Digitalization and Management Innovation IV
A. Lau and A.J. Tallón-Ballesteros (Eds.)

doi:10.3233/FAIA250736

Development of a Novel Integrated Ontology-Based ESG Assessment Tool with AI Assistance for SMEs

Adela S.M. LAU[a,b,1], Harry LIU[b], Veronica HUNG[b], Culsin LI[b] and Mars LAM[b]

[a]*Data Science Lab, Department of Statistics and Actuarial Science, School of Computing and Data Science, The University of Hong Kong, Hong Kong*
[b]*ESG Innovations Company Limited*
ORCiD ID: Adela S.M. Lau https://orcid.org/0000-0001-5918-8309
Harry Liu https://orcid.org/0009-0002-4183-6181
Veronica Hung https://orcid.org/0009-0003-3954-9906
Culsin Li https://orcid.org/0009-0005-4920-4076
Mars Lam https://orcid.org/0009-0002-8072-019X

Abstract. Existing environmental, social, and governance (ESG) standards and guidelines are difficult to assess and compare the ESG performance without a standardized and integrated framework. A comprehensive assessment tool is required to integrate these standards and guidelines into a consistent list for assessment; this is especially true for SMEs. The problem arises as to how these ESG standards and guidelines can be connected and interrelated to each other. This paper therefore aims to review the existing ESG standards and guidelines, and to propose an integrated ontology-based ESG assessment tool. The research method involves empirical review, content analysis and pilot testing. The proposed instrument includes three modules of the UN Sustainable Development Group (UNSDG) model, an UNSDG maturity model, and an ESG ontology A questionnaire and a rule-based AI recommendation assistant are developed. The instrument's validity and reliability testing are done with five companies (30 samples). The results indicate that the content validity has values of 0.909 for S-CVR, 0.964 for S-CVI/UA, and 0.982 for S-CVI/Ave. The construct validity has a Pearson's R of 0.7737, convergent validity of 0.983, divergent validity of −0.1, and construct validity of 0.883. The face validity has a Pearson's R of 0.7147 at a confidence level of 95%. The internal reliability has an alpha value of 0.902. Pre-post reliability testing of the instrument shows no significant difference between the two periods ($r=0.965$, $p<0.05$, $N=30$), indicating that the instrument is well designed. The future assessment of the instrument will be extended to 30 company cases and 77 industries.

Keywords. ESG assessment; CMM model, ESG ontology; UNSDG; rule-based system, AI recommender

[1] Corresponding Author: Adela S.M. Lau, Department of Statistics and Actuarial Science, Run Run Shaw Building, The University of Hong Kong, Pokfulam Road, Hong Kong. Email: adelalau@hku.hk
ESG Innovations Company Limited is a HKU startup and spinoff.

1. Introduction

Since 1890, many environmental, social, and governance (ESG) standards and guidelines have been developed in different countries, which relate to carbon emissions, climate risks, responsible investment in sustainability, social health and safety, human rights and intellectual capital, product and consumer quality, data integrity, sustainable finance disclosure, and sustainability accounting. However, there is no unified standard for SMEs, and no clear direction for developing ESG activities. To perform a benchmarking comparison, an AI assistance tool is needed to assist in a systematic assessment across companies for comparison. The objectives of this study are therefore to review different existing standards and guidelines, to develop an ESG ontology for assessment, and to design and validate the instrument. A system architecture for the ontology-based integrated ESG assessment tool will be proposed.

2. Existing Standards and Methods for ESG Ontology

The following sections will discuss the existing ESG standards and guidelines, and related theories for the development of an ESG ontology.

2.1 Existing ESG Standards and Guidelines

There are several well-known standards and guidelines for ESG assessment. The GRI standards are widely recognized for their comprehensive approach to sustainability reporting and are used by numerous national and institutional organizations [1]. They primarily cover environmental and social issues, with some aspects of governance, and reflect a broad range of ESG topics, from environmental impact and labor practices to governance issues. They are also aligned with other common frameworks, such as SASB and TCFD. Some frameworks, such as the ESG reporting guide from HKEX and TCFD, directly reference GRI for alignment. However, this approach focuses only on qualitative disclosures, and most of the disclosures are based on textual information rather than quantitative measurements. The G20/OECD, a broad, global framework focusing on environmental and social issues, has similar problems to those of GRI, as it only provides high-level guidance rather than specific, detailed criteria [2].

The Corporate Sustainability Reporting Directive (CSRD) is an EU regulation, and mandates companies to report on their ESG impacts to promote sustainable practices and investments [3, 4]. It is used to assess a company's sustainability and its internal management's efficacy and ethical practices [5] and provides quantitative measurements covering various industries and sectors. However, it does not narrowly define specific ESG performance metrics but instead focuses on meeting various standards and regulations across European countries. The SFDR, introduced by the European Commission [6], is targeted at financial market participants, and provides unified rules on sustainability-related disclosures with similar problems. It provides quantitative measurements and covers various industries and sectors but does not provide detailed measurement metrics.

The ESG reporting guide and regulations published by HKEX were developed to fill this gap [7]. These regulations cover most governance issues, with detailed definitions of measurement, and were utilized in designing the questionnaire. The HKEX reporting guide requires listed companies to disclose their ESG performance, and provides suitable

regional alignment with global ESG guidelines, integrating ESG considerations into broader corporate governance practices to complement the Corporate Governance Code. Similarly to SASB, the HKEX guide emphasizes materiality, requiring companies to report on the ESG issues that are most relevant to their business and stakeholders. However, the mandatory nature of this guide may lead companies to focus on compliance, with priority given to meeting the minimum requirements rather than pursuing higher standards of ESG performance. In addition, ISSB [8] is included in the HKEX guidelines, which requires a company to assess climate-related risks to their business and opportunities, such as climate-related transition risks, opportunities, and physical risks.

Although specific governance issues are addressed in different frameworks, these are not sufficiently detailed for concrete measurements. In a study by Cort and Esty, a validation procedure was presented for measuring sustainable measurement metrics and timelines [9]. An ontology that integrates all these standards and guidelines was therefore designed in this study, and an ESG questionnaire was developed based on this ontology. The determinants and constricts of the ontology are discussed below.

2.1.1 Environmental Assessment Construct

In the resource-based view theory [10], companies are assumed to gain a competitive advantage by developing unique and valuable resources. ESG initiatives, such as recycling waste, managing hazard waste, and reducing energy and water usage, can improve the operational efficiency and reputation of a company. SECR is a UK government initiative that was introduced in 2019 for large companies and large limited liability partnerships (LLPs) in the UK [11]. It involves actions on energy consumption, greenhouse emissions, and energy efficiency in annual reports, provides quantitative measurement metrics, and covers various industries and sectors. The scope is limited to a few criteria and large enterprises.

TCFD provides a framework for disclosing climate-related risks and opportunities, and emphasizes the importance of governance, strategy, risk management, metrics and targets in regard to understanding and reporting the financial impact of climate change [12]. It covers issues such as emissions, climate change, and supply chain management, and focuses primarily on environmental topics, although it also covers several areas of disclosure, including governance (e.g., climate-related risks and opportunities), strategy, risk management, and metrics and targets. The metrics and targets section focuses on the measurement of specific criteria and how these measurements can be assessed. The other climate risk standard, CPG229 Climate Change Financial Risks, for which a practice guide has been released by the Australian Prudential Regulation Authority (APRA), defines some frameworks for ESG disclosures, and particularly climate change. GRI and SASB cover most of the frameworks proposed by CPG229 [13].

SASB provides industry-specific standards that focus on financially material ESG issues, with 77 standards tailored to different industries. SASB standards typically emphasize quantitative metrics, making it easier to compare ESG performance across companies and industries [14]. This framework also covers environmental and social issues with more fine-grained definitions of measurement metrics. SASB emphasizes materiality, with a focus on the ESG factors that are most likely to impact a company's financial performance. SASB prioritizes the most critical sustainability metrics, leading to more meaningful and actionable ESG insights. However, SASB is less quantifiable aspects of sustainability, such as governance measurement metrics, and less measurement of broader social or environmental impacts.

Finally, the ESG-Related Investment Fund Disclosure from the Canadian Securities Administrators (CSA) does not provide a framework for companies to disclose their ESG performance [15]; instead, it offers practical guidance for investment funds, particularly ESG-related funds, in terms of compiling their regulatory disclosures in a way that is consistent with any ESG-related offerings.

From the above study, we suggest that the determinants for measuring environmental performance are resource management, GHG emissions, environment compliance and opportunities. Energy management, water management, waste management, hazard management, and biodiversity are the determinants for resource management, while GHG emissions and climate risk, environmental standards and measurement are determinants for environmental measurement. Environmental certificates, research and opportunity are the determinants for environmental opportunities.

2.1.2 Social Assessment Constructs

Stakeholder theory states that companies have responsibilities to employees, customers, and communities, beyond simply the company's shareholders [16]. An evaluation of how well these relationships are managed and stakeholder concerns are addressed is an essential aspect of a company's success in ESG development. Product quality and data security are the determinants for customer and product construct. Drawing from Maslow's pyramid of needs theory and motivator-hygiene theory, the major factors affecting employee satisfaction are assumed to be related to hygiene, social needs, and job competence. Thus, staff training, health and safety, and labor diversification are the major determinants for human capital constructs. In regard to improving community relationships, community engagement, investment and charity and social-related certificates can demonstrate the company's community contributions, and are the determinants for community constructs. Hence, the ontology proposed in this study uses these determinants for the community, human capital, and product and customer constructs.

2.1.3 Corporate Governance and Operations Constructs

A successful corporate operation requires a set of ESG guidelines and documentation for staff to follow. As described by agency theory, ESG disclosures provide information asymmetry and promote accountability, thereby overcoming potential conflicts of interest between company management and shareholders [17]. Corporate governance issues, such as shareholder rights, ownership and board disclosure, are essential for ESG disclosures. The involvement of stakeholders in voting enhances corporate governance. In contrast, the supply chain's ability for an ecosystem is the critical success factor for sustainability development [18]. When integrated into supply chain management, ESG processes can be streamlined horizontally, resulting in more effective sustainability development. ESG disclosure has become compulsory under modern regulations, and many companies underestimate the impacts of ESG risks, resulting in the company defaulting [19]. The integration of ESG risks into a company's overall risk management framework is required, as well as the development of strategies to migrate risk and capitalize on ESG opportunities [20]. Hence, in this study, the determinants of board disclosure, ownership, and shareholder rights are used to determine corporate governance performance. Guidelines and documentation, supply chain management, risk

management, and related certificates are the determinants for the corporate operation construct.

2.2 Ontology and AI Methods for ESG Assessment

An ontology is a knowledge representation that allows a set of concepts, relationships, and axioms in a specific domain to be grouped together and stored [21]. A user can apply the concepts and rules in the ontology for knowledge extraction, mapping, reasoning and representation [22]. It provides a controlled vocabulary and framework for communication, data integration, knowledge sharing and exchange between people and systems [23], improves data consistency, and supports information filtering, extraction, collaboration, personalization and decision making [24]. An ontology can be used to integrate the ESG standards and guidelines together into a single format. The attributes of the ontology can be defined by using the ESG standards and guidelines, while the rules of the ontology can be used to group the semantic meanings of the ESG terms or objects together by using controlled vocabulary, term relationships, and hierarchical subclass relationships between classes, properties and constraint specifications in classes. With this ontology, users can extract the required ESG standards by using the semantic rules in the ontology to meet the specific ESG requirements of their clients or suppliers for its sustainability supply chain collaboration [25].

To collect, process, organize and extract information from the ESG ontology, artificial intelligence (AI) can be used to gather and filter the data and communicate the extracted information to users. AI excels in data processing, intelligent decision making, process optimization, and recommendation [25]. Current AI techniques, such as machine learning, data mining, and natural language processing, primarily focus on how computer systems emulate human intelligence, learn, adapt to their environments and enable communication between humans and computers [26]. Researchers have recently used natural language processing and text analysis methods to extract information from annual reports for ESG analysis, and have developed AI chatbots for communicating with users with regard to ESG enquiries [27]. Several rule-based systems have been designed for ESG recommendation and decision making, and data mining methods have been developed for ESG risk forecasting and knowledge discovery [27]. The use of AI improves the efficiency and effectiveness of ESG assessment and ESG prediction. Hence, this study will investigate how AI can be used in the proposed ESG ontology for knowledge integration, filtering and communication.

2.3 Proposed Ontology-Based Integrated ESG Assessment Tool for SMEs

SMEs play important roles in sustainability supply chain management. These companies are vital to the economy in terms of employment, supplier support, production and distribution, sales and marketing, and customer services. They have a major economic impact, and are essential for environmental and social change. Investors and banks prioritize ESG factors as being particularly important for investment or loan approval decision making, and select companies with strong ESG performance for investment or loan approval. The adoption of sustainable practices in order to attract investment or loan approval is a new trend and requirement; customer purchasing behavior has also changed, with customers tending to be more environmentally friendly, with more emphasis being placed on sustainability in their purchasing decisions, thus pushing SMSs to align with these values. Most importantly, there are more local and global regulatory requirements

on ESG for SMEs. The greater numbers of ESG reporting demands and transparency requirements for environmental, social, and governance practices result in an urgent need for SMEs to carry out ESG assessments for reporting. By integrating ESG into an SME's business process, the company can mitigate business risks, improve its reputation, foster innovation, attract capital, and contribute to a more sustainable world. However, the main problems faced by SMEs in terms of ESG development are limited knowledge, skills and resources [28]. In this study, we therefore integrate the key components of the existing ESG standards and guidelines to develop an ESG ontology framework, and use an ontology-based rule-based system to define and relate the integrated ESG knowledge for personalized ESG assessments and decision making.

2.4 UNSDG Goals and the Capability Maturity Model

The UNSDGs include 17 goals that companies must achieve in regard to ESG assessment. These 17 goals represent a globally recognized framework for addressing critical sustainability issues, and will therefore be used in this study to align the activities in our ontology framework for ESG assessment. In addition, to assess the ESG performance of a company, the maturity levels of ESG governance practices will be considered. The capability maturity model (CMM) is a key indicator for organizational performance [29]. This is a traditionally used framework in which a classification of five levels of process maturity guides organizations towards improving their software processes [30]. It provides a roadmap for organizations to enhance their practices by moving from ad hoc processes to more mature and optimized ones that are defined with measurable items. This framework is integral to most management systems for improving the quality of development and delivery for all products and services. In this study, these categories are adopted and revised to classify the performance of a company in terms of maturity in ESG development. A five-level UNSDG-CMM is are defined in our instrument, in which a company moves from building to implementing best practices, standardization and continuous improvement, integration and alignment, and continuous innovation. At each UNSDG-CMM level, an ESG score is calculated based on the results of the questionnaire.

3. Research Methods

Based on the review presented above, an ESG ontology was developed to group together similar ESG components in a unified view. A questionnaire was devised based on this ontology framework for assessing the achievements of the companies in terms of ESG activities. Five companies with 30 samples were selected to form the ESG committee for this pilot study. Content validity, construct validity, criteria validity, face validity, internal reliability testing and pre-post reliability testing were done.

3.1 Development of the ESG Ontology

Figure 1 shows an overview of the integrated ESG ontology based on existing standards and guidelines, in which ESG issues are classified into three categories. The first layer represents the ESG categories, while the second layer shows the ESG areas to be measured, and the third layer represents the ESG assessment components.

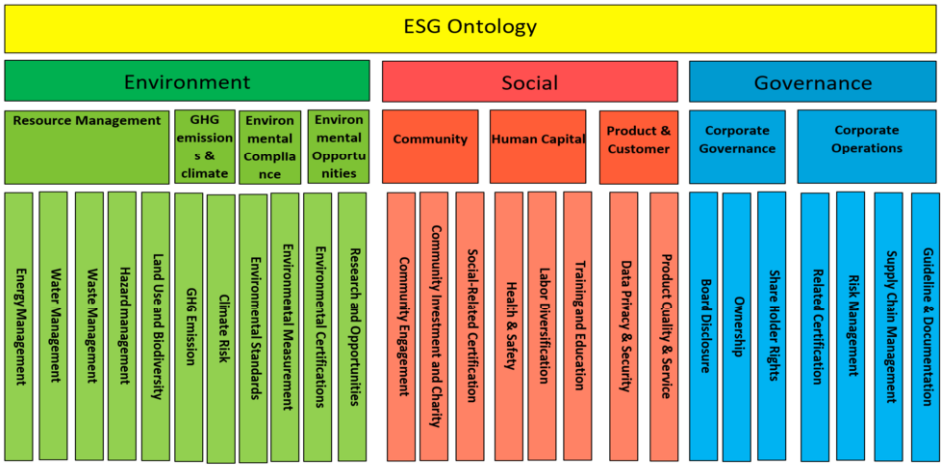

Figure 1. Overview of the integrated ESG ontology.

3.2 Questionnaire Design for the Instrument

To measure these ESG components, a questionnaire was designed based on the above ontology framework and existing ESG guidelines and standards, as shown in the Appendix.

3.3 ESG Score Measurement Methods

Three aspects are measured in this ESG assessment: the UNSDG maturity, achievement of UNSDG goals, and ESG activity performance. To measure the UNSDG maturity performance, an ESG maturity model is developed on this study. To measure how well the ESG activities are being carried out by the company, an ESG ontology is derived from the worldwide ESG standards and guidelines for different countries, and mapped to the 17 UNSDG goals.

- To assess the UNSDG maturity performance, five levels are used, which are quantified by the descriptors in Table x (see Table A.1) to assess the development status of the 17 UNSDG goals (see Table A.2).
- To assess how well the UNSDG goals are being achieved, a set of questions are used to quantify the performance for the 17 goals (see Table A.3). The average of the question scores for each UNSDG sub-target is used to assess whether the sub-target has been achieved, and to provide recommendations. The sub-target score is calculated by averaging the scores for all questions for the sub-target. Each question has a score of either one or zero. The score for each goal is finally calculated by averaging the scores for the sub-targets.
- To assess how well the ESG activities have been carried out to achieve the UNSDG goals, the average score is calculated for all the questions for each ontology component.

3.4 Implementation of AI Rules

Using the proposed ESG ontology and UNSDG sub-targets, the questions are mapped to the UNSDG sub-targets and ESG ontology components. A rule-based system is used to determine the score corresponding to each question for assessment of the ESG ontology scores and UNSDG scores by the experts.

3.5 Validation and Verification of the Instrument

To validate and verify the instrument itself and the content validity, construct validity, criteria validity, and face validity, inter-reliability testing and test-retest reliability testing were done with a confidence level of 95% [31]. For focus group and expert evaluation, the minimal sample size is five [32], while the minimal sample size for a survey is 30 subjects [33].

3.3.1 Content Validity Testing

Purpose: The purpose of content validity testing is to evaluate how well an instrument covers all relevant parts of the ESG construct (i.e., ESG ontology components) it aims to measure.
Sample size: The content validity was tested by five company experts, which is the minimal sample size for expert evaluation.
Sample selection: The inclusion criterion was that the subject had a basic ESG knowledge, whereas the exclusion criterion was that the subject had no ESG knowledge.
Method:
Step 1: Calculate the content validity ratio
The following formula was used to calculate the item content validity ratio (I-CVR) for each question and scale content validity ratio (S-CVR) for the instrument. The critical values for item content validity ratio and scale content validity ratio with five samples were 0.99 and 0.8, respectively. Values closer to one denote a higher content validity.
Item content validity ratio (I-CVR) = (ne − N/2) / (N/2)
where ne = number of SME participants indicating “measurable”
N = total number of SME panelists
Scale content validity ratio (S-CVR) = Mean of (ne/ N)
where ne = number of SME participants indicating “measurable”
N = total number of SME panelists
Step 2: Calculate the content validity index
The following formula was used to calculate the item content validity index (I-CVI) for each question and scale content validity index (S-CVI) for the instrument. The critical value for content validity with five samples is 0.8.
I-CVR = ne / N
where ne = number of SME participants indicating “measurable”
N = total number of SME panelists
The scale-level content validity index based on universal agreement (S-CVI/UA) is calculated by averaging all I-CVR values.

The scale-level content validity index based on average (S-CVI/Ave) is calculated by averaging the averaged item scores for the samples.

3.3.2 Construct Validity Testing

Purpose: Construct validity is used to determine how well the instrument measures the construct that it is intended to measure. There are two types of measurement, called convergent and discriminant validity. Convergent validity measures the extent to which a given measure corresponds to measures of related constructs, whereas discriminant validity measures the extent to which the measure is unrelated or negatively related to measures of distinct constructs.
Sample size: The content validity was tested based on a total of 30 samples from the five pilot companies, which is the minimal sample size for validation of a questionnaire.
Sample selection:
The inclusion criteria were that the subject had over two years of work experience at management level, and had some basic ESG knowledge. The exclusive criteria were that the subject had no ESG knowledge or less than two years of work experience.
Method
Convergent validity
A correlation analysis of the questions was carried out to measure each construct. We calculated the correlation coefficients between the results of the assessment and the results of assessments designed to measure the same constructs. Each correlation coefficient took a value of between −1 and +1. Finally, we took the average of the correlation coefficients. A high average correlation coefficient (i.e., close to +1) indicates high convergent validity, and the cut-off point for an acceptable convergent validity is generally considered to be +0.70.
Discriminant validity
To quantify the discriminant validity, we calculated the correlation coefficients between the results of the assessment and the results of other assessments designed to measure completely different constructs. Each correlation coefficient took a value of between −1 and +1. Finally, we took the average of these correlation coefficients. A correlation coefficient of close to zero indicates high discriminant validity, whereas if the value is close to −1 or +1, then the assessment has very low discriminant validity.
Combining convergent and discriminant validity
The following formula was applied to calculate the construct validity.

$$\text{Construct validity} = \text{Convergent coefficient} - |\text{Discriminant coefficient}|$$

A value close to one indicates very high construct validity, while any value less than 0.5 indicates a limited construct validity. Negative values represent an assessment with very low construct validity.

3.3.3 Criteria Validity Testing

Purpose: Criterion validity evaluates how accurately an instrument measures the outcome it was designed to measure. The criterion variable measures whether it has the same construct, conceptually relevant constructs, and conceptually relevant behavior or performance as similar instruments.
Sample size: The content validity was tested by five company experts through focus group discussion.
Sample selection: The inclusion criterion was that the subject had two years of ESG knowledge. The exclusion criterion was that the subject had no ESG knowledge.
Method: To establish criterion validity in this study, we compared the constructs in the proposed instrument with those of existing standards and guidelines in a comparative

study. In addition, five expert evaluations were done to compare the constructs of our ontology and the existing standards and guidelines.

3.3.4. Face Validity Testing

Purpose: Face validity aims to assess whether the instrument measures what it is intended to measure.
Sample size: The five companies in each case were used to validate whether the instrument could measure the company's ESG performance at the pilot testing stage.
Inclusion criteria for participants:

- General manager (company policy and operation, training, etc.)
- Project director/manager and/or procurement staff (vendor ESG requirement and operation, procurement, etc.)
- Administration staff and/or HR staff (special leave, training, policy, etc.)
- Accounting staff (annual report, profit and loss, paper-related payment, data extraction e.g., funding and donation to in-need community, etc.)
- Marketing staff
- Problem marker/key influencer (if appropriate)

Exclusion criterion for participants: People who were not on the ESG committee for the company.
Method: A focus group discussion was conducted to receive feedback from the five companies (a total of 30 participants) to see whether the instrument could measure what was intended.

3.3.5. Internal Consistency Reliability Testing

Purpose: Internal consistency ensures that each item on a test is related to the topic under research.
Sample size: The content validity was tested using 30 samples, the minimal sample size for questionnaire validation.
Sample selection: The inclusion criteria were that the participant should be an ESG committee member of a company and have at least two years of experience working in the company. The exclusion criterion was that the subject was not an ESG committee member of a company.
Method: The questions or items used to measure a given construct in the ESG ontology are used to measure the same and the difference among the answers. Cronbach's alpha is calculated to give the internal consistency value. A value for Cronbach's alpha of 0.70 or higher is generally considered acceptable for internal consistency
The following formula for Cronbach's alpha was used:

$\alpha = (k / (k - 1)) * (1 - (\Sigma\sigma^2_i / \sigma^2))$:

where α is Cronbach's alpha;

k is the number of items on the test;

$\Sigma\sigma^2_i$ is the sum of the variances for each individual item;

σ^2 is the variance of the total scores on the test.

3.3.6 Test-Retest Reliability

Purpose: The aim of test-retest reliability is to assess the consistency of the measurement instrument by applying the same test to the same individuals at two different times.
Sample size: The content validity was tested with 30 samples, the minimal sample size for questionnaire validations.
Sample selection: The inclusion criteria were that the subject should have over five years of working experience at management level, and some basic ESG knowledge. The exclusion criteria were that the subject had no ESG knowledge or less than five years' working experience
Method: We used the answers from the same responders as in the pre-post pilot testing, with a time interval of one week, to calculate the Pearson's R value. A Pearson's R correlation test with 30 samples (degrees of freedom = 28), the critical value for a one-tailed test at the same significance level, the critical value is 0.306.

4. Results

After the instrument validation and reliability testing was complete, the 88 questions and ontology rules were summarized as given in the Appendix. The following tables present the results for the instrument validation and reliability testing.

4.1 Content Validity

Table 1 presents the content validity testing results.

Table 1. Summary of results for content validity

I-CVR (Item-level Content Validity Ratio)	S-CVR (Scale-level Content Validity Ratio)	I-CVI (Item-Level Content Validity Index)	S-CVI/UA (Scale-level Content Validity Index based on Universal Agreement)	S-CVI/Ave (Scale-level Content Validity Index based on Average)
Critical value > 0.99	Critical value > 0.8	Critical value > 0.8	Critical value > 0.8	Critical value > 0.8
• 80 items have an I-CVR value of one. • Eight items have an I-CVR value of 0.6.	0.909 (80 out of 88)	• 80 items have an I-CVI value of one. • Eight items have an I-CVI value of 0.8	0.964	0.982

4.2 Construct Validity

Pearson correlation was calculated to compare the difference between the scores of the determinants and constructs of the ESG ontology. Table 2 shows that the values of convergent validity, divergent validity, and construct validity are 0.983, −0.1, of 0.883 respectively. Table 3 shows that Pearson's R is 0.7737 at a 95% confidence level.

Table 2. Results of the convergent validity, divergent validity, and construct validity.

Convergent validity	Discriminant validity	Construct validity
0.983	−0.1	0.883

Table 3. t-Test: Results of a paired two-sample test for means for comparison of the overall correlation of the constructs and determinants.

	0.95	*0.74934*
Mean	0.57718	0.592865
Variance	0.09558	0.058164
Observations	25	25
Pearson correlation	0.77377	
Hypothesized mean difference	0	
df	24	
t Stat	−0.40047	
P(T<=t) one-tail	0.34618	
t Critical one-tail	1.71088	
P(T<=t) two-tail	0.69235	
t Critical two-tail	2.0639	

4.3 Criteria Validity

Table 4 shows the results of a gap analysis of the existing standards and guidance for criteria validity testing. Our instrument covered all these ESF issues. In addition, we also introduce environmental, social and government certificates as an assessment criterion to measure the company's ESG performance.

Table 4. Gap analysis of existing ESG standards and guidelines

Construct name	**TCFD**	**CSRD**	**SEC**	**RCGP229**	**SASB**	**HKEX/ ISSB**	**GRI**	**G20/ OECD**	**Our UNSDG-CMM**
Energy management					Yes	Yes	Yes		Yes
Water management	Yes	Yes			Yes	Yes	Yes		Yes
Waste management		Yes			Yes	Yes	Yes		Yes
Hazard management		Yes				Yes	Yes		Yes
Land use and biodiversity					Yes	Yes	Yes		Yes
GHG emission	Yes	Yes	Yes	Yes	Yes	Yes	Yes		Yes
Climate risk	Yes	Yes		Yes	Yes	Yes	Yes		Yes
Environmental standards	Yes	Yes					Yes		Yes
Environmental measurement	Yes		Yes						Yes
Environmental certifications									Yes
Research and Opportunities							Yes		Yes
Community engagement	Yes								Yes
Investment and charity							Yes		Yes
Social-related certification									Yes
Health & safety					Yes	Yes	Yes		Yes
Labor diversification		Yes			Yes	Yes	Yes		Yes
Training and Education		Yes			Yes	Yes	Yes		Yes
Data privacy & security					Yes	Yes	Yes	Yes	Yes
Product quality & service					Yes	Yes		Yes	Yes
Board disclosure		Yes				Yes	Yes	Yes	Yes
Ownership								Yes	Yes

Shareholder rights					Yes	Yes
Related certification						Yes
Risk management	Yes	Yes	Yes	Yes	Yes	Yes
Supply chain management	Yes	Yes	Yes	Yes	Yes	Yes
Guidelines & documentation		Yes	Yes	Yes	Yes	Yes

4.4 Face Validity

Five pilot companies used the instrument to assess their ESG performance, and a focus group discussion was carried out to verify whether the assessment outcomes were aligned with the existing ESG situation in their company. The user satisfaction with the accuracy of the assessment results had a mean value of 0.7147 and standard deviation of 0.0788.

4.5 Internal and Test-Retest Reliability Testing

For internal reliability testing, the value of Cronbach's alpha value was 0.905. Table 5 summarizes the test-retest reliability results with a value for Pearson's R of 0.965 at a confidence level of 95%.

Table 5. t-Test: Paired two-sample for means

	Variable 1	*Variable 2*
Mean	53.1	54
Variance	72.3	81.517
Observations	30	30
Pearson correlation	0.9652605	
Hypothesized mean difference	0	
df	29	
t Stat	−2.081174	
P(T<=t) one-tail	0.0231777	
t Critical one-tail	1.699127	
P(T<=t) two-tail	0.0463554	
t Critical two-tail	2.0452296	

5. Discussion

The proposed ESG instrument was developed by integrating current ESG standards and guidelines. Five companies with 30 samples and similar ESG performance were selected to test the instrument. The following sections present the results for instrument validation and verification.

5.1 Content Validity Testing

The values of S-CVR, I-CVI, S-CVR, S-CVI/UA, and S-CVI/Average were calculated to assess the relevance and clarity of questionnaire items by five company experts. The results for the overall S-CVR, S-CVI/UA, and S-CVI/Average were 0.909, 0.964, and 0.982 respectively, all of which exceed the minimum required threshold of 0.8, thus confirming the overall validity of the scale. A total of 80 out of 88 questions had an I-CVR of one and an I-CVI of one, and for eight out of 88 questions the I-CVR was 0.6, i.e., less than the minimum threshold of 0.99, and the I-CVI was 0.8, i.e., equal to the minimum threshold of 0.8. The eight questions that were unclear were revised to improve the questionnaire. The high value of S-CVI indicates the strong content validity of our instrument.

5.2 Construct Validity Testing

The value of Pearson's R was 0.7737, greater than the critical threshold of 0.7. The value of the convergent validity was 0.983, i.e., greater than the critical threshold of 0.7 and close to one. The value of the divergent validity was −0.1, in other words, close to zero and less than 0.5. The value of the construct validity was 0.883, greater than the critical threshold of 0.7. The results therefore showed that the determinants and constructs have a high positive correlation, supporting the convergent validity of the instrument.

5.3 Criteria Validity Testing

The criterion variable measures whether it has the same construct, conceptually relevant constructs, and conceptually relevant behavior or performance of similar instruments. To establish the criterion validity, we compared the constructions of the instrument with those of existing standards and guidelines via a gap analysis. The criteria for this gap analysis were based on the determinants of the constructed ESG ontology. The comparative table shows that our instrument covers all the major components of the existing ESG standards and guidelines and filling the gaps of those blank items. Our ontology overcomes the limitations of inconsistency and incompleteness of the existing standards and guidelines to provide a unified set of activities that are required to achieve ESG goals.

5.4 Face Validity

The results of the focus group showed that all company representatives agreed that the assessment outcomes were aligned with their company's existing ESG situation. The value for user satisfaction with the assessed results was 0.717 on average. In future work, an additional user satisfaction survey could be done for face validity, in order to assess whether the instrument can measure what it is intended to measure. The companies could also be re-assessed in regard to ESG performance with the existing instrument for comparison. However, the main challenge is that there are no similar instruments to be opened to the public in the market, which results in difficulty in comparison.

5.5 Internal and Test-Retest Reliability Testing

The internal reliability was 0.902, and the test-retest reliability showed no significant difference between the two periods ($r=0.965$, $p<0.05$, $N=30$). These results indicate that the instrument can produce similar results under similar conditions: in other words, the instrument is stable and repeatable and provides consistent measurements. In future work, the interrater reliability could be used to assess the effect of several assessors using the same instrument, to further ensure the consistency and accuracy of the instrument.

5.6 Increased Sample Size in Future Work for Future Instrument Validation

Since the sample size was five companies, whereas the number of SMEs in Hong Kong is 360,000, we conclude that the confidence level of this pilot experiment was 80% and the marginal error was 32% for 50% of the accuracy of the instrument (i.e., unknown

population). In other words, if we randomly select a sample to conduct a survey with the proposed instrument, the accuracy rate will fall between 28% to 82% at an unknown proportion of the population (at true value 50%) of the accuracy of the instrument at a confidence level of 80%.

The acceptable margin of error used by most survey researchers typically falls between 4% and 8% at a 95% confidence level for an unknown proportion of the population (i.e., true proportion of population at 50%) [32,33]. For further tests of the instrument, Table 6 shows the sample size that should be considered in the future based on the expected margin error at a confidence level of 95%, with an SME population size of 360,000 and an unknown proportion of the population (i.e., true value at 50%) [32,33]. Alternatively, a known accuracy rate from previous research could be used to replace the unknown proportion of the population to recalculate the sample size [32,33].

Table 6. Sample size calculations at 95% confidence level for an unknown proportion of the population

Sample size of companies
600
384
150
30

5.7 System Architecture Design and Comparative Advantages over Existing Tools

Figure 2 shows the system architecture for the proposed ontology-based integrated ESG assessment platform. The architecture includes three layers: the ontology application layer, ontology knowledge layer, and ontology data layer. The ontology data layer collects the ESG document and information and provides virtual meeting rooms and an AI chatbot for interaction with users, in order to collect ESG data from company via the e-questionnaire. This layer pre-processes and stores the structured ESG data in the ontology database. The ontology knowledge layer applies statistics, data science, and AI methods to extract the ESG data, and provides rules for reasoning and deducting the ESG knowledge. A text summarization module uses the extracted knowledge for reporting. The ontology application layer creates dynamic ESG reports based on the company's needs. A recommender provides the ESG predictive models and knowledge rules for ESG strategy recommendations. Using Web 6.0 and IoT devices, the ESG activities of the company are monitored and alerts are generated. Since all extracted data are in ontology structure, this allows the user to extract the ESG data dynamically for benchmarking.

The proposed ontology-based integrated ESG assessment platform allows users to flexibly select ESG parameters for measurement based on a company's ESG assessment, needs or standard requirements, which existing ESG assessment tools on the market cannot offer. The ontology defines the ESG definition and rules for ESG measurement and strategy recommendation. The ontology rules used in the system can automatically generate an assessment score and standardize the measurement results. This approach improves the accuracy of the assessment in a comparable format and provides recommendations for ESG reporting and benchmarking. Most importantly, measurement of the ESG could be extended horizontally in future work to supply chain ESG measurements using this ontology architecture, rather than a traditional ESG assessment that uses a vertical approach within the company.

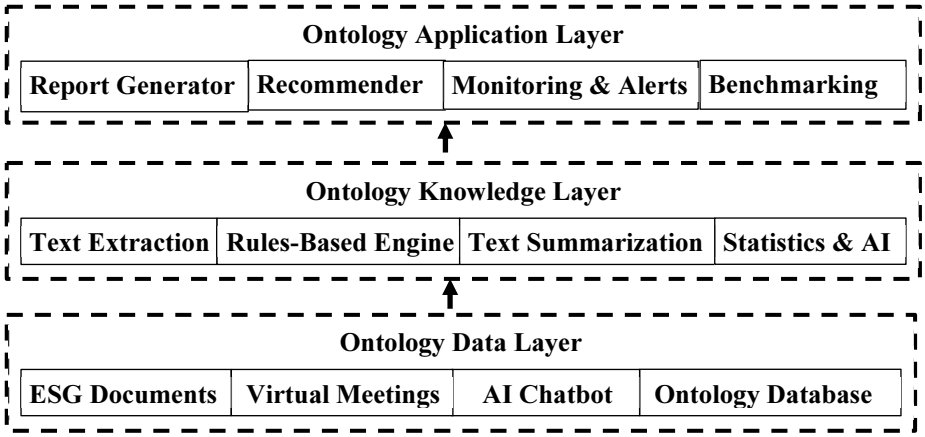

Figure 2. System architecture for the proposed ontology-based integrated ESG assessment platform.

6. Conclusion and Future Work

In this research, an ESG instrument was developed to close the gaps among the current ESG standards from different countries. This represents a novel approach for measuring a company's ESG performance dynamically, based on its ESG requirements. The architecture of the proposed ontology rule-based integrated ESG system demonstrates how an AI tool can be embedded into the ESG assessment process. An AI chatbot was designed to offer an e-questionnaire with AI assistance. A text analysis of company reports and meeting minutes can be conducted to extract ESG-related information for evidence-based measurement. The extracted text and audio-to-text answers can then be analyzed by using AI and mapped to the ESG measurement metrics to automatically generate a report and ESG strategy.

References

[1] Corporate Sustainability Reporting Directive (CSRD). https://finance.ec.europa.eu/capital-markets-union-and-financial-markets/company-reporting-and-auditing/company-reporting/corporate-sustainability-reporting_en.
[2] Global Reporting Initiative (GRI). https://www.globalreporting.org/.
[3] G20/OECD Principles of Corporate Governance 2023 (G20/OECD). https://www.oecd.org/en/publications/2023/09/g20-oecd-principles-of-corporate-governance-2023_60836fcb.html.
[4] Papafloratos T, Fragidis G. Corporate social responsibility (CSR), sustainability and ESG standards used by ATHEX ESG index listed companies. Standards. (2025) 5(2):12, doi:10.3390/standards5020012.
[5] Arora A, Sharma D. Do environmental, social and governance (ESG) performance scores reduce the cost of debt? Evidence from Indian firms. Australasian Accounting Business and Finance Journal. (2022) 16(5):4-18, doi: 10.14453/aabfj.v16i5.02.
[6] Sustainable Finance Disclosure Regulation (SFDR). https://finance.ec.europa.eu/sustainable-finance/disclosures/sustainability-related-disclosure-financial-services-sector_en.
[7] HKEX's ESG reporting guide. https://www.hkex.com.hk/Listing/Sustainability/ESG-Academy/Rules-and-Regulations?sc_lang=en.
[8] Elidrisy A. Comparative review of ESG reporting standards: ESRS "European Sustainability Reporting Standards" versus ISSB "International Sustainability Standards Board" (Comparative Analysis of ESG Reporting Standards). International Multilingual Journal of Science and Technology. 2024;9(3):2528-9810

[9] Cort T, Esty D. ESG standards: Looming challenges and pathways forward. Organization & Environment. 2020;33(4):491-510, doi:10.1177/1086026620945342
[10] Mailani D, Hulu MZR, Simamora MR, Kesuma SA. Resource-based view theory to achieve a sustainable competitive advantage of the firm: Systematic literature review. International Journal of Entrepreneurship and Sustainability Studies. 2024;4(1):1-15, doi:10.31098/ijeass.v4i1.2002
[11] Streamlined Energy and Carbon Reporting (SECR). https://www.gov.uk/government/publications/environmental-reporting-guidelines-including-mandatory-greenhouse-gas-emissions-reporting-guidance.
[12] Task Force on Climate-Related Financial Disclosures (TCFD). https://www.fsb-tcfd.org/.
[13] Climate Change Financial Risks (CPG229). https://www.carrotsandsticks.net/policies/8-60-prudential-practice-guide-draft-cpg-229-climate-change-financial-risks/.
[14] Sustainability Accounting Standards Board (SASB). https://sasb.ifrs.org/.
[15] ESG-Related Investment Fund Disclosure from the Canadian Securities Administrators (CSA). https://www.securities-administrators.ca/news/canadian-securities-regulators-publish-updated-guidance-on-esg-related-investment-fund-disclosure/.
[16] Mahajan R, Lim WM, Sareen M, Kumar S, Panwar R. Stakeholder theory. Journal of Business Research. 2023;166:114104,. doi:10.1016/j.jbusres.2023.114104.
[17] Eisenhardt KM. Agency theory: An assessment and review. Academy of Management Review. 1989;14(1):57-74, doi:10.2307/258191.
[18] Janssen M, Ostrom E. Resilience, vulnerability, and adaptation: A cross-cutting theme of the international human dimensions programme on global environmental change. Global Environmental Change. 2006;16(3):253-267, doi:10.1016/j.gloenvcha.2006.04.003.
[19] Li H, Zhang X, Zhao Y. ESG and firm's default risk. Finance Research Letters. 2022;47(B):102713, doi:10.1016/j.frl.2022.102713.
[20] Zikriani H, Fatwa N, Fatiyurrobbany F, Nasution LZ, Rini N. The impact of ESG principles implementation on risk management effectiveness in the banking sector. International Journal of Integrative Research. 2025;3(2):137-150, doi:10.59890/ijir.v3i2.338
[21] Lau A, Tsui E, Lee WB. An ontology-based similarity measurement for problem-based case reasoning. Expert Systems with Applications. 2009;36(3):6574-6579, doi:10.1016/j.eswa.2008.07.033
[22] Lau ASM. Implementation of an onto-wiki toolkit using web services to improve the efficiency and effectiveness of medical ontology co-authoring and analysis. Inform Health Soc Care. 2009;34(1):73-80, doi: 10.1080/17538150902779543
[23] Lau ASM, Tse SHM. Development of the ontology using a problem-driven approach: in the context of traditional Chinese medicine diagnosis. Journal of Knowledge Engineering and Data Mining. 2010;1(1):37-49, doi: 10.1504/IJKEDM.2010.032579.
[24] Lau A, Wu J, Ma P, Lee H. Using artificial intelligence, ontology, and 3D visualization in the metaverse for improving collaborative work and collective intelligence. International Journal of Entrepreneurship and Innovation. 2025;26(1):14657503241313362, doi:10.1177/14657503241313362.
[25] Xiao Y, Xiao L. The impact of artificial intelligence-driven ESG performance on sustainable development of central state-owned enterprises listed companies. Scientific Reports. 2025,15(1):s41598-025-93694-y, doi:10.1038/s41598-025-93694-y.
[26] George, K, John, B, Samuel, AH. Leveraging AI-Enhanced ESG Metrics for Effective Risk Assessment in Bank Treasury Operations. 2025 Feb, https://www.researchgate.net/publication/388862079_Leveraging_AI-Enhanced_ESG_Metrics_for_Effective_Risk_Assessment_in_Bank_Treasury_Operations.
[27] Chen Z, Sugiyama K, Tasaka K, Kito T, Yasuda Y. Impact of environmental, social and governance initiatives on firm value: Analysis using AI-based ESG scores for Japanese listed firms. Research in International Business and Finance. 2024;70(3):102303, doi:10.1016/j.ribaf.2024.102303.
[28] Sakiewicz P, Ober J, Kopiec M. Perception of ESG standards implementation in Polish SMEs - Pilot Study. System Safety Human - Technical Facility - Environment. 2024;6(1), doi:10.2478/czoto-2024-0032.
[29] Trentin L, Marques M. Level of maturity of ESG governance practices: Implications on organizational performance. Revista Ibero-Americana de Estratégia. 2025;24(2):e27483, doi:10.5585/2025.27483.
[30] Paulk MC, Curtis B, Chrissis MB, Weber CV. Capability maturity model, Version 1.1. IEEE Software. 1993;10(4):18-27, doi: 10.1109/52.219617.
[31] Hennink M, Kaiser BN. Sample sizes for saturation in qualitative research: A systematic review of empirical tests. Social Science & Medicine. 2022;292:114523, doi:10.1016/j.socsimed.2021.114523.
[32] Kwak SG, Kim JH. Central limit theorem: The cornerstone of modern statistics. Korean Journal of Anesthesiology. (2017) 70(2):144-156. doi:10.4097/kjae.2017.70.2.144
[33] Gilliland G, Melfi V. A note on confidence interval estimation and margin of error. Journal of Statistics Education. (2017) 18(1):10691898.2010.11889474. doi:10.1080/10691898.2010.11889474

Appendix

Table 7 is the summary of the questionnaire and AI rules for the 17 UNSDG goals and ESG ontology

Table 7. Questionnaire and AI rules for the 17 UNSDG goals and ESG ontology

ESG Ontology	UNSDG Goals, Its Targets and Questions	Decision tree
Social Community: Investment & charity	**Goal 1 No Poverty** **Target 1.1: Q4.** How many donations to poor people has your organization made?	If > 1, then 1. Otherwise, 0.
Social Community: Investment & charity	**Goal 2 Zero Hunger** **Target 2.1: Q5.** How many donations to hungry people has your organization made? **Target 2.2: Q66.** Did your company provide nutritious related donation?	If > 1, then 1. Otherwise, 0. If "yes", then 1. Otherwise, 0.
Environment Resource management; Land use & biodiversity	**Goal 2 Zero Hunger** **Target 2.4: Q67.** If you do not work in the food industry, fill in "NA" for this question. Otherwise, please answer the question: "Does your company have a sustainable food production process?"	If "yes", then 1. Otherwise, 0.
Environment Environmental opportunity: Research & opportunity	**Goal 2 Zero Hunger** **Target 2.6: Q68.** Has your company provided donations to sustainable agricultural research?	If "yes", then 1. Otherwise, 0.
Social Community: Community engagement	**Goal 3 Good Health & Well-being** **Target 3.4: Q6.** Has your company organized any activities for human well-being?	If "yes", then 1. Otherwise, 0.
Social Human capital: Health & safety	**Goal 3 Good Health & Well-being** **Target 3.5: Q69.** Has your company provided donations related to the prevention of drug or alcohol abuse? **Target 3.a: Q71.** Does your company have a tobacco-free policy in the office? **Target 3.b: Q72.** Has your company provided vaccines injection related medical benefit?	If "yes", then 1. Otherwise, 0. If "yes", then 1. Otherwise, 0. If "yes", then 1. Otherwise, 0.
Governance Corporate operations: Risk management	**Goal 3 Good Health & Well-being** **Target 3.9: 70.** Does your company have a policy on GHG emissions and pollution reduction (e.g., hazardous chemicals in the air, water and soil)?	If "yes", then 1. Otherwise, 0.
Social Human capital: Training & education	**Goal 4 Quality Education** **Target 4.4: Q41.** How many hours did your company allocate to employee training during the reporting period? **Target 4.4: Q42.** What is the total amount spent on employee training in HKD for your company, and how many employees does your company currently have? **Target 4.4: Q43.** Has your company implemented any initiatives to train new and existing employees on career development, education or skills, applicable to all employee levels? (Yes/No) **Target 4.7: Q73.** Does your company provide ESG training for staff?	If >0, then 1. Otherwise, 0 If >0, then 1. Otherwise, 0 If "yes", then 1. Otherwise, 0. If "yes", then 1. Otherwise, 0.
Social Community: Investment & charity	**Goal 4 Quality Education** **Target 4.8: Q74.** Has your company provided donations for learning facilities for special groups (e.g., children, disabled and gender-sensitive people) for safe, non-violent learning)? **Target 4.9: Q75.** Has your company provided donations for education and scholarship, especially for developing counties?	If "yes", then 1. Otherwise, 0. If "yes", then 1. Otherwise, 0.

Social	**Goal 5 Gender Equality**	
Human capital: Labor diversification	**Target 5.5: Q34.** What percentage of the total workforce at your company is made up of female employees?	If >0%, then 1. Otherwise, 0.
	Target 5.5: Q35. What percentage of your company's middle and/or other management positions are currently occupied by women?	If >0%, then 1. Otherwise, 0.
	Target 5.5: Q36. Does the company have a formal equal opportunity policy in place to ensure non-discrimination against any demographic group? (Yes/No)	If "yes", then 1. Otherwise, 0.
Environment	**Goal 6 Clean Water & Sanitation**	
Resource management: Water management	**Target 6.3: Q25.** Did your company recycle and reuse the waste water in your office?	If "yes", then 1. Otherwise, 0.
	Target 6.3: Q26. Did your company recycle and reuse the waste water from your production process?	If "yes", then 1. Otherwise, 0.
	Target 6.4: Q27. (i) Did your company discuss or implement any initiatives to reduce water consumption or improve water usage efficiency within your operations? (Yes/No) (ii) If yes, please decribe these initiatives.	If "yes", then 1. Otherwise, 0.
Social	**Goal 6 Clean Water & Sanitation**	
Community: Community engagement	**Target 6.8: Q76.** Does your company carry out activities related to water improvement for communities (e.g., donations, water recycle programs etc.)?	If "yes", then 1. Otherwise, 0.
Environment	**Goal 7 Affordable & Clean Energy**	
Resource management: Energy management	**Target 7.3: Q15.** (i) Did you use any energy-saving electricity devices/equipment (e.g., refrigerator, light bulb) in your office? (Yes/No) (ii) If yes, please specify the name of the device and the number of devices. (iii) What is the total number of electrical devices/equipment in your office?	If "yes", then 1. Otherwise, 0.
	Target 7.3: Q16. (i) Did you use any energy-saving electricity devices/equipment (e.g., refrigerator, light bulb) in your production process? (Yes/No) (ii) If yes, please specific the name of the device and the number of devices. (iii) What is the total number of electrical devices/equipment in your production process.	If "yes", then 1. Otherwise, 0.
Environment	**Goal 7 Affordable & Clean Energy**	
Environmental opportunities: Research & opportunities	**Target 7.2: Q22.** What is the total energy consumption in MWh for (i) renewable and (ii) non-renewable sources directly consumed through combustion in your owned or controlled business operations per month on average? (iii) Please state the consumption for each month in a year.	If "renewable energy > 0, then "1"; otherwise "0".
	Target 7.2: Q24. Does your company have a specific target in place for the use of renewable electricity within its operations? (Yes/No)	If "yes", then 1. Otherwise, 0.
	Target 7.3: Q23. Did the company implement any initiatives to make its use of energy more efficient through the establishment of an energy efficiency policy? (Yes/No)	If "yes", then 1. Otherwise, 0.
	Target 7.4: Q77. Did your company undertake clean energy research activity (e.g., donations, research, company investment)?	If "yes", then 1. Otherwise, 0.
Environment	**Goal 8 Decent Work & Economic Growth**	
Environmental opportunities: Research & opportunities	**Target 8.4: Q63.** How many metric tonnes of marketing and/or packaging materials used by the company are sourced from recycled materials?	If >0, then "1". Otherwise, "0".
Social	**Goal 8 Decent Work & Economic Growth**	
Human capital: Health & safety	**Target 8.7: Q44.** Has the company established a clear policy against child labor to ensure prevention in all aspects of its business operations? (Yes/No)	If "yes", then 1. Otherwise 0
	Target 8.7: Q45. Has the company or its subsidiaries reported a modern slavery statement in accordance with relevant legislation, such as the United Kingdom Modern	If "yes", then 1. Otherwise 0

	Slavery Act, the Australian Modern Slavery Act, or the California Transparency in Supply Chain Act? (Yes/No) **Target 8.7: Q47.** Has your company implemented initiatives to minimize the risk of slavery, human trafficking, or forced labor in the supply chain by engaging in verification of product supply chains? (Yes/No)	If "yes", then 1. Otherwise 0
Social Human capital: Health & safety	**Goal 8 Decent Work & Economic Growth** **Target 8.8: Q33.** What percentage of employees voluntarily left the company within the past year compared to the average total number of employees? **Target 8.8: Q37.** What is the total number (reported and non-reported) of incidents resulting in lost time from (i) full-time employees, (ii) part-time employees and (iii) contractors within your company, per 200,000 hours worked or per 100 employees and contractors for the past year? **Target 8.8: Q38.** What is the total number of reported incidents resulting in lost time from (i) full-time employees, (ii) part-time employees and (iii) contractors within your company, per 200,000 hours worked or per 100 employees and contractors for the past year? **Target 8.8: Q39.** In the reporting period, how many employees and contractors have died on a company site, at a company facility, or as a result of the company's operations? **Target 8.8: Q40.** (i) Does your company have a formal health and safety policy in place to address employee health and safety risks and responsibilities? (Yes/No) (ii) Has the company established a clear policy against child labor to ensure prevention in all aspects of its business operations? (Yes/No) **Target 8.8: Q48.** Has the company implemented any specific initiatives or policies to address social risks within its supply chain in order to ensure fair labor practices and safe working conditions for workers? (Yes/No)	If 100%, then 1. Otherwise, write the percentage. If =0, then 1. Otherwise, 0. If =0, then 1. Otherwise, 0. If =0, then 1. Otherwise, 0. If =0, then 1. Otherwise, 0. If "yes", then 1. Otherwise, 0.
Social Human capital: Labor diversification	**Goal 8 Decent Work & Economic Growth** **Target 8.5: Q78.** Does your company have full and productive employment including woman, men, young and disabled people), and equal pay for equal value?	If "yes", then 1. Otherwise, 0.
Environment Environmental opportunities: Research & opportunities	**Goal 9 Industry, Innovation & Infrastructure** **Target 9.5: Q7.** Did your company create any new products related to ESG? **Target 9.5: Q79.** Did your company adopt clean and environmentally sound technologies and industrial processes?	If "yes", then 1. Otherwise, 0. If "yes", then 1. Otherwise, 0.
Social Human capital: Health & safety	**Goal 10 Reduced Inequalities** **Target 10.4: Q46.** Has the company implemented any initiatives or policies to ensure the protection of human rights for all individuals it interacts with? (Yes/No)	If "yes", then 1. Otherwise, 0.
Governance Corporate operations: Guidelines & documentation	**Goal 10 Reduced Inequalities** **Target 10.3: Q80.** Does your company provide a policy on equal opportunities for all staff?	If "yes", then 1. Otherwise, 0.
Environment GHG emissions & climate change: GHG emissions	**Goal 11 Sustainable Cities & Communities** **Target 11.6: Q14.** Did your company achieve reductions in electricity usage?	If "yes", then 1. Otherwise, 0.
Environment Resource management: Waste management	**Goal 11 Sustainable Cities & Communities** **Target 11.6: Q64.** What percentage of your marketing materials are electronic?	If 50%, then 1. Otherwise, 0.

	Target 11.6: Q65. What percentage of your marketing and/or packaging materials are recycled for use in a year?	If 50%, then 1. Otherwise, 0.
Governance	**Goal 11 Sustainable Cities & Communities**	
Corporate operations: Guidelines & documentation	**Target 11.9: Q81.** Does your company have a policy on resource efficiency use to mitigate climate risk (e.g. electricity reduction)?	If "yes", then 1. Otherwise, 0.
Environment	**Goal 12 Responsible Consumption & Production**	
Resource management: Waste management	**Target 12.5: Q17.** (i) Estimate the volume of waste (e.g., one rubbish bag with a size of ...) that your company produces each day on average in your office? (ii) Does your company divide the waste into different categories? (Yes/No) (iii) If yes, what is the percentage of the waste that can be recycled?	If "yes", then 1. Otherwise, 0.
	Target 12.5: Q18. (i) Estimate the volume of waste (e.g., one rubbish bag with a size of ...) that your company produces each day on average in your production process? (ii) Does your company divide the waste into different categories? (Yes/No) (iii) If yes, what is the percentage of the waste that can be recycled?	If "yes", then 1. Otherwise, 0.
	Target 12.1: Q20. Did your company implement any initiatives specifically aimed at reducing waste generated during its operations? (Yes/No)	If "yes", then 1. Otherwise, 0.
	Target 12.3: Q82. If you are not working in the food industry, please fill in "NA" for this question. Otherwise, did your company reduce food waste in the production process?	If "yes", then 1. Otherwise, 0.
Environment	**Goal 12 Responsible Consumption & Production**	
Environmental opportunities: Environmental certifications	**Target 12.2: Q8.** Did your company obtain any environmental certificates this year?	If "yes", then 1. Otherwise, 0.
Environment	**Goal 12 Responsible Consumption & Production**	
Resource management: Hazard management	**Target 12.4: Q19.** (i) Did your company produce any hazardous waste? (Yes/No) (ii) If yes, please describe and state the percentage of hazardous waste. (iii) If yes, does your company have any procedure to manage this hazardous waste? (Yes/No)	If no or NA for (i) or (iii) for yes, then 1. Otherwise, 0.
	Target 12.4: Q21. Does your company implement a hazardous waste management policy to responsibly handle, manage, and dispose of hazardous waste generated during operations? (Yes/No)	If "yes", then 1. Otherwise, 0.
Governance	**Goal 12 Responsible Consumption & Production**	
Corporate operations: Supply chain management	**Target 12.6: Q83.** Does your company have a policy on requiring sustainable report from their suppliers?	If "yes", then 1. Otherwise, 0.
	Target 12.7: Q84. Does your company have a policy on sustainable requirements for suppliers in regard to tenders?	If "yes", then 1. Otherwise, 0.
Governance	**Goal 12 Responsible Consumption & Production**	
Corporate operations: Guidelines & documentation	**Target 12.1: Q1.** Does your organization document all the ESG related guidelines in a staff handbook or ESG handbook?	If "yes", then 1. Otherwise, 0.
Governance	**Goal 12 Responsible Consumption & Production**	
Corporate operations: Related certification	**Target 12.2: Q2.** Did your company get any awards or certificates or other evidence on efficiency use and/or governance of natural resources?	If "yes", then 1. Otherwise, 0.
Social	**Goal 12 Responsible Consumption & Production**	
Community: Community engagement	**Target 12.2: Q3.** How many certificates or awards for community services have been obtained by your organization?	If "yes", then 1. Otherwise, 0.
Environment	**Goal 12 Responsible Consumption & Production**	
Environmental compliance:	**Target 12.2: Q88.** Has your company developed metrics to measure ESG performance?	If "yes", then 1. Otherwise, 0.

Environmental measurement		
Environment	**Goal 13 Climate Action**	
GHG emissions & climate change: Climate risk	**Target 13.3: Q28.** (i) Does the Management Discussion and Analysis (MD&A) or its equivalent risk section of your company's report discuss business risks related to climate change? (Yes/No) (ii) If yes, where did they discuss (e.g., in company report, meeting)	If "yes", then 1. Otherwise, 0.
	Target 13.3: Q29. (i) Did the MD&A and its equivalent section of your company's report or anywhere else discuss business opportunities related to climate change? (Yes/No) (ii) If yes, where were these discussed (e.g., in company report, meeting)	If "yes", then 1. Otherwise, 0.
	Target 13.3: Q30. Did your company identify and discuss any physical material climate risks that may affect the performance of its economic activities during their expected lifetime? (Yes/No)	If "yes", then 1. Otherwise, 0.
Environment	**Goal 14 Life Below Water**	
GHG emissions & climate change: GHG emissions	**Target 14.3: Q10.** Did your company produce products with CO_2, methane, nitrous oxide (Nox), ozone-depleting substances (ODSs), sulfur oxides (SOx), or water vapor emissions from your direct operation (i.e., production in house or at client sites)? (Yes/No) (ii) If yes, please state which substance. (iii) If yes, can you estimate the weight of the substances emitted per month?	If "no or NA", then 1. Otherwise, 0.
	Target 14.3: Q11. (i) Did your company produce products with CO_2, methane, nitrous oxide (Nox), ODSs, SOx, or water vapor emissions from indirect operations (i.e., office operations)? (Yes/No) (ii) If yes, please state which substance. (iii) If yes, can you estimate the weight of the substances emitted per month?	If "no or NA", then 1. Otherwise, 0.
Environment	**Goal 15 Life On Land**	
Resource management: Land use & biodiversity	**Target 15.2: Q12.** (i) Did your (a) company, (b) supplier, or (c) clients disclose their ambitions and engagement related to setting science-based greenhouse gas emissions reduction targets? (Yes/No)	If "yes or NA", then 1. Otherwise, 0.
	Target 15.2: Q13. (i) Did your (a) company, (b) supplier, or (c) clients disclose their ambition and engagement related to achieving Net Zero greenhouse gas emissions reduction targets? (Yes or No) (ii) If yes, please describe these.	If "yes or NA", then 1. Otherwise, 0.
	Target 15.2: Q87. Did your company promote sustainability to protect the earth (e.g., use less paper or electronic materials)?	If "yes", then 1. Otherwise, 0.
Social	**Goal 16 Peace, Justice & Strong Institutions**	
Product & customer: Product quality & service	**Target 16.6: Q31.** (i) Does your company have a mechanism to measure the quality of the service or product? (ii) If yes, how? (iii) Which standard does your company use?	If "yes", then 1. Otherwise, 0.
	Target 16.6: Q54. Does your company have a policy in place for responsible labeling that ensures accurate, relevant, sufficient, and comprehensible information is provided to consumers when making purchasing decisions? (Yes/No)	If "yes", then 1. Otherwise, 0.
Social	**Goal 16 Peace, Justice & Strong Institutions**	
Product & customer: Data privacy & security	**Target 16.6: Q32.** Does your company have any instrument to measure the security of the company data? (ii) Does your company have any policy to protect customers' data privacy?	If "yes", then 1. Otherwise, 0.
		If "yes", then 1. Otherwise, 0.

	Target 16.6: Q51. Has the company implemented any initiatives to ensure consumer data protection and privacy through a formal data protection policy? (Yes/No)	If "yes", then 1. Otherwise, 0.
	Target 16.6: Q52. Does your company have established quality assurance processes and recall procedures in place for product safety and quality control? (Yes/No)	If "yes", then 1. Otherwise, 0.
	Target 16.6: Q53. Does your company have a product data security policy in place to ensure the protection of data throughout the entire product life cycle? (Yes/No)	
Governance Corporate operations: Risk management	**Goal 16 Peace, Justice & Strong Institutions**	
	Target 16.5: Q55. Does your company have a written anti-bribery ethics policy in place to prevent bribery and corrupt business practices within the organization? (Yes/No)	If "yes", then 1. Otherwise, 0.
	Target 16.5: Q56. Has the company established ethical guidelines and/or a compliance policy for its non-management/executive employees in the conduct of company business? (Yes/No)	If "yes", then 1. Otherwise, 0.
	Target 16.5: Q57. Does your company have a formal whistleblower policy in place to allow employees to report internal ethical compliance complaints without fear of retaliation? (Yes/No)	If "yes", then 1. Otherwise, 0.
Governance Corporate governance: Board disclosure	**Goal 16 Peace, Justice & Strong Institutions**	
	Target 16.6: Q58. What percentage of your company's board members are classified as independent directors?	If >0, then "1". Otherwise, "0".
	Target 16.6: Q59. What percentage of board members at your company are classified as non-executive directors?	If >0, then "1". Otherwise, "0".
Governance Corporate governance: Shareholder rights	**Goal 16 Peace, Justice & Strong Institutions**	
	Target 16.7: Q60. Do you have a cumulative voting system in place for the election of the board of directors within your company? (Yes/No)	If "yes", then "1". Otherwise, "0".
	Target 16.7: Q61. Does the company have unequal or restricted voting rights between common share classes? (Yes/No)	If "yes", then "1". Otherwise, "0".
Governance Corporate governance: Ownership	**Goal 16 Peace, Justice & Strong Institutions**	
	Target 16.7: Q62. Is the CEO the only person to vote or perform decision making at your company?	If “no”, then 1. Otherwise, 0.
Social Community: Social-related certification	**Goal 16 Peace, Justice & Strong Institutions**	
	Target 16.6: Q9. Did your company obtain any social-related certificates (e.g., for community services)?	If "yes", then 1. Otherwise, 0.
Governance Corporate operations: Supply chain management	**Goal 17 Partnerships For The Goals**	
	Target 17.g: Q49. What percentage of your company's suppliers were audited within the fiscal year to ensure compliance with your supply chain code of conduct and adherence to ESG criteria?	If >0, then "1". Otherwise, "0".
	Target 17.g: Q50. How many suppliers has your company audited to ensure compliance with the company's supply chain code of conduct based on ESG criteria?	If >0, then "1". Otherwise, "0".
Environment Environmental compliance: Environmental standards	**Goal 17 Partnerships For The Goals**	
	Target 17.f: Q85. Did your company use the worldwide ESG standards as a reference to develop its ESG policy?	If "yes", then 1. Otherwise, 0.
Governance Corporate operations: Guidelines & documentation	**Goal 17 Partnerships For The Goals**	
	Target 17.h: Q86. Did your company have partnerships with other companies for ESG resource sharing strategies?	If "yes", then 1. Otherwise, 0.