzoor et al. (2021) conducted research throughout data collection that found that SC agility and lean practices positively affect the operational performance of the buyer. Showing that a resilient SC is entirely connected with the success of a company. By considering the ESG momentum and the responsibility on suppliers' action, they need to work all these aspects down the chain. However, managers are finding difficulties to manage the increasingly complex SC despite adopting a variety of risk mitigation strategies. They are adopting various kinds of environmental and social sustainability practices in recent times to reduce carbon footprint, improving their image on the social front (Gouda & Saranga, 2018).

An analysis on Pakistan manufacturing firms shows that sustainable internal, supplier, and customer integration foster both green managerial and process innovations. Findings also suggest that green managerial innovation has a significant positive influence on the firm's financial performance. In contrast, the influence of green process innovations on firm performance is negatively significant, suggesting that rapid changes in manufacturing processes and operational procedures cost firms in multiple ways and decrease firms' profits (Junaid et al., 2021). Moreover, another study shows that social SC practices impact the firm's social performance. However, results indicate that the social element of sustainable procurement does not affect the firm social performance. Social fairness challenged manufacturing firms to comply with sustainable production and distribution. Most firms are still not aware of their role and social responsibility to develop the local suppliers and community (Fernando et al., 2022), which shows that it is important to be done and can result in significant improvements. This is a challenging issue that needs to be done in the right time and the right way.

The SC monitoring and traceability are fundamental to be able to address ESG topics and mitigate them. A multi-tier SC is complex since it has several levels, being hard to locate and structure the whole product path. In general, SC is divided in tiers, and it mainly has 3 groups: (i) tier 1 is the supplier that supplies directly to the owner of the chain, offering more sophisticated products; (ii) tier 2 is the one that supplies to tier 1, offering a less value-added product; and (iii) tier 3 is the one that supplier to tier 2, usually offering raw material or gross products. In some cases, it might have lower levels, but it follows the same logic. Companies affirm that tracing suppliers is costly and do not

provide clear benefits (Sodhi and Tang, 2019). SC traceability is achieved when the Anchor Company (AC) verifies and follows the entire operations from the lowest tier until the final customer, reporting that to the community the address of all ESG topics and footprint (Chen, 2022).

The contribution of SC activities to climate change and the depletion of natural, non-renewable resources by distribution, transportation and material disposal have drawn attention to the importance of addressing the sustainability of operations in the SC (Ageron et al., 2012; Klassen and Vereecke, 2012; Wong et al., 2012). This has resulted in an increased focus on SC sustainability in the extant literature (Hassini et al., 2012) and the development of the concept of Sustainable Supply Chain Management (SSCM). The SC globalization has transformed the concept of sustainability. Moreover, discussing ESG, the typical social issues in SCs include child labor; forced labor; poor health and safety; discrimination and government rules; and regulations (Andersen and Skjoett-Larsen, 2009). Luzzini et al. (2015) also identified a relationship between collaborative practices of ESG, combined environmental and social with sustainability (Malik et al., 2019).

Moreover, the World Economic Forum (2021) affirmed that tackling supply chain emissions offers companies the opportunity to multiply their climate impact several times over. Carbon Disclosure Project (CDP) (CDP, 2021) confirms that SC emissions are on average 11.4 times higher than operational emissions, more than double previous estimate due to more comprehensive emissions accounting (CDP, 2021). In addition, scope 3 emissions account for more than 70 percent of their carbon footprint. Measuring and managing these emissions can motivate a company to do business with greener suppliers, to improve the energy efficiency of its products, and to rethink its distribution network, actions that significantly reduce the overall impact on the climate (Aldridge, 2016). Hollinger (2021) showed a case from Diageo, the largest distilleries manufacturer in the world, which has calculated that around 90% of its carbon footprint is in scope 3, and it is not unique. This further highlights the great importance and relevance of a company's value and SC for it.

During hard times of COVID-19 pandemics, successful companies were the ones that used advanced analytic tools in their strategic planning. Alicke et al. (2021) concluded that these companies were 2.5 times more likely to have preexisting advanced analytics than the organizations that had problems. Among the companies that had

difficulties managing their SCs during the crisis, 7 out of 10 say that they are increasing their use of the technology. Even though monitoring supplier risks is an important factor for corporations, there is a big lack in their SC traceability and management considering ESG aspects. Less than 50% of corporations understands the location and risks of tier 1 suppliers, and only 2% assesses these factors in tier 3 and beyond. That is important to be managed since many of nowadays most pressing supply shortages occur in these low stream SC tiers (Alicke et al., 2021).

These points highlight the importance of measuring, analyzing, reducing, managing, and controlling the SC ESG aspects. Figures 2 and Figure 3 attest that scope 3 emissions (that occur in the SC) is the main source of a company total emission. On this basis, it is fair to assume that the ESG footprint follows the same logic, showing that SC is responsible for 70-90% of an enterprise's footprint, being essential for their success and decarbonization.

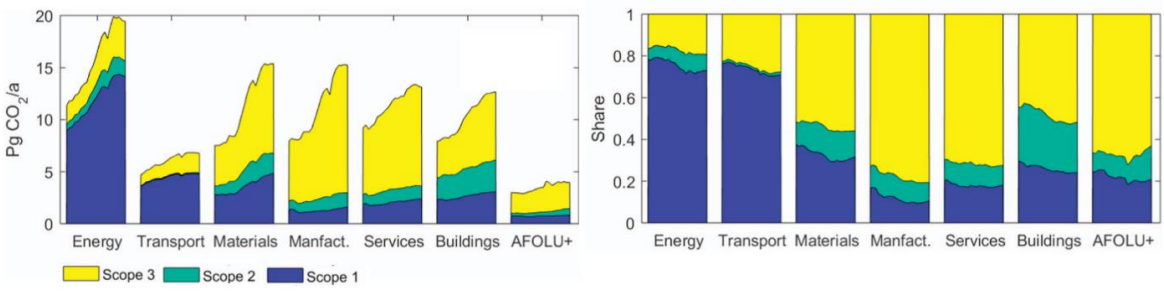

Figure 2 - Scopes 1-3 emissions of sectors
Source: adapted from Wood and Hertwic (2018)

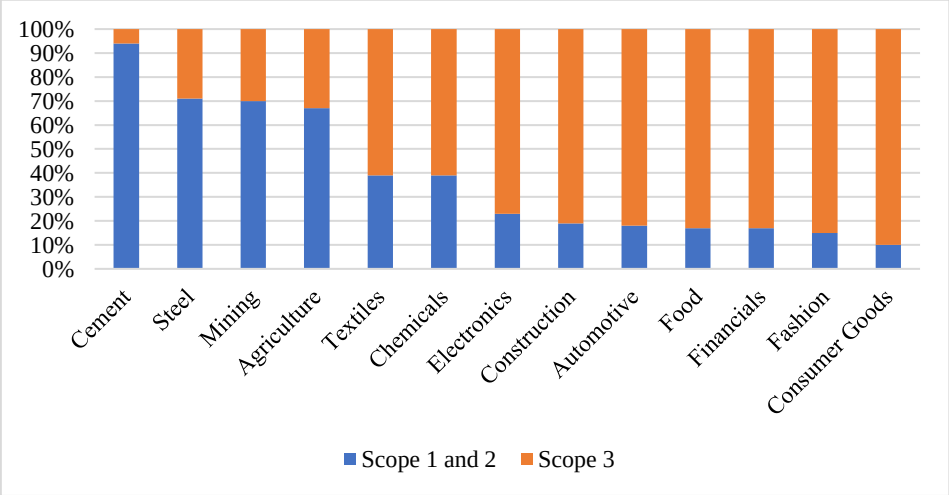

Figure 3 - Emission split in Scopes 1,2, and 3 for selected industries (CO_2e, 2019)
Source: adapted from World Economic Forum (2021)

The complexity of a supplier and their interaction with other suppliers must be a relevant factor on the supplier selection because they directly impact the disruptions experienced by the AC, and it can be intensified depending on the degree of dependence of the supplier (Wissuwa et al., 2022). Evidencing that an event affecting a supplier will, in turn, affects AC, which is the big buyer at the top of the SC. It could be any tier level supplier (Tier 1, 2, 3, or below), and it could include a breakdown in supply or an event that cascades upwards, ultimately affecting the big corporation. Historically, companies did not consider the SC to be important since companies had or claimed to have no influence on suppliers. However, in recent decades, corporate obligations go beyond their operations, and they are held liable for actions of their suppliers (Islam and Staden, 2018). These actions involve all ESG aspects, and it is not only significant for corporations but also for financial institutions as the latter are being held accountable for the actions (or inactions) of the companies they lend to.

Because of that, several innovative technologies and business models are being developed to help companies to access these topics, allowing them to become more consistent and successful. Moreover, there is a new industrial revolution era coming throughout the fast development of artificial intelligence, data-driven information, machine learning, energy sources, and others directly affecting the production and operations management (Liu et al., 2020). Furthermore, financial technology (Fintech), climate-tech, and clean-tech are the new industries that are increasing, and they are developing innovative solutions aligned with ESG practices to offer sustainable growth to companies. Due to the big demand, they are growing fast and gaining a lot of traction.

This work deals with a sustainable fintech product called Sustainable Supply Chain Finance (S2CF). It is a variation of the traditional Supply Chain Finance (SCF), aka reverse factoring (RF) that uses ESG metrics to evaluate the SC offering financial benefits. The idea is to furnish the traceability of the entire SC to the AC and, at the same time, provides better conditions to the suppliers by taking the operation risk of the AC. An ESG assessment for corporations is developed providing a quantitative measurement based on a personalized analysis by industry for their own operations and the entire SC from upstream to downstream tier. This methodology can be used to transform SCF in S2CF or any other evaluation that might interest the organization. It is proposed a score (0-10) to the AC, to their SC, and an aggregated value. This is a novel strategy with big potential repercussion for the production sector that demands for a fast, direct, and low

cost ESG evaluation system. Companies that do not assess ESG are not going to be competitive, however it is a high-costly and time-consuming process. The lack of the related literature also endorses the importance of the proposed methodology. The score is evaluated from different qualitative scenarios that allows the comprehension to the real impact of the SC score in an AC score, showing all the benefits and potential risks for both suppliers and the big corporation. Overall, this work develops a proprietary ESG classification system based on the materiality concept evaluating the impact of the SC in a company's ESG score.

As has been shown above, the main problem and motivation of this work is the urgent factor of sustainable businesses mitigating global ESG problems such as climate change, social inequality, and governance issues. Moreover, the SC is an important part of any AC, which requires a big effort to evaluate their suppliers' ESG footprint and there is very few knowledge on how the AC sustainability is affected by their SC performance.

1.2 Objective

The objective of this work is to develop an ESG score evaluating of ESG footprint based on industry materiality for their own operations and the SC. This methodology can be used to transform SCF in S2CF or any other evaluation that might interest the organization. The score (0-10) allows the evaluation of the AC and, the entire SC, providing an aggregated score to guide companies to better understand and mitigate their ESG risks and opportunities. To get the SC score, the work will establish the minimum sample size and weight of each category based on importance and contract size.

In addition, a scenario analysis is carried out showing the real impact of the SC score in an AC score, showing all the benefits and potential risks for both suppliers and the big corporation.

1.2.1. Main Objective

The main objective is to develop a weighted ESG valuation model for companies to receive a quantitative score of their operations and their supply chain footprint.

1.2.2. Specific Objectives

- To develop a quantitative model for companies to evaluate their operations ESG score.
- To evaluate all the suppliers of the Anchor's supply chain and evaluate the SC ESG score.
- To determine the weighted model to get the supply chain score based on importance level.
- To assess a scenario analysis to get a final ESG score based on the supply chain and the anchor scores.
- To understand the real impact of a supply chain in an Anchor company.

1.3 Structure of the Work

In favor of achieving these objectives, the work is structured as follows. This current chapter which introduces the topic with context and justification, shows both specific and general objectives, and finally presents the structure of the work. Chapter 2 focuses on the theoretical background, doing a literature review while focusing on important topics and concepts to the work such as ESG and decarbonization, sustainable supply chain and materiality, and finance and technology. Chapter 3 presents the methodology showing the step-by-step process on how the model works and how the ESG scores of the AC, SC and the consolidated is calculated. Chapter 4 focuses on the scenario analysis applying the model into real-life situations testing and certifying the process. Chapter 5 aims to conclude the work based on the results and the entire analysis, discussing the limitations and future work suggestions. Finally, the structure also has an annex's part with the appendix tables which are crucial to the work and the references. Figure 4 visually summarizes this structure of the work

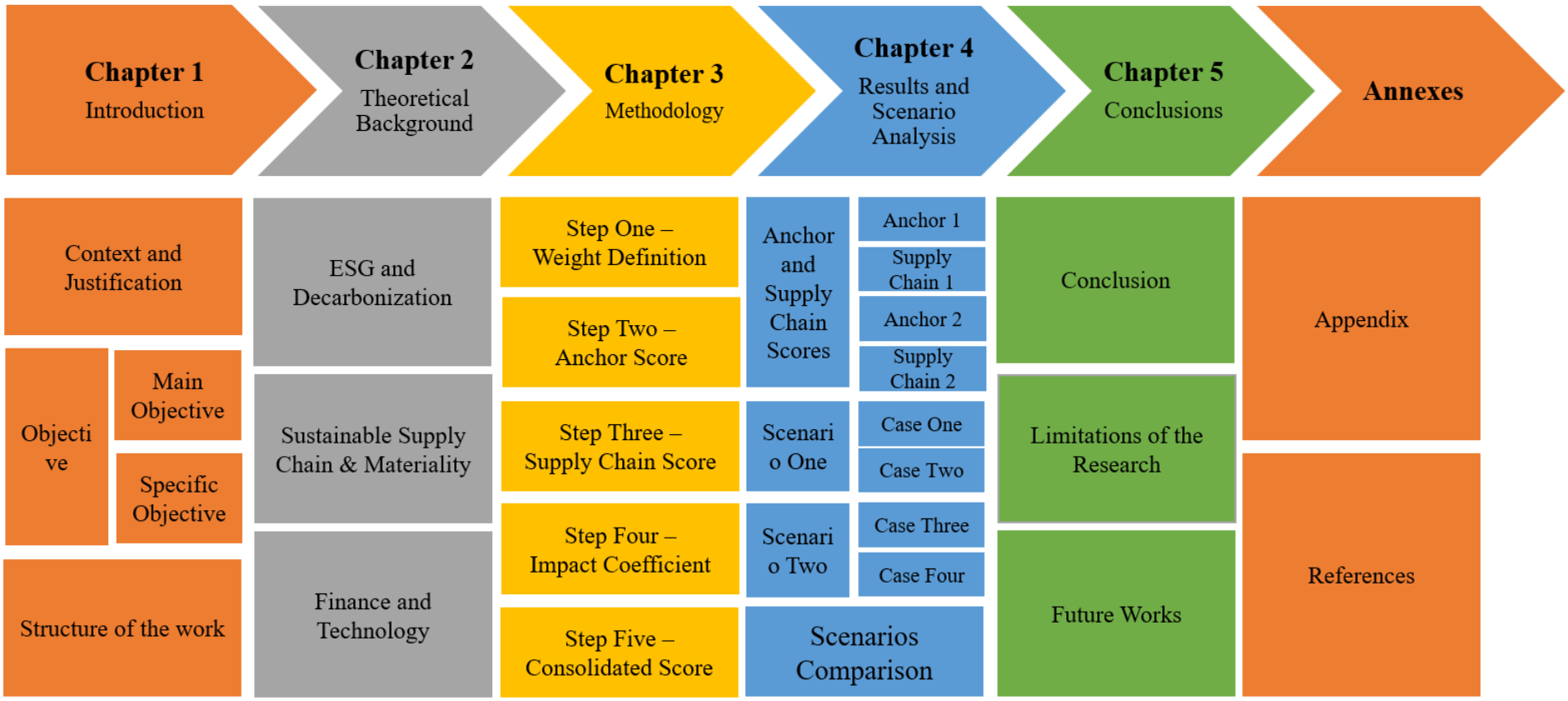

Figure 4 - Structure of the Work

Source: Own elaboration

2 THEORETICAL BACKGROUND

This chapter presents the theoretical backgrounds, discussing some key terms and definitions. The objective of this section is to clarify the understanding and contextualize the knowledge prior to work on the ESG analysis, being essential to the work. Initially, definitions and a literature review of broader concepts such as sustainability, ESG, supply chain, Sustainable Development Goals (SDGs) and the 2030 Agenda towards decarbonization is presented. Afterward, explanations of concepts of ESG Materiality, Fintech, SCF and S2CF are presented. The literature review extensively covered the most important databases as Clarivate (Web of Science), Google Scholar, and Elsevier (Scopus).

2.1 ESG and Decarbonization

A usual concept establishes that sustainability is living in harmony with the environment and nature without causing damage. A broader sustainability concept can be established by the ability of meeting our need without harming the ability of future generations to do the same. Nevertheless, sustainability is much bigger than that since it involves several different areas, being focused in three aspects: reduction of environmental impact; fulfillment of social needs; economical and financial matter. Following this concept, the Triple Bottom Line (TBT) of sustainability was created by John Elkington in the 90's: social, environmental, and economic. Figure 5 shows that sustainability cannot be reached if we ignore any of those three aspects.

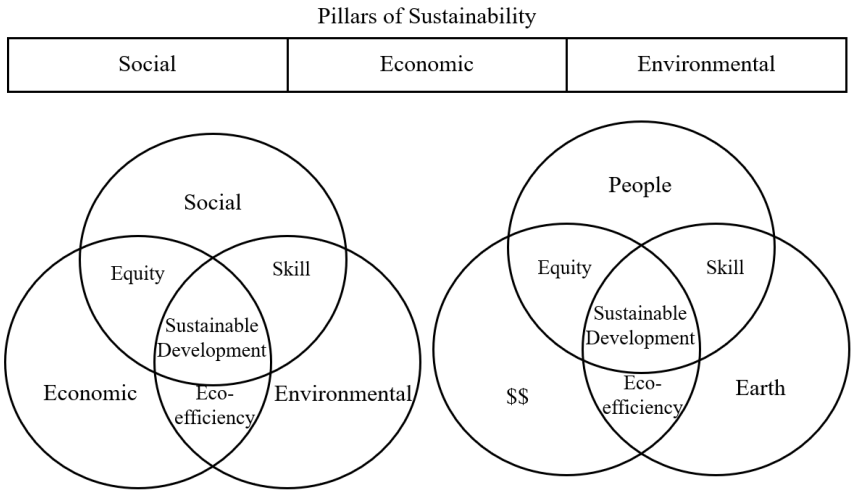

Figure 5 - Three pillars of sustainability
Source: Adapted from Barbieri et al. (2010)

Moreover, sustainability is everyone's responsibility, either in our daily actions or in our participation as stakeholder for companies. It is important to reduce our ecological footprint, but it is even more important to support sustainable business models and products. It is impossible to sustainable value proposition for customers without creating value to a broader range of stakeholders. Business is market-oriented and it is necessary to create value to the whole range of stakeholders and the natural environment to be able to achieve sustainable development, beyond customers and shareholders (Schaltegger et al., 2016).

In addition, for achieving a sustainable development, organizational leaders need to adopt future orientation strategies, which can be accomplished in organizations regardless of national culture (Stravropoulou, 2015). It is necessary to encourage corporations to seek environmental and social improvements that generate economic benefits. It focuses on business opportunities and enables companies to become more environmentally and socially responsible, being more profitable by motivating innovation and, therefore growth and competitiveness (Yemal et al., 2011).

In recent times, a new concept that reflects sustainability has been created to make it usage easier in real world. ESG stands for Environmental, Social and Governance aspects, a concept that first appeared in the United Nations (UN) report "Who Cares Wins" in 2004. After that, the United Nations principles for Responsible Investment (UN-PRI) was formally created in 2006, which puts forward the ESG framework and listed some factors for consideration. The same year, "Goldman Sachs Environmental Policy:

2006 Year-End" report was released, formally juxtaposing the seemingly unrelated terms (Gao et al., 2021).

By considering ESG issues, *Environmental* focuses on living in harmony with nature, saving and optimizing resources usage related to energy, water, wastewater, waste, emissions and ecology. *Social* focuses on the labor regulations, health and safety, discrimination and poverty. While *Governance* focus is on codes, conduct, principles, transparency, structure, rights, and corruption. All of them need to be worked together, which popularized the ESG issue as three-pillar single structure. Notably, depending on the branch of the organization, one part may gain more prominence than others, but it is always necessary to act on the three pillars. Therefore, ESG must go beyond the theoretical character, and need to be understood as practices, which make up the organizational culture. According to research made by the Institute Akatu and Globescan (2020), 60% of consumers expects companies to set goals that make the world a better place, which indicates that the market and investors have become inflexible with organizations that follow the reverse flow of what society requires through its purchasing power.

Therefore, ESG should be understood as a way of evaluating the actions of companies based on their policies that deals with environmental, social and governance. The subject can be extended to investments, as a condition of sustainability. On this basis, investors are looking at the ESG company strategies instead of looking only at financial indices.

Moreover, moving forward with ESG to fit the new market demand might be very challenging for companies, especially because there is a lack of historical data on these aspects. Besides, some aspects are hard to measure, and there is no standardization in metrics and format of reporting. In general, to promote a more environmentally informed society, more standardization would be required in both the format and metrics of ESG reporting and sustainability reports. Thus, ESG reporting, benchmarking, and rating need to be improved (Vergara & Agudo, 2021). In this regard, this challenging necessity is being treated by several international standards and taxonomies that companies can follow and focus. The most accepted are: Sustainability Accounting Standards Board (SASB), Global Reporting Initiative (GRI), EU Taxonomy, Carbon Disclosure Project (CDP), International Sustainability Standards Board (ISSB), Science Based Targets (SBTi), GHG Protocol, Task Force on Climate Related Financial Disclosures (TCFD),

and Climate Bonds Initiative. However, SASB offers the best path to the materiality concept aligned with society's demand for sustainable business and activities (Jebe, 2019).

Apart from that, it has been built over several years of work, research, and events around the globe. Since 1979, scientists from the biggest nations have been meeting on World Climate Conferences (in Geneva), concluding that it is indispensable that we start addressing and mitigating climate change. Other conferences occurred to ensure that we are acting towards a sustainable world, otherwise there will be irreversible factors affecting the world and living beings. Among these conferences, it should be highlighted the most important ones as the Rio Summit (1992), Kyoto Protocol (1997), and the Paris Agreement (2015). But there were several other events, cupules, and seminars to enforce the climate emergency status and to warn the insufficient progress (Ripple et al., 2017).

In 2015, country representatives were united again to discuss climate change and its impacts, elaborating the Paris Agreement where 194 countries have volunteered to reduce emissions by 2030. Their commitment was called *Nationally Determined Contributions* (NDCs). After that, a few countries have committed to a net zero goal, mainly by 2050 and it is expected an increase of these countries. In addition, the agenda 2030 of the UN defined 17 Sustainable Development Goals (SDGs) to change global efforts to move towards a sustainable and fair world (Janetschek et al., 2020). According to the UN (2022), the agenda 2030 provides a shared blueprint for peace and prosperity for people and the planet, now and into the future. The heart of the agenda 2030 is the 17 SDGs, which represents an urgent call for action by all countries - developed and developing - in a global partnership. They recognize that ending poverty and other deprivations must go together with strategies that improve health and education, reduce inequality, and spur economic growth – all while tackling climate change and working to preserve our oceans and forests.

The 2030 Agenda is a plan of action for people, planet, and prosperity. It also seeks to strengthen universal peace in larger freedom. All countries and all stakeholders need to act in collaborative partnership to implement this plan. We are resolved to free humans from the tyranny of poverty and want and to heal and secure our planet (UN 2022). The 17 goals and 169 targets will stimulate actions over the next years in areas of critical importance for humanity and the planet. Figure 6 illustrates a summary of all the SDGs number with their goal.

Figure 6 - Sustainable Development Goals (SDGs)
Source: United Nations (2022)

Among the most important problems related to climate change, the greenhouse gas (GHG) emissions have been increasing significantly, which points to the need for efforts to avoid the planet destruction (IPCC, 2018). Even though there are argues that climate change is not anthropomorphic, going against Intergovernmental Panel on Climate Change (IPCC) conclusions, there are several evidence pointing that it is really happening (Viola et al., 2010).

The emission of greenhouse gases is the most important problem related to climate change. In general, the Kyoto Protocol (2004) defined the greenhouse gases pointing to six main gases: CO_2 (Carbon Dioxide), CH_4 (Methane), N_2O (Nitrous Oxide), SF_6 (Sulphur Hexafluoride), HFC (Hydrofluorocarbons) and PFC (Perfluorocarbons). Among them, the CO_2 is responsible for around 80% of the general emissions (EPA, 2022), being over concentrated in the atmosphere due to human activities such as industries and the use of fossil fuels. The high increase of these gases in the atmosphere combined with deforestation, improper and abusive consumption without respecting the natural flow have been making earth's temperature to increase in the past decades. On this basis, it is expected to raise even more causing irreversible impacts to our planet that includes extreme meteorological events. Currently, we can already notice an increase in heat

waves, more intense and more frequent storms and hurricanes, and a change in the behavior of rainfall. However, this is just the beginning, since the expectation is that there will be an extinction of several species, collapse of ecosystems, oceans will become more stratified and less productive (20% of the population depends on the seas for nutrition), crops will fail more regularly. This all will cause economic imbalance, destruction of cities and societies (McNutt, 2013).

The companies and industries are big contributors to the air pollution, being divided into three categories: Scope 1, 2, and 3. Scope 1 are emissions that occur directly at the facility or company in question; scope 2 are the emissions associated with electricity consumption; and scope 3 are the emissions associated with other inputs mainly on the SC (Wood & Hertwic, 2018). Environmental Protection Agency (EPA) and Greenhouse Gases Protocol (GHG Protocol) defines scope 1 as being the direct emissions that occur from sources controlled by the organization; scope 2 as being the indirect emissions from purchasing of electricity, steam, air conditioning, etc.; scope 3 as being all the other indirect emission that happen in the SC. Even though, scope 2 and 3 do not direct emissions, they are both considered when making a GHG inventory. Enterprises are held responsible for all scopes, which means that all air emissions in the SC are also their responsibility. Figure 7 illustrates the emissions and the activity where they were originated.

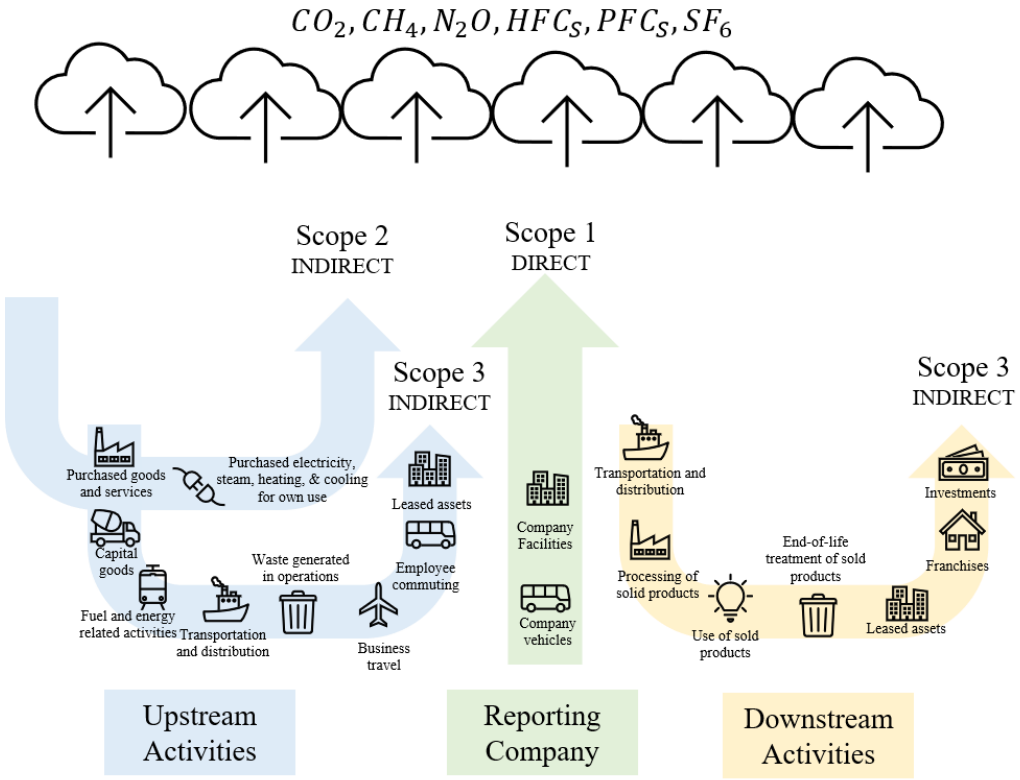

Figure 7 - Scope emissions
Source: Adapted from Bhatia et al. (2021)

2.2 Sustainable Supply Chain & Materiality

Furthermore, the research interest in SSCM has shifted from focusing on the AC to tier 1 suppliers (Wilhelm et al., 2016) and multi-tier SCs (Mena et al., 2013; Grimm et al., 2014; Tachizawa and Wong, 2014). Nevertheless, although organization leadership is essential to provide competitive advantage, very few researches focus on the role of SC leadership in the implementation of sustainable initiatives in a multi-tier SSCM (Defee et al., 2010; Gosling et al., 2016). (Jia et al., 2018). The SC is responsible for major environmental, social and governance impacts, and SC management is extremely important to identify and avoid these practices, risks, and issues (Jadhav et al., 2018).

The AC, buyer, is directly affected by the suppliers (Wissuwa et al., 2022) and they are held responsible for every action of their suppliers, which means that they can be directly affected by any illegal activity or negative behavior. There are several cases where the big corporate is significantly affected by any supplier.

Moreover, SSC follows the same concept of the SC, but monitor, assess, and incentivize practices considering suppliers' ESG responsibility, the environmental and human impact of the product or service in its entire journey (from lowest tier to final customer, including production, storage, transportation, etc.). To achieve that, it is essential that all the SC is mapped, identifying all risks. Usually, anchor companies have contracts and audits based on ESG criteria addressing global issues such as carbon emission, water and wastewater, deforestation, energy consumption, labor practices, corruption, fair trade, human rights, among others.

An SSC must avoid any harm to social or environmental systems as still making profit, being able to repeat their business cycle if necessary. However, SSC does not exist today (Pagell & Zhaohui, 2009). According to the Business Guide to a Sustainable SC (Tindall, 2003), the development of SSC enterprises should have a management system of raw materials and services from suppliers to manufacturer, service provider to customer, improving the social and environmental impacts explicitly. Moreover, a big portion of a company's ESG footprint lies in the SC, involving the whole journey of the operational process. Therefore, the focus in the SC is a step towards the broader adoption, development, and assessment of sustainability. However, it must also integrate issues and flows that extend actions beyond the core of SC management: product design, manufacturing by-products, by-products produced during product use, product life extension, product end-of-life, and recovery processes at end-of-life (Linton et al., 2007)

Furthermore, to achieve the supply chain sustainability, addressing all ESG topics might be very challenging, so it is important to use ESG materiality to guide their sustainability strategic planning by knowing which aspect would have a significant impact on the organization, influencing the assessments of all stakeholders. This concept is becoming extremely relevant for sustainability performance measurement, identification, focus, and reporting on topics and issues that are considered material to the business (Pedersen et al., 2022).

It is the perspective that has relevant and material exposure to the financial performance of the company. In addressing ESG issues, it helps to maintain and increase the ability of the corporation to create value over the long term (Busco et al., 2020). So, it represents the long-term financial success of the firm throughout effectiveness on ESG analysis and measurement. Usually, corporations rely on external partners to conduct their materiality assessment because most of the companies does not have the resources

to perform that at home, and third-party assessment is extremely valuable to stakeholders, especially when talking about controversial topics.

The Center for Sustainable Business of NYU Stern published a guide on how to do the materiality process (Rifkin, 2019). It generally includes the following steps:

1. Identification of main risks and opportunities for the business.
2. Data collection and analysis.
3. Definition of most relevant issues.
4. Alignment with mission, vision, and strategy.
5. Action Plan

One example of materiality would be on the financial service industry. Most of their SC and operation are consultant and tech companies. This means that their SC materiality is going to be some aspects related to energy, data security, and diversity. Therefore, the company should focus on them instead of making efforts for deforestation or waste, for example. They should never ignore any aspect, focusing on the most impactful direction.

In this dissertation, the focus is going to be on the SASB materiality: according to their website, they have a global diagnostic standard of sustainability disclosure that offers information about economic sectors, providing sustainability risks and opportunities to guide investors and stakeholders to make better decisions (SASB 2022). SASB industry materiality standards cover the topics that are most probable to have significant impact in operating and financial performance (Rifkin, 2019). In general, materiality affects ESG rankings and scores, allowing investors and stakeholders to selected best corporations based on their ESG key issues and opportunities (Madison & Schiehll, 2021). Moreover, SASB offers the best path to the materiality concept aligned with society's demand for sustainable business and activities (Jebe, 2019) and it is essential for information evaluation of investments and ESG performance (Madison & Schiehll, 2021).

It will serve as a materiality guide to define the weights of each sector on the development of the quantitative method of ESG evaluation that is about to be presented. Escoto et al. (2022) applied the SASB standards in small and medium-sized manufacturers to make it more sustainable by reflecting different types of measures based

on the specificity of each company; they found that by using materiality methodology it can result in business opportunities and risk reduction for introducing changes.

This dissertation is also going to use the SASB standards with a different approach, focusing on all companies instead of focusing only in the small and medium-sized manufactures. Matsumura et al. (2022) used the SASB materiality map to test if the corporations' discloser material climate risk based on market expectation affects the firms' risk based on the cost of equity. They have used the S&P 500 as a sample and results show that companies' with and without climate risk materiality that disclosers have lower risks than nondisclosures, directly affecting managers' decisions. It validates the quality and importance of SASB on addressing materiality, which will be the main standard used in this dissertation to define the weights of each ESG parameter per sector.

Betti et al. (2018) concluded that the sustainable development goals cannot be achieved without the private sector, but it will not harm their financial return. The work relates the development goals with the SASB materiality showing that some sectors need to focus on some specific SDGs depending on their material risk and impact, creating a guide for companies and investors on calculating the ESG performance and contribution to the SDGs. In the dissertation, it is going to be created a correlation of the SASB materiality map with the ESG quantitative scores guiding companies to have a fair assessment based on their singularities and activities.

2.3 Finance and Technology

New technologies that can develop sustainable growth products have been created by a new industry called climate technology (Climate-tech) and financial technology (Fintech), which are digital platforms or systems that solve a market pain by filling the market demand with innovative. The main focus of this work is on the Fintech, since it relates to the financial market, and we cannot move towards a sustainable world without the proper definitions about money. Furthermore, Fintech are aligned with ESG criteria using many tech tools such as crowdfunding, big data analytics, blockchain technology, and artificial intelligence. It shares many aspects with sustainable finance, and it can make financial business overall more sustainable, as it promotes green finance (Vergara & Agudo, 2021).

Moreover, they have the potential to disrupt and transform the financial sector by making it more transparent, secure, and less expensive. Besides, the big corporations would be forced to compete and adapt with new ESG-friendly business models (Kabulova & Stankeviciene 2020). In addition, many areas such as the financial system, economy, society, infrastructure, and energy sector are affected by these disruptive and great innovations. Hence, it has many effects on social and environmental by promoting the use of funds for sustainable projects (such as renewable energy and ecological), construction of renewable energy facilities, and environmental infrastructure leading to environmental and ecological development by providing cheap and adequate financing (Deng et al., 2019). In conclusion, some of the reasons for this rapid evolution of Fintech are the sharing and circular economy, favorable regulation, and information technology (Moro-Visconti et al., 2020).

A traditional financial product that helps big corporations to work with their SC, incentivizing their suppliers, is the supply chain finance (SCF) or reverse-factoring (RF), which is an improvement of the factoring. Factoring is a type of short-term, post-shipment financing in which suppliers sell their accounts receivable at a discount and receive immediate cash from the financial institution (FI), bank or fund. The benefit of factoring comes from the advanced cash that helps the supplier meet working capital needs and reduce liquidity risk during the period of payment delay (Kouvelis & Xu, 2021). Most of the suppliers are small and medium sized (SMEs) enterprises which are known to have insufficient working capital and limited access to financial market (Huang, 2022).

As estimated by the Asian Development Bank (2019), 45% of the SMEs around the world face regular rejection by financial institutions for trade finance, contributing to a global financing gap of $1.5 trillion (Huang, 2022). Moreover, 90% of SMEs are contributing to 60% to 70% of a country's employment (National Action Plans on Business and Human Right 2021). Therefore, there is a great potential and importance of them for the entire economy. Furthermore, limited capital available for investments is a barrier to the growth. However, it is possible to facilitate the financial flow and increase efficiency by working with the big corporation's SC. The innovation of fintech has further contributed to the adoption SCF by delivering financial services using information technologies (IT) and simplifying SMEs' loan and transaction processes (Soni et al., 2022).

SCF or RF is anchor centric. Anchor offers a financial mechanism to suppliers, allowing a pre-financing of the suppliers' receivables at the anchor's credit conditions (Seifert et al., 2013). The anchor has a better credit rating and therefore a lower interest rate is applied in the transaction. It is also beneficial to anchor because it reduces upstream financial SC risks and reduce one's own costs (Klapper, 2006). In practice, reducing own cost is often achieved through an extension of the anchor's payment terms with the supplier (Beyer & Herzon, 2021).

The concept of SCF implies managing financial flows in trade relationships more intelligently and at a lower cost of capital. It is well-known that SCF has win–win situations for both parties if marginal debt financing via a bank loan implies a higher interest burden and a lower financial flexibility for other investments (Hofmann & Belin, 2011). Yet, the financial impacts of SCF are dynamic and non-linear (Beyer & Herzon, 2021). The market share of reverse factoring is around 3% of the entire factoring market. The global volume of factoring is about 2.8 trillion euros, according to Factors Chain International in 2018 (Beyer & Herzon, 2021).

According to the BCR World SCF report 2022, the size of the market is 1.8 trillion USD in 2021 and it is growing in approximately 30% yearly since 2015 (BCR, 2022). SCF was mainly offered by the traditional banks, but recently, due to the new digital era, it has been promoted and offered by fintechs with digital platforms which connects anchor, their suppliers, and several lenders (banks, FIs, funds, etc). According to McKinsey, the expected compound annual growth rate is in exponential growth (CAGR) 2019-24 for SCF is 15-20% (Botta et al., 2020). However, since it is new to the market, only a few studies have considered the use of platform financing in SC context (Reza-Gharehbagh et al., 2021; Yu et al., 2020; Fatehi & Wagner, 2019; Gao et al., 2018; Yan et al., 2020; Reza-Gharehbagh et al., 2020; Reza-Gharehbagh et al., 2020).

As mentioned before, multiparty Fintech platforms (MPs) are gaining a lot of traction and the main reason for that is because of the increase of green entrepreneurs and their plan to develop new green products. To support them and enhance social welfare, usage of MPs and sustainable supply chain finance (S2CF) are being promoted by governments and others (Reza-Gharehbagh et al., 2022). The term S2CF was coined by Business for Social Responsibility (BSR), a US organization, in 2018. It can be defined as SCF practices that support trading and transactions in sustainable ways - promoting economic, environmental, and social benefits, mitigating any equivalent detrimental

impacts (Soni et al., 2022). Along with economic considerations, corporations must focus on its ESG impacts (mainly social and environmental) to gain more competitiveness, and an S2CF strategy should be adopted to sustainably improve working capital (Garcia-Muina et al., 2019). New technologies can improve S2CF implementation by enabling automation and streamlining the management of financial flows, including its impact on sustainability. Thus, the adoption of it is poised to improve an SC's overall performance (Soni et al., 2022).

Furthermore, S2CF provides a solution for achieving the sustainable development goals by stressing a profit-seeking improvement under more ecologically aware (Jia et al., 2020a, b). It is a financial mechanism offering trade activity to reduce adverse effects and generate values on SC sustainable performance (Jia et al., 2020a, b). It entails the employment of financial products and technologies to encourage SC partners to engage in sustainable initiatives voluntarily (Tseng et al., 2019). Firms adopting S2CF may relieve capital shortage pressure and behave in a sustainable manner, which are conducive to realizing their own profit benefits and environmental activities (Guo et al., 2022). In conclusion, adoption of S2CF is a key factor for firms to realize sustainable development goals relating financial and environmental performance (Jia et al., 2020a, b; Tseng et al., 2019). According to the BSR report (2018), the S2CF market will reach one third of the market, representing a big opportunity for financial service providers.

The SCF business model is illustrated in Figure 8: 1 – supplier sells product or service to the anchor client which would pay it X days from today (60, on the example); 2 – Supplier trades the receivable with lender to receive the payment today; 3 – Lender pays supplier with a discount fee based on anchor's credit risk; 4 – Anchor pays lender on the original payable date (d+60).

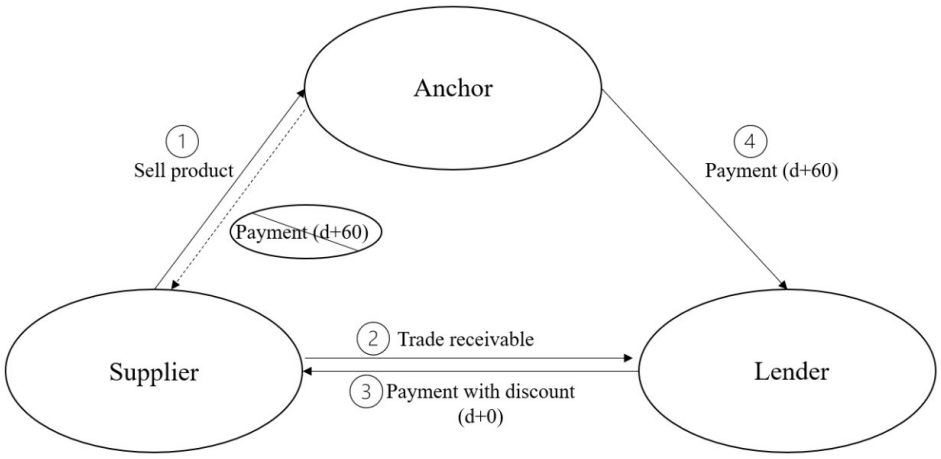

Figure 8 - SCF model
Source: Own elaboration

S2CF follows the same business model, but it is more complex since it involves an ESG assessment of all parties. As stated in Figure 9, each supplier that joined the program would be evaluated and monitored in ESG metrics, receiving a classification that would be part of credit risk and being considered when calculating the discount fee. Anchors would have a full ESG footprint view of the SC risks, while incentivizing them to improve with better conditions. Lenders would access an ESG pre-evaluated portfolio, offering best conditions for those with best classifications. Suppliers would be evaluated in ESG metrics with zero to low cost, receiving incentives to improve in the ESG agenda. It is clear a win-win situation to every party involved in the program.

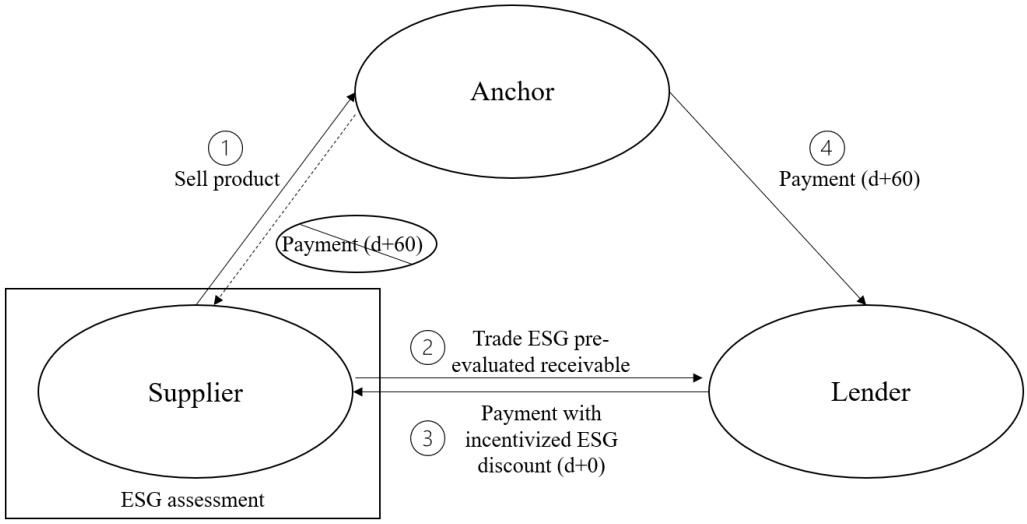

Figure 9 - S2CF model
Source: Own elaboration

3 METHODOLOGY

Therefore, this dissertation develops a weighted model for companies to quantify their ESG performance. As specified before, the weights are based on SASB materiality which it is necessary to have a score for each of the disclosure topics specified in the 'list of symbols' and on Table A2 in appendix. The score for each of them can be calculated based on the methodologies discussed in Dumrose et al. (2022), Frini & Diouf (2019), and D'Amato et al. (2022). Dumrose et al. (2022) discussed the ESG ratings based on the EU Taxonomy using related firm data in tobit regressions. In this dissertation the focus is going to be on SASB disclosure topics, but Dumrose et al. (2022) stated a logic of getting a ESG rating that could be used to get the needed scores.

In addition, Frini & Diouf (2019) proposed an indicator grid specific to monitor and measure the sustainable impacts of the manufacturing companies' operations allowing them to rank and compare; they made a systematic review of literature and professional standards to define the material aspects to be evaluated. In this dissertation, the evaluation methods are similar since some specific grids are defined for each sector, and it can follow the same scoring methodology they have used to monitor and measure the impacts of companies in each necessary topic. Moreover, D'Amato et al. (2022) employed a random forest algorithm to investigate how structural data affects the ESG scores for the companies. As a result, they found that the balance sheet is a crucial element to the ESG scores. In correlation to this dissertation, it is another example of how to get the score for each topic that is needed to apply the developed formulas to get the final ESG scores for the companies and SC.

This work develops an ESG evaluation assessment methodology for companies to be able to have a quantitative measurement. The analysis model must be replicated in the entire SC to provide a ESG score. Moreover, it also presents a formula to define the weightage to be able to completely assess the entire SC. This is a novel strategy with big potential repercussion for the production sector that demands for a fast, direct, and low cost ESG evaluation system. The lack of the related literature, identified by a deep search on Scopus (Elsevier) Research gate looking for similar topics, also endorses the importance of the proposed methodology. Different scenarios are going to be analyzed to simulate some typical situations, defining the impact of the SC score in the company. It can be used by any company at any level located in Brazil, since it is going to consider

some Brazilian indexes in the analysis. However, the model can be replicated in different geographies by using similar indexes.

The ESG evaluation assessment is going to use the SASB methodology based on materiality (Matsumura et al., 2022; Betti et al., 2018; Escoto et al., 2022). As stated in Madison & Schiehll (2021), materiality can better inform decisions, because it affects the value of ESG scores, performance, and rankings. In addition, SASB offers the best path to the materiality concept aligned with society's demand for sustainable business and activities (Jebe, 2019).

SASB has defined 11 economic sector groups divided into 77 subsectors, showed in Table A1 in appendix, defining the relevant issues for them. There are 26 disclosure topics divided into 5 groups, presented in Table A2 in appendix. For every subsector have been established the relevant issues are among the 26 options. This work is going to use the 11 economics sectors, which would be defined a weight methodology to calculate the ESG score based on the industry materiality aspects by counting the topics that are material for the subsectors inside the big sectors. Some limitations might apply, since 11 economic sectors have a macro level view of the industries; for example, the transportation sector considers both passengers and freight. The flow to represent the methodology and how to get the result are represented on the Figure 10.

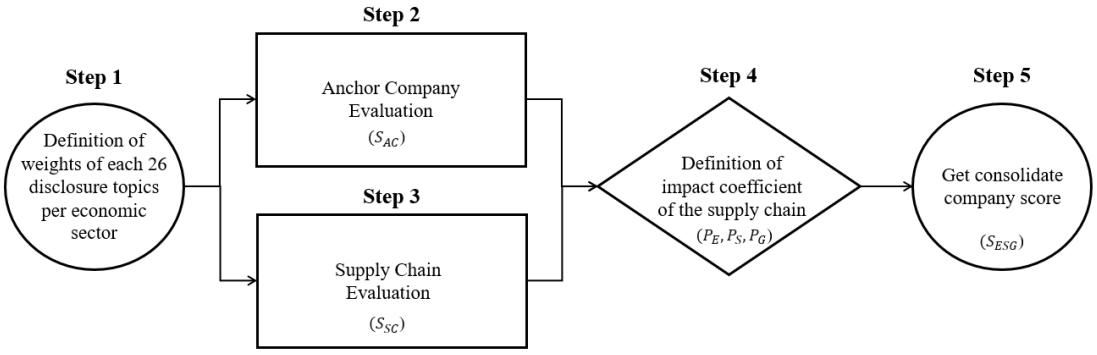

Figure 10 - Methodology workflow
Source: Own elaboration

Since every sector is going to follow the same process and logic, the Consumer Goods sector was chosen by convenience to be used as an example to clarify, guide, and

explain the entire journey step by step. Moreover, tables with sector variables and relevant information are shown to illustrate the process on the other sectors.

3.1 Step One: Weight definition

Step one consists of the definition of weights of each 26 disclosure topics per economic sector based on SASB. Figure 11 illustrates the process of this step.

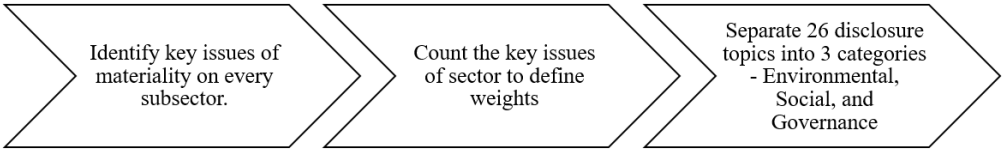

Figure 11 - Workflow weights definition
Source: Own elaboration

a. Identify key issues of materiality on every subsector.
   Table 1 shows the subsectors inside the consumer goods sector and identifies all relevant topic with an ‘X’
b. Count the key issues of sector to define weights

Table A3 in appendix shows the same process with all sectors by identifying the key issues with ‘X’ of each subsector and adding them up, resulting on the blue line at the top. In the consumer goods example, it is notable that Product Quality (PQ) and Product Design (PD) are the most relevant topics since it is relevant to 5 sub sectors of the sector.

Considering the analysis above and that all topics had previously all weights equals to one, table A4 in appendix shows the total weights for each one of the disclosure topics to be evaluated per sector.

Table 1 - Consumer goods example of materiality

Industry	Enviroment						Social Capital							Human Capital			Business Model					Governance				
	GE	AQ	EM	WW	WH	EI	HR	CP	DS	AA	PQ	CW	SP	LP	EH	EE	PD	BM	SM	MS	PI	BE	CB	ML	CI	SR
Consumer Goods	0	0	3	1	0	0	0	1	2	0	5	0	0	1	0	2	5	0	4	1	0	0	0	0	0	0
Apparel, Accessories & Footwear											X								X	X						
Appliance Manufacturing											X						X									
Building Products & Furnishings			X								X						X		X							
E-commerce			X					X	X							X	X									
Household & Personal Products				X							X						X		X							
Multiline and Specialty Retailers & Distributors			X						X					X		X	X									
Toys & Sporting Goods											X								X							

Source: Adapted from SASB 2022

c. Separate 26 disclosure topics into 3 categories - Environmental, Social, and Governance

SASB 5 aspects are going to be combined into three big categories: Environmental (E), Social (S) or Governance (G). E represents the first group called ‘environment’, S combines the second and third groups called ‘Social Capital’ and ‘Human Capital’, and G combines the fourth and fifth groups called ‘business model & innovation’ and ‘leadership and governance’.

3.2 Step Two: Anchor ESG Score

Step 2 represents the Anchor Company ESG Evaluation process and figure 12 illustrates the work to be done in this part of the process.

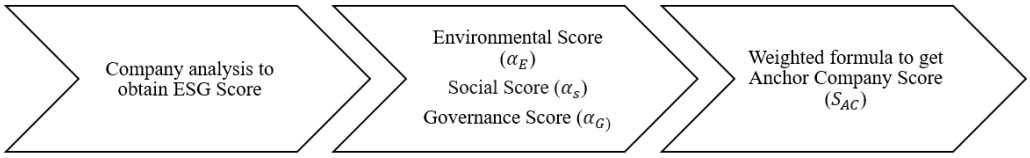

Figure 12 - Workflow AC evaluation
Source: Own elaboration

a. Company analysis to obtain ESG Score

All the disclosure topics mentioned must be assessed and evaluated to receive a score for each one of them. The score could be calculated based on methodologies discussed in Dumrose et al. (2022), Frini & Diouf (2019), and D’Amato et al. (2022) focusing on the Corporate Sustainability Index (ISE) for B3. Another possibility could be the usage of questionnaires; on Table A5 in appendix there is an example of questionnaire and score output for the Environment part.

b. Weighted formula to get Anchor Company Score (S_{AC})

Following the weights and groups defined on step 1, a formula is defined to calculate each of three scores. To illustrate, the consumer goods sector will serve as an example, but it can be adapted to any other sector by following the data on the tables mentioned above:

- Environmental Score for Consumer Goods companies (α_E):

$$\alpha_E = \frac{(\mathrm{GE+AQ+4EM+2WW+WH+EI})}{10} \quad (1)$$

- Social Score for Consumer Goods companies (α_S):

$$\alpha_S = \frac{(\mathrm{HR+2CP+3DS+AA+6PQ+CW+SP+2LP+EH+3EE})}{21} \quad (2)$$

- Governance Score for Consumer Goods companies (α_G):

$$\alpha_G = \frac{(\mathrm{6PD+BM+5SM+2MS+PI+BE+CB+ML+CI+SR})}{20} \quad (3)$$

Combining the three aspects, the company ESG Score (S_{AC}) is defined by the following formula considering the weighted methodology on table 2 which come from a combination of the data on step b and c:

$$S_{AC} = \frac{(\mathrm{WE}\ \alpha_E + \mathrm{WS}\ \alpha_S + \mathrm{WG}\ \alpha_G)}{WT} \quad (4)$$

where WE is the weight of the environmental, WS is the weight of the social, WG is the weight of governance, and WT is the total weight. These values are presented in Table 2. Note that for the Consumer goods example WE = 10, WS = 21, WG = 20, and WT = 51.

Table 2 - Weight for ESG aspects by industry
Source: Own elaboration

Industry	Environment (WE)	Social (WS)	Governance (WG)	Total (WT)
Consumer Goods	10	21	20	51
Extrative & Mineral Proccessing	42	22	30	94
Financials	6	20	25	51
Food & Beverage	26	31	26	83
Health Care	10	35	20	65
Insfrastructure	19	20	27	66
Renewable Resources & Alternative Energy	18	13	22	53
Resource Transformation	21	17	23	61
Services	11	25	14	50
Technology & Communications	15	24	24	63
Transportation	21	23	26	70

Therefore, this work develops a formula for each sector in the SASB materiality and a general formula creating a variable for the weights as shown in Table A4 in Appendix. Moreover, the indices used on the formulas on step 1 refers to SASB disclosure topics as specified in the 'list of symbols' and on Table A2 in Appendix.

3.3 Step Three: Supply Chain ESG Score

Step 3 is the Supply Chain ESG Evaluation process and figure 13 shows the parts and activities to be done in this step.

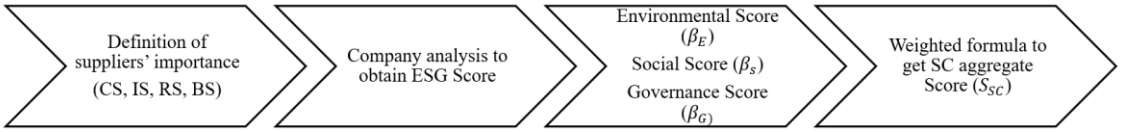

Figure 13 - Workflow SC Evaluation
Source: Own elaboration

The Anchor Company evaluation steps are the procedure to get the AC ESG score (S_{AC}), and it is necessary to repeat the process with all suppliers of the SC to receive the SC score (S_{SC}).

a. Definition of suppliers' importance

Suppliers have different level of importance on the chain, so it is necessary to weight them based on relevance to the Anchor company. They are going to be divided into four categories: (i) critical, (ii) important, (iii) relevant, (iv) basic. In this work, the categories are going to be defined by contract size ($), but the criterion can be decided by the AC. The higher the importance the higher the weight.

1. Critical (CS) – 0-14% biggest contracts → 40% weight
2. Important (IS) – 15-39% biggest contracts → 30% weight
3. Relevant (RS) – 40-69% biggest contracts → 20% weight
4. Basic (BS) – 70-100% biggest contracts → 10% weight

b. Company analysis to obtain ESG Score + Weighted formula to get SC aggregate Score

Therefore, after having followed the same process of getting the score of a company as stated on step 2 for each individual supplier, we should get the average score of each group, the formula to calculate the entire SC score is given by the formula:

$$S_{SC} = (0.4CS + 0.3IS + 0.2RS + 0.1BS) \quad (5)$$

3.4 Step Four: Impact Coefficient

Step 4 focusses on defining impact coefficient of the supply chain in the company for Environment, Social, and Governance aspects (P_E, P_S, P_G) and the steps for each of them is specified on figure 14.

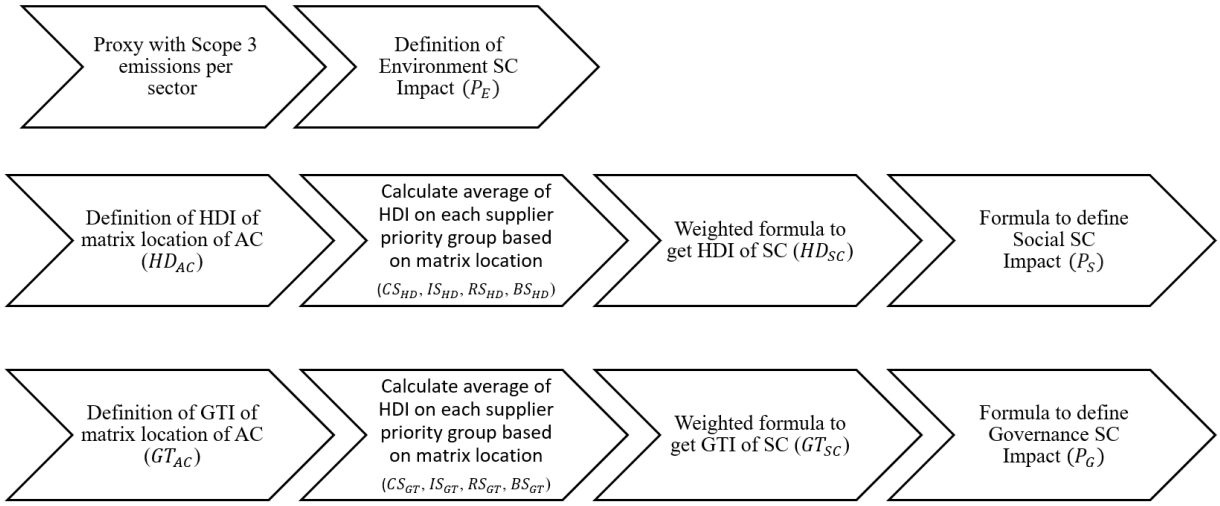

Figure 14 - Workflow Impact coefficient of SC
Source: Own elaboration

With the company score (S_{AC}) and the SC score (S_{SC}), it is now possible to calculate the consolidate company score (S_{ESG}). However, prior to do that, an impact coefficient of the supply chain in the company (P) must be defined. Environmental, social and governance have different impacts, so it is necessary three different 'P's, one for each of them. The Environmental SC impact (P_E) is going to be a proxy using the scope emissions (figure 3), percentage of emissions in the scope 3 are going to be replicated to all environmental aspects.

$$P_E = \%\ \text{Scope 3 emissions on the AC sector} \quad (6)$$

According to Zhang and Wu (2022), Human Development Index (HDI) is the widely adopted indicator for measuring sustainable development in socio-economy, emphasizing the improvement of human welfare. Therefore, the Social SC impact (P_S) is going to be calculated based on the HDI on Table 3 and can be calculated based on the following formula:

$$P_S = \frac{HD_{SC}}{(HD_{SC}+HD_{AC})} \quad (7)$$

where HD_{SC} is the HDI and the of the SC based on the location of the matrix/headquarter of the supplier, and HD_{AC} is the HDI of the Anchor Company based on the location of the matrix.

A study by Liu et al. (2022) used hierarchical linear models to show that strong Governance Transparency has a positive impact on a firm's value. Hence, the Governance SC impact (P_G) is going to be calculated based on the Governance Transparency Index (GTI) which would be calculated based on the following formula:

$$P_G = \frac{GT_{SC}}{(GT_{SC}+GT_{AC})} \quad (8)$$

where GT_{SC} is the GTI of the SC based on the location of the matrix of the supplier, and GT_{AC} is the GTI of the Anchor Company based on the location of the matrix.

Moreover, since the SC have multiple suppliers, it is necessary to make an average of the HDI or the GTI on each group and then use the same weights for them to get the HD_{SC} or the GT_{SC}:

$$HD_{SC} = (0.4CS_{HD} + 0.3IS_{HD} + 0.2RS_{HD} + 0.1BS_{HD}) \quad (9)$$

$$GT_{SC} = (0.4CS_{GT} + 0.3IS_{GT} + 0.2RS_{GT} + 0.1BS_{GT}) \quad (10)$$

where $CS_{HD}, IS_{HD}, RS_{HD}, and\ BS_{HD}$ are the average of HDI of all suppliers matrixes in the respective group, and $CS_{GT}, IS_{GT}, RS_{GT}, and\ BS_{GT}$ are the average of GTI of all suppliers matrixes in the respective group.

Table 3 - HDI and GTI by Brazilian states

State	Code	HDI	GTI
Acre	AC	0.663	6.53
Alagoas	AL	0.631	9.75
Amazonas	AM	0.674	8.67
Amapá	AP	0.708	9.83
Bahia	BA	0.660	8.60
Ceará	CE	0.682	10.00
Distrito Federal	DF	0.824	9.74
Espírito Santo	ES	0.740	10.00
Goiás	GO	0.735	8.85
Maranhão	MA	0.639	8.96
Minas Gerais	MG	0.731	10.00
Mato Grosso do Sul	MS	0.729	9.93
Mato Grosso	MT	0.725	9.74
Pará	PA	0.646	5.92
Paraíba	PB	0.658	9.83
Pernambuco	PE	0.673	9.60
Piauí	PI	0.646	7.18
Paraná	PR	0.749	9.96
Rio de Janeiro	RJ	0.761	7.80
Rio Grande do Norte	RN	0.684	9.10
Rondônia	RO	0.690	9.60
Roraima	RR	0.707	4.91
Rio Grande do Sul	RS	0.746	9.72
Santa Catarina	SC	0.774	9.21
Sergipe	SE	0.665	8.74
São Paulo	SP	0.783	9.60
Tocantins	TO	0.699	6.96

Source: adapted from IBGE 2010 and MBT 2020

3.5 Step Five: Consolidated ESG Score

Step 5 is the final step, and it shows how to apply formula to get consolidate company score (S_{ESG}). The impact of the SC score is calculated based on the corporation's score and the impact coefficient. The formula to calculate the final consolidated ESG score is given by:

$$S_{ESG} = \frac{[(1-P_E)\alpha_E+P_E\beta_E]\,WE+[(1-P_S)\,\alpha_S+P_S\,\beta_S]\,WS+[(1-P_G)\,\alpha_E+P_G\,\beta_G]\,WG}{WT} \quad (11)$$

where the following terms are defined:

P_E = Percentage of environmental impact of the SC in the company

α_E = Environment company score

β_E = Environment SC score

P_S = Percentage of social impact of the SC in the company

α_S = Social company score

β_S = Social SC score

P_G = Percentage of governance impact of the SC in the company

α_G = Governance company score

β_G = Governance company score

To apply the quantitative model, a scenario analysis will be made with the objective of testing using tangible scenarios is to proof the validity, quality, and applicability of the model using different possibilities and to illustrate the methodology with examples. By the end of the analysis, companies are going to have an ESG score reflecting their footprint and they will be able to fully understand, in a quantitative way, the real impact the SC has in their operations. The case scenarios that are going to consider real companies in different sectors assessing a sample of their suppliers, but their names will be not shown.

4 RESULTS AND SCENARIO ANALYSIS

The objective of this analysis is to identify the applicability and adaptability of the model by addressing AC and SC with different maturity levels of ESG, different sectorial activities, and combining them among all possible combinations. The expected outcome from this is to be able to develop a significant ESG evaluation methodology based on industry materiality to guide non-governmental organizations (NGO), every type of company, enterprise, and industry, and whom else it may concern to assess ESG. Moreover, it would be extended to the entire SC, since it is responsible for a relevant part of the ESG footprint.

To stress, test and stimulate the procedure, the scenario analysis will use different situations considering some real case examples with theoretical scores. Companies' data comes from a project that is being created for two anchor companies to assess and evaluate their suppliers with ESG criteria with a service provider in the climate-tech sector. Since the data is confidential the real names would be hidden, contract values will be divided by X, and only the industry (sector) will be shown. In addition, only a small sample of 10 suppliers for each SC were chosen to be part of the scenario analysis for convenience, and the scores for each topic are symbolical not being collected from the companies mentioned above.

The two selected AC, and both their SC will be assessed with a sample of 10 suppliers each. Table 4 is the SC of the first AC, which is an infrastructure company from São Paulo, and a sample of 10 supplier with industry, location, and contract size. Table 5 shows the SC of the second AC, which is a financial company from Rio de Janeiro, and a sample of 10 suppliers with industry, location, and contract size. All suppliers are from tier 1, being direct suppliers.

Table 4 - SC AC 1

AC 1 – Infrastructure (São Paulo)			
Company	**SASB Related Industry**	**Location (Matrix)**	**Contract Size (R$ Million)**
Supplier A	Services	São Paulo	360,00
Supplier B	Resource Transformation	Minas Gerais	295,00
Supplier C	Infrastructure	Paraná	288,00
Supplier D	Services	Bahia	231,00
Supplier E	Technology & Communications	Goiás	194,00
Supplier F	Extrative & Mineral Processing	Espirito Santo	156,00
Supplier J	Transportation	Rio Grande do Sul	132,00
Supplier K	Extrative & Mineral Processing	Santa Catarina	103,00
Supplier L	Renewable Resources & Alternative Energy	Mato Grosso	91,00
Supplier M	Consumer Goods	Piauí	52,00

Source: Own elaboration

Table 5 - SC AC 2

AC 2 – Financials (Rio de Janeiro)			
Company	**SASB Related Industry**	**Location (Matrix)**	**Contract Size (R$ Million)**
Supplier N	Services	São Paulo	1.080,00
Supplier O	Technology & Communications	Piauí	932,00
Supplier P	Technology & Communications	Mato Grosso	877,00
Supplier Q	Financials	Bahia	811,00
Supplier R	Technology & Communications	Minas Gerais	790,00
Supplier S	Infrastructure	Rio de Janeiro	767,00
Supplier T	Consumer Goods	São Paulo	412,00
Supplier U	Financials	Distrito Federal	390,00
Supplier V	Resource Transformation	Rio Grande do Sul	212,00
Supplier W	Transportation	Espirito Santo	180,00

Source: Own elaboration

To complete the assessment and to check if this model is applicable in different scenarios, the analysis will be done again but changing the owner of the SC. As illustrate in Figure 15, the first scenario will be to analyze AC 1 with SC 1 and AC 2 with SC 2, and the second scenario will analyze AC 1 with SC 2 and AC 2 with SC 1. The chosen colors are just illustrative with the objective to facilitate visually the understanding of the proposal. Moreover, even though the AC are the same in both scenarios, the objective of switching the SC sample is to test the interaction and the different impacts from different ESG maturity levels in the same company.

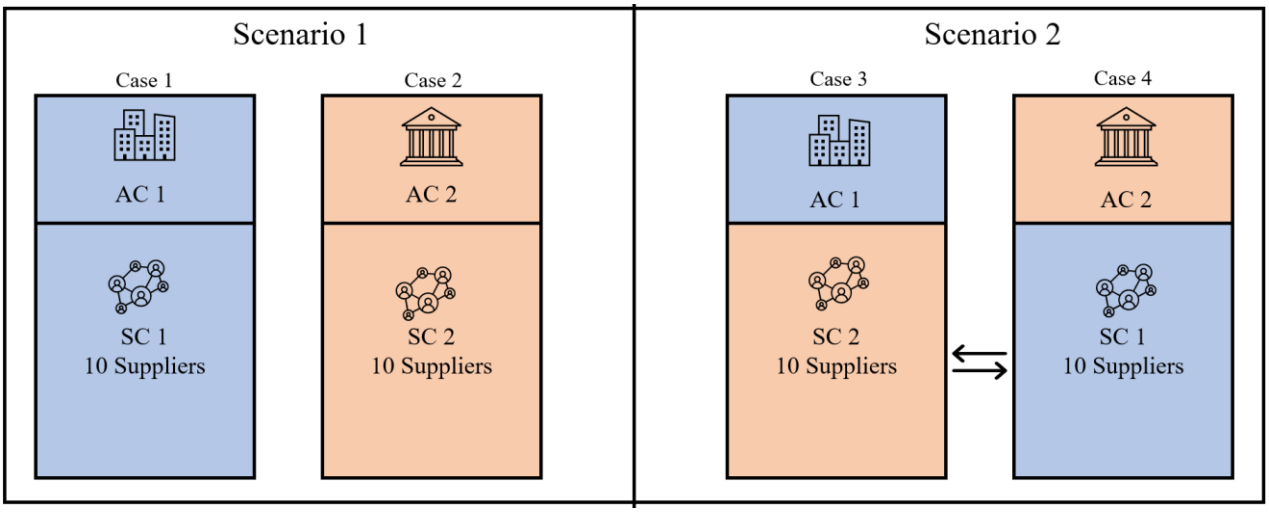

Figure 15 - Scenario analysis
Source: Own elaboration

4.1 Anchor and Supply Chain Scores

Initially, the definition of weights and evaluation of both AC and SC (steps 1, 2 and 3) are to evaluate and get the scores for each of them. Since it is going to be constant on each case and there is no need to repeat the same process more than one time. Afterward, results are used to calculate the supply chain coefficient of impact and the final score for each case and scenario individually.

4.1.1. Anchor 1 – Infrastructure Sector

To define the weights of each of the 26 disclosure topics of the infrastructure sector it is necessary to look at table A4 in appendix and find the sector there. Table 6 is the highlighted part of table A4 in appendix referring to the infrastructure sector, which will be the base of the formula to calculate the ESG score of the company, and the score that AC 1 got on each aspect on a ratio between 0-10 on this case scenario. The scores are dummy numbers to simulate a real-life scenario.

Table 6 - Infrastructure disclosure topics weights

			Infrastructure	AC 1 Score
Environment	**Enviroment**	**GE**	3	9
		AQ	3	10
		EM	3	10
		WW	4	10
		WH	3	9
		EI	3	10
Social	**Social Capital**	**HR**	1	1
		CP	1	9
		DS	1	8
		AA	4	10
		PQ	3	10
		CW	1	9
		SP	1	8
	Human Capital	**LP**	2	9
		EH	5	10
		EE	1	8
Governance	**Business Model & Innovation**	**PD**	5	10
		BM	6	10
		SM	1	7
		MS	2	9
		PI	3	10
	Leadership & Governance	**BE**	3	10
		CB	1	1
		ML	1	8
		CI	3	10
		SR	2	10
TOTAL			66	

Source: Own elaboration

After evaluating each disclosure topic and having a numerical score, the AC will apply the weighted formula based on table 6 to get the score for each aspect – environmental, social, and governance:

- Environmental Score for AC 1 (α_E) based on equation 1:

$$\alpha_{E1} = \frac{(3GE+3AQ+3EM+4WW+3WH+3EI)}{19} \quad (12)$$

$$\alpha_{E1} = 9.7$$

- Social Score for AC 1 (α_S) based on equation 2:

$$\alpha_{S1} = \frac{(\mathrm{HR+CP+DS+4AA+3PQ+CW+SP+2LP+5EH+EE})}{20} \quad (13)$$

$$\alpha_{S1} = 9.1$$

- Governance Score for AC 1 (α_G) based on equation 3:

$$\alpha_{G1} = \frac{(\mathrm{5PD+6BM+SM+2MS+3PI+3BE+CB+ML+3CI+2SR})}{27} \quad (14)$$

$$\alpha_{G1} = 9.4$$

Thus, note that the AC 1 received the lowest score (1) on topics HR and CB, and it does not have a big impact on the final ESG score because they have low weight. On a different scenario if the weak points are on EH and BM the ESG score would been impact significantly more. In the AC 1 case, if we switch the score of HR for EH and CB for BM, the α_{E1}= 9.7, α_{S1}= 7.3 and α_{G1}= 7.7. Which proves the point of the model that gives more importance for material aspects.

To calculate the ESG score of the AC it is necessary to apply the formula based on the weights for each of the calculated scores. Table 7 shows the weights of environmental, social and governance to be applied on the formula; it is based on table 2 cutting just the infrastructure industry.

Table 7 - Infrastructure weights per area

Industry	Environmental (WE)	Social (WS)	Governance (WG)	Total (WT)
Infrastructure	19	20	27	66

Source: Own elaboration

The result of the ESG score of the AC 1 is calculate based on equation 4:

$$S_{AC1} = \frac{(\mathrm{WE}\ \alpha_E + \mathrm{WS}\ \alpha_s + \mathrm{WG}\ \alpha_G)}{WT} = 9.4$$

Furthermore, it is necessary to calculate the HDI and the GTI of the company based on the location of the matrix. Since the AC 1 matrix is in São Paulo, based on table 3 we get:

$$HD_{AC1} = 0.783$$

$$GT_{AC1} = 9.60$$

4.1.2. Supply Chain 1

This work is going to consider the contract size as a parameter of suppliers' importance and use it to separate them in different groups (CS, IS, RS, BS). Table 8 separated the SC in 4 priority groups following the criteria suggested on the methodology. Plus, Table 8 also brings the HDI and GTI based on the location of the matrix considering table 3 values.

Table 8 - Supply Chain 1 HDI, GTI, and importance

Supply Chain 1					
Company	**Location (Matrix)**	**HDI**	**GTI**	**Priority Group**	**Contract Size (R$ Million)**
Supplier A	São Paulo	0.783	9.60	CS	360
Supplier B	Minas Gerais	0.731	10.00	CS	295
Supplier C	Paraná	0.749	9.96	IS	288
Supplier D	Bahia	0.660	8.60	IS	231
Supplier E	Goiás	0.735	8.85	RS	194
Supplier F	Espírito Santo	0.740	10.00	RS	156
Supplier J	Rio Grande do Sul	0.746	9.72	RS	132
Supplier K	Santa Catarina	0.774	9.21	BS	103
Supplier L	Mato Grosso	0.725	9.74	BS	91
Supplier M	Piauí	0.646	7.18	BS	52

Source: Own elaboration

Moreover, each individual supplier would be evaluated to obtain the ESG score of their operations using the same methodology applied to the AC. By the end of that, each company will have an individual score for Environmental, Social, Governance, and a consolidated one. Table 9 shows the score for each supplier on each area and the consolidated score on this case scenario. The scores are dummy numbers to simulate a real life scenario.

Table 9 - Supply Chain 1 – ESG Scores

Supply Chain 1 - Scores				
Company	**Environmental**	**Social**	**Governance**	**Consolidated**
Supplier A	3	2	3	2.5
Supplier B	4	1	3	2.8
Supplier C	3	2	4	3.1
Supplier D	2	3	2	2.5
Supplier E	2	3	4	3.1
Supplier F	1	3	3	2.1
Supplier J	3	4	1	2.6
Supplier K	8	9	10	8.9
Supplier L	10	7	10	9.3
Supplier M	9	10	8	9.0

Source: Own elaboration

Considering the weights for each priority group stablished on the methodology, it is possible to calculate the final score of each aspect, based on equation 5

$$\beta_{E1} = (0.4CS + 0.3IS + 0.2RS + 0.1BS) \quad (15)$$

$$\beta_{E1} = 3.5$$

$$\beta_{S1} = (0.4CS + 0.3IS + 0.2RS + 0.1BS) \quad (16)$$

$$\beta_{S1} = 2.9$$

$$\beta_{G1} = (0.4CS + 0.3IS + 0.2RS + 0.1BS) \quad (17)$$

$$\beta_{G1} = 3.6$$

$$S_{SC1} = (0.4CS + 0.3IS + 0.2RS + 0.1BS) = 3.3$$

Besides, even though suppliers K, L, and M have great ESG scores, they do not have a big impact on the scores of the SC because they are on the lowest priority group (BS). However, if we invert the order of the contracts (the last on would become the first and

so on), the scores would be: β_{E1} = 6.1, β_{E1}= 6.1, β_{E1}= 6.2, and S_{SC1}= 6.2. Which proves the point that the high priorities group have a significant impact on the score.

Furthermore, to calculate the HDI and the GTI of this SC, it is necessary to apply the formulas on the values presented on table 9. By doing that we get based on equation 9 and 10:

$$HD_{SC1} = (0.4CS_{HD} + 0.3IS_{HD} + 0.2RS_{HD} + 0.1BS_{HD}) = 0.734$$

$$GT_{SC1} = (0.4CS_{GT} + 0.3IS_{GT} + 0.2RS_{GT} + 0.1BS_{GT}) = 9.48$$

4.1.3. Anchor 2 – Financial Sector

The flow is going to be the same as the Anchor 1 but considering the specificities of this sector and their weights. Table 10 is the highlighted part of table A4 in appendix referring to the financial sector, which will be the base of the formula to calculate the ESG score of the company, and the score that AC 2 got on each aspect on a ratio between 0-10 on this case scenario. The scores are dummy numbers to simulate a real-life scenario.

Table 10 - Financial disclosure topics weights

			Financials	AC 2 Score
Environment	**Enviroment**	**GE**	1	2
		AQ	1	3
		EM	1	2
		WW	1	9
		WH	1	3
		EI	1	2
Social	**Social Capital**	**HR**	1	6
		CP	2	2
		DS	3	1
		AA	2	7
		PQ	1	2
		CW	1	2
		SP	5	3
	Human Capital	**LP**	1	1
		EH	1	2
		EE	3	2
Governance	**Business Model & Innovation**	**PD**	6	3
		BM	1	2
		SM	1	2
		MS	1	3
		PI	3	2
	Leadership & Governance	**BE**	5	3
		CB	1	10
		ML	1	1
		CI	1	2
		SR	5	1
TOTAL			51	

Source: Own elaboration

After evaluating each disclosure topic and having a numerical score, the AC will apply the weighted formula based on table 10 to get the score for each aspect – environmental, social, and governance, based on equation 1, 2, and 3 adapted for the sector:

- Environmental Score for AC 2 (α_E) based on equation 1:

$$\alpha_{E2} = \frac{(\mathrm{GE+AQ+EM+WW+WH+EI})}{6} = 3.5$$

- Social Score for AC 2 (α_S) based on equation 2:

$$\alpha_{S2} = \frac{(HR+2CP+3DS+2AA+PQ+CW+5SP+LP+EH+3EE)}{20} = 2.8$$

- Governance Score for AC 2 (α_G) based on equation 3:

$$\alpha_{G2} = \frac{(6PD+BM+SM+MS+3PI+5BE+CB+ML+CI+5SR)}{25} = 2.6$$

Thus, note that the AC 2 received a high score on WW (9), CB (10), AA (7), and HR (6) and, since these are aspects have a low weight, the score were not impacted by much. So, if the high score were on PD, BE, SP, and SR, the score would be very affected to a higher score. By switching the scores of CB for PD, WW for BE, AA for SP, and HR for SR, the scores would be α_{E2} = 2.5, α_{S2} = 3.1, and α_{G2} = 6.2, which would be a dramatic increase in the final ESG score again proving that the material topics are worth more and can really have an impact on the score.

In the AC 1 case, if we switch the score of HR for EH and CB for BM, the α_{S1}= 7,3 and α_{G1}= 77. Which proves the point of the model that gives more importance for material aspects.

The lowest score (1) on topics HR and CB, and it does not have a big impact on the final ESG score because they have low weight. On a different scenario if the weak points were on EH and BM the ESG score would been impact significantly more.

To calculate the ESG score of the AC it is necessary to apply the formula based on the weights for each of the calculated scores. Table 11 shows the weights of environmental, social and governance to be applied on the formula; it is based on table 2 cutting just the infrastructure industry.

Table 11 - Financial weights per area

Industry	Environmental (WE)	Social (WS)	Governance (WG)	Total (WT)
Financials	6	20	25	51

Source: Own elaboration

The result of the ESG score of the AC 1 is based on equation 4:

$$S_{AC2} = \frac{(\text{WE}\ \alpha_E + \text{WS}\ \alpha_s + \text{WG}\ \alpha_G)}{WT} = 2.7$$

Furthermore, it is necessary to calculate the HDI and the GTI of the company based on the location of the matrix. Since the AC 1 matrix is in Rio de Janeiro, based on table 3 we get:

$$HD_{AC2} = 0.761$$

$$GT_{AC2} = 7.80$$

4.1.4. Supply Chain 2

The process and steps are going to be the same as the 'Supply Chain 1'. So, first the priority groups (CS, IS, RS, BS) were defined and Table 12 shows a list of suppliers and their priority groups following the criteria suggested on the methodology. Plus, Table 12 also presents the HDI and GTI based on the location of the matrix considering table 3 values.

Table 12 - Supply Chain 2 HDI, GTI, and importance

Supply Chain 2					
Company	**Location (Matrix)**	**HDI**	**GTI**	**Priority Group**	**Contract Size (R$ Million)**
Supplier N	São Paulo	0.783	9.60	CS	1.080
Supplier O	Piauí	0.646	7.18	CS	932
Supplier P	Mato Grosso	0.725	9.74	IS	877
Supplier Q	Bahia	0.660	8.60	IS	811
Supplier R	Minas Gerais	0.731	10.00	RS	790
Supplier S	Rio de Janeiro	0.761	7.80	RS	767
Supplier T	São Paulo	0.783	9.60	RS	412
Supplier U	Distrito Federal	0.824	9.74	BS	390
Supplier V	Rio Grande do Sul	0.746	9.72	BS	212
Supplier W	Espírito Santo	0.740	10.00	BS	180

Source: Own elaboration

Moreover, using the same methodology applied to the AC, suppliers get their individual ESG evaluation. Table 13 shows the score for each supplier on each area and the consolidated score on this case scenario. The scores are dummy numbers to simulate a real-life scenario.

Table 13 - Supply Chain 2 – ESG Scores

Supply Chain 2 - Scores				
Company	**Environmental**	**Social**	**Governance**	**Consolidated**
Supplier N	8	9	10	9.1
Supplier O	10	9	8	8.9
Supplier P	8	9	9	8.8
Supplier Q	9	8	10	9.1
Supplier R	9	8	8	8.2
Supplier S	10	9	9	9.3
Supplier T	8	10	8	8.8
Supplier U	1	2	3	2.4
Supplier V	4	2	4	3.4
Supplier W	2	1	1	1.3

Source: Own elaboration

Considering the weights for each priority group stablished on the methodology, it is possible to calculate the final score of each aspect based on equation 5

$$\beta_{E2} = (0.4CS + 0.3IS + 0.2RS + 0.1BS) = 8.2$$

$$\beta_{S2} = (0.4CS + 0.3IS + 0.2RS + 0.1BS) = 8.1$$

$$\beta_{G2} = (0.4CS + 0.3IS + 0.2RS + 0.1BS) = 8.4$$

$$S_{SC2} = (0.4CS + 0.3IS + 0.2RS + 0.1BS) = 8.3$$

Besides, even though suppliers U, V, and W have low ESG scores, they do not have a big impact on the scores of the SC because they are on the lowest priority group (BS).

However, if we invert the order of the contracts (the last on would become the first and so on), the scores would be: β_{E1} = 5.3, β_{E1}= 5.0, β_{E1}= 5.4, and S_{SC1}= 5.3. Which proves the point that the high priorities group have a significant impact on the score.

Furthermore, to calculate the HDI and the GTI of this SC, it is necessary to apply the formulas on the values presented on table 9. By doing that we get based on equation 9 and 10:

$$HD_{SC2} = (0.4CS_{HD} + 0.3IS_{HD} + 0.2RS_{HD} + 0.1BS_{HD}) = 0.722$$

$$GT_{SC2} = (0.4CS_{GT} + 0.3IS_{GT} + 0.2RS_{GT} + 0.1BS_{GT}) = 8.92$$

4.2 Scenario One

4.2.1. Case One

To summarize the data from previous steps and the initial results of the AC 1 ESG evaluation:

$$S_{AC1} = 9.4$$
$$\alpha_{E1} = 9.7$$
$$\alpha_{S1} = 9.1$$
$$\alpha_{G1} = 9.4$$
$$HD_{AC1} = 0.783$$
$$GT_{AC1} = 9.60$$

Moreover, the results of the ESG evaluation process of SC 1:

$$S_{SC1} = 3.3$$
$$\beta_{E1} = 3.5$$
$$\beta_{S1} = 2.9$$
$$\beta_{G1} = 3.6$$
$$HD_{SC1} = 0.734$$
$$GT_{SC1} = 9.48$$

To get the consolidate company score (S_{ESG}) it is required to calculate the impact coefficient of the SC in the AC. It is going to be a different value for each area

(environment, social, and governance). For the environmental, based on figure 4, the infrastructure/construction sector has scope 3 of 81%, which will represent coefficient of impact to the environmental area for the AC 1. Based on equation 6 we get:

$$P_E = \%\ \text{Scope 3 emissions of infrastructure sector} = 0.81$$

Figure 16 illustrates the division in percentage of the consolidated ESG score for the environmental part that represents the AC and the SC.

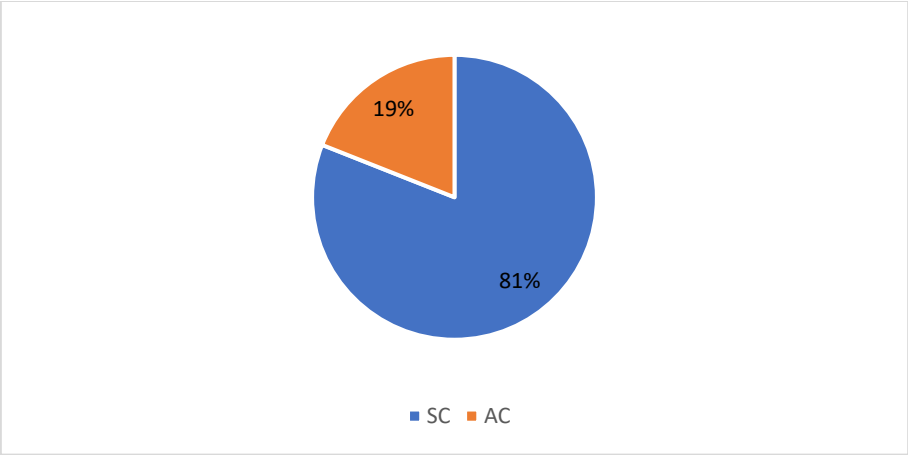

Figure 16 - Environmental SC Coefficient of Impact for Infrastructure (P_E)
Source: Own elaboration

The social coefficient of impact to the environmental area for case 1 is going to be based on the formula below. By using the variables summarized in the beginning of the section based on equation 7 the result is:

$$P_S = \frac{HD_{SC}}{(HD_{SC}+HD_{AC})} = 0.484$$

Figure 17 illustrates the division in percentage of the consolidated ESG score for the social part that represents the AC and the SC.

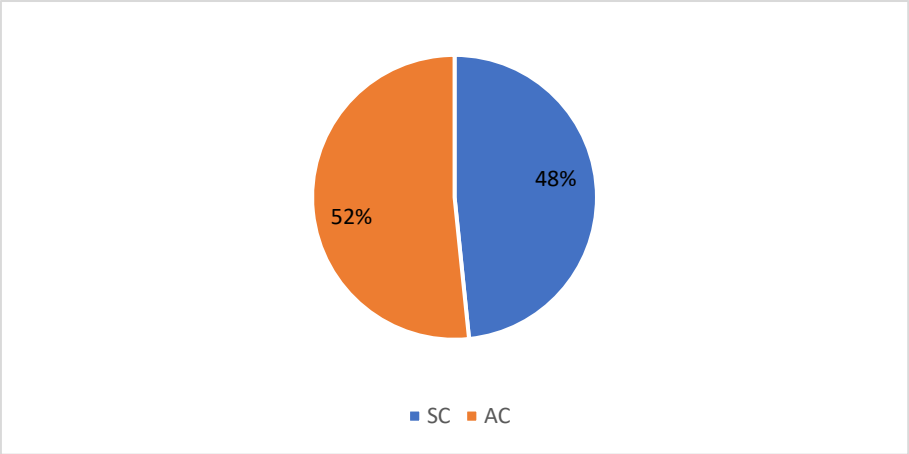

Figure 17 - Social SC Coefficient of Impact for Case 1 (P_S)
Source: Own elaboration

The governance area is going to use the same logic as the social but using a different parameter. The formula below based on equation 8 using the results from the analysis above that is summarized in the beginning of the case:

$$P_G = \frac{GT_{SC}}{(GT_{SC}+GT_{AC})} = 0.497$$

Figure 18 illustrates the division in percentage of the consolidated ESG score for the governance part that represents the AC and the SC.

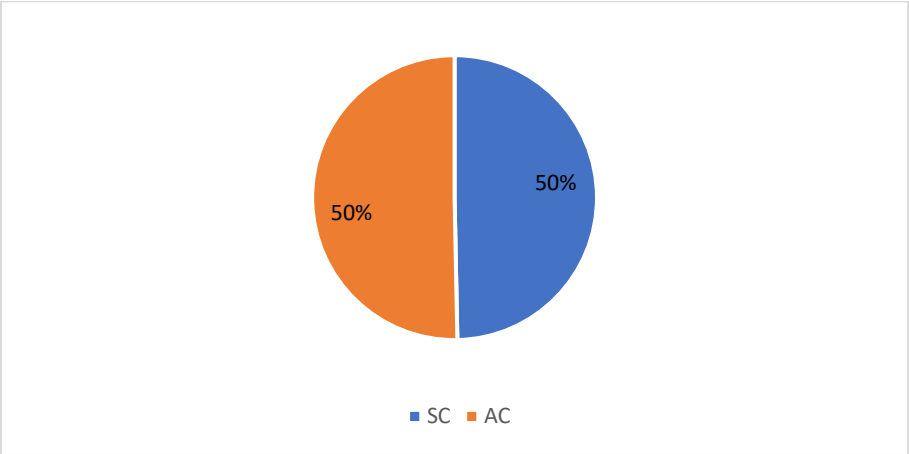

Figure 18 - Governance SC Coefficient of Impact for Case 1 (P_G)
Source: Own elaboration

Finally, to calculate the consolidated ESG score for the relationship between AC 1 and SC 1 and understand the real impact of the SC score in the AC score, the formula must be applied using the specific variables for each case scenarios. Based on equation 11 we get:

$$S_{ESG} = \frac{[(1-P_E)\alpha_E + P_E\beta_E]\,WE + [(1-P_S)\,\alpha_S + P_S\,\beta_S]\,WS + [(1-P_G)\,\alpha_E + P_G\,\beta_G]\,WG}{WT} = 5.9$$

Referring to figure 10 on the methodology section, Figure 19 shows all the results for each step of the process consolidating the output of case 1. First, the weight definition based on the industry of the AC. Next steps are evaluating both the AC and the SC in ESG metrics, and then define the impact coefficient of the SC and finally get the consolidated ESG score.

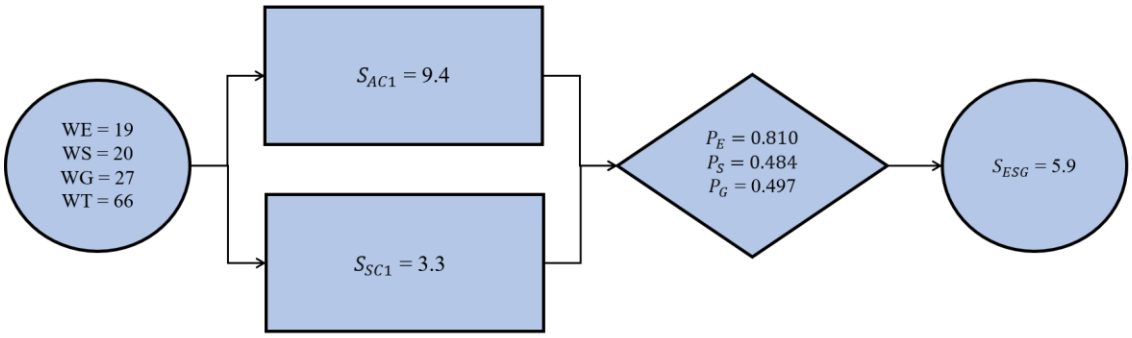

Figure 19 - Workflow results case 1
Source: Own elaboration

In conclusion, if the consolidated ESG score of this case is divided into the percentage it was affected by each party, the result would be on figure 20. The AC score representing 42% of the total score while the SC represents 58%.

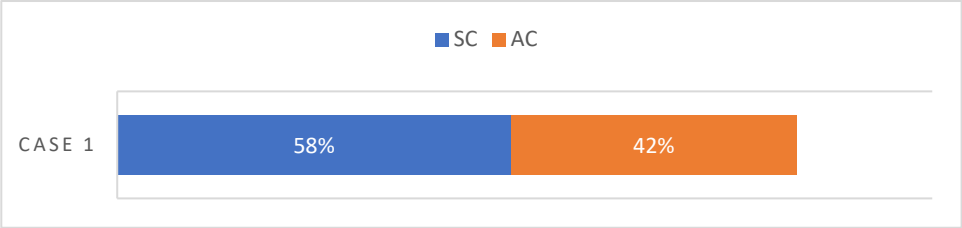

Figure 20 - Consolidated ESG Score distribution case 1
Source: Own elaboration

4.2.2. Case Two

This case scenario will have the same steps as case 1, which is first to summarize the data of the ESG analysis of both the AC and the SC involved. The data from AC 2 ESG analysis is:

$$S_{AC2} = 2.7$$

$$\alpha_{E2} = 3.5$$

$$\alpha_{S2} = 2.8$$

$$\alpha_{G2} = 2.6$$

$$HD_{AC2} = 0.761$$

$$GT_{AC2} = 7.80$$

The result of the SC 2 ESG analysis is:

$$S_{SC2} = 8.3$$

$$\beta_{E2} = 8.2$$

$$\beta_{S2} = 8.1$$

$$\beta_{G2} = 8.4$$

$$HD_{SC2} = 0.722$$

$$GT_{SC2} = 8.92$$

The Environmental impact coefficient of the SC in the AC is going to be based on figure 4, the financial sector has scope 3 of 83%, which according to the formula is the result. Based on equation 6 we get:

$$P_E = \%\ \text{Scope 3 emissions of the financial sector} = 0.83$$

Figure 21 illustrates the division in percentage of the consolidated ESG score for the environmental part that represents the AC and the SC.

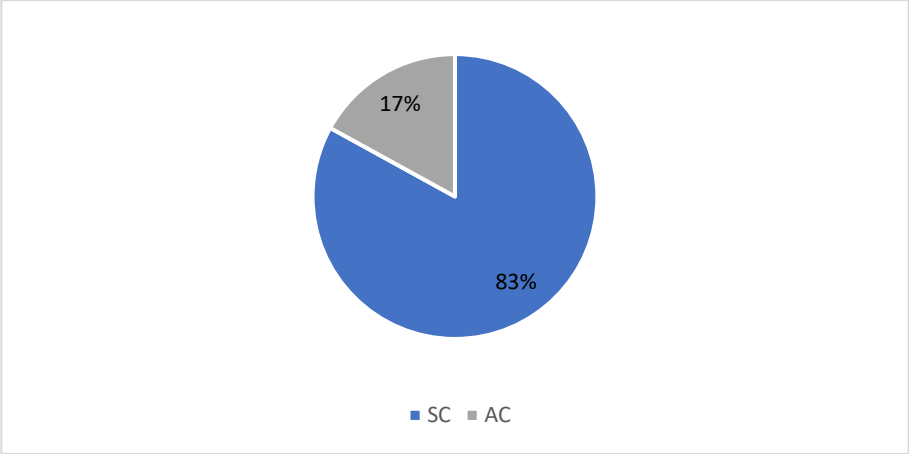

Figure 21 - Environmental SC Coefficient of Impact for Financial (P_E)
Source: Own elaboration

The social coefficient of impact to the environmental area for case 2 is going to be based on the formula below. By using the variables summarized in the beginning of the section based on equation 7 the result is:

$$P_S = \frac{HD_{SC}}{(HD_{SC}+HD_{AC})} = 0.487$$

Figure 22 illustrates the division in percentage of the consolidated ESG score for the social part that represents the AC and the SC.

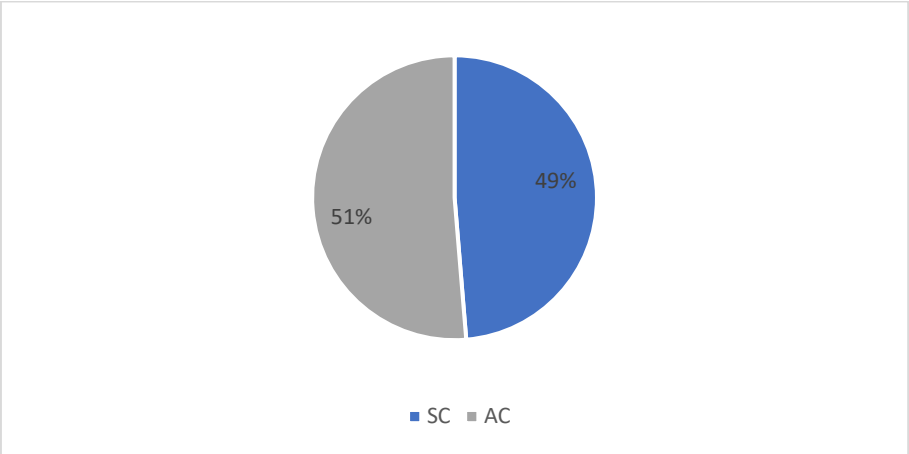

Figure 22 - Social SC Coefficient of Impact for Case 2 (P_S)
Source: Own elaboration

The governance area is going to use the same logic as the social but using a different parameter. The formula below based on equation 8 using the results from the analysis above that is summarized in the beginning of the case:

$$P_G = \frac{GT_{SC}}{(GT_{SC}+GT_{AC})} = 0.533$$

Figure 23 illustrates the division in percentage of the consolidated ESG score for the governance part that represents the AC and the SC.

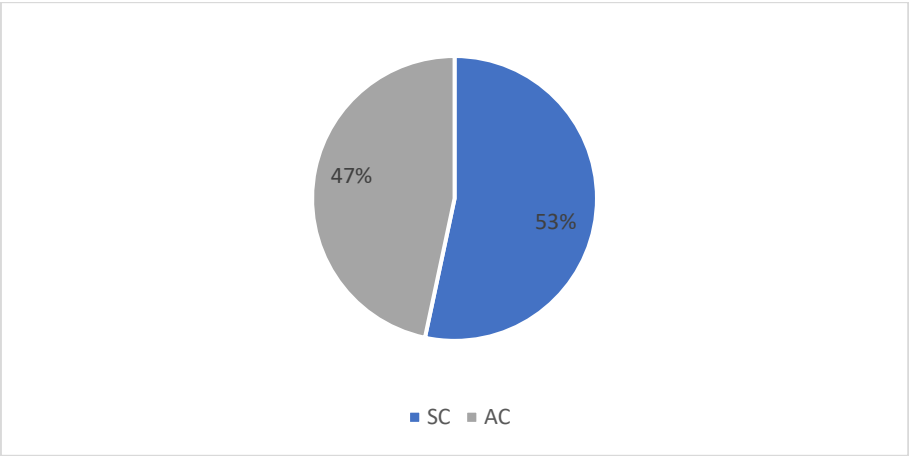

Figure 23 - Governance SC Coefficient of Impact for Case 2 (P_G)
Source: Own elaboration

Finally, to calculate the consolidated ESG score of the relationship between AC 2 and SC 2 and understand the real impact of the SC score in the AC score, the formula is applied based on equation 11, and the result is:

$$S_{ESG} = 5.8$$

Referring to figure 10 on the methodology section, Figure 24 shows all the results for each step of the process consolidating the output of case 1. First, the weight definition based on the industry of the AC. Next steps are evaluating both the AC and the SC in ESG metrics, and then define the impact coefficient of the SC and finally get the consolidated ESG score.

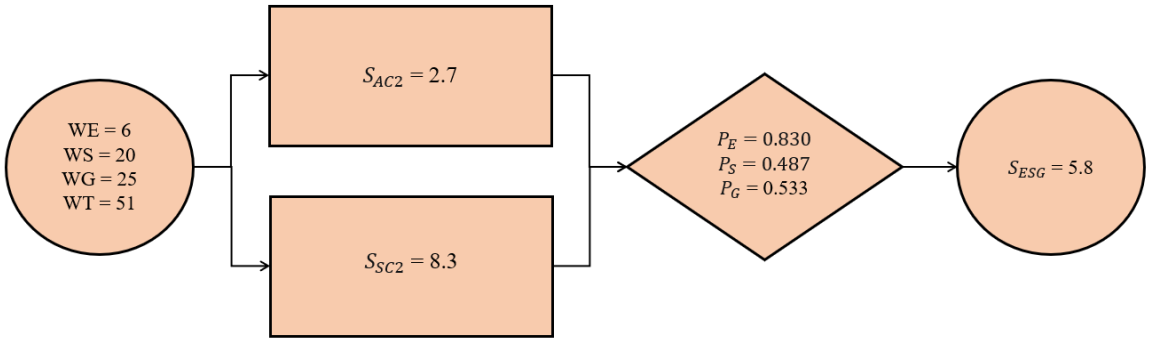

Figure 24 - Workflow results case 2
Source: Own elaboration

In conclusion, if the consolidated ESG score of this case is divided into the percentage it was affected by each party, the result would be on figure 25. The AC score representing 45% of the total score while the SC represents 55%.

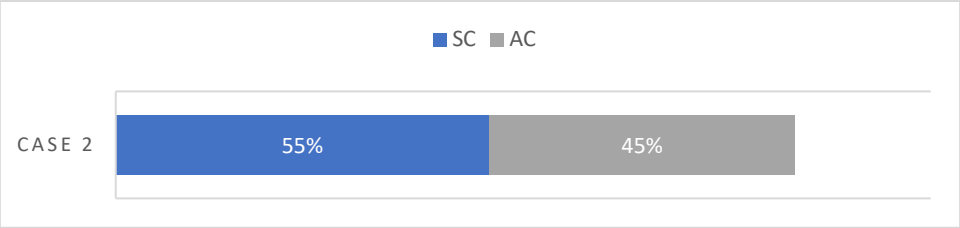

Figure 25 - Consolidated ESG Score distribution case 2
Source: Own elaboration

4.3 Scenario Two

Scenario two is going to have the same parties but testing different combinations. AC 1 now has a relationship with SC 2 (case 3), and AC 2 relates to SC 1 (case 4).

4.3.1. Case Three

ESG evaluation of AC 1:

$$S_{AC1} = 9.4$$

$$\alpha_{E1} = 9.7$$

$$\alpha_{S1} = 9.1$$

$$\alpha_{G1} = 9.4$$

$$HD_{AC1} = 0.783$$

$$GT_{AC1} = 9.60$$

ESG evaluation of SC 2:

$$S_{SC2} = 8.3$$

$$\beta_{E2} = 8.2$$

$$\beta_{S2} = 8.1$$

$$\beta_{G2} = 8.4$$

$$HD_{SC2} = 0.722$$

$$GT_{SC2} = 8.92$$

The environmental impact coefficient of the SC is going to be the same as case 1 since it based on the anchor client industry referring to scope 3 emissions percentage. Based on equation 6 we get:

$$P_E = 0.81$$

Figure 26 illustrates the division in percentage of the consolidated ESG score for the environmental part that represents the AC and the SC.

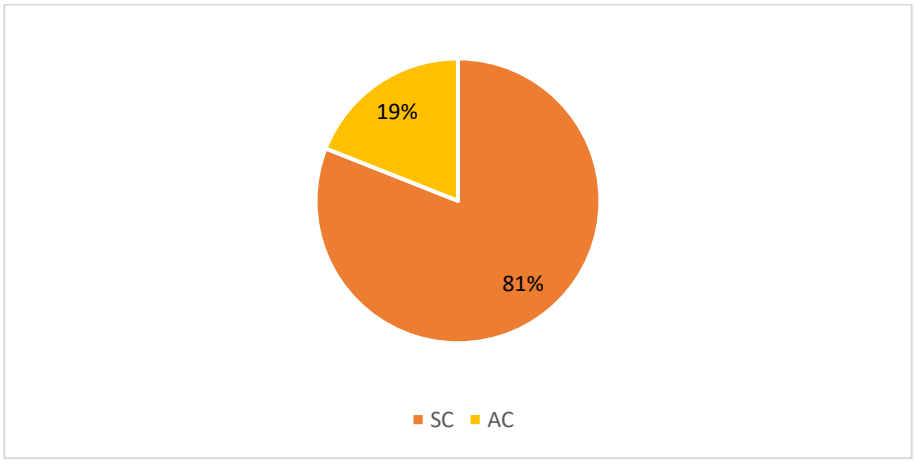

Figure 26 - Environmental SC Coefficient of Impact for Case 3 (P_E)
Source: Own elaboration

The social impact coefficient of the SC is going to be based on the formula based on equation 7 using the HDI of the location of the companies' matrix:

$$P_S = 0.480$$

Figure 27 illustrates the division in percentage of the consolidated ESG score for the social part that represents the AC and the SC.

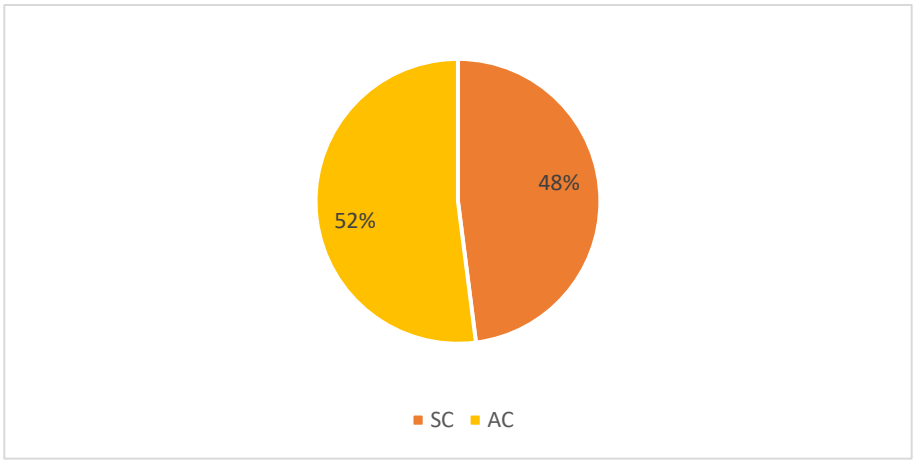

Figure 27 - Social SC Coefficient of Impact for Case 3 (P_S)
Source: Own elaboration

The governance impact coefficient of the SC is going to be based on the formula based on equation 8 using the GTI of the location of the companies' matrix:

$$P_G = 0.482$$

Figure 28 illustrates the division in percentage of the consolidated ESG score for the governance part that represents the AC and the SC.

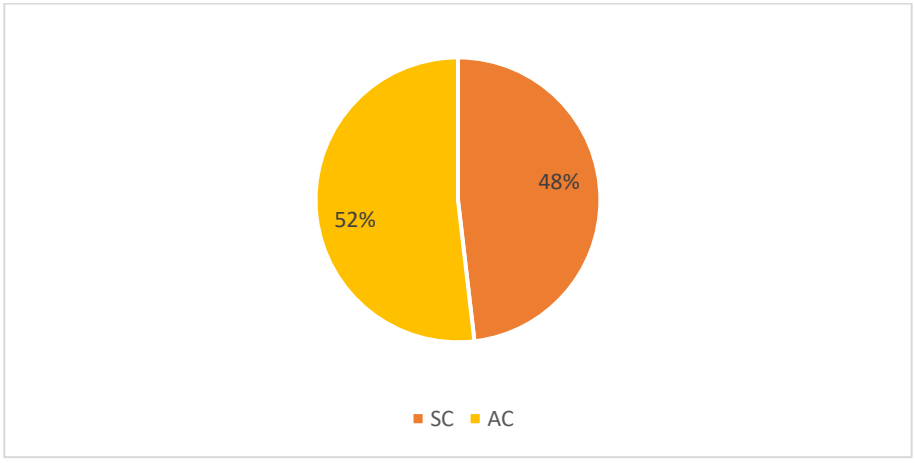

Figure 28 - Governance SC Coefficient of Impact for Case 3 (P_G)
Source: Own elaboration

Finally, the consolidated ESG score of the relationship between AC 1 and SC 2 and understanding of the real impact of the SC score in the AC score, the formula is applied based on equation 11, and the result is:

$$S_{ESG} = 8.7$$

Referring to figure 10 on the methodology section, Figure 29 shows all the results for each step of the process consolidating the output of case 1. First, the weight definition based on the industry of the AC. Next steps are evaluating both the AC and the SC in ESG metrics, and then define the impact coefficient of the SC and finally get the consolidated ESG score.

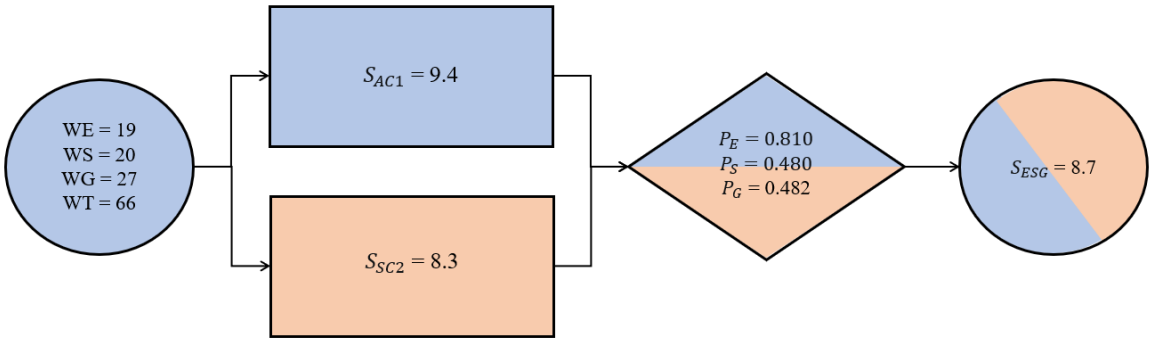

Figure 29 - Workflow results of case 3
Source: Own elaboration

In conclusion, if the consolidated ESG score of this case is divided into the percentage it was affected by each party, the result would be on figure 30. The AC score representing 42% of the total score while the SC represents 58%.

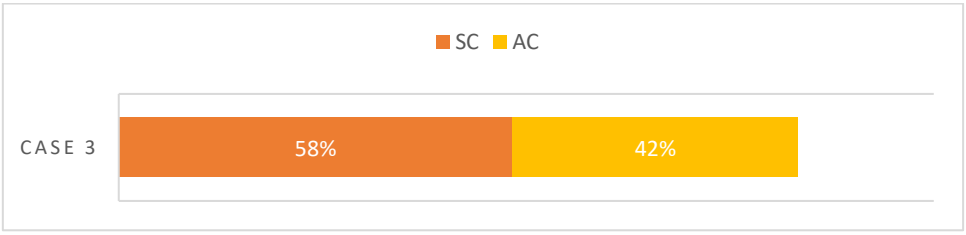

Figure 30 - Consolidated ESG Score distribution case 3
Source: Own elaboration

4.3.2. Case Four

ESG evaluation of AC 2:

$$S_{AC2} = 2.7$$
$$\alpha_{E2} = 3.5$$
$$\alpha_{S2} = 2.8$$
$$\alpha_{G2} = 2.6$$
$$HD_{AC2} = 0.761$$
$$GT_{AC2} = 7.80$$

ESG evaluation of SC 1:

$$S_{SC1} = 3.3$$
$$\beta_{E1} = 3.5$$
$$\beta_{S1} = 2.9$$
$$\beta_{G1} = 3.6$$
$$HD_{SC1} = 0.734$$
$$GT_{SC1} = 9.48$$

The environmental impact coefficient of the SC is going to be the same as case 2 since it based on the anchor client industry referring to scope 3 emissions percentage. Based on equation 6 we get:

$$P_E = 0.83$$

Figure 31 illustrates the division in percentage of the consolidated ESG score for the environmental part that represents the AC and the SC.

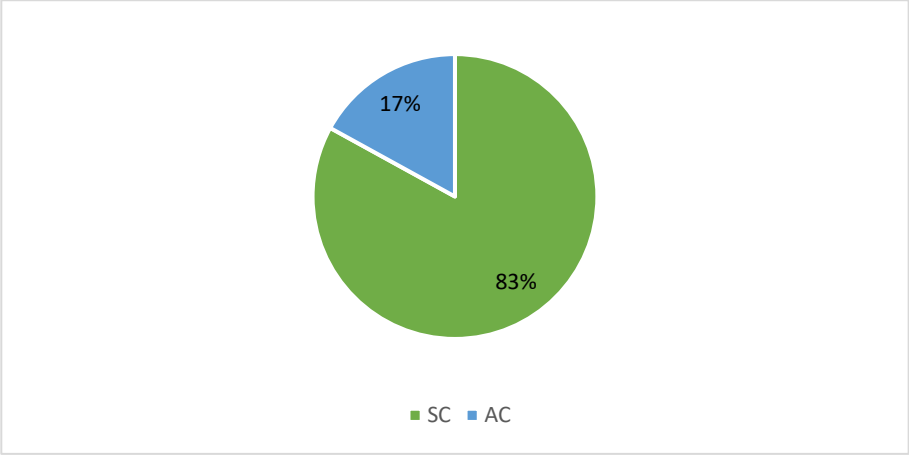

Figure 31 - Environmental SC Coefficient of Impact for Case 4 (P_E)
Source: Own elaboration

The social impact coefficient of the SC is going to be based on the formula based on equation 6 using the HDI of the location of the companies' matrix:

$$P_S = 0.491$$

Figure 32 illustrates the division in percentage of the consolidated ESG score for the social part that represents the AC and the SC.

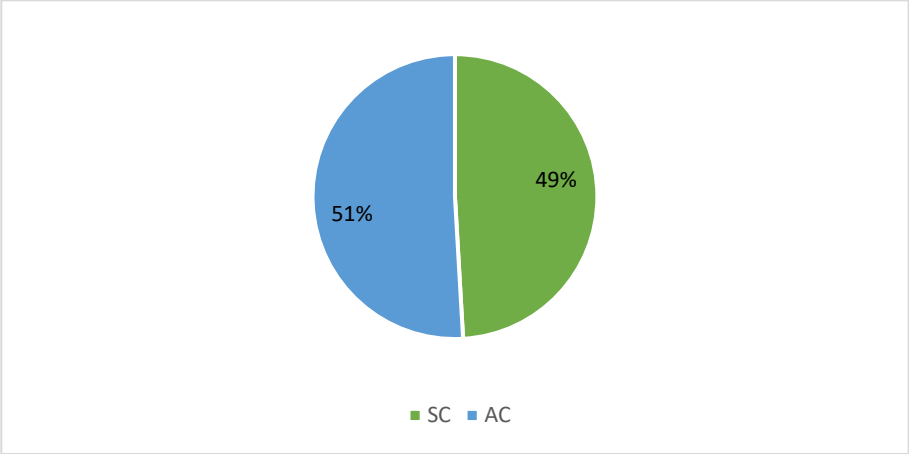

Figure 32 - Social SC Coefficient of Impact for Case 4 (P_S)
Source: Own elaboration

The governance impact coefficient of the SC is going to be based on the formula based on equation 8 using the GTI of the location of the companies' matrix:

$$P_G = 0.549$$

Figure 33 illustrates the division in percentage of the consolidated ESG score for the governance part that represents the AC and the SC.

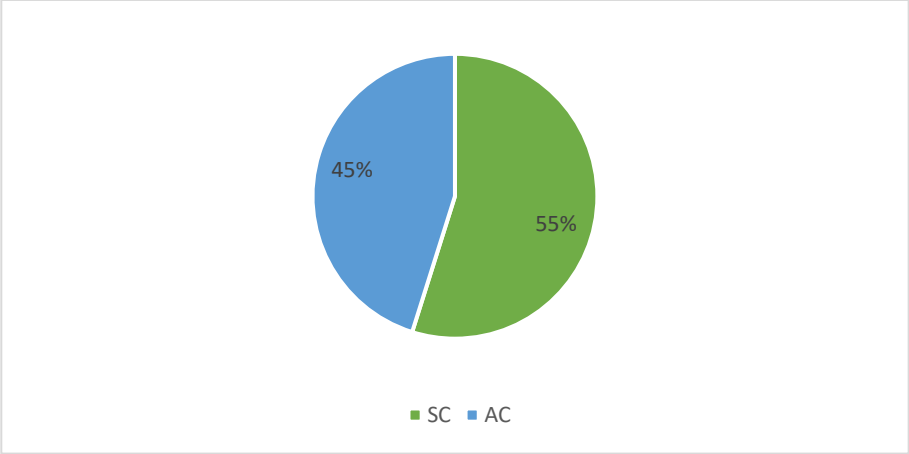

Figure 33 - Governance SC Coefficient of Impact for Case 4 (P_G)
Source: Own elaboration

Finally, the consolidated ESG score of the relationship between AC 2 and SC 1 and understanding of the real impact of the SC score in the AC score, the formula is applied based on equation 11, and the result is:

$$S_{ESG} = 3.1$$

Referring to figure 9 on the methodology section, Figure 34 shows all the results for each step of the process consolidating the output of case 1. First, the weight definition based on the industry of the AC. Next steps are evaluating both the AC and the SC in ESG metrics, and then define the impact coefficient of the SC and finally get the consolidated ESG score.

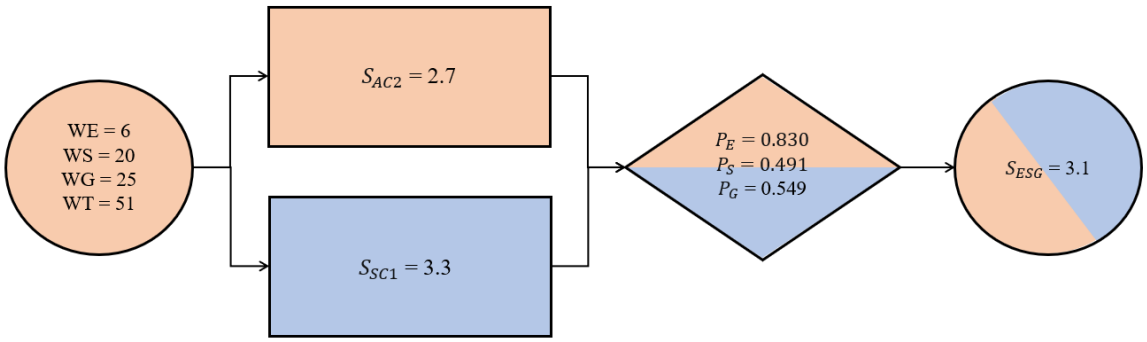

Figure 34 - Workflow results of case 4
Source: Own elaboration

In conclusion, if the consolidated ESG score of this case is divided into the percentage it was affected by each party, the result would be on figure 35. The AC score representing 44% of the total score while the SC represents 56%.

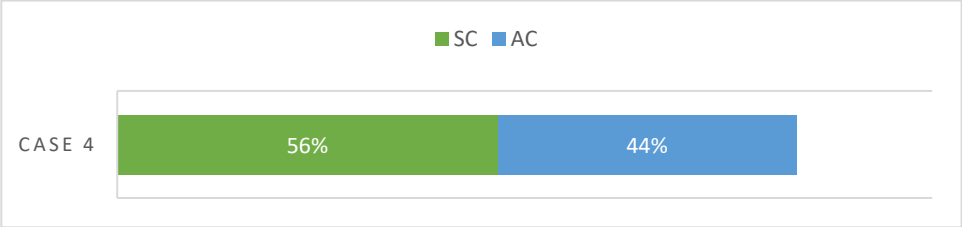

Figure 35 - Consolidated ESG Score distribution case 4
Source: Own elaboration

4.4 Scenarios Comparison

Finally, this section is dedicated summarize all the results and compare the scenarios analyzed. Table 14 shows the score of the AC, the SC, and the consolidated for each case. Both cases one and two ended up getting a consolidated score very similar with some room for improvement. Case one was a combination of AC1 which performed very well in ESG analysis with SC1 which still have a lot to improve, and the consolidated ESG score is on a mid-range. On the other hand, case two was a combination of AC 2 which performed very badly in ESG analysis with SC 2 which has pretty decent job on ESG aspects, and the consolidated ESG score is also on a mid-range. Even though AC 1

has a much better ESG score than AC 2, the score of the supply chains influenced a lot the final score.

Table 14 - Scenarios score comparison

	S_{AC}	S_{SC}	S_{ESG}
Case 1	9.4	3.3	5.9
Case 2	2.7	8.3	5.8
Case 3	9.4	8.3	8.7
Case 4	2.7	3.3	3.1

Source: Own elaboration

In the interest of identifying the real impact of the SC on the AC ESG analysis, the analysis of scenario two used the same parties were used on a different combination. This time case 3 is assumed AC1 had a relationshisp with SC2, since both have good scores, the consolidated score was good. On case 4, AC2 has a relationship with SC1, and both have bad scores, the consolidated was bad. Moreover, it is possible to see that in all cases the consolidated score found a spot inbetween the AC and the SC scores.

Seeking to understand how the SC score affected the consolidated score, Table 15 summarizes all the impact coefficient in environment, social, and governance in each case. Plus, it shows the percentage that the SC score represents on the final/consolidated score. The environment impact coefficient is very high, which means that the consolidated score on this section considers the SC the most. The social impact coefficient represents a little bit less than half, showing that the consolidated score on this section considers the SC quite less than the AC. The governance impact coefficient has similar results as the social, however in some cases it is a little bit more than half. Finally, the percentage that the SC score represents on the final/consolidated score is shown and for case 1 and 3 it is the same (58%), for case 2 it is 55%, and for case 4 it is 56%. That means that on Case 1, if the AC score was 10 and the SC was 0, the consolidate score would be 4.2.

Table 15 - Scenarios impact coefficient comparison

	P_E	P_S	P_G	% SC final
Case 1	0.810	0.484	0.497	58%
Case 2	0.830	0.487	0.533	55%
Case 3	0.810	0.480	0.482	58%
Case 4	0.830	0.491	0.549	56%

Source: Own elaboration

5 CONCLUSIONS

This chapter is going to be divided in three sections, which the main objective is to present the main conclusions, limitations of the research, and future works suggestions. The main conclusions are going to discuss the biggest outcomes from the research considering the objectives, methodology, and results. The section of the limitations of the research is going to show the shortcomings due to time constraints and lack of a consolidated ESG taxonomy & data. Moreover, the future works suggestions are going to present some ideas of how to evolve and contribute with the research based on the limitations and other inputs.

5.1 Main Conclusions

This work proposed a quantitative ESG weighted scoring evaluation model for considering both the SC and the AC operations. A scenario analysis is developed to test the methodology and the score proved to be functional on real-life potential scenarios, being flexible for multiple sectors. The defined weights based on the real sector business and priority groups based on contract size really have an impact on the final scores of the AC and the SC. When calculating the scores on the scenario analysis some variations were tested and the score proved to be significantly affected by the weights and the priority groups.

This work is a novel contribution to the literature in the field of economics and sustainability, because of the lack of related literature, identified by a search on Scopus (Elsevier) Research gate of similar work, and the real-life potential applicability. Both the corporate world and the academia can use the model to assess real case scenarios and to contribute to the model to make it more consistent to fit the specific demands. It was able to develop a framework for companies to evaluate their operations ESG score, to evaluate all the suppliers' members of the SC providing a ESG score, to determine suppliers' importance level, and finally to test the model in different case scenarios showing that the SC has a significant impact on the AC ESG evaluation process.

This model is applicable to support the decision and management process of companies mainly on the procurement, finance, sustainability, and supply chain areas making the company and the SC more resilient. Besides that, it can be a useful tool for

companies to evaluate in a quantitative way their ESG maturity including the SC with some personalized dashboards identifying the weaknesses, strengths, opportunities, and threats for all parties.

Moreover, in all presented scenarios, the SC had a significant impact on the consolidated ESG score. Which proves the point that assessing the SC is important if the company wants to improve in the ESG agenda. In all 4 cases the SC is responsible for more than 50% of the final consolidated ESG score. However, some other economic sectors focused on raw material might have a higher contribution of the AC since their footprint is not focused on scope 3. Based on the result, it is impossible to achieve a great consolidated score and achieve a sustainable ecosystem without addressing ESG key topics on the SC as well.

Even though the ESG score of AC 1 was much higher than the AC 2, in the first scenario they both ended up getting a similar consolidated ESG score. That happened because in case 1, the ESG score of AC was good, but it was really impacted by the bad ESG score of the SC; in case 2, AC had a very bad ESG score and the high score of the SC kept the good standard. On scenario 2, after changing the owner of the SC, the output was completely different; on case 3 the good ESG score of the SC helped the amazing AC score to keep the level up and receiving a great consolidated score, and on case 4, both AC and SC had bad scores, and the consolidated score reflected that.

5.2 Limitations of the research

This work has some potential limitations due to time constraints and lack of a consolidated ESG taxonomy & data. These shortcomings do not affect the work that has been done, but it can acknowledge a better understanding and guidance for future works and contributions. The time constraint was a challenge because the work assesses all the economic sectors and created a scoring model which could not be tested in several different scenarios in all sectors.

The lack of a consolidated/global ESG taxonomy and standard was a restriction because the work had to choose SASB but did not consider some other important global accredited institution, such as GRI, TCFD, and EU Taxonomy. Even though SASB is very well recognized, it is not unanimous and there are other acceptable approaches and taxonomies.

In addition, there is a lack of a ESG database and information of companies and institutions. There is a lack of literature and consequently not many data available when discussing ESG in the supply chain. It is a new subject, and it is gaining momentum and traction now. A robust database with more research on the area and some data of the real world would provide great guidance on this work and any other related work.

Moreover, the model is limited for the upstream suppliers, since it is not applicable for the downstream side (consumers and disposal), which might have a big ESG impact as well depending on the sector and product.

5.3 Future Works

This work main contribution is to create a ESG assessment quantitative model that can be used by any type of corporation and their SC using SASB methodology to define weights by each sector. It also defined a SC coefficient of impact for all environmental, social, and governance aspects and finally was able to identify the real impact of the SC on the AC with a consolidated ESG score.

A natural sequence of this work would be the usage of different proxies to the definition of the SC Coefficient of Impact for environmental, social, and governance aspects to identify the impact of the SC on the consolidated score using different approaches and parameters. In this work the proxies are scope 3 emissions, HDI and GTI. A suggestion would be to find an international index to be able to use the model on different geographies than Brazil or different parameters. Moreover, the work only considers the matrix of the companies, would be interesting do develop a model to include the branches and operating facilities.

It is also important to highlight that the work uses 11 economic groups, which means that they are broad sectors. So, another suggestion would be the usage of more specific subsectors focusing in just one economic group. Addressing more detailed analysis for each activity. One example would be the transportation sector, that considers both people and cargo as the same, so it is important to separate them and identify specific material topics for each of them.

Another important aspect to be investigated would be the usage of another global accredited taxonomy/standard to serve as a guide to the weights and disclosure topics

definition. This could give a different perspective to the analysis and a potential comparison. Another option would be to research the important, material, and relevant topics to each industry using another methodology. It could be interesting to develop an ESG questionnaire such as Table A5 with all disclosure topics addressed.

APPENDIX

This section aims to present tables to support the text with supplementary material containing tables that serve as a guide to weight definition and more details on the text that might help the understanding of the sectorial distribution, formulas, and concepts. Table A1 shows the SASB sectors and subsectors to guide the identification of a company's activity based on the economic sector they might belong. Table A2 describes all disclosure topics that are going to be assessed on the ESG evaluation methodology. Table A3 cross check all sectors with all disclosure topics defining which of them are material topic for the sectors. Table A4 are the weights definition for each disclosure topics on each sector, which are the guide for the formulas to get ESG scores. Table A5 shows an example of questionnaire on how to assess and quantify the disclosure topics.

Table A 1 - SASB Sectors and subsectors

Consumer Goods	Extrative & Mineral Proccessing	Financials	Food & Beverage	Health Care	Insfrastructure	Renewable Resources & Alternative Energy	Resource Transformation	Services	Technology & Communications	Transportation
Apparel, Accessories & Footwear	Oil & Gas – Exploration & Production	Asset Management & Custody Activities	Agricultural Products	Biotechnology & Pharmaceuticals	Electric Utilities & Power Generators	Biofuels	Aerospace & Defense	Advertising & Marketing	Electronic Manufacturing Services & Original Design Manufacturing	Air Freight & Logistics
Appliance Manufacturing	Oil & Gas – Midstream	Commercial Banks	Alcoholic Beverages	Drug Retailers	Engineering & Construction Services	Forestry Management	Chemicals	Casinos & Gaming	Hardware	Airlines
Building Products & Furnishings	Oil & Gas – Refining & Marketing	Consumer Finance	Food Retailers & Distributors	Health Care Delivery	Gas Utilities & Distributors	Fuel Cells & Industrial Batteries	Containers & Packaging	Education	Internet Media & Services	Auto Parts
E-commerce	Oil & Gas – Services	Insurance	Meat, Poultry & Dairy	Health Care Distributors	Home Builders	Pulp & Paper Products	Electrical & Electronic Equipment	Hotels & Lodging	Semiconductors	Automobiles
Household & Personal Products	Coal Operations	Investment Banking & Brokerage	Non-Alcoholic Beverages	Managed Care	Real Estate	Solar Technology & Project Developers	Industrial Machinery & Goods	Leisure Facilities	Software & IT Services	Car Rental & Leasing
Multiline and Specialty Retailers & Distributors	Construction Materials	Mortgage Finance	Processed Foods	Medical Equipment & Supplies	Real Estate Services	Wind Technology & Project Developers		Media & Entertainment	Telecommunication Services	Cruise Lines
Toys & Sporting Goods	Iron & Steel Producers	Security & Commodity Exchanges	Restaurants		Waste Management			Professional & Commercial Services		Marine Transportation
	Metals & Mining		Tobacco		Water Utilities & Services					Rail Transportation
										Road Transportation

Table A 2 - SASB materiality topics

Environment	Social Capital	Human Capital	Business Model & Innovation	Leadership & Governance
GHG Emissions (GE)	Human Rights & Community Relations (HR)	Labor Practices (LP)	Product Design & Lifecycle Management (PD)	Business Ethics (BE)
Air Quality (AQ)	Customer Privacy (CP)	Employee Health & Safety (EH)	Business Model Resilience (BM)	Competitive Behavior (CB)
Energy Management (EM)	Data Security (DS)	Employee Engagement, Diversity & Inclusion (EE)	Supply Chain Management (SM)	Management of the Legal & Regulatory Environment (ML)
Water & Wastewater Management (WM)	Access & Affordability (AA)		Materials Sourcing & Efficiency (MS)	Critical Incident Risk Management (CI)
Waste & Hazardous Materials Management (WH)	Product Quality & Safety (PQ)		Physical Impacts of Climate Change (PI)	Systemic Risk Management (SR)
Ecological Impacts (EI)	Customer Welfare (CW)			
	Selling Practices & Product Labeling (SP)			

Table A 3 - SASB subsector relevant issues

Industry	Enviroment						Social Capital							Human Capital			Business Model					Governance				
	GE	AQ	EM	WW	WH	EI	HR	CP	DS	AA	PQ	CW	SP	LP	EH	EE	PD	BM	SM	MS	PI	BE	CB	ML	CI	SR
Consumer Goods	0	0	3	1	0	0	0	1	2	0	5	0	0	1	0	2	5	0	4	1	0	0	0	0	0	0
Apparel, Accessories & Footwear											X								X	X						
Appliance Manufacturing											X						X									
Building Products & Furnishings			X								X						X		X							
E-commerce			X					X	X							X	X									
Household & Personal Products				X							X						X		X							
Multiline and Specialty Retailers & Distributors			X						X					X		X	X									
Toys & Sporting Goods											X								X							
Extrative & Mineral Proccessing	8	6	3	7	6	6	3	0	0	0	0	0	0	2	7	0	2	2	1	0	0	3	3	3	6	0
Oil & Gas – Exploration & Production	X	X		X		X	X								X			X				X		X	X	
Oil & Gas – Midstream	X	X				X																	X		X	
Oil & Gas – Refining & Marketing	X	X		X	X										X		X						X	X	X	
Oil & Gas – Services	X			X	X	X									X							X		X	X	
Coal Operations	X			X	X	X	X							X	X			X							X	
Construction Materials	X	X	X	X	X	X									X		X						X			
Iron & Steel Producers	X	X	X	X	X										X				X							
Metals & Mining	X	X	X	X	X	X	X							X	X							X			X	
Financials	0	0	0	0	0	0	0	1	2	1	0	0	4	0	0	2	5	0	0	0	2	4	0	0	0	4
Asset Management & Custody Activities													X			X	X					X				
Commercial Banks									X	X							X					X				X
Consumer Finance								X	X				X													
Insurance													X				X				X					X
Investment Banking & Brokerage																X	X					X				X
Mortgage Finance													X								X					
Security & Commodity Exchanges																	X					X				X
Food & Beverage	4	0	7	6	2	1	0	0	1	0	5	6	5	2	2	0	4	0	7	5	0	0	0	0	0	0
Agricultural Products	X		X	X							X				X				X	X						
Alcoholic Beverages			X	X									X				X		X	X						
Food Retailers & Distributors	X		X		X				X		X	X	X	X					X							
Meat, Poultry & Dairy	X		X	X		X					X	X			X		X		X	X						
Non-Alcoholic Beverages	X		X	X								X	X				X		X	X						
Processed Foods			X	X							X	X	X				X		X	X						
Restaurants			X	X	X						X	X		X					X							
Tobacco												X	X													
Health Care	1	0	2	0	1	0	1	0	3	4	6	5	3	0	1	2	2	0	2	0	2	4	0	0	0	0
Biotechnology & Pharmaceuticals							X			X	X	X	X			X			X			X				
Drug Retailers			X						X		X	X														
Health Care Delivery			X		X				X	X	X	X	X		X	X					X	X				
Health Care Distributors	X										X	X					X					X				
Managed Care									X	X	X	X									X					
Medical Equipment & Supplies										X	X		X				X		X			X				
Insfrastructure	2	2	2	3	2	2	0	0	0	3	2	0	0	1	4	0	4	5	0	1	2	2	0	0	2	0
Electric Utilities & Power Generators	X	X		X	X					X					X			X							X	46:A
Engineering & Construction Services						X					X				X		X					X				
Gas Utilities & Distributors										X								X							X	
Home Builders						X									X		X	X								
Real Estate			X	X													X				X					
Real Estate Services																	X					X				
Waste Management	X	X			X									X	X			X								
Water Utilities & Services			X	X						X	X							X		X	X					
Renewable Resources & Alternative Ener	1	2	3	3	1	2	1	0	0	0	0	0	0	0	2	0	4	0	2	3	1	0	0	1	1	0
Biofuels		X		X													X		X					X	X	
Forestry Management						X	X														X					
Fuel Cells & Industrial Batteries			X												X		X			X						
Pulp & Paper Products	X	X	X	X															X							
Solar Technology & Project Developers			X	X	X	X											X			X						
Wind Technology & Project Developers															X		X			X						
Resource Transformation	2	2	5	2	4	0	1	0	1	0	3	0	0	0	2	0	5	0	1	3	0	2	0	1	1	0
Aerospace & Defense			X		X				X		X						X			X		X				
Chemicals	X	X	X	X	X		X								X		X							X	X	
Containers & Packaging	X	X	X	X	X						X						X		X							
Electrical & Electronic Equipment			X		X						X						X			X		X				
Industrial Machinery & Goods			X												X		X			X						
Services	0	0	3	1	0	1	0	1	2	0	1	3	3	1	2	2	0	0	0	0	1	2	1	0	0	0
Advertising & Marketing								X					X			X										
Casinos & Gaming			X									X			X							X				
Education									X			X	X													
Hotels & Lodging			X	X		X								X							X					
Leisure Facilities			X								X				X											
Media & Entertainment												X	X										X			
Professional & Commercial Services									X							X						X				
Technology & Communications	1	0	4	2	2	0	0	3	4	0	0	0	0	1	2	4	3	0	1	4	0	0	4	0	0	2
Electronic Manufacturing Services & Original Design Manu				X	X									X	X		X			X						
Hardware									X							X	X		X	X						
Internet Media & Services			X					X	X							X							X			
Semiconductors	X		X	X	X										X	X	X			X			X			
Software & IT Services			X					X	X							X							X			X
Telecommunication Services			X					X	X											X			X			X
Transportation	6	5	1	0	1	2	0	0	0	0	4	0	0	4	5	0	3	0	1	2	0	1	3	0	6	0
Air Freight & Logistics	X	X												X	X				X						X	
Airlines	X													X									X		X	
Auto Parts			X		X						X						X			X			X			
Automobiles											X			X			X			X						
Car Rental & Leasing											X						X									
Cruise Lines	X	X				X					X			X	X										X	
Marine Transportation	X	X				X									X							X			X	
Rail Transportation	X	X													X								X		X	
Road Transportation	X	X													X										X	

Table A 4 - Weights for ESG calculation

Industry	Environment						Social										Governance										TOTAL
	Enviroment						Social Capital							Human Capital			Business Model & Innovation					Leadership & Governance					
	GE	AQ	EM	WW	WH	EI	HR	CP	DS	AA	PQ	CW	SP	LP	EH	EE	PD	BM	SM	MS	PI	BE	CB	ML	CI	SR	
Consumer Goods	1	1	4	2	1	1	1	2	3	1	6	1	1	2	1	3	6	1	5	2	1	1	1	1	1	1	51
Extrative & Mineral Proccessing	9	7	4	8	7	7	4	1	1	1	1	1	1	3	8	1	3	3	2	1	1	4	4	4	7	1	94
Financials	1	1	1	1	1	1	1	2	3	2	1	1	5	1	1	3	6	1	1	1	3	5	1	1	1	5	51
Food & Beverage	5	1	8	7	3	2	1	1	2	1	6	7	6	3	3	1	5	1	8	6	1	1	1	1	1	1	83
Health Care	2	1	3	1	2	1	2	1	4	5	7	6	4	1	2	3	3	1	3	1	3	5	1	1	1	1	65
Insfrastructure	3	3	3	4	3	3	1	1	1	4	3	1	1	2	5	1	5	6	1	2	3	3	1	1	3	2	66
Renewable Resources & Alternative Energy	2	3	4	4	2	3	2	1	1	1	1	1	1	1	3	1	5	1	3	4	2	1	1	2	2	1	53
Resource Transformation	3	3	6	3	5	1	2	1	2	1	4	1	1	1	3	1	6	1	2	4	1	3	1	2	2	1	61
Services	1	1	4	2	1	2	1	2	3	1	2	4	4	2	3	3	1	1	1	1	2	3	2	1	1	1	50
Technology & Communications	2	1	5	3	3	1	1	4	5	1	1	1	1	2	3	5	4	1	2	5	1	1	5	1	1	3	63
Transportation	7	6	2	1	2	3	1	1	1	1	5	1	1	5	6	1	4	1	2	3	1	2	4	1	7	1	70

Table A 5 - Example of Questionnaire Assessment Evaluation

Questions	Answers			
Environment	10	7	3	0
GHG Emissions				
Does the company have targets to reduce GHG emissions?	Specific targets (ex.: 30% reduction by 2025)	Generic Target (ex.: reduce emissions next year)	Under discussion to be implemented	No
What actions does the company takes to reduce GHG emissions?	Measure scopes, report, and reduced emission in comparisson with previous year	Measure and report Scope 1, 2 and 3	Measure scope 1 and 2	No action
Air Quality				
Does the company have any policy to improve air quality?	Yes			No
Does the company have a program to neutralize its emissions?	Carbon Neutral (Measure, target, compensate, report)	Measure, target, and report	Measure	No
Energy Management				
Does the company have targets to reduce non-renewable energy consumption?	Specific targets (ex.: 30% reduction by 2025)	Generic Target (ex.: reduce consumption next year)	Under discussion to be implemented	No
What action does the company takes to reduce NR energy consumption?	Renewable energy + efficient operations reducing consumption	Using renewable energy sources (ex.: solar, wind, etc)	More efficient operations reducing consumption	No action
Water & Wastewater Management				
Does the company have targets to reduce water consumption?	Specific targets (ex.: 30% reduction by 2025)	Generic Target (ex.: reduce consumption next year)	Under discussion to be implemented	No
What action does the company takes to reduce water & wastewater consumption?	wastewater treatment systems that fits the local situation + reduction + reuse of water	Rationalize consumption and avoid waste + reuse water and capture it from the rain	Rationalize consumption and avoid waste	No action
Waste & Hazardous Materials Management				
Does the company have targets to reduce Waste & hazardous materials?	Specific targets (ex.: 30% reduction by 2025)	Generic Target (ex.: reduce consumption next year)	Under discussion to be implemented	No
What action does the company takes to reduce waste & hazardous materials?	Reduce, Reuse, Repair, Rot, Recycle	Reduce waste and separate waste to recycling	Reduce waste from operations	No action
Ecological Impacts				
Does the company have targets to reduce the ecological impacts?	Specific targets (ex.: 30% reduction by 2025)	Generic Target (ex.: reduce consumption next year)	Under discussion to be implemented	No
What action does the company takes to reduce ecological impact?	Projects to reforest forests and natural spaces focusing on biodiversity + do not clear vegetation to operate	Not necessary to clear vegetation to operate	Clear vegetation to operate but have projects to projects to reforest forests and natural spaces focusing on biodiversity	No action

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