Evaluating Supply Chain Sustainability through Triple Bottom Line

by

Katherine Arnold
Bachelor of Science in Supply Chain Management and International Business

and

Lauren Konopinski
Bachelor of Science in Supply Chain Management and Information Systems/Information Technology

SUBMITTED TO THE PROGRAM IN SUPPLY CHAIN MANAGEMENT
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF APPLIED SCIENCE IN SUPPLY CHAIN MANAGEMENT
AT THE
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

May 2022

Signature of Author: _____
Department of Supply Chain Management
May 6, 2022

Signature of Author: _____
Department of Supply Chain Management
May 6, 2022

Certified by: _____
Dr. Ozden Tozanli
Postdoctoral Associate, Center for Transportation and Logistics
Capstone Advisor

Accepted by: _____
Prof. Yossi Sheffi
Director, Center for Transportation and Logistics
Elisha Gray II Professor of Engineering Systems
Professor, Civil and Environmental Engineering

Evaluating Supply Chain Sustainability through Triple Bottom Line

by

Katherine Arnold

and

Lauren Konopinski

Submitted to the Program in Supply Chain Management
on May 6, 2022 in Partial Fulfillment of the
Requirements for the Degree of Master of Applied Science in Supply Chain Management

ABSTRACT

Avetta, a supply chain risk management & compliance firm, is introducing a new ESG (Environmental, Social, & Governance) offering to better support clients on their sustainability journeys, as they look to increase transparency and ensure compliance across the supply chain. In support of this new program, Avetta requires an understanding of the most critical sustainability policies and practices. This research identifies and ranks the key critical success factors (CSFs) that determine supply chain sustainability performance across five key industries (agriculture, construction, extraction, manufacturing, and retail). A Triple Bottom Line (TBL) approach – encompassing environmental, social, and economic perspectives – provides a comprehensive evaluation of supply chain sustainability. A thorough literature review was conducted to collect and define common critical success factors within each of the TBL buckets: ten environmental CSFs with thirty-one subfactors, eleven social CSFs with twenty-eight subfactors, and five economic CSFs with eleven subfactors. Analytical Hierarchy Process (AHP) was employed to rank the CSFs in terms of relative importance based on the results of an expert questionnaire. Results of the AHP analysis were further supported with findings and insights from Avetta's supplier responses to detailed sustainability survey questions. By looking holistically at supply chain sustainability key criteria and success factors across a specific selection of industries, this research provides a baseline point of reference for managing supply chain sustainability.

Capstone Advisor: Dr. Ozden Tozanli
Title: Postdoctoral Associate, Center for Transportation and Logistics

ACKNOWLEDGMENTS

We would like to thank our advisor, Dr. Ozden Tozanli, for her unwavering support throughout the duration of this project. Her guidance and feedback not only helped shape our final output, but helped us to learn and grow as researchers. Thank you for motivating us to create the best version of our work.

We would also like to express our sincere gratitude to our sponsoring company, Avetta, for bringing us this research question and for supporting our work throughout the year. In particular, thank you to Indy Chakrabarti for your dedication to this project.

A special thank you to everyone at Avetta and MIT CTL who participated in our expert questionnaire. We greatly appreciate your input and support of our research.

We would also like to thank Pamela Siska for the guidance and detailed edits at each stage of the process. We appreciate you taking the time to diligently read over our drafts and provide input.

Finally, none of this would have been possible without the moral and emotional support of our MIT SCM cohort. Thank you for keeping us going throughout the year with motivation and support, feedback and assistance, or simply a bit of fun.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Chapter 1 Introduction

Supply chain sustainability is a notably broad topic that organizations, industries, and governments alike have a vested interest in defining. Depending on the context, it can encompass a variety of factors such as environmental standards, ethical labor practices, social governance, and risk mitigation. In academic research, supply chain sustainability is often classified through the Triple Bottom Line (TBL), which breaks the topic into three main components: environmental, social, and economic (Blackhurst et al., 2012). An economic view focuses on a company's financial position and profits. The social category highlights the impact that companies have on communities and people through practices such as fair labor and working conditions (*The Triple Bottom Line*, 2020). Finally, environmental refers to the impact on the planet through factors such as greenhouse gas emissions; this subject is increasing in focus as growing attention is called to the role organizations play in climate change acceleration. Some companies focus primarily on ESG (Environment, Social, & Governance), which covers the environmental and social components of TBL but is limited in its consideration of financial factors.

Sustainability is an area of increased focus primarily because of stakeholder pressure and the need for long-term resource accessibility (Wolf, 2014). Consumer preferences and loyalties are changing, investors are looking to integrate sustainability performance into their portfolios, and governments and independent agencies are introducing new regulations. According to a Nielsen study, "nearly half (48%) of U.S. consumers say they would definitely or probably change their consumption habits to reduce their impact on the environment" (*Was 2018 the Year of the Influential Sustainable Consumer*, n.d.), making sustainability a critical topic for companies seeking long-term success. Corporations are responding by "implementing triple bottom line initiatives" and paying "more attention to the environmental and resource consequences of their operations" (Blackhurst et al., 2012).

To properly respond to and address increasing external pressure (from consumers, partners, governments, and other agencies, for example), it is imperative that companies evaluate their sustainability performance and identify areas for improvement across their entire supply chains. The growth in global, multi-tier supply chains contributes to both the importance and complexity of this task. While sustainability standards and risks can generally be evaluated for first-tier suppliers, it becomes increasingly challenging to assess the performance of suppliers further upstream (Awasthi et al., 2018). Upstream suppliers are often smaller-sized companies, sometimes far-removed geographically, that tend to have less granular and publicly available sustainability reports, making it difficult for companies to enforce sustainability across the entire value chain (Indy Chakrabarti (Chief Strategy & Marketing Officer, Avetta), personal communication, October 15, 2021). Sustainable supply chain management, therefore, faces a growing need for transparency and accountability despite increasingly complex and dynamic systems. This predicament partially explains why, according to Jabbour et al. (2019), supply chain sustainability "can be considered one of the fastest growing management topics."

1.1 Avetta's ESG Compliance Offer

Avetta, a supply chain risk management & compliance firm, has identified a growing interest in monitoring sustainability across multi-tiered supply chains among its client base. Avetta's global supplier compliance network allows organizations to connect with qualified suppliers, contractors, and vendors to enable growth while promoting supply chain safety and sustainability. Clients from various industries rely on Avetta's vetting and evaluation process to manage verified suppliers via a trusted SaaS-based platform. Suppliers, contractors, and vendors, in turn, utilize Avetta software to connect with clients and illustrate compliance with various guidelines, regulations, and industry best practices (*Avetta Connect*™, 2021). Avetta as a solution delivers dependable connections and promotes supply chain resiliency by increasing transparency, reducing incidents, and mitigating risk (*Why Avetta*, 2021).

Avetta's products currently offer insight into areas such as supplier compliance and insurance status, safety performance, financial position, and (more recently) compliance with Covid-19 guidelines. In response to an increasing interest in sustainability, Avetta is expanding and updating its offering to help clients better measure sustainability success and compliance across their supply chains (Indy Chakrabarti (Chief Strategy & Marketing Officer, Avetta), personal communication, September 24, 2021). Clients will be able to seek out and maintain working relationships with reliable suppliers that align with their sustainability goals based on timely and accurate data. To develop and implement a sustainability compliance offering, Avetta will require both a qualitative and quantitative understanding of key metrics.

1.2 Evaluating Supply Chain Sustainability through Triple Bottom Line

To date, studies centered on evaluating the sustainability of supply chain networks have been mainly qualitative, descriptive, or conceptual in nature (Milman & Short, 2008). As a result, few existing quantitative models are available for measuring sustainability in detail (Jabbour et al., 2019). By looking holistically at supply chain sustainability key criteria and success factors across a specific selection of industries, this research provides a baseline point of reference for managing supply chain sustainability. Sustainability experts' opinions, supplemented by Avetta sustainability survey results and independent studies, were analyzed against carefully selected criteria to refine and rank a set of sustainability success factors. This research culminates in a ranked matrix of supply chain sustainability criteria and success factors (environmental, social, and economic) to consider when evaluating supplier sustainability performance.

To narrow the focus of this work and provide a more comprehensive analysis, five industries that are leading in supply chain sustainability or where sustainability compliance is of particular concern were selected: agriculture, construction, extraction (e.g., oil & gas, mining), manufacturing, and retail. This study also focused primarily on the United States and Europe due to data availability and sustainable

development to date. Within the framework of these industries and regions, current sustainability trends and supplier practices were studied and documented. An exploration of the measures that organizations are taking with suppliers, the regulatory agencies that play a role in shaping guidelines, the impact of company size, and other trends were considered in determining the primary success factors of supply chain sustainability. Data from various sources, including public and government agencies, academic literature, expert opinions, and the Avetta database, was used to refine and rank the key criteria that best indicate supply chain sustainability and compliance.

The first step of this study was to identify and organize supply chain sustainability criteria and related success factors for the industries outlined above. Examining the existing literature and documentation on this topic aided in identifying the key criteria (in areas including but not limited to environmental, social, financial, and health & safety). The relevance and importance of certain success factors may vary by industry, and supplementary research and subjective opinion were used to shine a light on these variations.

Candidate models for evaluating the strength of the sustainability factors included multi-criteria decision-making (MCDM) techniques and multiple regression modeling. For example, utilizing Analytical Hierarchy Process (AHP) – in conjunction with other MCDM models – would be particularly useful in evaluating and comparing the complex interactions between sustainability factors and alternatives, thereby “systematizing and structuring the decision-making process" (Dos Santos et al., 2019).

The impact of the criteria and success factors selected was further supplemented through the analysis of Avetta’s supplier compliance data. Over the last few years, Avetta has leveraged a sustainability-focused survey to collect nearly seven million responses from over 32,000 suppliers (Indy Chakrabarti (Chief Strategy & Marketing Officer, Avetta), personal communication, October 13, 2021). Additionally, Avetta has substantial safety, financial, and governance data for suppliers, vendors and contractors that could be

examined for connections to sustainability factors or representative trends. Finally, publicly available data and independent research results were reviewed and included where applicable. Ultimately, the data was used to create and execute analysis using Analytical Hierarchy Process (AHP) to validate criterion, rank the relationships between the identified success factors, and provide a baseline for evaluating sustainability performance.

The selected methodology of Analytical Hierarchy Process was employed as outlined in Chapter 3 to enable pairwise comparisons of selected critical success factors (CSFs) based on expert opinion collected through a questionnaire on environmental, social, and economic sustainability criteria. The environmental, social, and economic CSFs were ranked, and those of the highest relative importance should be an area of focus for organizations committed to supply chain sustainability. The results of the analysis along with further discussion of the CSF rankings are presented in Chapter 4 Analysis & Findings and Chapter 5 Discussion.

Chapter 2 Literature Review

This study examines supply chain sustainability and compliance through the lens of multi-tiered networks across five industries. It identifies and ranks the key criteria and related success factors required to evaluate and measure a company's supply chain sustainability. In this chapter, a high-level overview of supply chain sustainability – with a particular focus on the impact of industry, company size, and geographic region – is presented. A discussion of the critical success factors in the relevant literature to date is provided, followed by a comparison of potential supplier evaluation methodologies highlighting two specific components, various multi-criteria decision-making (MCDM) techniques and multiple linear regression. This chapter concludes with a summary of findings regarding supplier sustainability evaluation criteria and methodology and highlights existing gaps in the related body of research.

2.1 Supply Chain Sustainability

Academic researchers have long been using the concept of the Triple Bottom Line (TBL) to gauge long-term profitability and sustainability. TBL has also been applied by companies to operations and supply chains, especially when considering multi-tiered supply chains and associated sustainability-related risks (Miemczyk, 2019). Supply chain sustainability itself is often characterized through TBL, broken down into three main categories of economic, environmental, and social (Slaper & Hall, 2020). TBL is also commonly referred to as people, planet, and profit. Economic variables include factors such as income, job growth, and the percentage of firms in a sector (Slaper & Hall, 2020). Environmental variables typically relate to resource quality and consumption, with factors like electricity consumption and the use of recycled materials. Lastly, social variables refer to factors relating to communities and people – compensation management and average annual training time, for example (Erol et al., 2011).

Holistically, Sustainable Supply Chain Management (SSCM) focuses on improving the long-term performance of the Triple Bottom Line and incentivizing partners to enforce proper social and environmental policies. Primary drivers of SSCM are stakeholder pressure, including that of non-governmental organizations and consumers, and the need for access to resources in the future (Wolf, 2014). Understanding sustainability across the entire supply chain becomes vital as corporations seek to improve their sustainability performance. Green Supply Chain Management (GSCM), which is similar to SSCM, focuses more heavily on the environmental component of corporate sustainability (Govindan et al., 2013). The concept of GSCM includes all aspects of a supply chain with dimensions ranging from green purchasing to environmental education and can increase a company's competitive advantage since it is difficult to duplicate (Çankaya & Sezen, 2019). However, not every dimension of GSCM may have a significant positive effect on TBL performance. It is crucial to understand the relationship between top priorities and sustainable performance (Çankaya & Sezen, 2019).

An Environmental, Social, & Governance (ESG) framework is often practiced within industry to capture and evaluate sustainability. However, the ESG framework, which specifically addresses the social and environmental components of sustainability, is not typically used as the basis for sustainability criteria research. The framework excludes economic impact and does not provide a comprehensive view of corporate sustainability. Researchers such as Jabbour & Jabbour (2009), Erol et al. (2011), and Govindan et al. (2013) have used TBL to shape the direction of sustainability criteria selection. Some researchers who have studied sustainability find that TBL uniquely covers corporate sustainability in that it also considers the impact on profitability and shareholders (Slaper & Hall, 2020).

Though there are many approaches to sustainability, this study takes a Triple Bottom Line approach to provide a holistic review of sustainability performance. It investigates which factors are most critical for evaluating company sustainability performance across the five industries of focus for each component of TBL, viz. environment, social and economic. Quantifying performance will provide additional insight and

transparency for companies seeking to choose suppliers that align with their own sustainability initiatives. The following sections will elaborate on additional context through which to evaluate sustainability, including industry or trade, company size, and region.

2.1.1 Industries & Trades

In conducting a systematic literature review focused on the use of Analytical Hierarchy Process (AHP) as a decision-making tool in sustainable development, Dos Santos et al. (2019) created mental maps to classify manuscripts by application area (industry), before further breaking down into particular area (e.g., sustainability decision-making, implementation of sustainable concepts) and specific topic. Of the 173 publications deemed relevant and included in the review, Dos Santos et al. (2019) classified one-third as manufacturing, 10% as construction, and another 8% energy, fuels, or biofuels. Other significant application areas include urban/public (15%) and business (10%). As discussed, the scope of this study includes the agriculture, construction, extraction, manufacturing, and retail industries. For each of these industries, supply chain sustainability and sustainability compliance are of particular importance (Indy Chakrabarti (Chief Strategy & Marketing Officer, Avetta), personal communication, October 1, 2021).

The individual success factors (and their relative importance) that drive an organizations' performance across sustainability criteria will differ by industry as each faces unique conditions, risks, and opportunities. In the oil & gas industry, for example, health & safety practices may be of particularly high importance; over the last decade, most major energy companies have increasingly emphasized a culture of safety first and many place safety at the top of their core values (Godwin, 2017). Agriculture encounters uniquely high-risk and associated regulations – particularly around the use of pesticides – as the end product is ultimately consumed or ingested. Oil & gas (O&G), construction, and mining are all carbon-intensive industries with high emission levels and hazardous products or materials (Indy Chakrabarti (Chief Strategy & Marketing Officer, Avetta), personal communication, October 1, 2021). Industries also face

different degrees of external pressure (from shareholders, customers, or society at large) to operate more sustainably. Interestingly, a number of organizations that rely on energy supply for operations or logistics are demanding that O&G suppliers increase sustainability efforts to further reduce their own impact and carbon footprint (Ahmad et al., 2017). As the specific characteristics and operating context of each industry drives implementation of sustainable practices, sustainability compliance, and speed of adoption, sustainability critical success factors and their relative importance will vary across industries. As critical success factors are reviewed in Section 2.2, details and potential differences across each industry of focus are highlighted.

2.1.2 Company Size

Another potential factor impacting a company's sustainability performance is company size. Research from Horisch et al. (2015), Seroka-Stolka & Fijorek (2020), and Drempetic et al. (2020) suggested that company size plays a crucial role in evaluating sustainability performance; however, their views on how and to what extent vary. According to Horisch et al. (2015), although small- and medium-sized enterprises develop sustainability strategies, they tend to implement fewer initiatives and tools as compared to larger corporations. This may stem from smaller firms' lack of knowledge about sustainability rather a lack of motivation (Horisch et al., 2015). It also implies that these firms will implement sustainability frameworks more similarly to large companies as sustainability knowledge grows. In addition to this knowledge gap, a lower level of external pressure contributes to small- and medium-sized companies performing less sustainably than large companies. The degree of external pressure is higher for large corporations as a result of increased visibility. However, large companies also tend to spend resources on lobbying, making them less susceptible to claims from NGOs (Seroka-Stolka & Fijorek, 2020).

Alternatively, Drempetic et al. (2020) stated that the underlying hurdle with ESG scores is that they favor larger organizations due to data availability and the resources available to them. Smaller companies

appear to be less sustainable than larger companies since sustainability assessments improve as more data is provided. As firms often collaborate with suppliers of various sizes further upstream in their supply chains, visibility will be a crucial challenge when implementing and operating a sustainability compliance platform. Given that company size has a notable impact on sustainability, this study considers the role of size (primarily using number of employees) in the analysis.

2.1.3 Regions

Regulations and policies continue to change and play a role in shaping company expectations and performance related to sustainability. This study focuses on the United States and Europe, given their progress and increasing focus on sustainable development. Within these two regions, there are various similarities and differences in how sustainability and ESG are approached, mainly driven by the regulations and policies in place.

In the United States, for example, the Occupational Safety & Health Administration (OSHA) plays a key role in outlining and enforcing workplace health and safety measures. As part of the United States Department of Labor, OSHA enforces employer violations at a federal level, though some states also have their own OSHA-approved Occupational Safety and Health Plans (*OSHA Penalties*, 2021). OSHA violations can result in significant monetary penalties for businesses. In contrast, EU-OSHA, also known as the European Agency for Safety and Health at Work, sets and communicates guidelines for companies to follow and promotes positive change; the European Commission implements legislation (Safety and health legislation, 2021). In addition to OSHA in the United States, the National Labor Relations Board also has an impact on the social and economic dimensions of TBL. For example, the National Labor Relations Act prohibits employers from preventing employees from joining unions or working to improve employment terms and conditions (*Employer/Union Rights and Obligations*, n.d.). In 2016, 10.7% of US wage and salary workers were union members (*Union Members – 2016,* 2017). As of 2020, 10.8% of US

wage and salary workers were union members, showing very little change over time in the overall unionization rates (*Union Members - 2020*, 2021). This contrasts with some European countries such as Germany, which had a trade union density of 17% in 2017 (*Industrial relations in Germany*, 2019), giving companies less control over workplace terms and conditions.

From an environmental perspective, the Environmental Protection Agency (EPA) drives the environmental policies by which companies within the United States operate. The EPA segments regulations at a federal level based on key industries such as construction, agriculture, and oil & gas. States also have their own environmental and health agencies that can create and enforce regulations. Regulations are codified in the Code of Federal Regulations, which is updated on an annual basis (*Laws & Regulations*, 2021). When compared to the United States or other nations, Europe is typically on the forefront of environmental policy. The European Commission continuously reviews and adjusts its sustainability policies. In 2009, the Commission determined that sustainability policies should focus on the three aspects of the Triple Bottom Line and drew attention to several successful policies, specifically the decarbonization of energy, transport, production, and consumption (Domorenok, 2018). As studied by Leukhardt et al. (2013), Germany developed a sustainability strategy in 1998 consisting of four key areas: intergenerational equity, quality of life, social cohesion, and international responsibility. Specific environmental factors such as energy consumption and greenhouse gas emissions are included within the broader buckets of social and economic sustainability.

2.2 Critical Success Factors – the Triple Bottom Line

The first step in creating a supplier evaluation model is to develop a comprehensive set of criteria that covers the primary area(s) of focus. In most related studies, this criteria set is carefully collected through a literature review. This section compiles and analyzes the critical success factors referenced across the relevant literature and illustrates how a potential criteria set can be organized for further evaluation.

Depending on the study and relevant scope, the success factors considered vary, making "consensus criteria" challenging to come by (Govindan et al., 2015). Traditionally, supplier evaluation criteria centered on supply chain management basics (e.g., product quality, service level, delivery), financial performance (e.g., cost), or the strategic fit of a firm. In many of the papers reviewed for this section, however, these more traditional factors are integrated with sustainability factors to create a more comprehensive evaluation framework (Chiou et al., 2008; Kaviani et al., 2020; Li and Nie, 2017; Yang and Wu, 2008; Wang et al., 2017; Wen and Chi, 2010). Performance assessment of supplier sustainability can be approached through the Triple Bottom Line, with criteria spanning environmental, social, and economic sustainability. Erol et al. (2011), for example, approached SSCM and supplier sustainability using a TBL framework, arguing that, for sustainable firms, supply chains need to be evaluated across a wider set of criteria. Govindan et al. (2013) employed a similar Triple Bottom Line approach in measuring supplier sustainability performance.

Another important consideration is the desired level of detail or specificity of each criterion. Some researchers tailor the evaluation metrics to a particular organization or industry, leaving little flexibility in the resulting model and preventing wider application. Li and Nie (2017) looked specifically at China's coal industry, for example, while Marzouk and Sabbah (2021) and Wang et al. (2017) solely considered construction. Although there is overlap between the criteria sets used in these studies, there are also unique factors that fit to the context of a particular industry only (e.g., dust or noise control in mining, prestige in the Architecture Engineering Construction (AEC) industry). Similarly, focusing solely on broad, overarching criteria, can lead to ambiguity and uncertainty in model results. There must be a balance between specificity and broadness – criteria should be comprehensive enough to fit the desired scope but detailed enough to be practical in application. Explicit descriptions of criteria must also be offered to ensure consistency in application and the evaluation of results (Govindan et al., 2015). Within this

capstone, each TBL criterion is broken down into specific success factors with detailed subfactors and definitions; further detail can be found in Tables 4, 5, and 6 of Chapter 3 Methodology.

2.2.1 Environment

Environment is one key aspect of both TBL and ESG, and it is a crucial component in evaluating supplier sustainability. Lamming & Hampson (1996) may have been the first to explicitly propose implementing environmental management practices holistically across the entire supply chain, citing consumer pressure, legislation, and waste as key drivers for the shift in thinking. While individual companies and organizations are developing and implementing environmental management at very different paces, the incorporation of environmental criteria in supplier evaluation is growing (Awasthi et al., 2018; Ahmad et al., 2017; Chiou et al., 2008; Erol et al., 2011; Yang and Wu, 2008; Wen and Chi, 2010).

Environmental criteria should be of particular importance for each of the five industries of focus selected for this study and for Avetta in developing a supply chain sustainability offer. In the oil & gas industry, for example, operations are inherently carbon-intensive and many of the products themselves (including some raw materials, finished goods, and waste) are hazardous. For the mining industry, the use of green technology to improve efficiency, increase recovery rates, and minimize environmental damage is a key component of operating more sustainably (Li and Nie, 2017). Emissions, water and energy consumption, and waste are essential criteria across all five industries included in this study; however, the degree of importance as well as the specific details or application may vary across industries. For example, CO2 emissions are relevant across all industries, while evaluating methane emissions may be most suited to extraction and agriculture. Similarly, although complying with government regulations is applicable to all industries, the regulations themselves will vary.

Quantitative environmental criteria, offer clearly defined metrics that suppliers can be evaluated against, and usually correspond to operations and measurable costs. Example criteria include energy

consumption, emission levels and pollution, and environmental costs (e.g., costs to mitigate risks, or investments in green initiatives). Quantitative criteria are, in general, easy to understand and straightforward to evaluate.

Considering quantitative criteria alone, however, cannot completely capture supply chain sustainability. Incorporating qualitative criteria allows for the consideration of more intangible success factors, such as environmental management competencies, image, and training (Jabbour & Jabbour 2009). In a literature review focused on 1997 to 2011, Govindan et al. (2015) found that the "implementation of environmental management systems" is a key factor in evaluating supplier sustainability; in fact, this criterion appeared in over 30% of the papers reviewed. Qualitative criteria can be key indicators of an organization's culture and ability to manage stakeholder perception over time.

Table 1 presents a summary of the common environmental critical success factors found across the relevant literature.

Table 1

Summary of Environmental Critical Success Factors (CSFs) from the Literature

Environmental	Description	Frequency Mentioned	Relevant Research
Sustainable Operations	**Environmental criteria that directly relate to production or operations; usually evaluated quantitatively (e.g., costs)**		
Energy Consumption	Energy consumption; oil & gas resources	2	Erol et al. (2011); Handfield et al. (2002)
Water Consumption	Water consumption	5	Ahmad et al., (2017); Erol et al. (2011); Handfield et al. (2002); Jabbour and Jabbour (2009); Li and Nie (2017)
Emissions	CO_2, methane, and other hazardous emissions; transportation/logistics emissions	7	Ahmad et al. (2017); Awasthi et al. (2018); Handfield et al. (2002); Jabbour and Jabbour (2009); Kaviani et al.

			(2020); Yan (2009); Wang et al. (2017)
Waste Management	Waste minimization; hazardous waste; recycling rates; reverse logistics; resource recovery	5	Erol et al. (2011); Handfield et al. (2002); Liu and Liu (2010); Jabbour and Jabbour (2009); Yan (2009)
Environmental Costs	Costs of environmental improvement efforts (e.g., recycling efforts, green technology, acquisition of environmental raw materials or products); investment in green projects/R&D	4	Awasthi et al. (2018); Jabbour and Jabbour (2009); Li and Nie (2017); Wang et al. (2017)
Compliance to Government Requirements	ISO 14001 Certification; ISO 9000 Certification; EPA/RCRA non-compliance	7	Awasthi et al. (2018); Chiou et al. (2008); Erol et al. (2011); Handfield et al. (2002); Liu and Liu (2010); Jabbour and Jabbour (2009); Yang and Wu (2008)
Organizational Culture	**Environmental criteria that relate to organizational culture; usually evaluated qualitatively**		
Environmental Management System	Environmental policy, planning, and implementation; top management/management commitment; supplier evaluation	5	Awasthi et al. (2018); Chiou et al. (2008); Handfield et al. (2002); Jabbour and Jabbour (2009); Wen and Chi (2010)
Environmental Competencies	Use of environmental materials and technologies; capacity to reduce impact and operate green	3	Chiou et al. (2008); Jabbour and Jabbour (2009); Noci (1997)
Environmental Training	Effectiveness of employee or supplier training on environmental issues; exchange of information	5	Awasthi et al. (2018); Erol et al. (2011); Handfield et al. (2002); Liu and Liu (2010); Jabbour and Jabbour (2009)
Environmental Image	Market share; partnership with green organizations; relationship with stakeholders; image and retention of green consumers	5	Awasthi et al. (2018); Chiou et al. (2008); Jabbour and Jabbour (2009); Noci (1997); Wen and Chi (2010)

2.2.2 Social

Social governance is another critical component of supply chain sustainability. Yet O'Riordan, Zmuda, and Heineman (2015) observed that the social aspect is often given less consideration than the environmental by both organizations and researchers alike, a point echoed by both Köksal et al. (2018) and Marzouk and Sabbah (2021). Rossi and Krey (2018) suggested that the slow rate of adoption of social sustainability issues may be driven by the fact that they are "not generally universally understood." However, particularly from a consumer or competitive lens, social sustainability can contribute to the overall performance of a business (O'Riordan et al., 2015). Approaching supplier sustainability evaluation through a Triple Bottom Line framework ensures that social critical success factors are captured.

One way to approach social sustainability is through an emphasis on people. Employee demographics such as gender, race, and age, as well as diversity and inclusion (D&I) initiatives are indicators of an organization's social performance. Employee training and turnover can also be considered in evaluating a firm's commitment to its employees.

Health and safety are particularly critical for high-risk industries. While health and safety of employees should be an important consideration for any organization, safety is embedded in the culture of certain industries (e.g., oil & gas, mining, and construction). Within oil & gas, for example, there are unique health, safety, and environmental (HS&E) risks due to the nature of production processes and the products themselves (Ahmad et al., 2017). Sub-criteria related to health and safety include recordable incidents (e.g., days away from work), HS&E management systems (e.g., OSHA compliance), and fair employment practices.

Corporate social responsibility should also be considered as part of the social aspect of TBL. It incorporates sub-criteria such as a social code of conduct, external investments in social projects, and public reporting or information disclosure. An organization's performance across these criteria has implications on its

public perception. For this reason, there may be interdependencies between corporate social responsibility criteria and environmental criteria sets (Vafadarnikjoo et al., 2020). The relationship between these criteria should be considered when creating a framework, particularly in clarifying the intent of each criterion.

Table 2 presents a summary of the common social critical success factors found across the relevant literature.

Table 2

Summary of Social Critical Success Factors (CSFs) from the Literature

Social	Description	Frequency Mentioned	Relevant Research
People	**Emphasis on people and culture in the workplace**		
Average Training	Average training time per employee	4	Erol et al. (2011); Kaviani et al. (2020); Marzouk and Sabbah (2021); Vafadarnikjoo et al. (2020)
Annual Personnel Turnover	Annual turnover	1	Erol et al. (2011)
Annual # of Employee Incidents	Recorded harassment, discrimination, violence, complaints	1	Erol et al. (2011)
Annual # of Customer Incidents	Recorded customer complaints	1	Erol et al. (2011)
Diversity, Equity, & Inclusion	Gender, race, age non-discrimination	2	Erol et al. (2011); Marzouk and Sabbah (2021)
Wages	Fair & equitable wages	1	Marzouk and Sabbah (2021)
Health & Safety	**Safety in the workplace – working conditions, safety practices, emphasis on physical and mental well-being**		
Recordables	Recordable employee/contractor accidents	3	Erol et al. (2011); Li and Nie (2017); Marzouk and Sabbah (2021)
Occupational HS&E Management System	OSHA compliance	3	Ahmad et al. (2017); Marzouk and Sabbah (2021); Vafadarnikjoo et al. (2020)

Work Safety & Labor Health	Employment practices; contract labor; child labor; forced labor	2	Marzouk and Sabbah (2021); Vafadarnikjoo et al. (2020)
Corporate Social Responsibility	**Commitment level towards improving social sustainability**		
Social Code of Conduct	Conducting code on social responsibility/social sustainability	3	Marzouk and Sabbah (2021); Kaviani et al. (2020); Köksal et al. (2018)
External Investments	External investments in social projects	2	Erol et al. (2011); Marzouk and Sabbah (2021)
External Reporting	External/public reporting; corporate responsibility documents; information disclosure	3	Liu and Liu (2010); Köksal et al. (2018); Vafadarnikjoo et al. (2020)

2.2.3 Economic

While environmental and social considerations are critical additions to evaluating supplier sustainability and growing in consideration, the more traditional supply chain factors cannot be ignored (Wang et al., 2017). Economic factors, including market context and a firm's financial stability, are key to evaluating overall sustainability. A firm's stakeholders – and in particular, shareholders – as well as their influence on operations, for example, can impact sustainability (Erol et al., 2011; Marzouk and Sabbah, 2021).

A firm's financial performance is an important indicator of sustainability in the long-term. Cost is one of the primary criteria in traditional supplier evaluation models (Chiou et al., 2008; Jabbour and Jabbour, 2009; Kaviani et al., 2020; Li and Nie, 2017; Noci, 1997; Yan, 2009; Wang et al., 2017). Economic conditions such as the volatility of commodity markets, exchange rates, and interest rates, can significantly affect an organization's profitability and overall performance (Petrobras, 2011; Repsol, 2011). Industries like mining and oil & gas are particularly susceptible to fluctuations in commodity markets (in particular, precious metals and crude oil, respectively).

Financial security and a certain amount of liquidity are required not only to operate but to invest in and fund sustainability efforts. Investing in environmental and social initiatives are frequently referenced critical success factors across the relevant literature. Again, the interdependencies among criteria should be considered when selecting economic success factors and building an evaluation framework.

Table 3 presents a summary of the common economic critical success factors found across the relevant literature, broken down into external and internal factors.

Table 3

Summary of Environmental Critical Success Factors (CSFs) from the Literature

Economic	Description	Frequency Mentioned	Relevant Research
External	**Market conditions**		
Stakeholder Relationship	Relationship with stakeholders; influence of stakeholders on operations	1	Marzouk and Sabbah (2021)
Number of Shareholders	Number of investors/shareholders	1	Erol et al. (2011)
Internal	**Financial performance and stability**		
Financial Stability	Overall financial stability; credit standing	3	Liu and Liu (2010); Yang and Wu (2008); Wen and Chi (2010)
Net Price	Share price	3	Liu and Liu (2010); Yan (2009); Yang and Wu (2008); Wen and Chi (2010)
Resource Costs	Cost of acquiring resources, raw materials, etc.	1	Li and Nie (2017)
Total Production Costs	Comprehensive production costs; transaction costs	7	Chiou et al. (2008); Jabbour and Jabbour (2009); Kaviani et al. (2020); Li and Nie (2017); Noci (1997); Yan (2009); Wang et al. (2017)
Promoting New Investments	Investments in new technologies, opportunities, etc.	1	Erol et al. (2011)

2.3 Multi-Criteria Decision-Making Techniques

Multi-criteria decision-making (MCDM) is often employed in supplier evaluation and selection due to the ability to conduct comparison across a variety of criteria (often overlapping and conflicting). MCDM can lead to “clear and straightforward prioritization,” even within highly complex systems (Govindan et al., 2015). A number of different MCDM techniques are commonly applied in this space, including but not limited to Analytical Hierarchy Process (AHP), Analytic Network Process (ANP), Data Envelopment Analysis (DEA), Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), and Preference Ranking Organization Method of Enrichment Evaluation (PROMETHEE). Hybrid method approaches, where individual MCDM techniques are integrated (usually with AHP), are also fairly common. However, these integrated approaches (depending on implementation) can create barriers to acceptance (Govindan et al., 2015). Applying multiple MCDM techniques can increase model complexity and make the methodology behind a study more difficult to understand - particularly for readers unfamiliar with the specific techniques selected. A successful integrated approach should, instead, simplify the process. For example, an initial MCDM tool can be used to filter criteria, thereby narrowing alternatives in subsequent steps (Wen and Chi, 2010).

According to Dos Santos et al. (2019), Analytical Hierarchy Process (AHP) is among the most accepted and frequently used multi-criteria decision-making techniques in sustainable development. Due to the complexity and delicate interactions of factors that impact the Triple Bottom Line (environment, social, and economic), AHP – often combined with other MCDM techniques – is a natural choice for “systematizing and structuring the decision-making process" (Dos Santos et al., 2019). In completing a comprehensive literature review of green supplier selection (1997-2011), Govindan et al. (2015) found that AHP was the most common approach, appearing in over 16% of the journal articles reviewed through the study. Furthermore, this research highlighted the extensive use of fuzzy analysis across the identified papers, seemingly regardless of approach or MCDM technique selected (Govindan et al., 2015). A fuzzy

approach uses ranges or relative terms to define criteria or make an assessment rather than concrete, singular values. While the use of fuzzy techniques can create additional complexity in modeling by expanding the range of solutions, it is a popular approach to capture the inherent uncertainty of some decision-making settings (Kaviani et al., 2020).

Erol et al. (2011) approached supply chain sustainability using AHP given the complex, conceptual nature of sustainability performance. A fuzzy framework was also identified by Erol et al. (2011) as most effective since it incorporates techniques to address uncertainty. This particular study used the entropy method to calculate indicator weights because it is seen as more objective. To further evaluate sustainability development, Erol et al. (2011) created an alert system to highlight year over year changes in a company's sustainability performance.

Wen and Chi (2010) proposed an integrated evaluation model for green supplier selection of Data Envelopment Analysis (DEA) and AHP. The limitations of AHP in evaluating large scale problems is cited as the main reason for introducing DEA. First, DEA was used to differentiate between the "efficient and the inefficient suppliers," as an initial screening process (Wen & Chi, 2010). AHP or ANP was then applied for further evaluation of the results.

Both Yan (2009) and Yu and Sun (2010) also took an integrated approach combining Analytical Hierarchy Process (AHP) and Genetic Algorithm (GA) to construct their evaluation models. Genetic Algorithm (GA) is an "adaptive global optimization probability search algorithm" with its roots in biology genetics (Yan, 2009). GA, when combined with AHP, allows for dynamic weighting and further enhances the "fairness and efficiency" of a systematic evaluation (Yan, 2009).

2.4 Empirical Models

Several other methodologies, though not used within this particular study, can be considered for future research. One such modelling technique is Exploratory Factor Analysis (EFA), a statistical model that is

commonly used to identify and sort evaluation criteria and help group critical success factors based on commonalities. Multiple linear regression is also an alternate method that can be used to measure and rank criteria and appears to be a more common approach for sustainability evaluation than EFA. Ghadge et al. (2019) used multiple linear regression to identify the statistical significance of specific sustainability criteria to various tiers and regions of suppliers within a supply chain.

Similarly, Luthra et al. (2016) utilized multiple regression analysis to determine the impact of critical success factors on a company's green practices and performance. Additionally, Malesios et al. (2020) used regression modeling with latent variables to investigate criteria and criteria weights for regions and small- to medium- enterprises. Structural equation modeling and the use of regression modeling with latent variables is a technique that has been used by researchers like Malesios et al. (2020) to score and combine factors to determine average sustainability performance. Empirical models such as these can be considered for future research, especially where larger empirical datasets are present.

2.5 Conclusion & Gaps in Today's Methods

Though many studies across the related literature aimed to identify and evaluate sustainability criteria and performance, the use of empirical data has been limited. This particular study was conducted in partnership with Avetta for a more practical approach. It also seeks to provide new insights into how criteria differ beyond regions by focusing on five specific industries. In order to identify and evaluate performance criteria, two methodologies were presented – multi-criteria decision-making and predictive models. Given the research conducted through the literature review and the data available for this study, the selected methodology is Analytical Hierarchy Process (AHP). Multi-criteria decision-making techniques are frequently used in sustainability studies given the conceptual and qualitative nature of the subject, and AHP appears particularly common. Despite the complexity and closeness of the critical success factors selected for this research, as well as the presence of qualitative factors, AHP allows for methodical,

pairwise comparisons to be made across factors and sub-factors to determine relative importance. It is used in this study to evaluate and rank three sets of critical success factors – specifically environmental, social, and economic – to determine the relative importance of each in evaluating supply chain sustainability performance.

Chapter 3 Methodology

As the importance of sustainability grows across all regions and industries, Avetta is expanding its supplier compliance offering to help clients measure supply chain sustainability performance. This study identifies and ranks key sustainability success factors across five industries of focus: agriculture, construction, extraction (e.g., oil & gas, mining), manufacturing, and retail.

This chapter begins by explaining the initial selection of Critical Success Factors (CSFs) for each component of the Triple Bottom Line (TBL) – environmental, social, and economic. Then, it discusses the steps involved in the selected methodology of Analytical Hierarchy Process (AHP). Finally, it provides a brief overview of the data and information relevant to this study, including empirical supplier responses and expert opinion.

3.1 Critical Success Factors

Through a detailed literature review spanning various regions, industries, and applications, common sustainability criteria were identified and organized under economic, environmental, and social (TBL) headers. The initial selection of critical success factors (CSFs) was based primarily on the research question at hand and frequency (number of appearances) in the referenced literature. Based on the scope and purpose of this study, the criteria were refined or adjusted and broken down into subfactors to support analysis.

3.1.1 Environment

Environment is one key aspect of the Triple Bottom Line framework, and environmental criteria are increasingly considered in supplier evaluation models (Ahmad et al., 2017; Awasthi et al., 2018; Chiou et al., 2008; Erol et al., 2011; Yang and Wu, 2008; Wen and Chi, 2010). While the relative importance or final

weighting of criteria may differ across industry, the environmental critical success factors in this section are relevant for each of the five industries of focus.

An initial set of environmental critical success factors was selected and refined through a review of existing research, presented in Figure 1. Table 4 shows a breakdown of each critical success factor into subfactors including a brief description.

Figure 1

Environmental Critical Success Factors (CSFs)

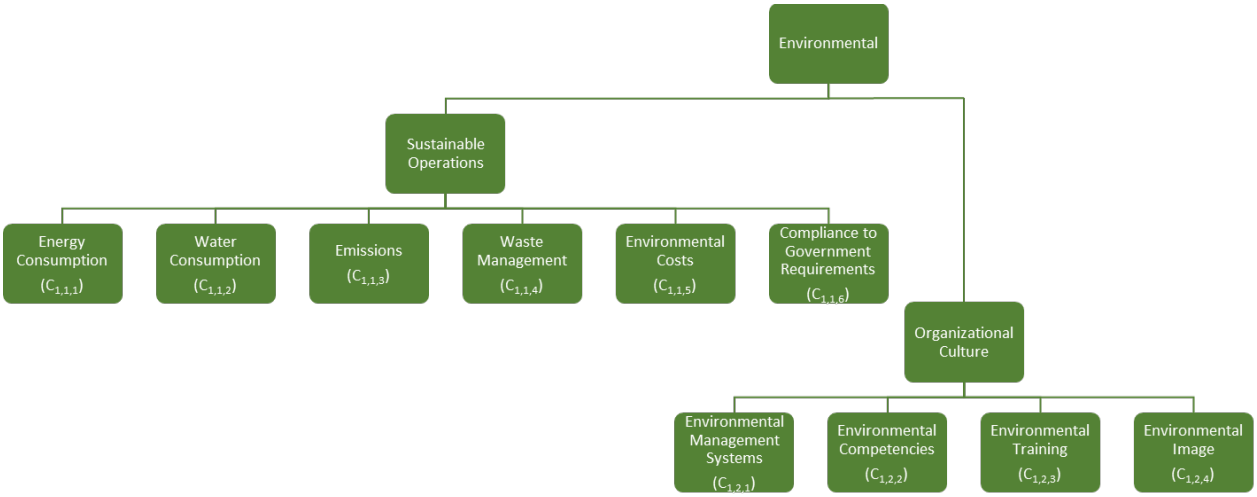


Table 4

Environmental Critical Success Factors (CSFs) with Subfactors and Description

Critical Success Factor & Subfactors	Description
Energy Consumption ($C_{1,1,1}$)	
Production	Amount of energy consumed through the production of finished goods or delivery of services
Transportation	Amount of energy consumed through the transportation of materials, WIP, and finished goods
Building Operations	Amount of energy consumed through indirect operations (e.g., refrigeration, heating, lighting, fans, pumps, equipment)
Energy Mix	Use of green energy in place of or in addition to traditional energy sources and fossil fuels
Water Consumption ($C_{1,1,2}$)	

Production	Amount of water consumed through the production of finished goods or delivery of services
Building Operations	Amount of water consumed in commercial and production locations (e.g., restrooms, kitchens, heating & cooling, landscape irrigation)
Water Management System	Clearly defined water management system to maximize efficiency of water-use and minimize damage to the environment
Emissions ($C_{1,1,3}$)	
Scope 1 Emissions	Direct greenhouse emissions from operations
Scope 2 Emissions	Indirect greenhouse emissions related to the acquisition of energy (e.g., heating, cooling, electricity)
Scope 3 Emissions	Emissions from indirectly related activities (activities not owned or controlled by the organization) throughout the value chain (e.g., partners, suppliers, customers upstream and downstream)
Waste Management ($C_{1,1,4}$)	
Waste Minimization	Minimization of product waste through the supply chain including overproduction, over-processing, rework, inventory waste, and idle time
Packaging	Minimization of packaging through the supply chain and for finished products; use of biodegradable or reusable materials
Product Recovery	Facilitation of recycling, reuse, refurbishing, and remanufacturing of materials or finished goods
Reverse Logistics	Collection of used or discarded goods/materials - for product recovery (as above) or safe discard
Hazardous Waste & Contamination	Minimization of hazardous waste and risk of contamination
Environmental Costs ($C_{1,1,5}$)	
Sequestration	Overall cost of offsetting or sequestering exiting pollution
Direct Environmental Costs	Level of capital allocated to environmental projects and efforts (internal)
Environmental Investments	Level of capital invested in external green projects, firms, and activities that benefit the environment
Compliance to Government Requirements ($C_{1,1,6}$)	
Iso 14001 Certification	Achievement of this environmental management certification
Iso 9000 Certification	Achievement of this quality management certification
Epa/Rcra Non-Compliance Violations	Number and extent of EPA/RCRA non-compliance violations or fines
Environmental Management System ($C_{1,2,1}$)	

Environmental Policy	Clearly defined environmental policy in effect across business operations including planning, implementation, and evaluation
Management Commitment	Top-level management committed to environmental policies and practices
Supplier Evaluation	Consistent evaluation of suppliers' environmental policies and practices
Environmental Competencies ($C_{1,2,2}$)	
Knowledge, Talent & Capacity	Organization has existing knowledge, talent and capacity to reduce environmental impact and operate green; employees equipped and empowered to make sustainably driven decisions in their roles
Materials & Technologies	Environmentally sustainable materials and technologies used in production or operations
Environmental Training ($C_{1,2,3}$)	
Internal Training & Best Practices	Training and knowledge sharing exists across all levels of the organization, executed effectively within the organization (including across teams, functions, and locations)
Supplier Training & Best Practices	Training and knowledge sharing exist, executed effectively with suppliers and external partners
Environmental Image ($C_{1,2,4}$)	
Partnerships	Partners with environmentally friendly or "green" organizations
Stakeholders	Stakeholders or shareholders perceive the organization as environmentally conscious
Consumers	Able to retain or hold positive image with environmentally conscious consumers

3.1.2 Social & Governance

Following a TBL approach, social criteria should also be considered in evaluating supplier sustainability. This social aspect can be further broken down into three areas – people, health & safety, and corporate social responsibility. An initial set of social critical success factors was selected, as shown in Figure 2. Table 5 includes a description of social critical success factors and subfactors.

Figure 2

Social Critical Success Factors (CSFs)

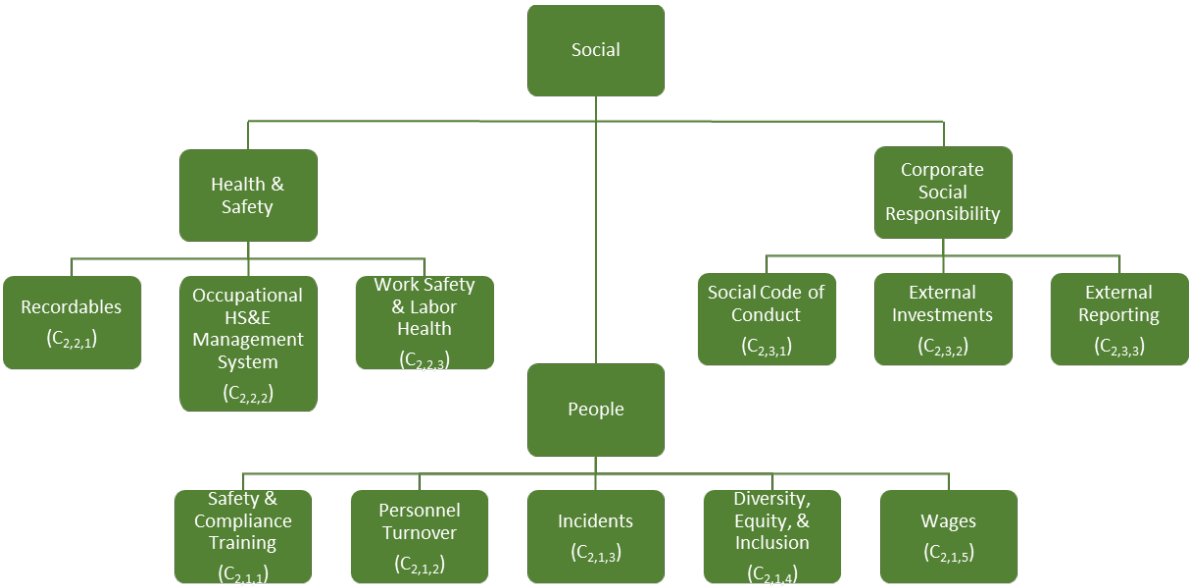


Table 5

Social Critical Success Factors (CSFs) with Subfactors and Description

Critical Success Factor & Subfactors	Description
Safety & Compliance Training ($C_{2,1,1}$)	
Employee Training	Average required training time per employee
Contractor Training	Average required training time for contracted personnel
Training Frequency	Frequency of training (e.g., once per year, quarter)
Additional Training	Availability and accessibility of optional training and development programs
Personnel Turnover ($C_{2,1,2}$)	
Employee Turnover	Annual employee turnover
Contractor Turnover	Annual turnover for contracted labor
Management Turnover	Annual employee turnover for management positions
Incidents ($C_{2,1,3}$)	
Harassment, Discrimination, or Bullying	Annual number of recorded incidents
Workplace Violence	Annual number of recorded incidents, including criminal intent (e.g., physical security breaches or other attacks), ideological violence (e.g., terrorist attack)

	customer/client, worker-to-worker, and personal/domestic violence
Complaints	Annual number of recorded complaints (employee, client and customer complaints)
Diversity, Equity, & Inclusion ($C_{2,1,4}$)	
Gender	Gender diversity targets and quotas set and measured against
Race	Race diversity targets and quotas set and measured against
Age	Age-diverse and age-inclusive workforce
Non-Discrimination	Non-discrimination policies and procedures set and followed
Fair Wages ($C_{2,1,5}$)	
Wages	Compliant with relevant international, federal, state, and local minimum wage laws
Equitable Wages	Equitable wages and compensation - internally (no discrimination across roles, race, or gender), externally (aligned with industry and competitors), individual (in-line with individual performance)
Recordables ($C_{2,2,1}$)	
Recordable Employee/Contractor Accidents	Annual number of recordable accidents (e.g., serious injuries, medical treatment, loss of consciousness, fatalities time of work, restricted work/job transfer)
Occupational HS&E Management System ($C_{2,2,2}$)	
HS&E Management System	Health Safety and Environment Management System in place for managing health and safety in the workplace
HS&E Compliance	Compliant with international federal/state, and local hazard-specific safety and health standards; number and extent of non-compliance violations or fines (e.g., OSHA violations)
Workplace Safety & Labor Health ($C_{2,2,3}$)	

Employment Practices	Standards, policies, and procedures in place to protect worker's health and safety
Contract Labor	Percent of labor contracted; adherence to regional and local contract labor laws
Child Labor	No presence of child labor; adherence to regional and local child labor laws (e.g., US Fair Labor Standards Act)
Forced Labor	No presence of forced labor; adherence to regional, local, and trade related forced labor laws (e.g., Charter of Fundamental Rights of the European Union)
Social Code of Conduct ($C_{2,3,1}$)	
Code of Conduct	Established code of conduct covering social responsibility & social sustainability
External Investments ($C_{2,3,2}$)	
Social Projects	Spend (monetary, employee time) & impact of external investments in social projects, organizations, and campaigns; political contributions
External Reporting ($C_{2,3,3}$)	
External/Public Reporting	Proper external financial reporting on a periodic basis; Compliant with public reporting requirements (e.g., SEC requirements); Discloses relevant business and financial information to the public
Corporate Responsibility	Corporate Social Responsibility policies, commitments and investments are communicated externally; publishes an annual corporate social responsibility report to communicate efforts and impact on the environment and community
Information Disclosure	Discloses facts and information to the public to inform customers, investors, and analysts

3.1.3 Economic

Finally, economic critical success factors – both internal (e.g., an organizations' financial performance) and external (e.g., environment and market conditions) – were identified (see Figure 3). Table 6 provides a description of each economic critical success factor and the related subfactors.

Figure 3

Economic Critical Success Factors (CSFs)

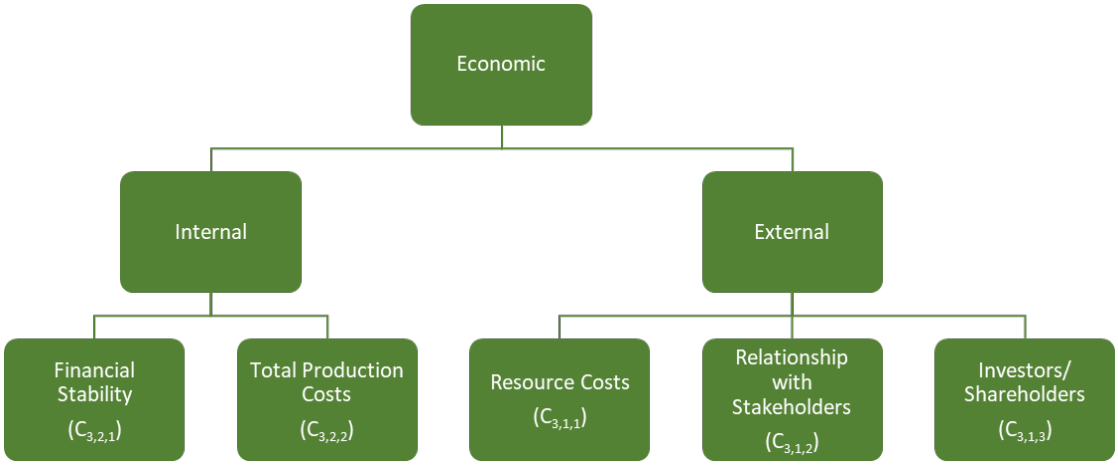


Table 6

Economic Critical Success Factors (CSFs) with Subfactors and Description

Critical Success Factor & Subfactors	Description
Resource Costs ($C_{3,1,1}$)	
Raw Materials	Costs of acquiring raw materials for the production of finished goods or delivery of services
Other Resources	Costs of other resources required for the production of finished goods or delivery of services (e.g., additives, catalysts, coolants)
Transaction Costs	Costs of making a transaction, including planning, analysis, fees, invalid or incomplete orders
Stakeholder Relationship ($C_{3,1,2}$)	
Relationship with Stakeholders	Strength of relationship and level of engagement with stakeholders
Influence of Stakeholders on Operations	Degree of influence (financial power, political power, voting rights) that stakeholders have over business operations

Investors/Shareholders ($C_{3,1,3}$)	
Investors/Shareholders	Type and number of investors or shareholders
Financial Stability ($C_{3,2,1}$)	
Overall Financial Stability	Financial stability of the individual firm, industry, local markets, and currency
Credit	Credit standing (ability to secure loans, raise capital, and make transactions)
Total Production Costs ($C_{3,2,2}$)	
Direct Production Costs	Direct costs from production of finished goods or delivery of services
Indirect Operations & Overhead	Indirect costs from operations (e.g., refrigeration, heating, lighting, fans, pumps, equipment)
Transaction Costs	Costs of making a transaction, including planning, analysis, fees, or commissions (e.g., purchase fees, brokers fees, sales commissions), refunds and returns

3.2 Analytical Hierarchy Process

The primary methodology for this study is Analytical Hierarchy Process (AHP). The majority of literature discussing the AHP methodology references Saaty (1980). AHP is a commonly used technique to quantify qualitative metrics through pairwise comparisons (Yan, 2009). In this study, comparisons were made across the criteria selected to determine the ranking of environmental, social, and economic critical success factors (CSFs). This section details the four key steps used to conduct the AHP analysis.

Step 1. Develop pairwise comparisons across each set of features or CSFs.

Pairwise comparisons are used to determine the relative importance of each factor $\left(X_{kj}\right)$ by calculating non-numeric categories (e.g., equally important, somewhat more important, significantly more important) to integers (*AHP Approach - an Overview | ScienceDirect Topics*, n.d.). The relative importance of factor C_k to factor C_j is denoted by X_{kj} and C_j with respect to C_k is set as the reciprocal $\left(X_{kj} = \frac{1}{X_{kj}}\right)$, developing a reciprocal matrix (*AHP Approach - an Overview | ScienceDirect Topics*, n.d.).

Step 2. Calculate and normalize the criteria weights using the eigenvector method (Wang et al., 2017).

The eigenvector, viz. relative value vector (RVV), is calculated by multiplying the entries in each row by each other and taking the *n*th root of each of those products. The eigenvector is normalized by taking the *n*th root, so the eigenvector factors sum up to one.

Step 3. Find the λ_{max} value.

λ_{max} is calculated by summing the products of the eigenvector values and criteria weights. For example, the first element within the matrix is multiplied by the row one eigenvector value, the second element in that row is multiplied by the row two eigenvector value, and so on for each row. These products are then summed together, resulting in a single value for each row of the reciprocal matrix. If the matrix consisted of five rows, for example, there would be five values after these calculations are completed. Each of these values is then divided by the corresponding eigenvector value. The resulting numbers are summed to calculate the λ_{max} value.

Step 4. Calculate the Consistency Index, which is found using $\left(\frac{\lambda_{max}-n}{n-1}\right)$(Coyle, 2004).

An expected Consistency Index is identified from Saaty's random matrix (as displayed in Table 7) based on the number of features in the reciprocal matrix (Saaty, 1980). The calculated Consistency Index is divided by Saaty's CI and the resulting Consistency Ratio is used to determine if the level of consistency is acceptable.

Table 7

Consistency Index for Random Judgements

n	1	2	3	4	5	6	7	8	9	10	11	12	13
Expected CI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.42	1.45	1.49	1.51	1.48	1.56

Assuming the Consistency Ratio is less than 0.10 (10%), the AHP analysis can be accepted and final conclusions drawn from the results.

3.3 Avetta Survey Data

In addition to a detailed literature review, Avetta's historical supplier responses to sustainability-related survey questions were analyzed for current trends and supplier practices, enabling a more practical approach to identifying sustainability success factors and evaluating supply chain sustainability.

Starting in 2019, Avetta began surveying its supplier base on sustainability-specific questions, collecting nearly seven million responses from over 32,000 suppliers (Indy Chakrabarti (Chief Strategy & Marketing Officer, Avetta), personal communication, October 13, 2021). For this research, twenty relevant survey questions – twelve focused on social factors and eight on environmental impact – across five independent surveys were identified and selected. The twenty questions in scope are displayed in Appendix A.

Supplier responses to these questions were extracted from Avetta's system. The data was cleaned (e.g., checking for duplicate responses, null values) and vetted for inconsistencies. The final data set consists of three years of responses, 2019 to 2021, from 25,000 suppliers across many client connections.

During exploratory data analysis, Cronbach's alpha was calculated to validate that responses were consistent (and not randomly selected answers, for example). Cronbach's alpha is a measure of internal consistency that is often used to confirm the validity of survey responses (Vaske et al., 2017). According to Vaske et al. (2017), the general formula for calculating Cronbach's alpha is:

$$\alpha = \frac{N}{N-1}\left(\frac{\sigma_x^2 - \sum_{i=1}^{N}\sigma_{Y_i}^2}{\sigma_x^2}\right)$$

N = the number of survey items in the scale

σ_x^2 = the variance of the observed total scores

$\sigma_{Y_i}^2$ = the variance of item *i* for person *y*

Alpha measures how much of the variance within the survey response set is consistent, or essentially computing correlation of each survey item to its observed total score as compared to the variance across scores (Vaske et al., 2017).

Expert opinion was collected using an independent questionnaire to supplement the research found through the literature review and insights from the empirical data analysis. Sustainability experts, including Avetta ESG managers, external sustainability consultants, and MIT CTL (Center for Transportation and Logistics) faculty and researchers, were asked to indicate the importance of common environmental, social, and economic sustainability critical success factors. For each Triple Bottom Line (TBL) component (environmental, economic, and social), questions covered a scaled rating (one to five) of the importance of specific critical success factors plus a ranking of the five industries of focus based on importance (see Appendix B for the full questionnaire).

Chapter 4 Analysis & Findings

This chapter presents the process and results of the Analytical Hierarchy Process (AHP) analysis for each component of the Triple Bottom Line (TBL) – environmental, social, and economic. Then, it presents the analysis and findings from data collection and preparation of empirical data sources, including Avetta's historical supplier responses to survey questions and the output of the independent expert questionnaire.

4.1 AHP Analysis

Six expert opinions were collected and used to conduct the AHP analysis for each of the TBL components (environmental, economic, and social), following the four steps described in Section 3.2 Analytical Hierarchy Process. The scores for subfactors were averaged to determine the overall critical success factor score and compared to create a relativity matrix. The mode was considered as a reference in the event of equivalent ratings across multiple factors. The final rankings of the critical success factors are presented with business insights presented in Chapter 5 Discussion.

4.1.1 Environmental AHP Analysis

The initial comparison matrix for environmental critical success factors (CSFs) is presented in Table 8. The criteria weights were assigned based on expert opinion collected through the questionnaire. Where necessary and relevant, expert opinion was validated or supplemented with judgment and intuition, primarily from previous research, industry knowledge, and the underlying scope of research. Thirty-one environmental subfactors were included in the questionnaire and consolidated into ten primary critical success factors for the purpose of the AHP analysis. The ten environmental CSFs (as displayed in Table 4 in Section 3.1.1 Environment) were ranked beginning with the factor with the greatest relative importance, shown in Table 10. The AHP analysis resulted in equivalent rankings for several factors. For example, Emissions, Environmental Management System, and Image were all ranked as most important.

Table 8

*AHP Pairwise Comparison Matrix for Environmental CSFs**

	$C_{1,1,1}$	$C_{1,1,2}$	$C_{1,1,3}$	$C_{1,1,4}$	$C_{1,1,5}$	$C_{1,1,6}$	$C_{1,2,1}$	$C_{1,2,2}$	$C_{1,2,3}$	$C_{1,2,4}$
$C_{1,1,1}$	1	1	1/3	1/3	1	3	1/3	1	1	1/3
$C_{1,1,2}$	1	1	1/3	3	1	3	1/3	1	1	1/3
$C_{1,1,3}$	3	3	1	5	3	5	1	3	3	1
$C_{1,1,4}$	3	1/3	1/5	1	1/3	1	1/5	1/3	1/3	1/5
$C_{1,1,5}$	1	1	1/3	3	1	3	1/3	1	1	1/3
$C_{1,1,6}$	1/3	1/3	1/5	1	1/3	1	1/5	1/3	1/3	1/5
$C_{1,2,1}$	2	3	1	5	3	5	1	3	3	1
$C_{1,2,2}$	1	1	1/3	3	1	3	1/3	1	1	1/3
$C_{1,2,3}$	1	1	1/3	3	1	3	1/3	1	1	1/3
$C_{1,2,4}$	3	3	1	5	3	5	1	3	3	1

**Column and row headers correspond to CSFs as abbreviated in Table 4 Environmental Critical Success Factors (CSFs) with Subfactors and Description in Section 3.1.1 Environment*

For the purpose of this study, the AHP was conducted on a scale of one to nine using odd numbers for simplicity, as shown in Figure 4 with the relative importance $\left(X_{kj} = \frac{1}{X_{kj}}\right)$ set as the reciprocal (*AHP Approach - an Overview | ScienceDirect Topics,* n.d.). Based on the results of the expert questionnaire, there were no dominant criterion of very strong or extreme importance relative to the other criteria.

Figure 4

Scale of Relative Importance

Intensity of Importance	Definition
1	Equal importance
3	Moderate importance
5	Strong importance
7	Very strong importance
9	Extreme importance

When comparing C_k relative to C_j, five indicates that *k* has a greater relative importance, three indicates a slightly greater relative importance, and one indicates equal importance. In Table 8, $CSF_{1,1,1}$ (Energy Consumption) was deemed "somewhat more important" than $CSF_{1,1,2}$ (Water Consumption), for example.

$CSF_{1,1,1}$ as compared to $CSF_{1,1,2}$ was assigned a three, while the reverse pairing was assigned one-third, as explained in Step 1 of Section 3.2 Analytical Hierarchy Process. The remainder of the pairwise comparisons were completed in the same manner, and the principal diagonal (each factor compared to itself) was populated with ones.

Table 9

AHP Pairwise Comparison Matrix for Environmental CSFs with Eigenvector

CSF	*n*th Root	Normalized
$C_{1,1,1}$	0.71922	0.05861
$C_{1,1,2}$	0.89596	0.07301
$C_{1,1,3}$	2.38976	0.19473
$C_{1,1,4}$	0.44378	0.03616
$C_{1,1,5}$	0.89596	0.07301
$C_{1,1,6}$	0.35624	0.02903
$C_{1,2,1}$	2.38976	0.19473
$C_{1,2,2}$	0.89596	0.07301
$C_{1,2,3}$	0.89596	0.07301
$C_{1,2,4}$	2.38976	0.19473
Eigenvector	**12.27237**	

A new vector was calculated as the sum product of each row of the judgement matrix and the eigenvector, as discussed in Step 2 of Section 3.2 Analytical Hierarchy Process (results shown in Table 9). Per Step 3 of the AHP process, the λ_{max} was then calculated by dividing each component of the new vector of elements by the corresponding eigenvector element and taking an average down the vertical (results shown in Table 10) (Coyle, 2004).

Table 10

AHP of Environmental CSFs through Calculation of λ_{max}

CSF	New Vector	Estimated $\boldsymbol{\lambda_{max}}$
$\mathbf{C_{1,1,1}}$	0.64	11.00
$\mathbf{C_{1,1,2}}$	0.74	10.15
$\mathbf{C_{1,1,3}}$	1.96	10.08
$\mathbf{C_{1,1,4}}$	0.46	12.59
$\mathbf{C_{1,1,5}}$	0.74	10.15
$\mathbf{C_{1,1,6}}$	0.30	10.30
$\mathbf{C_{1,2,1}}$	1.96	10.08
$\mathbf{C_{1,2,2}}$	0.74	10.15
$\mathbf{C_{1,2,3}}$	0.74	10.15
$\mathbf{C_{1,2,4}}$	1.96	10.08
	$\boldsymbol{\lambda_{max}}$	**10.470**

A Consistency Index (CI) was calculated, as described in Step 4 of Section 3.2 Analytical Hierarchy Process. Finally, a Consistency Ratio (CR) was found by dividing the calculated CI by the appropriate value (based on order of the judgement matrix) in Table 7 in Section 3.2 Analytical Hierarchy Process, derived from Saaty's book published in 1980, *The Analytic Hierarchy Process* (Coyle, 2004).

The Consistency Ratio (CR) in this example was obtained 0.035, which is below the 0.1 threshold for randomness in the judgements.

Once the consistency of the AHP data was validated, the AHP results were used to determine a final ranking and draw conclusions for each set of CSFs, which is shared in Table 11.

Table 11

Environmental Critical Success Factor (CSF) Ranking Based on AHP Analysis

Relative Ranking	CSF 1	CSF 2 (if applicable)	CSF 3 (if applicable)	CSF 4 (if applicable)
1	Environmental Management System ($C_{1,2,1}$)	Environmental Image ($C_{1,2,4}$)	Emissions ($C_{1,1,3}$)	-
2	Water Consumption ($C_{1,1,2}$)	Training ($C_{1,2,3}$)	Competencies ($C_{1,2,2}$)	Environmental Costs ($C_{1,1,5}$)
3	Energy Consumption ($C_{1,1,1}$)	-	-	-
4	Waste Management ($C_{1,1,4}$)	-	-	-
5	Compliance to Government Requirements ($C_{1,1,6}$)	-	-	-

4.1.2 Social AHP Analysis

Following the same process as above (and outlined step by step in Section 3.2 Analytical Hierarchy Process), an AHP analysis was conducted on the social CSFs (as presented in Table 5 in Section 3.1.2 Social & Governance). Tables 12 to 14 show the results at each step of the process. Twenty-eight social subfactors were included in the questionnaire and consolidated into eleven primary critical success factors for the purpose of the AHP analysis. The eleven social CSFs were ranked beginning with the factor with the greatest relative importance.

Table 12

*AHP Pairwise Comparison Matrix for Social CSFs**

	$C_{1,1,1}$	$C_{1,1,2}$	$C_{1,1,3}$	$C_{1,1,4}$	$C_{1,1,5}$	$C_{1,1,6}$	$C_{1,2,1}$	$C_{1,2,2}$	$C_{1,2,3}$	$C_{1,2,4}$	$C_{1,2,5}$
$C_{1,1,1}$	1	1	1	1/3	1/5	1/3	1/3	1/5	1/5	1	1/5
$C_{1,1,2}$	1	1	1	1/3	1/5	1/3	1/3	1/5	1/5	1	1/5
$C_{1,1,3}$	1	1	1	1/3	1/5	1/3	1/3	1/5	1/5	1	1/5
$C_{1,1,4}$	3	3	3	1	1/3	1	1	1/3	1/3	3	1/3
$C_{1,1,5}$	5	5	5	3	1	3	3	1	1	5	1
$C_{1,1,6}$	3	3	3	1	1/3	1	1	1/3	1/3	3	1/3
$C_{1,2,1}$	3	3	3	1	1/3	1	1	1/3	1/3	3	1/3
$C_{1,2,2}$	5	5	5	3	1	3	3	1	1	5	1
$C_{1,2,3}$	5	5	5	3	1	3	3	1	1	5	1
$C_{1,2,4}$	1	1	1	1/3	1/5	1/3	1/3	1/5	1/5	1	1/5
$C_{1,2,5}$	5	5	5	3	1	3	3	1	1	5	1

**Column and row headers correspond to CSFs as abbreviated in Table 5 Social Critical Success Factors (CSFs) with Subfactors and Description in Section 3.1.2 Social & Governance*

Table 13

AHP Pairwise Comparison Matrix for Social CSFs with Eigenvector

CSF	*n*th Root	Normalized
$C_{1,1,1}$	0.41277	0.02878
$C_{1,1,2}$	0.41277	0.02878
$C_{1,1,3}$	0.41277	0.02878
$C_{1,1,4}$	1.00000	0.06973
$C_{1,1,5}$	2.42267	0.16892
$C_{1,1,6}$	1.00000	0.06973
$C_{1,2,1}$	1.00000	0.06973
$C_{1,2,2}$	2.42267	0.16892
$C_{1,2,3}$	2.42267	0.16892
$C_{1,2,4}$	0.41277	0.02878
$C_{1,2.5}$	2.42267	0.16892
Eigenvector	**14.34176**	

Table 14

AHP of Social CSFs through Calculation of λ_{max}

CSF	New Vector	Estimated λ_{max}
$C_{1,1,1}$	0.32	11.12
$C_{1,1,2}$	0.32	11.12
$C_{1,1,3}$	0.32	11.12
$C_{1,1,4}$	0.78	11.18
$C_{1,1,5}$	1.88	11.12
$C_{1,1,6}$	0.78	11.18
$C_{1,2,1}$	0.78	11.18
$C_{1,2,2}$	1.88	11.12
$C_{1,2,3}$	1.88	11.12
$C_{1,2,4}$	0.32	11.12
$C_{1,2.5}$	1.88	11.12
	λ_{max}	**11.139**

The Consistency Ratio (CR) found in this example was 0.0092, which is below the 0.1 threshold for randomness in the judgements. The AHP results were then used to determine a final ranking of social CSFs, as shown in Table 15, and draw conclusions presented in Chapter 5 Discussion.

Table 15

Social Critical Success Factor (CSF) Ranking Based on AHP Analysis

Relative Ranking	CSF 1	CSF 2 (if applicable)	CSF 3 (if applicable)	CSF 4 (if applicable)
1	Social Code of Conduct ($C_{2,3,1}$)	Fair Wages ($C_{2,1,5}$)	Work Safety & Labor Health ($C_{2,2,3}$)	External Reporting ($C_{2,3,3}$)
2	Diversity, Equity, & Inclusion ($C_{2,1,4}$)	Recordables ($C_{2,2,1}$)	Occupational HS&E Management System ($C_{2,2,2}$)	-
3	Safety & Compliance Training ($C_{2,1,1}$)	Personnel Turnover ($C_{2,1,2}$)	Incidents ($C_{2,1,3}$)	External Investments ($C_{2,3,2}$)

4.1.3 Economic AHP Analysis

Following the same process as Section 4.1.1 Environmental AHP Analysis (and outlined step by step in Section 3.2 Analytical Hierarchy Process), an AHP analysis was conducted on the economic CSFs (as

presented in Table 6 in Section 3.1.3 Economic). Tables 16 to 18 show the results at each step of the process. Eleven economic subfactors were included in the questionnaire and consolidated into five primary critical success factors for the purpose of the AHP analysis. The five economic CSFs are ranked beginning with the factor with the greatest relative importance.

Table 16

*AHP Pairwise Comparison Matrix for Economic CSFs**

	$C_{1,1,1}$	$C_{1,1,2}$	$C_{1,1,3}$	$C_{1,1,4}$	$C_{1,1,5}$
$C_{1,1,1}$	1	1	3	1/3	3
$C_{1,1,2}$	1	1	3	1/3	3
$C_{1,1,3}$	1/3	1/3	1	1/5	1
$C_{1,1,4}$	3	3	5	1	5
$C_{1,1,5}$	1/3	1/3	1	1/5	1

**Column and row headers correspond to CSFs as abbreviated in Table 6 Economic Critical Success Factors (CSFs) with Subfactors and Description in Section 3.1.3 Economic*

Table 17

AHP Pairwise Comparison Matrix for Economic CSFs with Eigenvector

CSF	*n*th Root	Normalized
$C_{3,1,1}$	1.24573	0.19526
$C_{3,1,2}$	1.24573	0.19526
$C_{3,2,1}$	0.46704	0.07321
$C_{3,2,2}$	2.95418	0.46306
$C_{3,2,3}$	0.46704	0.07321
Eigenvector	**6.37973**	

Table 18

AHP of Economic CSFs through Calculation of λ_{max}

CSF	New Vector	Estimated λ_{max}
$C_{3,1,1}$	0.98	5.04
$C_{3,1,2}$	0.98	5.04
$C_{3,2,1}$	0.37	5.04
$C_{3,2,2}$	2.37	5.11
$C_{3,2,3}$	0.37	5.04
	λ_{max}	**5.055**

The Consistency Ratio (CR) found in this example was 0.012, which is well below the 0.1 threshold for randomness in the judgements. The AHP results were used to determine a final ranking of economic CSFs, as shown in Table 19, and draw conclusions presented in Chapter 5 Discussion.

Table 19

Economic Critical Success Factor (CSF) Ranking Based on AHP Analysis

Relative Ranking	CSF 1	CSF 2 (if applicable)
1	Financial Stability ($C_{3,2,1}$)	-
2	Resource Costs ($C_{3,1,1}$)	Stakeholder Relationships ($C_{3,1,2}$)
3	Investors/Shareholders ($C_{3,1,3}$)	Total Production Costs ($C_{3,2,2}$)

4.2 Data Collection & Preparation

Section 4.2 presents the analysis and findings from the data collection and preparation of Avetta's supplier responses to sustainability questions including consistency validation, environmental and social findings, industry rankings, and a gold standard comparison.

4.2.1 Exploratory Data Analysis on Empirical Data

Avetta's supplier responses to sustainability-related questions (see Appendix A) were analyzed to further explore current supplier sustainability trends and best practices.

First, the reliability of the data needed to be vetted using Cronbach's alpha. Cronbach's alpha is used as a measure of internal consistency with typical minimum acceptable values ranging from 0.65 to 0.80 (Vaske et al., 2017). To be conservative, the minimum acceptable Cronbach's alpha value for this study is 0.8. For this exercise, the data was filtered to include only suppliers that responded to all questions within a given survey. This filtering was done by removing any null values and 'NA' responses which were not relevant for this exercise. Cronbach's alpha was then calculated for each of the multi-question Avetta surveys to

ensure reliability of supplier responses. The calculated Cronbach's alpha values for each of the survey samples are displayed in Table 20.

Table 20

Cronbach's Alpha Values by Survey

Survey Topic	Number of Responses (2021)	Cronbach's Alpha Value
Environmental: GHG Emissions	144	0.817
Environmental: Solid & Water Waste	86	0.939
Social: Modern Slavery & Child Labor	357	0.953
Social: Slavery & Human Trafficking	18,265	0.910

For all surveys, the calculated Cronbach's alpha value was above the minimum value for this study and, therefore, acceptable. Additional exploratory data analysis was then conducted on the sustainability survey response data to identify trends and draw key insights or takeaways.

4.2.2 Environmental & Social Findings

Empirical data analysis conducted on the sustainability survey response data revealed information on supplier sustainability that – in addition to supporting the findings from the AHP analysis – was used to inform managerial insights for Avetta.

For the purposes of the exploratory data analysis, supplier responses to each of the twenty questions selected (see Appendix A) were looked at individually, meaning that there are a different number of responses to each question and specific suppliers may not have answered all questions, even within a given survey. Responses collected from 2019 to 2021 were considered in scope to allow for trending overtime, looking across the three-year period to identify patterns or adoption rate. Supplier trades are self-identified in the dataset and, although suppliers can list multiple relevant trades, only a "primary" trade was considered.

Looking at the eight environmental questions specifically, a few key trends stood out. First, there is a distinct correlation between supplier size and environmental sustainability; large suppliers are out-pacing both medium- and small-sized suppliers almost uniformly over time and across industries. Further extraction and manufacturing suppliers are out-performing suppliers from other industries (including construction, wholesale trade, information, etc.), while construction suppliers appear to be lagging behind the majority. Finally, while some suppliers measure environmental impact (in terms of greenhouse gas emissions, solid waste, and water use from production and operations), roughly half then go a step further to set publicly available reduction targets.

When asked if their organization measures corporate greenhouse gas emissions, 15% of respondents (949 total) answered "yes" in 2021. When asked whether or not those same organizations that measure greenhouse gas emissions also set publicly available targets, however, only 45% answered "yes." A similar pattern can be seen for both solid waste and water use. For solid waste, 10% of respondents (343 total) claim to measure the amount generated from facilities/production, but only 55% of those suppliers set publicly available solid waste reduction targets. Similarly, 12% of suppliers (out of 341) measure total water use, and a further 52% set publicly available water use reduction targets.

For each of these questions, there is a clear correlation between supplier size and measuring environmental impact or setting publicly available reduction targets. Large suppliers (over 500 employees) are outperforming small- (under 50 employees) and medium-sized (50-500 employees) suppliers in this dataset. For example, 51% of large suppliers answered "yes" to measuring corporate greenhouse gas emissions in 2021; only 6% of medium suppliers and 4% of small suppliers answered "yes," however. The charts in Figure 5(a), (b), (c), and (d) further reveal the correlation between supplier size and responses for the environmental questions.

Figure 5

Supplier Responses to Environmental Questions by Supplier Size

Figure 5a – Does your company measure its corporate greenhouse gas emissions?

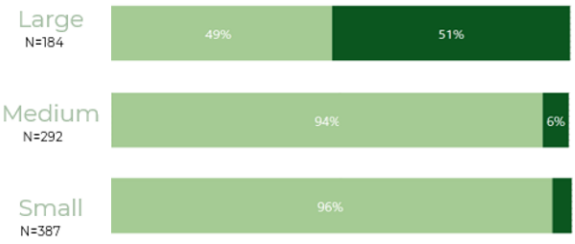


Figure 5b – Does your company set publicly available greenhouse gas emissions reduction targets?

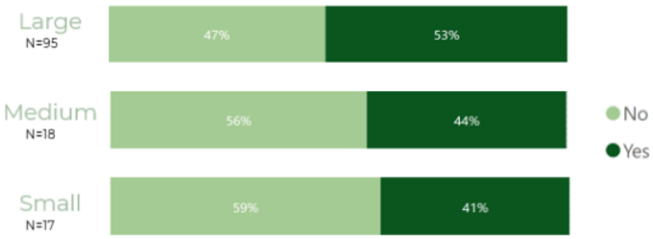
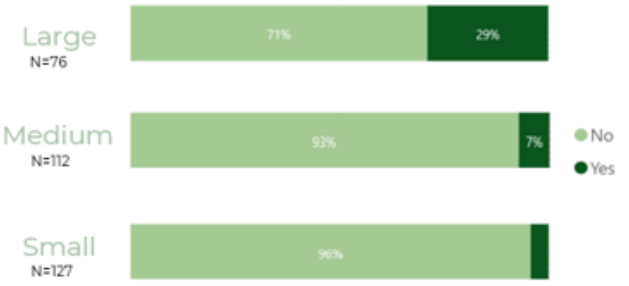


Figure 5c – Does your company measure the total amount of solid waste generated from the facilities that produce your products?

Figure 5d – Does your company measure the total water use from the facilities that produce your products?



Additionally, there appears to be a pattern between supplier trade and environmental sustainability. Extraction and manufacturing suppliers are outperforming other trades in this dataset. Construction suppliers, on the other hand, are lagging behind the majority. Looking specifically at large suppliers, 100% of extraction and 77% of manufacturing measure corporate greenhouse gas emissions, while only 28% of construction suppliers do. A similar pattern can be seen for both solid waste and water use. 50% of large extraction suppliers and 56% of large manufacturing suppliers measure solid waste and total water use from facilities/production, while only 12% of large construction suppliers say the same. One point of

caution on statistical significance to note, the count of supplier responses can be quite small for certain segments when the data is cut by both supplier size and trade.

Looking next at the twelve social sustainability questions, three key trends or insights can again be highlighted. First, retail suppliers appear further along in their social sustainability journey – in terms of underage worker and modern slavery policies, specifically – as compared with suppliers from other trades. Agriculture suppliers, however, appear to be falling behind the majority of the pack – specifically in terms of developing policies prohibiting forced labor and protecting underage workers. Finally (and similar to environmental trends), large suppliers are outperforming small suppliers though there are some exceptions.

In terms of trade, B2B retail suppliers appear further along than other trades. Focusing on modern slavery specifically, 100% of retail suppliers have developed a Slavery and Human Trafficking Statement; the next closest trade at 91% is Construction. However, this should be further vetted given the limited number of retail supplier responses. Retail continues to be in-line with, and even lead, other industries in developing policies around prohibiting forced labor and preventing underage workers in the workplace. Agriculture suppliers, on the other hand, appear to be lagging behind. The charts in Figure 6(a), (b), and (c) illustrate supplier performance by trade for certain social questions.

Figure 6

Supplier Responses to Social Questions by Supplier Trade

Figure 6a – Has your company developed a Slavery & Human Trafficking Statement?

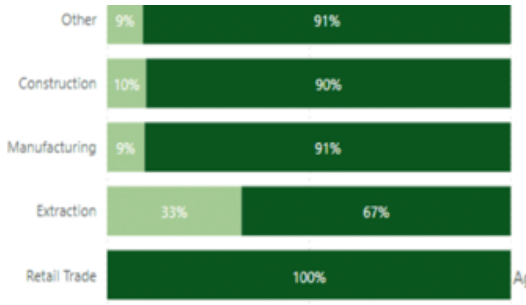


Figure 6b – Does your company have a policy that prohibits forced labor in its various forms (e.g., debt bondage, compelled involuntary overtime, forced prison labor, trafficked labor)?

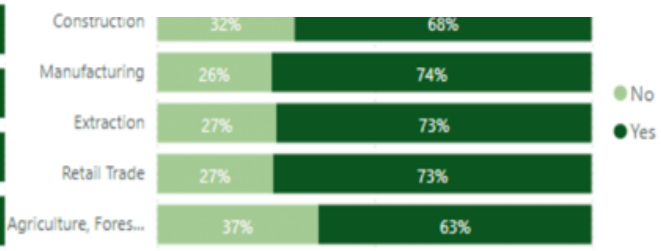
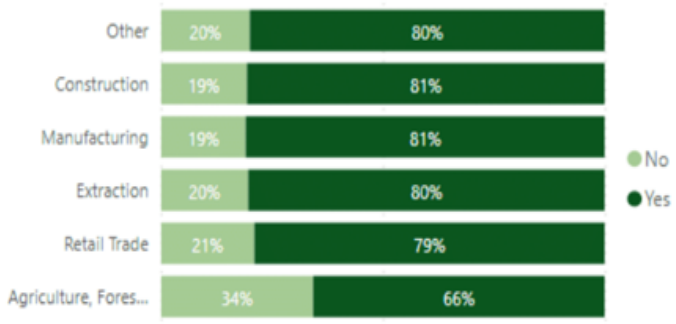


Figure 6c – Does your company have guidelines in place that specify and prohibit tasks which are hazardous or harmful to health, safety, or morals for workers under the age of 18?



Similar to the environmental data, there is a correlation between supplier size and social sustainability; large suppliers are outperforming small suppliers in the dataset. For example, large companies are leading in developing guidelines to protect workers under the age of 18. When asked if the organization had specific policies in place to prohibit tasks that are “hazardous or harmful to health, safety, or morals” for workers under 18, 90% of large suppliers answered “yes,” while only 84% of medium and 78% of small suppliers answered “yes.” Similarly, when asked if the company has developed policies that prohibit forced labor, 87% of large suppliers said “yes”, while only 74% of medium and 67% of small suppliers said “yes”. Surprisingly, the correlation between size and sustainability does not exist when reviewing

responses related to the development of Slavery and Human Trafficking Statements. When asked if the organization has developed a Slavery & Human Trafficking Statement, 88% of large suppliers answered "yes", while 87% of medium and 95% of small suppliers answered "yes".

4.2.3 Industry Rankings

The experts were asked to rank the industries in terms of importance for each category of the Triple Bottom Line (environment, social, economic). The relative importance of each industry was determined using the mode of the responses.

Environmental factors were identified as most important for the extraction and agriculture industries. Therefore, companies within the extraction industry should place a high degree of focus on the top environmental CSFs like emissions, for example, given the high level generated through production processes. The oil & gas industry, included within the category of extraction, has often been subject to criticism because of negative environmental impacts and scandals such as oil spills and fracking (Ahmad et al., 2017). To add complexity, global demand for energy continues to increase though resources are finite. Agricultural processes also require the use of natural resources (e.g., land, water, energy). In fact, 70% of the fresh water withdrawn from rivers, streams and lakes is consumed by agriculture (*Food and Agriculture Organization of the United Nations*, 2011). This high amount of water usage forces a certain level of responsibility onto the agriculture industry to focus on environmental sustainability factors. While the other industries rely on and use certain resources, agriculture and extraction were identified within the expert questionnaire as requiring the highest level of focus on environmental CSFs, which is supported by the intensity with which they consume natural resources in everyday production and processes.

The questionnaire results showed that social and economic factors are most critical for agriculture and manufacturing. Social and economic CSFs, similar to environmental, were identified as being especially critical to the agriculture industry. This is likely because sustainable agriculture requires a high level of

balance across all three components. Agriculture, to be considered sustainable, must be profitable, give a strong quality of life for farmers, provide food for communities, and protect earth's natural resources (Laurett et al., 2021). When considering the manufacturing industry, social factors are extremely important because of the number of past incidents and high-level risk associated with factory and plant conditions. Countries with particularly labor-intensive workplace environments may not have as strict of policies in place or the same level of government control over social standards within manufacturing companies (Awan et al., 2018). In addition to social, economic factors are of high importance for manufacturing firms as they often compete primarily on price or cost efficiency; manufacturers should pay particular attention to their resource and production costs and the impact on overall financial standing.

The questionnaire revealed that experts view retail as having the lowest relative importance for each focus area of TBL. The result is somewhat expected (as retail was being held in comparison with some particularly carbon-intensive, notorious industries), but it is one area that could be investigated further in future research.

For further information, experts were presented with a list of 18 industries or trades (based loosely on the NAICS Industry Codes) and asked more broadly to rank based on the criticality of Triple Bottom Line factors in determining sustainability performance (*SEARCH NAICS CODES BY INDUSTRY*, n.d.). As expected, sustainability experts responded by selecting most of the industries included in the scope of this research – including Agriculture, Forestry, Fishing and Hunting; Manufacturing; Construction; and Extraction (e.g., mining, oil & gas). Agriculture and manufacturing, in particular, were favored by experts. Transportation & warehousing and utilities were also highlighted and could be areas of focus for future research. Retail, however, was not selected by respondents, further reinforcing the initial insight above.

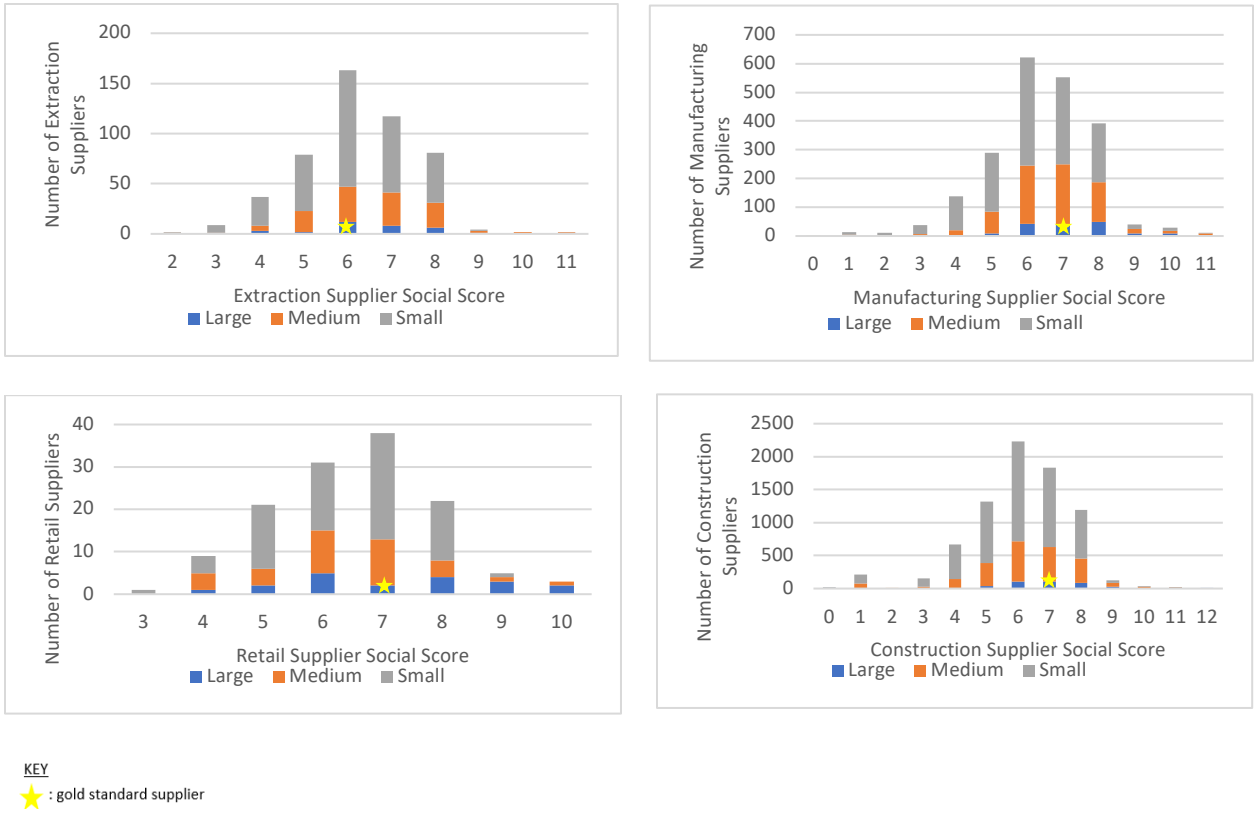
4.2.4 Gold Standard Suppliers

A comparison of sustainability performance across companies was completed by first identifying a gold standard supplier within each industry. The selection for gold standard companies was narrowed down to consider only large companies, since they typically lead their industry in sustainability efforts. The MSCI ESG Index was found for large, well-known suppliers within the Avetta dataset, and those designated as leaders by MSCI were selected to be the gold standard for this analysis (*ESG Ratings & Climate Search Tool*, 2022). Agriculture was excluded from the gold standard comparison because the empirical dataset did not include any large agricultural companies. The analysis also focused primarily on social performance due to a lack of responses related to environmental performance within the chosen subset of data.

To conduct the comparison, social scores were found for each supplier. To do this, the Avetta survey responses were transformed from linguistic to binary form and summed to create scores. An empty response or a response of "No" was considered zero while a response of "Yes" was considered one. The sum of the binary response variables was taken as each company's score. The highest possible scores for social and environmental performance were twelve and eight, respectively. The distribution of social performance scores for each gold standard analysis can be found in Figure 7.

Figure 7

Social Sustainability Scores by Industry



KEY

★ : gold standard supplier

The gold standard for social sustainability within the extraction industry had a score of six, with only 26% of suppliers lagging behind either due to a lack of policies or survey responses. This score indicates that companies in the extraction industry should focus more heavily on developing and implementing policies to prevent modern slavery and protect underage workers. It may also indicate that large companies, while often perceived as leaders in sustainability, still have significant progress to make when it relates to individual policies. Most suppliers within extraction did not respond to the chosen subset of environmental questions, so this is an area that will need to be further explored. The gold standard supplier scored a six based on responses related to the measurement of and reduction targets for greenhouse gas emissions, solid waste, and water waste. While all three are measured, reduction targets

are only published for greenhouse gas emissions and water waste. This may be related to the nature of production within the extraction industry.

The retail gold standard company for social performance scored a seven with 48% of suppliers scoring a six or below. The policies in place that contributed to this score focus on preventing forced labor and modern slavery. The majority of retail suppliers that responded are in-line with the gold standard, indicating that Avetta's retail suppliers overall may be progressing well within the social sustainability space. Retail suppliers could not be assessed on environmental performance due to lack of data collection.

The construction gold standard supplier for social performance scored a seven, with 59% of suppliers scoring below this mark. Based on supplier responses, there is room for improvement within the construction industry especially in relation to the implementation and enforcement of underage worker policies. Construction suppliers could not be assessed on environmental performance due to lack of data collection.

The gold standard company for social performance within the manufacturing industry scored a seven while 52% of suppliers scored a six or below. The majority of suppliers that responded scored a six, showing that many suppliers are only slightly lagging behind the gold standard. Manufacturing suppliers could not be assessed on environmental performance due to lack of data collection.

The MSCI ESG rating and leader classification tool is all encompassing of sustainability factors while the empirical data used in this study was limited to a specific subset of twenty questions. As a result, there were several gaps such as the lack of environmental responses and the potential social factors not included in the social performance evaluation above. Additional data and analysis should be collected to be able to draw more conclusive insights regarding sustainability best practices and leaders.

Chapter 5 Discussion

This chapter focuses on the results of the AHP analysis with further discussion on the ultimate ranking of environmental, social, and economic critical success factors (CSFs). Supplementary information – related research and insights from Avetta's supplier survey responses – was drawn on to provide further insights into the relative rankings of criteria and industries.

5.1 Environmental CSF Conclusions

The environmental CSFs ranked as having the most importance include Environmental Management System, Environmental Image, and Emissions. While these CSFs had equivalent importance scores, the average of the expert responses clearly showed that the presence of an Environmental Management System is most important. In the questionnaire, Environmental Management System encompassed three sub-categories: Environmental Policy, Management Commitment, and Supplier Evaluation. Having an Environmental Management System in place is critical since environmental sustainability initiatives often require support and commitment from top level management and clear policies communicated throughout the organization. This level of internal pressure and support increases the possibility of environmental practices and changes being implemented (Luthra et al., 2016; Ghadge et al., 2019). Having a set policy with which to evaluate supplier's environmental performance is also necessary to be able to maintain alignment and adherence to policies across the supply chain. Environmental Image in this study refers to external partnerships, stakeholder perception, and consumer perception of the company. This is also a critical success factor of top importance as many well-known companies face the risk of value and reputation degradation from negative publicity for poor supply chain sustainability management (Jabbour and Jabbour, 2009). Sustainability related scandals can result in long-lasting impacts on a company's reputation and success. The third of the most important environmental CSFs is Emissions. Emissions had an insignificantly lower average response score than Environmental Management System and Image.

Emissions includes a company's Scope 1, 2, and 3 emissions, which should be measured and monitored to ensure that costs and environmental impact remain low. Emissions are also listed in the GRI G4 sustainability reporting guidelines as a key environmental indicator regardless of industry (Awasthi et al., 2018).

Water Consumption, Training, Competencies, and Environmental Costs were all ranked as slightly less important, but were identified as more important than factors such as Energy Consumption, Waste Management, and Compliance to Government Requirements.

Expert opinion from the independent questionnaire indicates that Compliance to Government Requirements is somewhat less important than the other critical success factors. While experts rated this CSF lower in importance than the others, this may be because adherence to governmental requirements and regulations is a base level expectation for companies and does not indicate performance beyond the legal standards. It is also possible that this factor was rated lower because the consequence for violations can often be a one-time monetary fine versus a CSF such as Environmental Image that has the potential for much broader implications.

5.2 Social CSF Conclusions

The AHP analysis conducted for the social critical success factors resulted in several CSFs ranked with equal importance. The CSFs ranked as having the highest level of importance include Social Code of Conduct, Fair Wages, Work Safety & Labor Health, and External Reporting. Though the modes were equal for the top four CSFs, Fair Wages had the highest average score based on the expert responses. Fair Wages in this case focuses on equitable wages for all employees and compensation based on merit and performance (not subject to any potential discriminatory factors). The use of a social code of conduct was also identified as a CSF of top importance. According to the 2021 State of Sustainability, a social code of conduct is the most common practice firms use to manage sustainability (*State of Sustainability 2021*,

2021); it can be viewed as a baseline requirement for companies committed to social responsibility. Two of the top CSFs, Fair Wages and Work Safety & Labor Health, relate directly to the treatment and conditions of employees. Further, workplace safety is a highly regulated area with clear rules, governing bodies, and potential fines. External Reporting was also ranked with the greatest relative importance. This CSF is broken down further into two subfactors: Corporate Responsibility and Information Disclosure. There are certain reporting requirements that companies must follow in this space, at the federal, regional, and industry level, for example. Transparency for consumers and shareholders is also of high (and growing) importance, so it is expected that this CSF would rank towards the top of the AHP results.

The CSFs ranked of least relative importance were Safety & Compliance Training, Personnel Turnover, Incidents, and External Investments. Incidents, for the purpose of this questionnaire, included workplace violence and complaints. These may have been interpreted by experts as isolated incidents rather than indicators of overall work health & safety culture, and therefore viewed with slightly less relative importance. A consistently high personnel turnover rate and frequent or severe incidents could be indicative of a poor company culture which could be detrimental to long-term social sustainability. However, some turnover is inevitable and even isolated incidents can be expected; the real concern would be a repeated pattern of behavior.

External Investments was also ranked of least relative importance. While an organizations' support of positive social issues, projects, and movements may be important to consumers, there are few tangible negative consequences for a lack of support of external investments. Donating to social justice organizations and taking a firm, public stance on social issues could, however, serve a differentiator for socially sustainable firms. In June 2020, for example, many companies came out with new commitments to combat racial inequality and eradicate systematic racism within their organizations following the murder of George Floyd and subsequent social outrage (*State of Sustainability 2021*, 2021).

5.3 Economic CSF Conclusions

Among economic critical success factors identified for this study, Financial Stability was ranked most important. Intuitively, this result makes sense and is aligned with expectations. Financial Stability, while broad, serves as a comprehensive marker for the overall financial position and economic sustainability of a firm. The subfactors consolidated under this CSF for the expert questionnaire included Overall Stability (e.g., the financial stability of the individual firm, industry, local markets, and currency) and Credit (e.g., credit standing – ability to secure loans, raise capital, make transactions). Both factors would be important indicators of a firm's overall financial health, which is crucial to the ability to survive and grow overtime as well as to invest in and improve on sustainability. However, due to the broad nature of the category, Financial Stability may have been seen by the experts as overlapping with other CSFs, particularly the more quantifiable ones like Resource Costs or Total Production Costs.

Resource Costs and Stakeholder Relations also ranked relatively important. Particularly in the extraction and construction industries, resource costs (and more specifically, cost of raw materials) play a significant role in the financial performance of firms (Petrobras, 2011; Repsol, 2011). For example, crude oil price has a direct impact on the bottom-line of most oil & gas companies, but it can be extremely volatile and sensitive to external factors. Stakeholder Relationships, in the expert questionnaire, was broken down into two subfactors: relationship with stakeholders and influence of stakeholders on operations. The degree of influence (including financial power, political power, and voting rights, for example) that stakeholders have over business operations and strategy has important implications for sustainability (Marzouk and Sabbah, 2021).

Through the AHP analysis and ranking, Investors/Shareholders and Total Production Costs were shown to be the least important among the economic CSFs included in this study. Investors/Shareholders (e.g.., type and number of investors or shareholders) may have been seen by experts as overlapping with

Stakeholder Relationship, or simply viewed as less important in this context. Total Production Costs (including direct production costs, indirect operations & overhead, and transaction costs) could be viewed as somewhat standard across industry or assumed to stabilize over the life-cycle of an organization.

Due to Avetta's specific focus on ESG (Environmental, Social & Governance) and the fact that it mainly employs third-party services for financial auditing, these economic CSFs are probably less relevant than the environmental or social CSFs, at least for the new sustainability service. However, the literature review and expert opinion made it clear that economic factors play an important role in overall supply chain sustainability. Taking a TBL approach and including an economic component allows for the integration of more traditional supplier evaluation metrics (including cost and financial position) (Wang et al., 2017). Furthermore, economic factors can be important indicators of overall sustainability in the long-term (Erol et al., 2011). Where possible, the economic CSFs (and particularly Financial Stability, Resources Costs, and Stakeholder Relationship) should be integrated into sustainable supply chain management.

5.4 Business Insights

Between an Environmental Management System and a Social Code of Conduct, it is clear that established policies and programs are required to promote, evaluate, and ensure sustainability compliance. Visibility, influence, and ultimately control over the environmental and social practices of partners across the supply chain is, inevitably, limited. Organizations committed to supply chain sustainability need to collaborate closely with suppliers when designing and implementing a sustainable supply chain management system – to set expectations, align on best practices, and find synergy.

Organizations also need to be aware of and carefully manage their image. Whether truly green or not (unfortunately), environmental image is a crucial component of how consumers, shareholders, and even suppliers view an organization's commitment to sustainability. It can affect a firm's ability to secure capital, collaborate with desirable partners, and develop and maintain customer loyalty. External

reporting (of progress towards environmental reduction targets, corporate responsibility (e.g., D&I milestones), and audited financial statements) is not only a requirement in many instances but an expectation from third-party partners, shareholders, and consumers alike.

When it comes to the more traditional metrics, organizations should pay particular attention to emissions (including actual emission levels, compliance with regulations, and reduction targets) on the environmental side. Companies must also offer fair and equitable wages to their workforce and maintain workplace safety & labor health. The specific details and requirements of a robust HS&E program will differ significantly by industry and region. To maintain a sustainable image and progress despite increasing pressure from consumers and regulatory agencies, companies should ensure strong baseline policies are in place and seek to expand beyond these traditional metrics.

Finally, even within the context of sustainability, organizations cannot ignore the financial component of the Triple Bottom Line. To manage supply chain risk and flexibility, it is crucial to understand the financial standing of suppliers before entering into long-term contracts and relationships. Supplier payment terms and compliance are an important tool in managing working capital, for example. Financial sustainability – and particularly the financial stability – of partners and suppliers should be considered in any comprehensive evaluation of supply chain sustainability.

Chapter 6 Conclusion

Sustainability is an area of increasing focus in both academia and industry. Consumer preferences and loyalties are changing, investors are integrating sustainability into their portfolios and evaluations, and governments and independent agencies are introducing new regulations. Organizations need the ability to evaluate sustainability performance across the entire supply chain to address this increasing external pressure. Sustainability, however, is a broad topic that organizations, industries, and governments have a vested interest in defining differently. Further, sustainable supply chain management requires transparency and accountability - both ambitious due to increasingly complex and dynamic systems. While sustainability standards, targets, and risks may be simple enough for top management to set, it becomes increasingly challenging to assess and influence the performance of suppliers further upstream. By looking holistically at supply chain sustainability critical success factors across a specific set of industries, this research provides a baseline point of reference for managing supply chain sustainability.

Taking a triple bottom line approach to supply chain sustainability, this research identifies and ranks the key environmental, social, and economic critical success factors that determine supply chain sustainability performance across five key industries (agriculture, construction, extraction, manufacturing, and retail). Selecting a Triple Bottom Line approach allowed for a comprehensive evaluation of supply chain sustainability and related critical success factors (CSFs). Although other frameworks (e.g., Green Supply Chain Management (GSCM), Environmental, Social & Governance (ESG)) can be useful for approaching sustainability and targeting specific areas of concerns, TBL is a uniquely comprehensive framework aligned with all the various components of corporate sustainability (Slaper & Hall, 2020). A thorough literature review was conducted to collect and define common criteria within each of the TBL buckets.

Multi-criteria decision-making, specifically Analytical Hierarchy Process, was employed to compare and ultimately rank the selected critical success factors in terms of relative importance based on the results

of an independent expert questionnaire. This approach was particularly useful in overcoming the complexity and uncertainty of supply chain sustainability in this context. With a growing focus on sustainability across industries (both internal and through external pressure), the environmental, social, and economic critical success factors (CSFs) that were ranked most important through this research should be of top priority for organizations committed to supply chain sustainability.

Results of the AHP analysis were further supported with findings and insights from Avetta's supplier responses to detailed sustainability survey questions. The ultimate ranking of environmental, social, and economic critical success factors (CSFs) – as well as related research and insights – will enable Avetta to tailor their evaluation of supplier sustainability compliance to only the most relevant indicators by industry.

6.1 Limitations & Challenges

The scope of this research was limited to five key industries (agriculture, construction, extraction, manufacturing, and retail), and the final analysis was dependent on the availability and the usefulness of the data.

The five key industries were selected primarily since supply chain sustainability is of particular importance to industry players. Due to limitations in the questionnaire design (e.g., length of questionnaire, scope of participants), the expert opinion collected was not sufficient to support a complete AHP analysis for each individual industry. As a result, one AHP analysis was conducted and one final ranking produced for the environmental, social, and economic critical success factors. Supplementary information from the related literature and the empirical data analysis was used to draw conclusions about how that ranking may apply to or differ across certain industries. Further, expert opinions revealed some variation among the relative importance of each TBL component (environmental, social, and economic) across industries. However,

the variation was, in areas, limited and opinions conflicted. Further research could look to differentiate CSF rankings across industries more explicitly.

The integration of supplier size into the analysis and ranking of critical success factors was also limited. Existing research shows that company size has an impact on supplier sustainability performance and transparency (Horisch et al., 2015; Drempetic et al., 2020; Seroka-Stolka & Fijorek, 2020; *State of Sustainability 2021*, 2021). Across certain topics, the influence of company size is evident in Avetta's suppliers' responses to sustainability questions. Particularly for environmental initiatives, large suppliers appear further along in their sustainability journeys than medium- and small-sized suppliers. For example, large suppliers are more likely to set publicly available greenhouse gas emissions, solid waste, and water use reduction targets. While supplier size was considered to draw conclusions about the relative importance of critical success factors, it was not within scope for the expert questionnaire. One of the challenges outlined in the beginning of this capstone was maintaining visibility across multi-tiered, global supply chains. Understanding how company size specifically impacts each CSF would be important for an organization measuring compliance across its entire supply chain or implementing a sustainable supply chain management program.

6.2 Future Research

Through this research, environmental, social, and economic sustainability critical success factors were identified and ranked. These CSFs are important areas of focus for organizations looking to improve the sustainability of their supply chains, particularly within the five industries of focus. Future applications of this research could expand on the initial selection of criteria to include a more comprehensive set of sustainability factors. Although TBL an appropriate, comprehensive framework for this research, the environmental, social, and economic buckets are broad and require discretion. Financial criteria, in particular, were limited – the literature review was partly biased towards environmental and social

sustainability research due to the scope of the project and key words searched. Further, critical success factors could be focused in specific areas such as safety or (another example?). With a broader criteria set, however, it would be wise to look for and eliminate any correlation or overlap between criterion. An initial MCDM tool (DEA or AHP again, for example) can be used to filter criteria to narrow alternatives in subsequent steps (Wen and Chi, 2010).

While this study initially considered various methodologies, AHP was ultimately used as the basis of analysis. AHP is an effective method for analyzing and ranking qualitative datapoints. However, alternate multi-criteria decision making (MCDM) techniques (e.g., TOPSIS, DEA) as well as empirical models (e.g., EFA, Structural Equation Modeling) can be considered for future research. Though not included in this research, other studies may consider using a fuzzy approach to AHP or other MCDM methodologies, depending on the dataset available.

In creating and tailoring a new ESG offering to best support its clients, Avetta can rely on the highest-ranked CSFs to ensure compliance and evaluate sustainability. As the program progresses and more data is collected, supplier responses to ESG questions – particularly those that map to key critical success factors – should be monitored for adoption and refined as needed to tease out areas of concern. For further analysis, Avetta's existing safety data (also collected via surveying) could be used to make assumptions regarding speed of adoption or other important factors. As this data has been more consistently collected and thoroughly analyzed internally, it could help validate the findings from the sustainability data and indicate trends.

While the results of this study show the relative importance of critical success factors to supply chain sustainability, it does not go as far as to suggest methods for implementing and evaluating sustainable supply chain management (e.g., recommend specific performance metrics or sustainability targets). For certain CSFs used in this study, appropriate metrics may be obvious in application (e.g., $C_{2,3,2}$ External

Investments (U.S. dollars, for example)) or compliance (e.g., $C_{2,3,1}$ Social Code of Conduct (yes if in place, otherwise no)). For other CSFs, metrics and targets would differ drastically across industries, regions, and supplier sizes. Future research in this topic should delve more specifically into the role of industry, region and supplier size in sustainable supply chain management. Organizations must always tailor their supply chain management program and practices to their unique supply chain and individual suppliers in support of supply chain sustainability.

References

Ahmad, N. K. W., de Brito, M. P., Rezaei, J., & Tavasszy, L. A. (2017). An integrative framework for sustainable supply chain management practices in the oil and gas industry. *Journal of Environmental Planning and Management*, *60*(4), 577–601. https://doi.org/10.1080/09640568.2016.1178105

AHP Approach—An overview | ScienceDirect Topics. (n.d.). Retrieved March 8, 2022, from https://www.sciencedirect.com/topics/economics-econometrics-and-finance/ahp-approachs

Avetta Connect™. (2021). Avetta. https://www.avetta.com/platform

Awan, U., Kraslawski, A., & Huiskonen, J. (2018). Understanding influential factors on implementing social sustainability practices in Manufacturing Firms: An interpretive structural modelling (ISM) analysis. Procedia Manufacturing, 17, 1039–1048. https://doi.org/10.1016/j.promfg.2018.10.082

Awasthi, A., Govindan, K., & Gold, S. (2018). Multi-tier sustainable global supplier selection using a fuzzy AHP-VIKOR based approach. *International Journal of Production Economics*, *195*, 106–117. https://doi.org/10.1016/j.ijpe.2017.10.013

Blackhurst, J., Cantor, D., & O'Donnell, M. (2012). *Sustainable Supply Chains: A Guide for Small to Medium-size Manufacturers*. Iowa State University Extension.

Çankaya, S. Y., & Sezen, B. (2019). Effects of green supply chain management practices on sustainability performance. *Journal of Manufacturing Technology Management*, *30*(1), 98–121. http://dx.doi.org/10.1108/JMTM-03-2018-0099

Chiou, C. Y., Hsu, C. W., & Hwang, W. Y. (2008). Comparative investigation on green supplier selection of the American, Japanese and Taiwanese Electronics Industry in China. *2008 IEEE International Conference on Industrial Engineering and Engineering Management*, 1909–1914. https://doi.org/10.1109/IEEM.2008.4738204

Coyle, G. (2004). *Practical Strategy*. Pearson Education Limited.

Domorenok, E. (2018). *In Governing Sustainability in the EU*. Routledge.

Dos Santos, P. H., Neves, S. M., Sant'Anna, D. O., Oliveira, C. H. de, & Carvalho, H. D. (2019). The analytic hierarchy process supporting decision making for sustainable development: An overview of applications. *Journal of Cleaner Production*, *212*, 119–138. https://doi.org/10.1016/j.jclepro.2018.11.270

Drempetic, S., Klein, C., & Zwergel, B. (2020). The Influence of Firm Size on the ESG Score: Corporate Sustainability Ratings Under Review. *Journal of Business Ethics*, *167*(2), 333–360. https://doi.org/10.1007/s10551-019-04164-1

Employer/Union Rights and Obligations. (n.d.). National Labor Relations Board. https://www.nlrb.gov/about-nlrb/rights-we-protect/your-rights/employer-union-rights-and-obligations

Erol, I., Sencer, S., & Sari, R. (2011). A new fuzzy multi-criteria framework for measuring sustainability performance of a supply chain. Ecological Economics, 70(6), 1088–1100. https://doi.org/10.1016/j.ecolecon.2011.01.001

ESG Ratings & Climate Search Tool. (2022). Retrieved April 1, 2022, from https://www.msci.com/research-and-insights/esg-ratings-corporate-search-tool/issuer/target-corporation/IID000000002186212

Food and Agriculture Organization of the United Nations (2011). *The State of the World's Land and Water Resources for Food and Agriculture*. Routledge. https://doi.org/10.4324/9780203142837

Ghadge, A., Kidd, E., Bhattacharjee, A., & Tiwari, M. K. (2019). Sustainable procurement performance of large enterprises across supply chain tiers and geographic regions. *International Journal of Production Research*, *57*(3), 764–778. https://doi.org/10.1080/00207543.2018.1482431

Godwin, S. R. (2017). *Offshore Oil and Gas Industry Safety Culture.* Retrieved October 1, 2021, from https://onlinepubs.trb.org/onlinepubs/trnews/trnews308sr321

Govindan, K., Khodaverdi, R., & Jafarian, A. (2013). A fuzzy multi criteria approach for measuring sustainability performance of a supplier based on triple bottom line approach. *Journal of Cleaner Production*, *47*, 345–354. https://doi.org/10.1016/j.jclepro.2012.04.014

Govindan, K., Rajendran, S., Sarkis, J., & Murugesan, P. (2015). Multi criteria decision making approaches for green supplier evaluation and selection: A literature review. *Journal of Cleaner Production*, *98*, 66–83. https://doi.org/10.1016/j.jclepro.2013.06.046

Handfield, R., Walton, S. V., Sroufe, R., & Melnyk, S. A. (2002). *Applying environmental criteria to supplier assessment: A study in the application of the Analytical Hierarchy Process*. https://doi.org/10.1016/S0377-2217(01)00261-2

Hörisch, J., Johnson, M. P., & Schaltegger, S. (2015). Implementation of Sustainability Management and Company Size: A Knowledge-Based View. *(24*(8)). *Business Strategy & the Environment* (pp. 765–779). John Wiley & Sons, Inc. https://doi.org/10.1002/bse.1844

Industrial relations in Germany. (2019). Etui. Retrieved from https://www.etui.org/covid-social-impact/germany/industrial-relations-in-germany-background-summary-updated-april-2019

Jabbour, A. B. L. S., & Jabbour, C. J. C. (2009). Are supplier selection criteria going green? Case studies of companies in Brazil. *Industrial Management & Data Systems*, *109*(4), 477–495. http://dx.doi.org/10.1108/02635570910948623

Jabbour, C. J. C., de Sousa Jabbour, A. B. L., & Sarkis, J. (2019). Unlocking effective multi-tier supply chain management for sustainability through quantitative modeling: Lessons learned and discoveries to be made. *International Journal of Production Economics*, *217*, 11–30. https://doi.org/10.1016/j.ijpe.2018.08.029

Kaviani, M. A., Yazdi, A. K., Ocampo, L., & Kusi-Sarpong, S. (2020). An integrated grey-based multi-criteria decision-making approach for supplier evaluation and selection in the oil and gas industry. *Kybernetes*, *49*(2), 406–441. http://dx.doi.org/10.1108/K-05-2018-0265

Köksal, D., Strähle, J., & Müller, M. (2018). Social Sustainability in Apparel Supply Chains—The Role of the Sourcing Intermediary in a Developing Country. *Sustainability*, *10*(4), 1039. https://doi.org/10.3390/su10041039

Lamming, R., & Hampson, J. (1996). The Environment as a Supply Chain Management Issue. *British Journal of Management*, *7*(s1), S45–S62. https://doi.org/10.1111/j.1467-8551.1996.tb00147.x

Laurett, R., Paço, A., & Mainardes, E. W. (2021). Measuring sustainable development, its antecedents, barriers and consequences in agriculture: An exploratory factor analysis. *Environmental Development*, *37*, 100583. https://doi.org/10.1016/j.envdev.2020.100583

Laws & Regulations. (2021). United States Environmental Protection Agency. https://www.epa.gov/laws-regulations

Leukhardt, F., & Allen, S. (2013). How environmentally focused is the German sustainability strategy? A critical discussion of the indicators used to measure sustainable development in Germany. *Environment, Development and Sustainability*, *15*(1), 149–166. https://doi.org/10.1007/s10668-012-9380-6

Li, C.-M., & Nie, R. (2017). An evaluating system for scientific mining of China's coal resources. *Resources Policy,* 53, 317–327. https://doi.org/10.1016/j.resourpol.2017.07.01

Liu, B., & Liu, H. (2010). A Research on Supplier Assessment Indices System of Green Purchasing. *2010 International Conference on Measuring Technology and Mechatronics Automation*, *1*, 314–317. https://doi.org/10.1109/ICMTMA.2010.694

Luthra, S., Garg, D., & Haleem, A. (2016). The impacts of critical success factors for implementing green supply chain management towards sustainability: An empirical investigation of Indian automobile industry. *Journal of Cleaner Production*, *121*, 142–158. https://doi.org/10.1016/j.jclepro.2016.01.095

Malesios, C., Dey, P. K., & Abdelaziz, F. B. (2020). Supply chain sustainability performance measurement of small and medium sized enterprises using structural equation modeling. *Annals of Operations Research*, *294*(1–2), 623–653. https://doi.org/10.1007/s10479-018-3080-z

Marzouk, M., & Sabbah, M. (2021). AHP-TOPSIS social sustainability approach for selecting supplier in construction supply chain. *Cleaner Environmental Systems*, *2*, 100034. https://doi.org/10.1016/j.cesys.2021.100034

Miemczyk, J., & Luzzini, D. (2019). Achieving triple bottom line sustainability in supply chains: The role of environmental, social and risk assessment practices. *International Journal of Operations & Production Management*, *39*(2), 238–259. http://dx.doi.org/10.1108/IJOPM-06-2017-0334

Milman A, Short A. 2008. Incorporating resilience into sustainability indicators: an example for the urban water sector. *Global Environmental Change* 18(4): 758–767. https://doi.org/10.1016/j.gloenvcha.2008.08.002

MIT Center for Transportation & Logistics and Council of Supply Chain Management Professionals. *State of Supply Chain Sustainability 2021*. Cambridge, Mass.: MIT Center for Transportation & Logistics. 2021.

Noci, G. (1997). Designing 'green' vendor rating systems for the assessment of a supplier's environmental performance. *European Journal of Purchasing & Supply Management*, *3*(2), 103–114. https://doi.org/10.1016/S0969-7012(96)00021-4

O'Riordan, L., Zmuda, P., & Heinemann, S. (Eds.). (2015). *New Perspectives on Corporate Social Responsibility: Locating the Missing Link*. Springer Fachmedien Wiesbaden. https://doi.org/10.1007/978-3-658-06794-6

OSHA Penalties. (2021). OSHA. https://www.osha.gov/penalties

Petrobras. 2011. “Sustainability Report 2010.” In Corporate Communication/ Social Responsibility/ Sector Management for Guidelines and Practices of Social Responsibility. Rio de Janeiro, Brazil: Petrobras.

Repsol. 2011. Repsol Corporate Sustainability Report. Madrid: Repsol.

Rossi, P., & Krey, N. (Eds.). (2018). Marketing Transformation: Marketing Practice in an Ever Changing World: Proceedings of the 2017 Academy of Marketing Science (AMS) World Marketing Congress (WMC). Springer International Publishing. https://doi.org/10.1007/978-3-319-68750-6

Saaty T L. (1980). The Analytic Hierarchy Process, McGraw Hill, New York.

Safety and health legislation. (2021). European Agency for Safety and Health at Work. https://osha.europa.eu/en/safety-and-health-legislation

SEARCH NAICS CODES BY INDUSTRY. (2018). NAICS Association. Retrieved April 17, 2022, from https://www.naics.com/search-naics-codes-by-industry/

Seroka-Stolka, O., & Fijorek, K. (2020). Enhancing corporate sustainable development: Proactive environmental strategy, stakeholder pressure and the moderating effect of firm size. *Business Strategy and the Environment*, *29*(6), 2338–2354. https://doi.org/10.1002/bse.2506

Slaper, T. F., Hall, T. J. (2011). The Triple Bottom Line: What Is It and How Does It Work? *Indiana Business Review*, 4-8. article2.pdf (indiana.edu)

Union Members—2016. (2017). Retrieved November 4, 2021, from https://www.bls.gov/news.release/pdf/union2.pdf

Union Members—2020. (2021). Retrieved November 4, 2021, from https://www.bls.gov/news.release/pdf/union2.pdf

Vafadarnikjoo, A., Ahmadi, H. B., Hazen, B. T., & Liou, J. J. H. (2020). Understanding Interdependencies among Social Sustainability Evaluation Criteria in an Emerging Economy. *Sustainability*, 12(5), 1934. https://doi.org/10.3390/su12051934

Vaske, J. J., Beaman, J., & Sponarski, C. C. (2017). Rethinking Internal Consistency in Cronbach’s Alpha. *Leisure Sciences*, *39*(2), 163–173. https://doi.org/10.1080/01490400.2015.1127189

Wang, T.-K., Zhang, Q., Chong, H.-Y., & Wang, X. (2017). Integrated Supplier Selection Framework in a Resilient Construction Supply Chain: An Approach via Analytic Hierarchy Process (AHP) and Grey Relational Analysis (GRA). *Sustainability*, *9*(2), 289. http://dx.doi.org/10.3390/su9020289

Was 2018 the year of the influential sustainable consumer? (n.d.). NielsenIQ. Retrieved October 27, 2021, from https://nielseniq.com/global/en/insights/analysis/2018/was-2018-the-year-of-the-influential-sustainable-consumer/

Wen, U. P., & Chi, J. M. (2010). Developing green supplier selection procedure: A DEA approach. *2010 IEEE 17th International Conference on Industrial Engineering and Engineering Management*, 70–74. https://doi.org/10.1109/ICIEEM.2010.5646615

Why Avetta. (2021). Avetta. https://www.avetta.com/supply-chain-network

Wolf, J. (2014). The Relationship Between Sustainable Supply Chain Management, Stakeholder Pressure and Corporate Sustainability Performance. *Journal of Business Ethics*, *119*(3), 317–328. https://doi.org/10.1007/s10551-012-1603-0

Yan, G. (2009). Research on Green Suppliers' Evaluation Based on AHP amp; Genetic Algorithm. *2009 International Conference on Signal Processing Systems*, 615–619. https://doi.org/10.1109/ICSPS.2009.92

Yang, Y.-Z., & Wu, L.-Y. (2008). Extension Method for Green Supplier Selection. *2008 4th International Conference on Wireless Communications, Networking and Mobile Computing*, 1–4. https://doi.org/10.1109/WiCom.2008.1564

Yu, J., & Sun, B. (2010). Research of education evaluation information mining technology based on analytical hierarchy process (AHP) and Genetic Algorithm (GA). *2010 3rd International Conference on Advanced Computer Theory and Engineering (ICACTE)*, *4*, V4-289-V4-292. https://doi.org/10.1109/ICACTE.2010.5579725

Appendix

Appendix A

Avetta Supplier Survey Questions

Survey	**Selected Questions**
Social: Child Labor Laws & Safety	- Does your company have a policy regarding the minimum age for employment that complies with national laws but is no less than 15 years of age? - If a child is found to be working in your company, does your company have a procedure to remove the child from work but protect its well-being and help sustain the family's income? - Does your company check the age of all workers through birth certificates, other official identification, or alternative procedures? - Does your company have guidelines in place that specify and prohibit tasks which are hazardous or harmful to health, safety, or morals for workers under the age of 18?
Social: Slavery & Human Trafficking	- Has your company developed a Slavery & Human Trafficking Statement? - Has your company appointed a senior representative who is responsible for compliance? - Has your company published your annual "Slavery and Human Trafficking Statement?"
Social: Fair Work Hours	- Are staff working hours kept in compliance with local laws and standards, with no regularly scheduled working week in excess of 60 hours (or lower if prescribed by local laws or local industry standards)?
Social: Modern Slavery	- Does your company have a policy that prohibits forced labor in its various forms (e.g., debt bondage, compelled involuntary overtime, forced prison labor, trafficked labor)? - Are all workers free to leave company premises after their shifts?

	- Does your company have employees who work to pay off a debt owed to the company or recruiting agencies? - Does your company require workers to deposit original documents (e.g., travel documents, identity cards) with the company?
Environmental: Greenhouse Gas Emissions	- Does your company measure its corporate greenhouse gas emissions? - Does your company set publicly available greenhouse gas reduction targets? - Does your company report its greenhouse gas emissions to the Carbon Disclosure Project (CDP)? - Please state your greenhouse gas reduction targets.
Environmental: Solid & Water Waste	- Does your company measure the total amount of solid waste generated from the facilities that produce your product(s)? - Does your company set publicly available solid waste reduction targets? - Does your company measure the total water use from the facilities that produce your product(s)? - Does your company set publicly available water use reduction targets?

Appendix B

Expert Questionnaire

<u>Environment</u>

For the environmental factors below, please indicate the importance of each component in determining supply chain sustainability (1 – not at all important; 2 – not very important; 3 – neutral; 4 – somewhat important; 5 – very important).

		Please select importance below.
Energy Consumption		
Production	Amount of energy consumed through the production of finished goods or delivery of services	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important

Transportation	Amount of energy consumed through the transportation of materials, WIP, and finished goods	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Building Operations	Amount of energy consumed through indirect operations (e.g., refrigeration, heating, lighting, fans, pumps, equipment)	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Energy Mix	Use of green energy in place of or in addition to traditional energy sources and fossil fuels	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Water Consumption		
Production	Amount of water consumed through the production of finished goods or delivery of services	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Building Operations	Amount of water consumed in commercial and production locations (e.g., restrooms, kitchens, heating & cooling, landscape irrigation)	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Water Management System	Clearly defined water management system to maximize efficiency of water-use and minimize damage to the environment	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Emissions		
Scope 1 Emissions	Direct greenhouse emissions from operations	

		○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Scope 2 Emissions	Indirect greenhouse emissions related to the acquisition of energy (e.g., heating, cooling, electricity)	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Scope 3 Emissions	Emissions from indirectly related activities (activities not owned or controlled by the organization) throughout the value chain (e.g., partners, suppliers, customers upstream and downstream)	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Waste Management		
Waste Minimization	Minimization of product waste through the supply chain including overproduction, over-processing, rework, inventory waste, and idle time	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Packaging	Minimization of packaging through the supply chain and of finished products; use of biodegradable or reusable materials	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Product Recovery	Facilitation of recycling, reuse, refurbishing, and remanufacturing of materials or finished goods	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Reverse Logistics	Collection of used or discarded goods/materials - for product recovery (as	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important

	above) or safe discard	
Hazardous Waste & Contamination	Minimization of hazardous waste and risk of contamination	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Environmental Costs		
Sequestration	Overall cost of offsetting or sequestering exiting pollution	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Direct Environmental Costs	Level of capital allocated to environmental projects and efforts (internal)	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Environmental Investments	Level of capital invested in external green projects, firms, and activities that benefit the environment	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Compliance to Government Requirements		
ISO 14001 Certification	Achievement of this environmental management certification	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
ISO 9000 Certification	Achievement of this quality management certification	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
EPA/RCRA Non-Compliance Violations	Number and extent of EPA/RCRA non-compliance violations or fines	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Environmental Management System		
Environmental Policy	Clearly defined environmental policy in effect across business operations	

	including planning, implementation, and evaluation	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Management Commitment	Top-level management committed to environmental policies and practices	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Supplier Evaluation	Consistent evaluation of suppliers' environmental policies and practices	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Environmental Competencies		
Knowledge, Talent & Capacity	Organization has existing knowledge, talent and capacity to reduce pollution and operate green; employees equipped and empowered to make sustainably driven decisions in their roles	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Materials & Technologies	Environmentally sustainable materials and technologies used in production or operations	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Environmental Training		
Internal Training & Best Practices	Training and knowledge sharing exists across all levels of the organization, executed effectively within the organization (including across teams, functions, locations)	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Supplier Training & Best Practices	Training and knowledge sharing exist, executed	

	effectively with suppliers and external partners	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Environmental Image		
Partnerships	Partners with environmentally friendly or "green" organizations	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Stakeholders	Stakeholders or shareholders perceive the organization as environmentally conscious	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Consumers	Able to retain or hold positive image with environmentally conscious consumers	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important

Social

For the social factors below, please indicate the importance of each component in determining supply chain sustainability (1 – not at all important; 2 – not very important; 3 – neutral; 4 – somewhat important; 5 – very important).

		Please select importance below.
Safety & Compliance Training		
Employee Training	Average required training time per employee	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Contractor Training	Average required training time for contracted personnel	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Training Frequency	Frequency of training (e.g., once per year, quarter)	

		○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Additional Training	Availability and accessibility of optional training and development programs	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Personnel Turnover		
Employee Turnover	Annual employee turnover	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Contractor Turnover	Annual turnover for contracted labor	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Management Turnover	Annual employee turnover for management positions	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Incidents		
Harassment, Discrimination, or Bullying	Annual number of recorded incidents	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Workplace Violence	Annual number of recorded incidents, including criminal intent (e.g., physical security breaches or other attacks), ideological violence (e.g., terrorist attack) customer/client, worker-to-worker, and personal/domestic violence	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important

Complaints	Annual number of recorded complaints (employee, client and customer complaints)	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Diversity, Equity, & Inclusion		
Gender	Gender diversity targets and quotas set and measured against	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Race	Race diversity targets and quotas set and measured against	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Age	Age-diverse and age-inclusive workforce	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Non-Discrimination	Non-discrimination policies and procedures set and followed	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Fair Wages		
Wages	Compliant with relevant international, federal, state, and local minimum wage laws	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Equitable Wages	Equitable wages and compensation - internally (e.g., no discrimination across roles, race, gender), externally (aligned with industry and competitors), individual (in-line with individual performance)	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important

Recordables		
Recordable Employee/Contractor Accidents	Annual number of recordable accidents (e.g., serious injuries, medical treatment, loss of consciousness, fatalities time of work, restricted work/job transfer)	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Occupational HS&E Management System		
HS&E Management System	Health Safety and Environment Management System in place for managing health and safety in the workplace	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
HS&E Compliance	Compliant with international federal/state, and local hazard-specific safety and health standards; number and extent of non-compliance violations or fines (e.g., OSHA violations)	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Workplace Safety & Labor Health		
Employment Practices	Standards, policies, and procedures in place to protect worker's health and safety	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Contract Labor	Percent of labor contracted; adherence to regional and local contract labor laws	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Child Labor	No presence of child labor; adherence to regional and local child labor laws	

	(e.g., US Fair Labor Standards Act)	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Forced Labor	No presence of forced labor; adherence to regional, local, and trade related forced labor laws (e.g., Charter of Fundamental Rights of the European Union)	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Social Code of Conduct		
Code of Conduct	Established code of conduct covering social responsibility/social sustainability	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
External Investments		
Social Projects	Spend (monetary, employee time) & impact of external investments in social projects, organizations, and campaigns; political contributions	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
External Reporting		
External/Public Reporting	Proper external financial reporting on a periodic basis; Compliant with public reporting requirements (e.g., SEC requirements); Discloses relevant business and financial information to the public	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Corporate Responsibility	Corporate Social Responsibility policies, commitments and investments are	

	communicated externally; Publishes an annual corporate social responsibility report to communicate efforts and impact on the environment and community	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Information Disclosure	Discloses facts and information to public to inform customers, investors, and analysts	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important

Economic

For the economic factors below, please indicate the importance of each component in determining supply chain sustainability (1 – not at all important; 2 – not very important; 3 – neutral; 4 – somewhat important; 5 – very important).

		Please select importance below.
Resource Costs		
Raw Materials	Costs of acquiring raw materials for the production of finished goods or delivery of services	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Other Resources	Costs of other resources required for the production of finished goods or delivery of services (e.g., additives, catalysts, coolants)	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Transaction Costs	Costs of making a transaction, including planning, analysis, fees, invalid or incomplete orders	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Stakeholder Relationship		
Relationship with Stakeholders	Strength of relationship and	

	level of engagement with stakeholders	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Influence of Stakeholders on Operations	Degree of influence (financial power, political power, voting rights) that stakeholders have over business operations	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Investors/Shareholders		
Investors/ Shareholders	Type and number of investors or shareholders	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Financial Stability		
Overall Stability	Financial stability of the individual firm, industry, local markets, and currency	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Credit	Credit standing (ability to secure loans, raise capital, make transactions, etc.)	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Total Production Costs		
Direct Production Costs	Direct costs from production of finished goods or delivery of services	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Indirect Operations & Overhead	Indirect costs from operations (e.g., refrigeration, heating, lighting, fans, pumps, equipment)	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important
Transaction Costs	Costs of making a transaction, including planning, analysis, fees, or commissions (etc. purchase fees,	○ Not at all important ○ Not very important ○ Neutral ○ Somewhat important ○ Very important

	brokers' fees, sales' commissions), refunds and returns	