

Article

Corporate Carbon Footprint Disclosure Quality in Latin America: A Multi-Country Assessment Using the Carbon Integrity Index

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Abstract

Although responsible for 10% of global greenhouse gas emissions, Latin America faces disproportionate vulnerability to climate-related events, making the need for clear, transparent, and rigorous action critically urgent. Corporate disclosure practices across the region show high variability in transparency and methodological consistency, posing a substantial obstacle in evidence-based measures against climate change. This study provides the first multi-country assessment of the quality and rigor of carbon footprint disclosures in the Latin American context, analyzing 103 company reports across five countries (Chile, Colombia, Ecuador, Mexico, and Peru) with the Carbon Integrity Index, a 10-indicator standardized metric quantifying the transparency of Scopes 1, 2, and 3 and uncertainty disclosures. Three distinct patterns emerged from the analysis. Although 83.5% of companies disclose some value-chain emission data, Scope 3 disclosure quality remains a systemic deficiency across the region (average 0.19–0.31) with uncertainty quantification nearly absent (94% non-disclosure). Median scores for all five countries cluster narrowly (2.65–4.20), independently of heterogeneous governance frameworks. Finally, disclosure deficiencies appear uniform across sectors, suggesting structural rather than industry-specific barriers. These findings suggest that voluntary or international frameworks produce regional convergence at low quality levels, whereas adequate transparency requires differentiated capacity-building initiatives and national enforcement frameworks in emerging market contexts.

Keywords: Carbon Integrity Index; carbon footprint disclosure; disclosure quality; Latin America; corporate sustainability reporting; Scope 3 emissions; climate governance; emerging markets; greenhouse gas accounting



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1. Introduction

Latin America contributes approximately 10% of global greenhouse gas (GHG) emissions [1] but experiences climate impacts that far exceed this share, with extreme weather events, droughts, and ecosystem degradation [2] among them. This emission–vulnerability imbalance creates an urgent demand for effective, rigorous, and transparent carbon accountability mechanisms to measure and guide mitigation and adaptation [3,4]. However, disclosure quality across the region remains highly variable, with no systematic assessments of the level of transparency and methodological consistency of corporate reporting practices. This variability reflects broader challenges in sustainability reporting identified across different contexts [5]. Moreover, as an emerging market region, Latin America faces

distinct and specific challenges that distinguish it from developed markets, making the differences in institutional capacity, stakeholder pressure, and regulatory enforcement relevant for the analysis [6].

Transparent and traceable disclosures of environmental information, particularly carbon footprint as a key indicator in climate action [7,8], serve critical functions beyond regulatory compliance [5]. Across climate-vulnerable regions, transparent emission data can influence investor perceptions and the cost of capital [9,10], guide policy makers in designing evidence-based mitigation targets [11], and give civil society the tools to hold companies and state actors accountable for their decarbonization commitments [12]. The effectiveness of these accountability mechanisms, however, depends critically on the quality of said disclosures, the level of transparency and methodological rigor on which they stand is key in going from symbolic to transcending compliance [13]. Latin America presents a particularly interesting scenario for assessing disclosure quality due to its diversity in institutional capacity, market development, and climate governance models. Understanding the value of quality disclosure is essential to guide corporate practices towards evidence-based climate action [10].

Understanding corporate environmental disclosure requires analyzing the theoretical frameworks that drive the firms' reporting decisions. The corporate disclosure literature has converged on several complementary perspectives to explain disclosure incentives and structure, among them are the following: (i) stakeholder theory, (ii) legitimacy theory, and (iii) agency theory.

- (i) Stakeholder theory [14] explains why firms decide to disclose information based on the informational needs and expectations of the multiple stakeholder groups. This analysis extends beyond the shareholders to include investors, regulators, customers, and civil society, providing valuable inputs for environmental carbon disclosure. Evidence from the Latin American context suggests that board structure and size, ownership concentration and institutional characteristics are significant predictors of environmental disclosure, with firms in sensitive sectors facing greater pressure [15,16]. When it comes to carbon disclosure, emission disclosure can be seen as a signal of responsiveness to comprehensive climate impact concerns, particularly Scope 3 emissions [17].
- (ii) Legitimacy theory [18] positions companies within broader organizational environments where disclosure serves as a key instrument for organizational legitimacy by demonstrating alignment between corporate action and societal norms, particularly when legitimacy gaps arise from heightened expectations. In environmental disclosure terms, legitimacy theory is key in distinguishing between disclosure presence and disclosure quality, showing how firms use environmental reporting to maintain their social license to operate. Regional studies show significant gaps in the disclosure quality of symbolic (qualitative) and substantive (quantitative) reporting in contexts as the Colombian [19], with case studies in Peru showing sustainability reporting quality (SQR) to be a mainly independent variable from regulatory requirements in sustainability disclosure [20].
- (iii) Agency theory [21] frames disclosure as a governance mechanism that reduces information asymmetry between managers and investors, lowering agency costs and facilitating more effective monitoring of managerial performance. In this sense, environmental disclosure quality can be seen as a direct reflection of internal governance structures and mechanisms [22]. The Latin American carbon disclosure landscape is framed within a corporate ecosystem characterized by concentrated ownership structures and variable governance quality and board characteristics [15,23]. Contextual evidence from Chilean, Brazilian, and multi-country Latin American studies confirm the impact of variables such as gender diversity or board independence in

ESG disclosure [23–25]. Under this theoretical lens, it would be reasonable to assume that firms with stronger boards and audit quality will provide more credible carbon disclosures, with key questions remaining in emerging markets, where governance mechanisms may be weaker and external assurance less prevalent [26].

Additionally, alternative frameworks such as institutional theory, emphasizing the convergence of organizational practices across diverse contexts through isomorphic pressures [27], offer supplementary insights for understanding disclosure patterns across countries with heterogeneous regulatory frameworks. Coercive (regulatory), mimetic (peer imitation), and normative (professional standards) isomorphism may drive disclosure convergence even absent direct regulatory harmonization, a dynamic particularly relevant for multinational corporations operating across Latin American markets.

When it comes to applying disclosure research to carbon disclosure, a clear favor of developed markets can be identified [28], with less attention being paid to emerging markets. Studies examining CDP reporting standards [29] or European reporting practices [30] demonstrate that even though aggregate emissions reporting is increasingly common, detail on methodology of calculus, emission factor disclosure or uncertainty ranges remain scarce and mostly incomplete [31]. Quality assessment frameworks make the key distinction that legitimacy theory emphasizes, the importance of distinguishing between symbolic reporting (mostly based on qualitative claims without quantifiable data) and substantive disclosure (traceable calculations with defined boundaries) [32]. In Latin American contexts, the literature points out significant gaps in quantitative reporting versus qualitative assessments in case studies as Colombia [19] where sectoral heterogeneity reveals a mostly qualitative disclosure ecosystem over quantitative disclosure. Multi-country assessments across the region demonstrate that institutional factors as governance quality, enforcement rigor, and sustainability index listing significantly influence disclosure intensity [33]. Studies focusing on Peruvian [20], Chilean [15], and broader Latin American markets [23,25] consistently identify systemic disclosure quality deficiencies, with a higher propensity towards general sustainability statements.

Despite recognition of the importance of disclosure quality's significance across theoretical frameworks, several research gaps persist in the Latin American research context. While studies analyze disclosure determinants and variables in the region [16,34], systematic assessment of disclosure quality as a distinct feature from disclosure presence remains limited across multinational contexts. In order to provide a quality assessment of regional disclosure quality, many studies build custom frameworks to contextually provide answers to this carbon disclosure quality gap [35] or focus on operational capacity specificities [36], limiting comparability and replicability of the results across diverse contexts. Alternative approaches that adopt a more systematic approach tend to analyze disclosure as a binary issue, focusing exclusively on the presence or non-presence of disclosure as the main driver of transparency [37,38] or focusing exclusively on voluntary versus mandatory reporting requirements [39,40]. Additionally, most of the literature's focus lies on developed markets [13,41], with emerging markets or less industrialized contexts receiving much less attention.

This study addresses these gaps by providing the first systematic multi-country assessment of carbon disclosure quality across some of Latin America's largest corporations. Our research provides three distinct contributions to the carbon disclosure literature. First, we operationalize disclosure quality through the CIX, providing, to our knowledge, the first Scope 1, 2, and 3 disclosure assessment in the region. Second, we analyze a total of 103 publicly traded companies across heterogeneous contexts, providing empirical evidence on whether institutional diversity can still produce disclosure convergence. Finally, our

findings inform capacity-building priorities and regulatory design in emerging market contexts, usually experiencing disproportionate climate vulnerability.

This study centers around the following two fundamental research questions grounded in disclosure theory:

RQ1: What is the current state of corporate carbon disclosure quality across Latin American countries, and how do observed patterns reflect broader normative principles on disclosure?

RQ2: What systematic deficiencies characterize regional reporting practices?

We provide the first comprehensive multi-country assessment of carbon disclosure quality in Latin America, analyzing 103 publicly available reports from large corporations across five countries (Chile, Colombia, Ecuador, Mexico, Peru) using the Carbon Integrity Index (CIX). The CIX methodology is a standardized 10-indicator framework that assesses the level of rigor and transparency of corporate carbon footprint disclosures across Scopes 1, 2, and 3 emissions. This particular framework was selected over other alternatives (such as CDP scoring systems [6], custom disclosure indexes [35,36], or GRI compliance checklists [26]) for three distinct reasons. Firstly, the level of granularity and nuance in CIX scoring (0.0/0.4/0.8/1.0) across 10 indicators over binary presence/absence measures [37,38]. This level of detail allows for distinction of symbolic versus substantive reporting, particularly relevant for emerging market contexts. Secondly CIX's GHG Protocol foundation [42] and standardization across activity data boundaries and methodological definitions facilitates cross-country and cross-sector comparisons, overcoming the generalizability issues that may arise from the use of custom-designed frameworks [35]. Finally, the CIX framework offers the most comprehensive Scope 3 value-chain emissions, with five distinct indicators (CIX 5–9), specifically addressing and quantifying the systematic deficiencies in value-chain emissions recognized in the literature [43].

2. Materials and Methods

2.1. Sample Selection

This study focuses on the analysis of the publicly disclosed carbon footprint reports from the main publicly traded companies in the year 2023 of the following Latin American countries: Chile, Colombia, Ecuador, Mexico, and Peru. These countries were selected based on the following criteria, ensuring regional representativeness and methodological feasibility.

Firstly, economic and demographic significance. This sample represents 38.6% of the total population of the region (Latin America and the Caribbean), covering over 253 million people [44], and encompasses a wide range of economic profiles, from resource-dependent economies (Peru, Ecuador, or Chile) to more diversified industrial economies (Mexico, Colombia). This allows for a deeper analysis of sectoral and country-specific trends regarding sustainability disclosure maturity.

Secondly, institutional capacity and data availability. The selection prioritized countries where corporate sustainability reports were publicly accessible and warranted sufficient quality for assessment. Additionally, the geographical concentration in the Andean–Pacific region facilitated coordination of institutional partnerships with universities in Peru (UNALM) and Ecuador (ESPOL), enabling efficient quality assurance processes across neighboring countries (Chile, Colombia) while maintaining methodological rigor.

Finally, sectoral representativeness and economic structure were the last criterion considered. These countries collectively host significant representation across key carbon-intensive sectors critical to Latin American economies, from mining and raw extraction (Chile, Peru) to oil and gas (Colombia, Ecuador, Mexico), agriculture (all five countries), and financial services. This sectoral diversity ensures that findings reflect disclosure patterns

across industries with varying emission profiles, stakeholder pressures, and reporting incentives, rather than biasing toward any single economic sector.

To ensure comparability and objectivity across countries, the sample of companies was extracted from the principal stock exchange index or equivalent business ranking in each country, focusing on large corporations where sustainability reporting practices are most established.

Following these criteria meant that several major regional economies were excluded from our analysis, most notably Argentina and Brazil. Brazil in particular presented linguistic evaluation challenges for standardized disclosure quality assessments, as corporate reporting operates predominantly in Portuguese, requiring dedicated reviewer pools to preserve inter-rater reliability. Argentina was not included due to the predefined scope and coordination limitations of this first multi-country CIX assessment. Both countries should be incorporated in future studies.

Chile: The analysis included companies from the Selective Stock Price Index (IPSA), Chile's main stock exchange index comprising 29 companies that measure the performance of the largest and most liquid stocks traded on the Santiago stock exchange. Of the 29 companies analyzed, 21 published carbon footprint information (72% disclosure rate). The sample includes eight key sectors: banking and finance (3/21), commerce and retail (5/21), energy and utilities (4/21), industry and manufacturing (3/21), mining and natural resources (1/21), water and sanitation services (2/21), telecommunications and technology (2/21), and transport and logistics (1/21).

Colombia: Companies were selected from the COLCAP index, the main index of the Colombian stock exchange, which includes the 20 most liquid stock issuers based on adjusted market capitalization. Of the total analyzed, 15 companies published carbon footprint information (75% disclosure rate). The sample presents five sectors: banking and finance (5/15), energy and utilities (4/15), industry and manufacturing (3/15), mining and natural resources (2/15), and transport and logistics (1/15).

Ecuador: Given the limited size of the ECUINDEX (10 companies), an alternative sampling approach was employed using the Ekos business ranking [45]. This ranking uses comparable financial criteria (revenue, market presence, etc.), yielding companies of similar size and structure as a stock index. This approach yielded 36 companies, of which 17 published carbon footprint disclosures (47% disclosure rate). The sample covers six sectors: agribusiness and food (3/17), banking and finance (3/17), commerce and retail (3/17), industry and manufacturing (5/17), mining and natural resources (1/17), and telecommunications and technology (2/17).

Mexico: The analysis included companies from the Price and Quotations Index (IPC), the main indicator of the Mexican stock exchange measuring liquidity and capitalization of the country's leading companies, comprising 38 companies. (The company "Alfa" operates three independent subsidiaries in different sectors with separate carbon footprint reports, bringing the total possible companies from 35 to 38). Of these, 34 published carbon footprint information (90% disclosure rate). The sample represents six sectors: banking and finance (6/34), commerce and retail (6/34), industry and manufacturing (12/34), mining and natural resources (3/34), telecommunications and technology (4/34), and transport and logistics (3/34).

Peru: Companies were selected from the Selective Index of the Lima Stock Exchange (ISBVL), which classifies the country's most liquid and highest capitalization companies. The index comprises 20 companies, of which 16 published carbon footprint information for 2023 (80% disclosure rate). The sample includes six sectors: banking and finance (2/16), construction (2/16), commerce and retail (3/16), energy and utilities (3/16), industry and manufacturing (2/16), and mining and natural resources (4/16).

In total, 103 corporate sustainability reports were analyzed across the five countries (Figure 1).

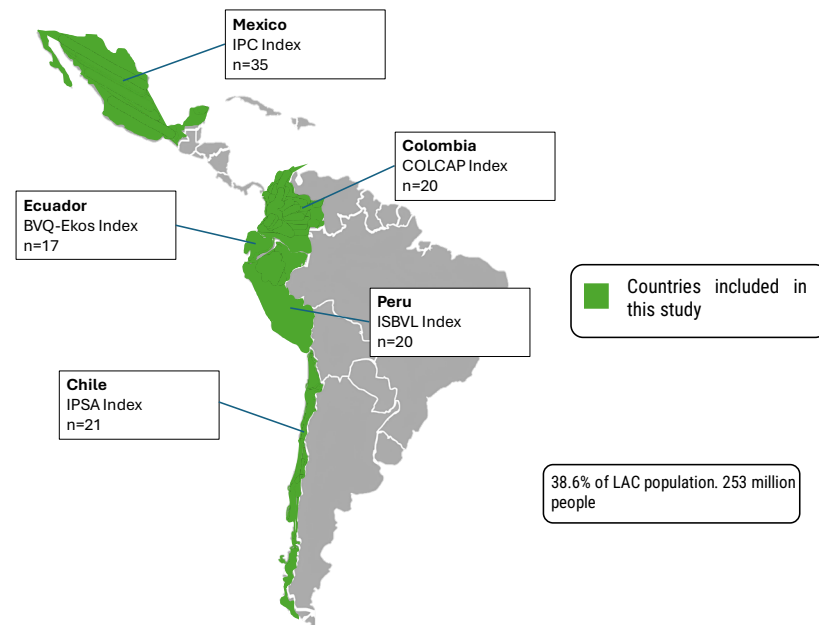


Figure 1. Geographic distribution and data sources for the study. The five selected countries represent 38.6% of Latin America and the Caribbean’s total population (253 million people). Stock exchange indices and sample sizes of companies analyzed are indicated for each country.

2.2. CIX Application

This study employs the Carbon Integrity Index (CIX) as the analytical framework for assessing corporate carbon disclosure quality. The CIX methodology represents a structured evaluation framework that assesses the level of transparency and rigor in corporate carbon footprint disclosures with 10 structured indicators (see Table 1) revolving around Scopes 1, 2, and 3, activity data, emissions factors, and uncertainty [42]. Each indicator is scored on a four-level scale (0.0, 0.4, 0.8, 1.0) and is revised through a system of expert peer review to ensure objective evaluation, detailed in previous CIX analysis [42].

Table 1. CIX indicators.

Indicator	Description
CIX 1	Activity data for Scopes 1 and 2
CIX 2	Emission factors
CIX 3	Scope 1
CIX 4	Scope 2
CIX 5	Scope 3: Purchased goods and services
CIX 6	Scope 3: Other upstream activities
CIX 7	Scope 3: Waste
CIX 8	Scope 3: Other downstream activities
CIX 9	Scope 3: Regular mobility of users and employees
CIX 10	Uncertainty assessment

Each company’s sustainability report was independently evaluated by three reviewers. Following this initial assessment, the three reviewers participated in a quality control meeting coordinated by an expert methodological reviewer to assess the level of concordance and reconcile possible discrepancies. Inter-rater agreement was assessed through systematic comparison of independent evaluations, with discrepancies resolved through expert-mediated consensus. The evaluation process took place between September 2024

and January 2025 and evaluated public disclosures from the years 2022 and 2023. The only reports included in the study were those publicly downloadable from companies' websites to enhance traceability and transparency.

When companies published multiple sustainability documents (separate reports for different business units, general and local sustainability strategies, supplementary carbon footprint disclosures. . .) the most comprehensive and consolidated report was the one analyzed. If no consolidated report was available at the time of evaluation, parent company reports were considered whenever specific mention of the subsidiary was provided.

This study employs multiple analytical variables derived from the CIX framework. Carbon disclosure quality serves as the primary dependent variable, operationalized through individual indicator scores (CIX 1–10) and aggregate company-level CIX scores. Full detail on individual indicator scoring and the peer review process are inspired on global standards as the GRI, GHG Protocol, or CDP, more detail can be found in previous CIX studies [42].

Country and sector serve as categorical independent variables for comparative analysis. Country classification is based on corporate headquarters location (Chile, Colombia, Ecuador, Mexico, Peru), following standard approaches in crossnational sustainability research [46]. Sector classification employs a functional categorization system grouping companies by primary business activity (banking and finance, industry and manufacturing, mining and natural resources, commerce and retail, energy and utilities, telecommunications and technology, transport and logistics, agribusiness and food, construction, and water and sanitation). This sectoral taxonomy aligns with established industry classification frameworks used in environmental disclosure research and is based on the UN Standard Industrial Classification [47].

To enable regional coordination across this multinational context, the evaluation was implemented through a coordinated network assessment involving institutional partnerships with Universidad Nacional Agraria La Molina (UNALM) in Lima, Peru, and Escuela Superior Politécnica del Litoral (ESPOL) in Guayaquil, Ecuador. These partnerships facilitated the recruitment of evaluators and coordination of methodological alignment across all participating countries, ensuring consistent application of the CIX framework throughout the regional assessment.

2.3. Limitations

Sample size variations are identified as a key methodological limitation for the comparability and development of cross-country comparisons. This variation limits certain statistical comparisons but enables the identification of regional disclosure patterns.

The geographical scope of 38.6% of LAC's population coverage also excludes major regional economies such as Brazil or Argentina, therefore results should be interpreted as indicative of the selected markets, and not of Latin America as a whole.

As for the sample selection and omission of certain countries, the omission of Argentina and Brazil in particular represents an additional limitation. Brazil was excluded due to the high number of Portuguese-only disclosures among the indexed companies, which would require dedicated bilingual reviewers and translation protocols to maintain scoring reliability for nuanced methodological statements. Argentina was not included for resource, coordination, and scope constraints in this first multi-country CIX assessment. Both countries should be prioritized in future research to strengthen regional representativeness.

Selecting only large publicly traded companies can also induce certain bias in the analysis, missing the reporting trends of small and medium enterprises, as well as the broader business ecosystem.

Methodological variations across countries also require mention as a potential limitation. Ecuador's sampling approach due to the low number of companies included in the ECUINDEX as of 2023 was necessary for adequate coverage. Even though minor methodological variation is included in the study, the core criterion of large corporations with established practices remains.

All company reports analyzed correspond to 2023, with the exception of Mexico, where 2022 disclosures were evaluated due to data availability constraints at the time of analysis. We verified that no major regulatory changes affecting carbon disclosure for the selected sample of companies became effective immediately in 2023. As corporate disclosure practices tend to evolve gradually, with specific measures being implemented by phases as the general norm, this one-year difference presents minimal comparability risk.

This study employs descriptive statistics to characterize disclosure patterns across countries and sectors. While our analysis reveals apparent convergence in median CIX scores, inferential statistical testing (e.g., Kruskal–Wallis tests for cross-country comparisons) would strengthen claims about the statistical significance of observed differences. Future research should employ such tests to validate the patterns identified here.

Finally, inability to access the actual calculations and internal processes of the analyzed companies makes this study an assessment of disclosure quality rather than emissions accuracy. Our analysis centers around transparency and rigor in reporting but does not verify the actual accuracy of reported emission values.

3. Results

3.1. Regional Overview of Carbon Disclosure Quality

Country-level CIX scores revealed moderate score convergence across the region studied (Figure 2). Chile exhibits the highest disclosure quality across the five countries, with a median score of 4.20 (IQR = 2.40), followed by Mexico with 3.59 (IQR = 1.70) and Peru with 3.55 (IQR = 3.50). Colombia is positioned as the fourth country by ranking with a median of 3.41 (IQR = 1.60), while Ecuador obtained the lowest CIX score with 2.65 (IQR = 2.90). Country median scores remained remarkably consistent within a 1.55-point range, with moderate regional convergence across disclosure practices.

Individually, the highest rated companies were Grupo ISA (6.8; Colombia), Credicorp (6.6; Peru), Ecopetrol (6.4; Colombia), America Movil (6.4; Mexico), and Banco de Chile (6.4; Chile). Low-scoring outliers include Banco del Pacífico (0.4; Ecuador), Novacero (0.4; Ecuador), Sonda (0.4; Chile), TIA (0.8; Ecuador), and ENEL Generacion (0.8; Peru).

Standard Deviation (SD) (σ) values for each country are as follows: Chile ($\sigma = 1.58$), Colombia ($\sigma = 1.56$), Ecuador ($\sigma = 1.83$), Mexico ($\sigma = 1.33$), and Peru ($\sigma = 1.92$). These values show similar absolute dispersion across the board. Due to sample size and the outlier cases detailed previously, SD values will be complemented with the Coefficient of Variation (CV), standardizing the variability within each sample group. CV analysis reveals distinct patterns across countries. Mexico exhibits the lowest variability (CV = 37%), followed closely by Chile (CV = 38%). Colombia (CV = 46%) and Peru (CV = 54%) present higher variations, with Ecuador presenting the highest variability (CV = 69%). Ecuador's high CV combined with its lowest median score (2.65) indicates greater dispersion of CIX scores, while Mexico's low CV paired with moderate median (3.59) reflects more concentrated score distribution. Chile demonstrates moderate variability despite achieving the highest median score (4.20).

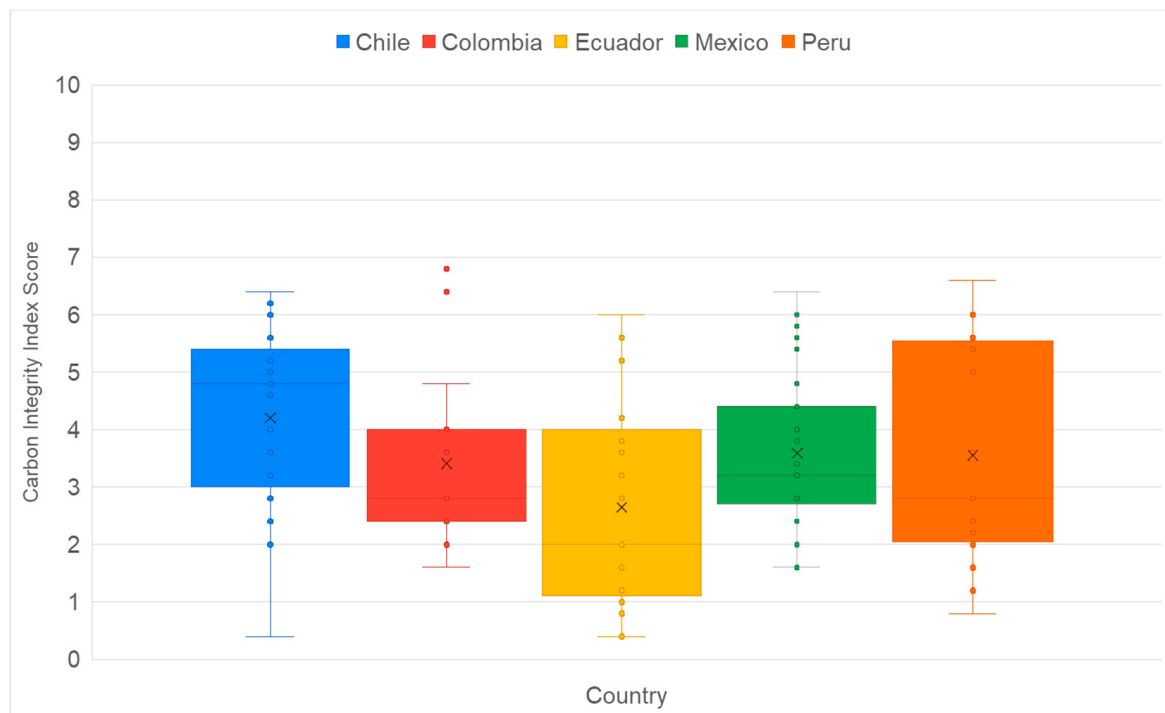


Figure 2. Distribution of Carbon Integrity Index scores across five Latin American countries. Box boundaries represent the interquartile range (IQR), horizontal lines indicate medians, whiskers extend to $1.5 \times$ IQR, and individual points (circles) represent individual company scores, with those extending beyond the whiskers being outliers. Median is represented in the chart with an “x”. Median CIX values per country: Chile ($\bar{x} = 4.20$), Colombia ($\bar{x} = 3.41$), Ecuador ($\bar{x} = 2.65$), Mexico ($\bar{x} = 3.59$), Peru ($\bar{x} = 3.55$). Sample sizes: Chile ($n = 21$), Colombia ($n = 15$), Ecuador ($n = 17$), Mexico ($n = 34$), Peru ($n = 16$).

Analyzing the results by distributional shape and skewness, several consistent patterns emerge across national profiles. Chile exhibits negative skewness (-0.68), with platykurtic characteristics (kurtosis: -0.06), indicating a relatively uniform distribution across the range. Colombia demonstrates strong positive skewness ($+1.18$) as well as positive kurtosis ($+0.67$) and moderate peakedness. Ecuador ($+0.54$) and Mexico ($+0.48$) show moderate positive skewness, with platykurtic distributions of slightly different intensities of -0.95 and -0.63 , respectively. Peru’s distribution shows the lowest skewness ($+0.16$) with very marked platykurtic characteristics (-1.45), resembling a near number distribution. The regional aggregate shows near-symmetry (skewness: $+0.16$) with platykurtic characteristics (kurtosis: -0.90), indicating that cross-country heterogeneity produces a relatively flat distribution when combined. Complete statistical values for each country can be found in Table 2.

Table 2. Distributional characteristics by country.

Country	<i>n</i>	Median	Mean	SD	SE	CV	Skewness	Kurtosis
Chile	21	4.80	4.20	1.58	0.35	38%	-0.68	-0.06
Colombia	15	2.80	3.41	1.56	0.40	46%	$+0.67$	$+0.67$
Ecuador	17	2.00	2.65	1.83	0.44	69%	-0.95	-0.95
Mexico	34	3.20	3.59	1.33	0.23	37%	-0.63	-0.63
Peru	16	2.80	3.55	1.92	0.48	54%	-1.45	-1.45
Regional	103	3.20	3.53	1.64	0.16	47%	-0.90	-0.90

3.2. Sectoral Analysis of Disclosure Performance

3.2.1. Regional Sectoral Patterns

Regional sectoral analysis has been limited to those sectors with representation in all five countries, with regional sample sizes of at least 10 companies ($n \geq 10$): banking and finance ($n = 20$), industry and manufacturing ($n = 25$), and mining and natural resources ($n = 10$) (Figure 3). Sectors not meeting the cross-country comparability are addressed separately in Section 3.2.2.

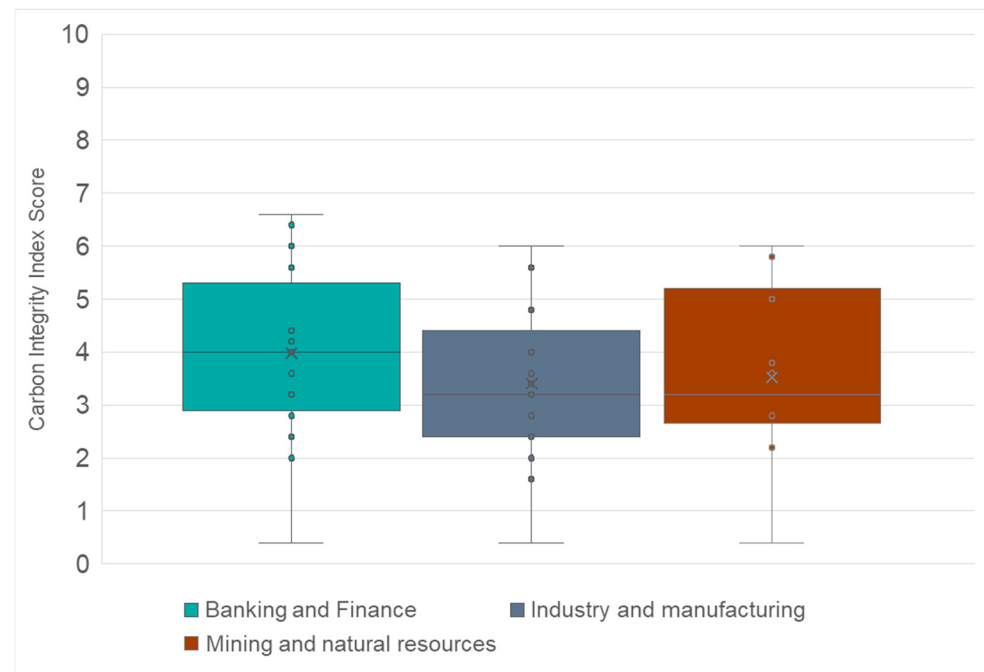


Figure 3. Distribution of Carbon Integrity Index scores across three sectors in five Latin American countries. Box boundaries represent the interquartile range (IQR), horizontal lines indicate medians, whiskers extend to $1.5 \times$ IQR, and individual points (circles) represent individual company scores, with those extending beyond the whiskers being outlier. Median is represented in the chart with an “x”. Median CIX values per sector: banking and finance ($\bar{x} = 3.98$), industry and manufacturing ($\bar{x} = 3.40$), mining and natural resources ($\bar{x} = 3.52$). Sample sizes: banking and finance ($n = 20$), industry and manufacturing ($n = 25$), mining and natural resources ($n = 10$).

Banking and finance demonstrates the highest disclosure quality across the region, with a regional mean of 3.98 (median: 4.00, SD: 1.55), and a nearly symmetrical distribution (skewness: -0.20 , kurtosis: 0.26). The convergence of mean and median (3.98 vs. 4.00) indicates balanced distribution, with near-symmetric characteristics (skewness: -0.20) and mesokurtic properties (kurtosis: 0.26). Standard error of 0.35 indicates moderate precision in the sectoral estimate.

Industry and manufacturing achieves moderate regional performance (mean: 3.40, median: 3.20, SD: 1.41), with a variability of $CV = 42\%$. Median and mean show less convergence (3.2 vs. 3.40) accompanied by slight positive skewness (0.19) and platykurtic characteristics (kurtosis: -0.34). The sector’s standard error (0.28) is lower than banking despite higher sample size, reflecting the sector’s broader absolute variability.

Mining and natural resources presents a regional mean of 3.52 (median: 3.20, SD: 1.72), positioning itself between banking and industry in central tendency. The sector demonstrates the highest variability ($CV = 49\%$) in spite of having the smallest sample size ($n = 10$). Distribution characteristics show near-symmetry (skewness: -0.09) with platykurtic properties (kurtosis: -0.15). Elevated standard error (0.54) reflects both small

sample size and high sector heterogeneity. The shared minimum value (0.4) across all three sectors indicates presence of common outlier cases (see Table 3).

Table 3. Distributional characteristics by sector.

Sector	<i>n</i>	Median	Mean	SD	SE	CV	Skewness	Kurtosis
Banking and Finance	20	3.98	4.00	1.55	0.35	39%	−0.20	−0.26
Industry and Manufacturing	25	3.40	3.20	1.41	0.28	46%	+0.19	+0.34
Mining and Resources	10	3.52	3.20	1.72	0.54	69%	−0.09	−0.15

3.2.2. Country-Specific Sectoral Patterns

Chile's corporate landscape demonstrates varied sectoral performance beyond the three regionally comparable sectors. Commerce and retail achieves a mean score of 4.88 ($n = 5$), representing strong disclosure in consumer-facing operations. Transport and logistics shows very high performance (6.2) although with a very limited sample size ($n = 1$). Energy and utilities achieves moderate performance (4.35, $n = 4$). Lower sample size cases include telecommunications (4.2, $n = 2$) and water and sanitation services (2.4, $n = 2$). Chile's single mining company (0.4) represents an extreme outlier.

Colombia's sectoral profile is dominated by energy and utilities (4.0, $n = 4$), achieving the highest national sectoral mean, outpacing banking and finance (3.2, $n = 5$). Industry and manufacturing (3.1, $n = 3$) and mining and natural resources (2.8, $n = 2$) demonstrate moderate performance, while transport and logistics (1.6, $n = 1$) shows low disclosure with a very limited sample.

Ecuador presents limited sectoral diversity in the evaluated sample. Beyond the three regionally comparable sectors, agribusiness and food (2.0, $n = 3$), commerce and retail (1.2, $n = 3$), and telecommunications and technology (3.1, $n = 2$) are represented. The concentration of low scores across diverse sectors (range: 1.2 to 3.8) suggests disclosure gaps transcend sectoral boundaries, pointing to broader institutional or capacity constraints rather than sector-specific phenomena.

Mexico's sectoral representation is the most comprehensive in the sample, including adequate representation across banking and finance (3.8, $n = 6$), industry and manufacturing ($n = 12$), commerce and retail (3.8, $n = 6$), mining and natural resources (3.0, $n = 3$), telecommunications and technology (4.1, $n = 4$), and transport and logistics (3.4, $n = 3$). Telecommunications demonstrates notably strong performance (4.1), while other sectors cluster between 3.0 and 3.8, reflecting Mexico's relatively standardized disclosure practices indicated by low national CV (37%).

Peru's sectoral profile shows considerable variation despite limited sectoral diversity. Banking and finance leads substantially (6.3, $n = 2$), followed by commerce and retail (4.3, $n = 3$) and mining and natural resources (4.2, $n = 4$). Construction (2.6, $n = 2$), industry and manufacturing (2.2, $n = 2$), and energy and utilities (2.4, $n = 3$) demonstrate weaker performance. The pronounced gap between financial services and other sectors (3+ points) exceeds patterns observed in other countries, suggesting sector-specific rather than economy-wide disclosure patterns.

3.3. Indicator-Level Performance Patterns

3.3.1. Regional Indicator Performance

Regional indicator analysis reveals several systematic patterns and tendencies across the CIX framework (Figure 4 and Table 4). Performance is stratified across three distinct tiers: high-scoring indicators with a mean ≥ 0.50 (CIX 1,2,4), mid-range indicators with 0.25–0.50 (CIX 3, 5, 6), and low-scoring indicators with a mean ≤ 0.25 (CIX 7, 8, 9, 10).

Country	Company	CIX 1	CIX 2	CIX 3	CIX 4	CIX 5	CIX 6	CIX 7	CIX 8	CIX 9	CIX 10	Mean
CHILE	Agua Andina	0.8	0.4	0	0.8	0	0	0	0.4	0	0	0.24
	Banco de Chile	0.4	0.8	0.8	0.8	0.8	0.8	0.4	0.8	0.8	0	0.64
	Banco ITAU	0.8	0.8	0.8	0.8	0.8	0.4	0.4	0.4	0.4	0	0.56
	Banco Santander Chile	0.8	0.8	0.8	0.8	0.8	0.4	0.4	0.4	0.4	0	0.56
	CAP	0.4	0.8	0.4	0.8	0	0.4	0	0	0.8	0	0.36
	CENCOSUD	0.8	0.4	0.4	0.8	0.4	0	0.4	0	0	0	0.32
	COLBUN	0.8	1	0.8	0.8	0	0.4	0.4	0.4	0.4	0	0.5
	Empresas CMPC	0.8	0.4	0.8	0.8	0.4	0.8	0.4	0.8	0.4	0	0.56
	Emotelladora Andina	0.8	0.4	0.8	0.8	0.4	0.4	0.4	0.4	0.4	0	0.48
	ENEL Américas	0.4	0.8	0.8	0.8	0.8	0.4	0	0.4	0	0.4	0.48
	ENEL Chile	0.4	0.8	0.8	0.8	0.8	0.4	0	0.4	0	0.4	0.48
	ENTEL	0.4	0.4	0.4	0.4	0.4	0.4	0	0.4	0.4	0	0.32
	Engie Energía Chile	0	0.4	0	0.4	0	0.4	0	0.4	0.8	0.4	0.28
	Inversiones Aguas Metropolitanas	0.8	0.4	0	0.8	0	0	0	0.4	0	0	0.24
	LATAM Airlines Group	0.8	1	0.8	0.8	0.4	0.8	0.4	0.8	0.4	0	0.62
	Mallplaza	0.4	0.8	0.4	0.8	0.4	0.8	0.4	0.8	0.4	0	0.52
	Parque Arauco	0.8	0.4	0.8	0.8	0.8	0.8	0.4	0.8	0.4	0	0.6
	SACI Falabella	0.4	0.8	0.8	0.8	0.4	0.4	0.4	0.8	0.4	0	0.52
	SMU	0.4	0.4	0.4	0.8	0	0.4	0.8	0.4	0.4	0	0.4
	SOC Química Minera	0.8	0.4	0.8	0.8	0.8	0.4	0	0.4	0	0	0.46
	Sonda	0	0.4	0	0	0	0	0	0	0	0	0.04
COLOMBIA	Bancolombia	0.8	0.8	0.8	0.8	0.4	0.4	0	0	0	0	0.4
	Celsia	0.4	0.4	0.4	0.4	0	0.4	0.4	0	0	0	0.24
	Cementos Argos	0.4	0.4	0	0.8	0.4	0.8	0.8	0.8	0.4	0	0.48
	Corficolombiana	0.4	0.4	0.8	0.8	0	0	0	0.4	0	0	0.28
	Corporación Financiera Colombiana	0.4	0.4	0.8	0.8	0	0	0	0.4	0	0	0.28
	Davivienda	0.4	0.4	0.8	0.8	0.4	0.4	0.4	0.4	0	0	0.4
	Ecopetrol	0.8	0.8	0.8	0.8	0.8	0.8	0.4	0.8	0.4	0	0.64
	Grupo Aval	0.4	0.4	0	0.4	0.4	0.4	0	0	0	0	0.2
	Grupo Argos	0.4	0	0.8	0.8	0	0.4	0	0	0	0	0.24
	Grupo Energía Bogotá	0.4	0.4	0	0.4	0.4	0	0	0	0	0	0.16
	Grupo ISA	1	1	1	1	0.4	0.4	0.4	0.4	0.4	0.8	0.68
	Grupo Nutresa	0.4	0.4	0	0.8	0	0	0	0.4	0	0	0.2
	Grupo Sura	0.4	0.4	0.8	0.4	0	0.4	0	0.4	0.8	0	0.36
	Mineros	0.8	0.4	0.8	0.8	0	0	0	0	0	0	0.28
	Promigas	0.8	0.8	0	0.8	0.4	0	0	0	0	0	0.28
ECUADOR	Aurelian	0.8	1	0.8	0.8	0.4	0	0	0	0	0	0.38
	Banco del Pacífico	0	0	0	0.4	0	0	0	0	0	0	0.04
	Banco Guayaquil	0.8	1	0.8	0.8	0.4	0.4	0	0	0	0	0.42
	Claro	0	0	0	0	0	0	0	0	0	0	0.1
	Corporación Favorita	0.4	0.8	0	0.4	0	0	0	0	0	0	0.16
	Farmasilea CIA LTDA	0.4	0	0	0.4	0	0.4	0	0	0	0	0.12
	General Motors Ecuador	0.8	0.4	0.4	0.8	0.4	0	0	0.4	0	0	0.32
	HOLCIM Ecuador	0.8	0.4	0.4	0.8	0.4	0	0	0.4	0	0	0.32
	La FABRIL S.A.	0.8	0.8	0.4	0.8	0	0.4	0.4	0	0	0	0.36
	NIRSA	0.4	0	0.4	0.4	0	0.4	0	0	0	0	0.16
	Novacero	0	0	0	0.4	0	0	0	0	0	0	0.04
	Pronaca	0.4	0.4	0.4	0.8	0	0	0	0	0	0	0.2
	Produbanco	0.8	0.4	0.8	0.4	0.8	0.4	0.8	0.4	0.8	0	0.56
	Sketting	0.4	0	0	0.4	0.4	0.4	0	0	0	0	0.16
	Telefónica Movistar	0.8	0.8	0.8	0.8	0.4	0.4	0.4	0.4	0.4	0	0.52
MEXICO	TIA	0.4	0	0	0.4	0	0	0	0	0	0	0.08
	Vitapro Ecuador	0.4	0.4	0.8	0.8	0.4	0	0	0	0	0	0.28
	Alfa SA Sigma	0.8	0.4	0.8	0	0	0	0	0	0	0.4	0.24
	Alfa SA Alpek	0.8	0.4	0.4	0.8	0.4	0.8	0.4	0.8	0.8	0	0.56
	Alfa SA Axtel	0.8	0.4	0.4	0.8	0	0.4	0	0	0	0	0.28
	Aisea SA	0.4	0.4	0	0.8	0	0	0	0	0	0	0.16
	América Móvil SAB	0.8	0.4	0.8	0.8	0.8	0.4	0.4	0.4	0.4	0	0.64
	Arca Continental SAB de CV	0.4	0.4	0.4	0.8	0	0.8	0.4	0.4	0.8	0	0.54
	Banco del Bajío S.A.	1	0.8	1	0.8	0.4	0.4	0	0	0	0	0.44
	Becle, S.A. De C.V.	0.4	0.8	0.4	0.8	0	0	0	0	0	0	0.24
	Bolsa Mexicana de Val	0.8	0	0.4	0.4	0.4	0	0	0	0.4	0	0.24
	Cemex SA CPO	0.8	0.4	0.4	0.8	0.4	0.4	0.8	0.8	0.8	0	0.56
	Coca-Cola Femsa SAB	0.4	0	0	0.8	0	0.4	0.8	0	0	0	0.24
	Controladora Vuela	0.4	0.4	0.4	0.8	0	0	0	0	0	0	0.2
	Corporación Inmobiliaria Vesta	0.8	0.8	0.8	0.8	0	0.8	0	0	0	0	0.4
	Fomento Económico	0.8	0	0.4	0.8	0	0.4	0.4	0	0	0	0.28
	Genomma Lab Int.	0.8	0.8	0.8	0.8	0.4	0.4	0.8	0.4	0.8	0	0.6
	Genera SAB de CV	0.8	0.8	0.4	0.4	0	0.4	0	0	0.4	0	0.32
	Gruma SAB B	0.8	0	0.4	0.8	0	0	0.4	0	0	0	0.24
	Grupo Arpt. del Centro Norte	0.8	0.8	0.4	0.8	0	0	0.4	0	0	0	0.32
	Grupo Arpt. Pacifico	0.8	0.8	0.4	0.8	0	0	0.4	0	0	0	0.34
	Grupo Arpt. Sureste	0.8	0.8	0.8	0.4	0	0	0.4	0	0	0	0.32
	Grupo Bimbo S.A.B.	0.8	0.4	0.8	1	0	0	0.4	0.4	0	0	0.38
	Grupo Carso SAB	0.8	0.4	0	0	0	0	0.4	0	0	0	0.16
	Grupo Cem entos	0.8	0.8	0.8	0.8	0.4	0.4	0.4	0	0	0	0.44
	Grupo Com. Chedraui	0.8	0.8	0.4	0.8	0	0	0	0.4	0	0	0.32
	Grupo Elektra S.A.B.	0.8	0.8	0.8	0.8	0	0.4	0.4	0	0	0	0.4
	Grupo Financiero Norte	0.8	0.8	0.4	0.4	0.4	0.8	0.4	0.4	0	0	0.44
	Grupo Mexico SAB de CV B	0.8	0.4	0.8	1	0.4	0.8	0.4	0.4	0.8	0	0.58
	Grupo Televisa SAB CPO	0.4	0.8	0.4	0.4	0	0.4	0	0	0.4	0	0.28
	Industrias Penoles	0	0.8	0	0.8	0	0	0	0	0	0	0.16
	Kimberly Clark de Mx	0.8	0.8	0.4	0.8	0	0	0	0	0	0	0.28
PERU	ORBA ADVANCE CORPORATION	0.8	0.8	0.4	0.8	0.4	0.4	0	0.4	0	0	0.4
	Qualitas Controladora SAB CV	0.4	0.8	0.4	0.4	0.4	0.8	0.4	0.4	0.4	0	0.44
	Regional S.A. de C.V.	0.8	0.8	0.8	0.8	0	0.4	0	0	0	0.4	0.4
	Walmart de Mexico SAB de CV	0.4	0.4	0.4	0.8	0	0.4	0	0.4	0	0	0.28
	Aceros Arequipa	0.4	0.4	0.4	0.4	0.4	0.4	0	0.4	0	0	0.28
	Aicorp	0.4	0.4	0.4	0.4	0.4	0	0	0	0	0	0.2
	BBVA	0.4	0.8	0.8	0.8	0.8	0.8	0.4	0.4	0.8	0	0.6
	Cementos Pacasmayo	0.8	0.4	0	0.8	0.4	0	0	0	0	0	0.24
	Credicorp Ltd.	0.8	1	0.8	0.4	0.8	0.8	0.4	0.8	0.8	0	0.66
	ENEL Distribución	0.4	0	0.4	0.4	0	0	0	0	0	0	0.12
	ENEL Generación	0.8	0	0	0	0	0	0	0	0	0	0.08
	Engie Perú	0.8	0.8	0	0.4	0.4	0.4	0	0	0	0	0.28
	Ferreycorp	0.4	0.4	0.4	0.4	0	0	0	0	0	0	0.16
	InRetail	0.4	0.8	1	0.4	0.4	0.8	0.4	0.8	0.4	0	0.54
	Intercorp	0.4	0.8	0.4	1	0.4	0.4	0.4	1	0.8	0	0.56
	Minsur	1	0.4	0.8	1	0.8	0.8	0.4	0	0.8	0	0.8
	Nexa Resources	0	0.4	0.8	0.8	0.4	0.4	0.4	0.4	0.4	0	0.5
	Southern Copper	0.8	0	0.4	0.8	0.4	0.4	0.4	0.4	0	0	0.36
	UNACEM	0.8	0.8	0.4	0.4	0.4	0	0	0	0	0	0.28
	Volcan	0.4	0.4	0.4	1	0	0	0	0	0	0	0.22

Figure 4. Heatmap of Carbon Integrity Index indicator performance across 103 companies in 5 Latin American countries. Each cell displays the CIX score (0.00–1.00 scale) for individual indicators. Color gradient represents disclosure quality: dark green (maximum performance: 1.00), light green (high performance: 0.80), yellow (moderate performance: 0.40), and red (non-disclosure: 0.00). The rightmost column shows company-level mean CIX scores.

Table 4. Regional distribution characteristics by indicator.

Indicator	Mean	Median	Mode	SD	CV	Skewness	Kurtosis	<i>n</i> ¹ Scoring 1	<i>n</i> ¹ Scoring 0
CIX 1	0.61	0.80	0.80	0.26	42%	−0.56	−0.49	6	6
CIX 2	0.52	0.40	0.40	0.30	57%	−0.28	−0.88	6	15
CIX 3	0.48	0.40	0.80	0.32	67%	−0.24	−1.21	4	23
CIX 4	0.68	0.80	0.80	0.24	35%	−1.04	0.44	9	4
CIX 5	0.27	0.40	0.00	0.29	108%	0.65	−0.65	1	49
CIX 6	0.31	0.40	0.40	0.29	93%	0.38	−0.98	0	41
CIX 7	0.20	0.00	0.00	0.26	125%	0.95	0.14	1	58
CIX 8	0.24	0.00	0.00	0.29	118%	0.80	−0.47	1	54
CIX 9	0.19	0.00	0.00	0.29	150%	1.15	−0.13	0	67
CIX 10	0.03	0.00	0.00	0.12	425%	4.65	23.27	0	97

¹ *n* Represents the total number of companies across all five countries in the 103 company sample.

Among high-scoring indicators, CIX 4 (Scope 2 emissions) achieves the highest performance across the board. The proximity of mean (0.68), median (0.8), and mode (0.8) combined with the negative skewness (−0.22) and lowest variability (CV = 35%) indicates clustering in the upper performance range, with nine companies achieving the maximum score and only four companies scoring 0. CIX 1 (activity data for Scopes 1 and 2) demonstrates similarly strong performance, with negative skewness and low CV (42%), while CIX 2 (emission factors) shows slightly higher variability (CV = 57%).

Mid-range indicators include CIX 3 (Scope 1 emissions) nearly missing the mean threshold from the previous subgroup (0.48). The data reveals bimodal characteristics, evidenced by the difference between median (0.40) and mode (0.80), accompanied by a moderately high CV (67%), indicating important internal variation and dispersion, as evidenced by the platykurtic tendency (kurtosis: −1.21). Nearly one in every four companies analyzed obtained 0 in this indicator. CIX 5 (Scope 3: purchased goods and services) and CIX 6 (Scope 3: other upstream activities) both refer to upstream Scope 3 categories, and both present similar means (0.27 and 0.31) and CV (108% and 93%), with identical medians (0.40) and SD (0.29). CIX 5's modal score of 0.00 implies that non-disclosure is the dominant pattern, whereas CIX 6's modal score of 0.40 points to partial disclosure as being more typical. This difference can also be seen in the differences in *n* scoring 1 and 0 (Table 4).

CIX 8 (Scope 3: other downstream activities), 7 (Scope 3: waste), 9 (Scope 3: regular mobility of users and employees), and 10 (uncertainty assessment) are the lowest scoring indicators. All of these indicators show severe underperformance on the regional scale, with CIX 7, 8, and 9 sharing several relevant aspects. The previous indicators share modal and median values of 0.00, suggesting that the most common outcome across the region is the non-disclosure of downstream Scope 3 data. The great dispersion signaled by the CV (125%, 118%, and 150%, respectively) is caused by a minority of companies that do report on this data, which generates accordingly high skewness values (0.95, 0.80, and 1.15, respectively) as well as non-reporting (58, 54, and 67 companies, respectively). CIX 10 represents the most serious deficiency, with only six companies providing uncertainty assessments in their reports (94% of the sample). Despite region-wide low disclosure scores in Scope 3, only 17 companies report no Scope 3 or uncertainty data (16.5%), indicating a majority of companies have started reporting some data.

3.3.2. Sectoral Indicator Performance

Sectoral analysis reveals differential indicator performance patterns across banking and finance (*n* = 20), industry and manufacturing (*n* = 25), and mining and natural resources (*n* = 10) (Tables 5–7).

Table 5. Banking and finance ¹ distribution characteristics by indicator.

Indicator	Mean	Median	Mode	SD	CV	Skewness	Kurtosis	<i>n</i> Scoring 1	<i>n</i> Scoring 0
CIX 1	0.61	0.80	0.80	0.26	42%	−0.61	−0.30	1	1
CIX 2	0.62	0.80	0.80	0.30	48%	−0.83	−0.16	2	2
CIX 3	0.65	0.80	0.80	0.28	43%	−1.37	0.97	1	2
CIX 4	0.62	0.80	0.80	0.20	33%	−0.22	−2.18	0	0
CIX 5	0.40	0.40	0.40	0.32	79%	0.00	−1.37	0	6
CIX 6	0.44	0.40	0.40	0.29	65%	−0.15	−0.88	0	4
CIX 7	0.20	0.00	0.00	0.24	121%	0.78	−0.21	0	11
CIX 8	0.28	0.40	0.40	0.26	94%	0.40	−0.55	0	8
CIX 9	0.30	0.20	0.00	0.34	113%	0.53	−1.42	0	10
CIX 10	0.00	0.00	0.00	0.00	0%	0.00	0.00	0	20

¹ *n* = 20.**Table 6.** Industry and manufacturing ¹ distribution characteristics by indicator.

Indicator	Mean	Median	Mode	SD	CV	Skewness	Kurtosis	<i>n</i> Scoring 1	<i>n</i> Scoring 0
CIX 1	0.61	0.80	0.80	0.23	39%	−0.76	−0.32	0	1
CIX 2	0.45	0.40	0.40	0.27	59%	−0.13	−0.56	0	4
CIX 3	0.45	0.40	0.40	0.27	59%	−0.13	−0.56	0	4
CIX 4	0.73	0.80	0.80	0.21	28%	−2.36	5.92	1	1
CIX 5	0.22	0.00	0.00	0.26	119%	1.11	1.67	1	13
CIX 6	0.29	0.40	0.00	0.29	102%	0.51	−0.92	0	11
CIX 7	0.26	0.00	0.00	0.30	118%	0.73	−0.81	0	13
CIX 8	0.27	0.40	0.00	0.30	110%	0.62	−0.89	0	12
CIX 9	0.21	0.00	0.00	0.33	158%	1.15	−0.45	0	17
CIX 10	0.02	0.00	0.00	0.08	500%	5.00	25.00	0	24

¹ *n* = 25.**Table 7.** Mining and natural resources ¹ distribution characteristics by indicator.

Indicator	Mean	Median	Mode	SD	CV	Skewness	Kurtosis	<i>n</i> Scoring 1	<i>n</i> Scoring 0
CIX 1	0.74	0.80	0.80	0.31	42%	−1.76	3.06	3	1
CIX 2	0.46	0.40	0.40	0.27	58%	0.71	1.77	1	1
CIX 3	0.56	0.80	0.80	0.34	60%	−1.00	−0.67	0	2
CIX 4	0.78	0.80	0.80	0.29	37%	−2.52	7.33	3	1
CIX 5	0.32	0.40	0.00	0.32	99%	0.41	−1.07	0	4
CIX 6	0.28	0.20	0.00	0.33	118%	0.69	−1.04	0	5
CIX 7	0.20	0.20	0.00	0.21	105%	0.00	−2.57	0	5
CIX 8	0.16	0.00	0.00	0.21	129%	0.48	−2.28	0	6
CIX 9	0.20	0.00	0.00	0.34	170%	1.36	0.11	0	7
CIX 10	0.00	0.00	0.00	0.00	0%	0.00	0.00	0	10

¹ *n* = 10.

The banking and financial sector demonstrates the strongest and most consistent indicator performance from the three sectors analyzed. Scope 1 (CIX 3) disclosure obtains the highest mean value (0.65), followed closely by CIX 1, 2, and 4 (0.61, 0.62, and 0.62). From this we can see that the disclosure of Scopes 1 and 2 is a consolidated practice in the banking sector. Across these four indicators there is negative skewness (−0.22 to −1.37) and low CV values (33–48%), indicating clustering towards high performance. Scope 3 indicators reveal several systemic gaps across the sector. Upstream Scope 3 indicators present higher overall performance, with CIX 5 exhibiting a near perfect distributional symmetry (mean: 0.40, median: 0.40, mode: 0.40, skewness: 0.00). Downstream Scope 3 represents more critical sectoral deficiencies, with CIX 7, 8, and 9 achieving means of 0.20, 0.28, and 0.30, respectively. High CV values (94–121%) reflect important statistical dispersion, with many

companies not reporting: 11 companies (55%) provide no waste disclosure, 8 companies (40%) report no downstream activities, and 10 companies (50%) omit mobility emissions. CIX 10 (uncertainty) shows complete sectoral absence—all 20 companies score zero (mean: 0.00, SD: 0.00), indicating that uncertainty assessment is entirely absent from financial sector carbon reporting despite operational emissions being well-documented.

Industry and manufacturing presents certain similarities, with the disclosure of Scopes 1 and 2 being more complete than Scope 3, although with certain differences. CIX 4 achieves the highest mean with 0.73 and a low CV, with very pronounced negative skewness (−2.36) and positive kurtosis (5.92), demonstrating concentration at maximum values. Despite this, it should be noted that only one company of 25 obtained the maximum score. CIX 1 indicates strong performance in the disclosure of activity data for Scopes 1 and 2, with the second highest mean (0.61) and low CV (39%). CIX 2 and 3 show moderate performance among this cluster, with values that are exactly the same across the board, indicating parallel performance in both indicators. Scope 3 indicators (CIX 5–9) show a significant dip in disclosure quality, with very similar patterns and concentration between 0.22 and 0.29 means. Approximately half of the companies scored zero in these indicators on average. Lastly, CIX 10 reproduces the dynamics of non-reporting seen thus far with uncertainty assessment.

Lastly, mining and natural resources presents the highest variability in its results, mainly due to the reduced sample size ($n = 10$). CIX 4 achieves the highest mean across sectors, with low CV (37%), extreme negative skewness (−2.52), and severe positive kurtosis (7.33), since 3/10 companies score perfectly in this indicator. This pattern, although less pronounced, repeats for CIX 1. CIX 2 and 3 show moderate performance, with slight variation in median, mode, and kurtosis values. Indicators CIX 5–9 show a remarkable dip, consistent so far with Scope 3 reporting trends with the modal value being 0.00 for all of them. CIX 7–9 show particularly low performance (means 0.16–0.20) and extreme CV values (105–170%). CIX 10 mirrors banking with a complete sectoral absence of uncertainty reporting.

3.3.3. National Indicator Performance

Chile demonstrates the strongest and most balanced indicator profile across operational categories (Table 8). Consistent with most case studies analyzed, CIX 4 achieves the highest score (mean: 0.72, median: 0.80, mode: 0.80) with extreme negative skewness and positive kurtosis (7.92), indicating pronounced clustering at maximum scores, despite no companies obtaining the maximum score of “1”. Indicators CIX 1–3 also show robust performance beyond the 0.5 mark, with the only three companies obtaining the maximum scores being located in CIX 1 and 2. This cluster of indicators shows negative skewness (exception of CIX 2: 0.32) and negative kurtosis values, with CIX 3 concentrating the highest number of companies scoring 0 amongst the group. All Scope 1 and 2 indicators are over 0.50. Upstream Scope 3 indicators (CIX 5 and 6) show the highest scores among the region (means: 0.40 and 0.42). Downstream Scope 3 indicators show moderate performance compared to the region, with the exception of CIX 8, exceeding mean values with 0.46 mean and a moderate CV (57%). Chile represents the country with the highest CIX 10 score (mean: 0.06).

Colombia exhibits strong Scope 2 performance, moderate Scopes 1–2 performance and pronounced gaps in Scope 3 reporting (Table 9). CIX 4 (Scope 2) achieves a mean of 0.71 with negative skewness (−0.87) and low CV (28%), matching Chile’s strength with no zero-score cases and one “1”-scoring case. Proportionally, the country has the most cases scoring a full point among the regional sample. CIX 1 exhibits positive skewness (0.98), a trend unique among all countries. CIX 2 shows moderate performance (0.49) with positive skewness (0.47), while CIX 3 achieves 0.52 but with high variability (CV = 77%) and five companies (33%) scoring zero. Scope 3 indicators show a notable drop in performance. CIX 5 and 6 achieve

means of only 0.24 and 0.29 with elevated CV values (105% and 96%), and zero-score rates of 47% and 40%, respectively. Downstream Scope 3 categories represent Colombia's most severe deficiencies. CIX 7 (waste) achieves a mean of 0.16 with extreme CV (158%) and modal score 0.00, as 10 of 15 companies (67%) provide no disclosure. CIX 9 (mobility) shows even weaker performance (mean: 0.13, CV = 185%) with 11 companies (73%) scoring zero and extreme positive skewness (1.79) and kurtosis (2.63). CIX 10 has minimal presence (mean = 0.05) due to being the only case so far of complete uncertainty assessment (one company scoring a full point), whereas the rest do not disclose it completely, skewing the sample.

Table 8. Chile ¹ distribution characteristics by indicator.

Indicator	Mean	Median	Mode	SD	CV	Skewness	Kurtosis	<i>n</i> Scoring 1	<i>n</i> Scoring 0
CIX 1	0.58	0.80	0.80	0.28	49%	−0.64	−0.42	1	2
CIX 2	0.61	0.40	0.40	0.23	38%	0.32	−1.69	2	0
CIX 3	0.55	0.80	0.80	0.32	58%	−0.84	−0.87	0	4
CIX 4	0.72	0.80	0.80	0.20	28%	−2.83	7.92	0	1
CIX 5	0.40	0.40	0.00	0.33	84%	0.00	−1.58	0	7
CIX 6	0.42	0.40	0.40	0.27	64%	−0.05	−0.50	0	4
CIX 7	0.25	0.40	0.40	0.24	95%	0.30	−0.61	0	9
CIX 8	0.46	0.40	0.40	0.26	57%	−0.14	−0.43	0	3
CIX 9	0.32	0.40	0.40	0.27	84%	0.25	−0.64	0	7
CIX 10	0.06	0.00	0.00	0.14	251%	2.20	3.14	0	18

¹ *n* = 21.

Table 9. Colombia ¹ distribution characteristics by indicator.

Indicator	Mean	Median	Mode	SD	CV	Skewness	Kurtosis	<i>n</i> Scoring 1	<i>n</i> Scoring 0
CIX 1	0.55	0.40	0.40	0.22	40%	0.98	−0.80	1	0
CIX 2	0.49	0.40	0.40	0.25	51%	0.47	0.57	1	1
CIX 3	0.52	0.80	0.80	0.40	77%	−0.54	−1.73	1	5
CIX 4	0.71	0.80	0.80	0.20	28%	−0.87	−0.66	1	0
CIX 5	0.24	0.40	0.40	0.25	105%	0.55	−0.38	0	7
CIX 6	0.29	0.40	0.40	0.28	96%	0.43	−0.67	0	6
CIX 7	0.16	0.00	0.00	0.25	158%	1.41	1.26	0	10
CIX 8	0.27	0.40	0.00	0.29	109%	0.63	−0.65	0	7
CIX 9	0.13	0.00	0.00	0.25	185%	1.79	2.63	0	11
CIX 10	0.05	0.00	0.00	0.21	387%	3.87	15.00	1	14

¹ *n* = 15.

Ecuador demonstrates the lowest national indicator profile, with only one indicator (CIX 4) exceeding the 0.5 benchmark (Table 10). CIX 1 remains close to the mean threshold (0.49), with moderate CV (61%). CIX 2 reaches a mean of 0.38, with a bimodal distribution evidenced by the median–mode difference (0.40 and 0.00), as well as the fact that two companies obtain the maximum score, illustrating pronounced internal divisions in disclosure quality. CIX 3 shows similarly weak performance (mean: 0.35, CV = 97%) with seven zero-score cases and positive skewness (0.24), indicating a tendency towards non-disclosure. Scope 3 indicators reveal a nearly systematic absence across reports. CIX 5 and 6 achieve means of only 0.21 and 0.16 with modal scores of 0.00, extreme CV values (118% and 123%), and zero-score rates exceeding half the sample. Downstream Scope 3 indicators achieve the weakest performance, with CIX 7, 8, and 9 achieving means between 0.07 and 0.09, all with modal and median scores of 0.00, extreme CV values (186–300%), and very high zero-score rates. CIX 10 shows complete national absence with all 17 companies scoring zero.

Table 10. Ecuador ¹ distribution characteristics by indicator.

Indicator	Mean	Median	Mode	SD	CV	Skewness	Kurtosis	<i>n</i> Scoring 1	<i>n</i> Scoring 0
CIX 1	0.49	0.40	0.80	0.30	61%	−0.43	−0.99	0	3
CIX 2	0.38	0.40	0.00	0.38	101%	0.44	−1.30	2	7
CIX 3	0.35	0.40	0.00	0.34	97%	0.24	−1.63	0	7
CIX 4	0.62	0.80	0.80	0.22	36%	0.05	−1.87	1	0
CIX 5	0.21	0.00	0.00	0.25	118%	0.75	−0.22	0	9
CIX 6	0.16	0.00	0.00	0.20	123%	0.39	−2.11	0	10
CIX 7	0.09	0.00	0.00	0.22	239%	2.47	5.84	0	14
CIX 8	0.09	0.00	0.00	0.17	186%	1.37	−0.15	0	13
CIX 9	0.07	0.00	0.00	0.21	300%	3.14	9.80	0	15
CIX 10	0.00	0.00	0.00	0.00	0%	0.00	0.00	0	17

¹ *n* = 17.

Mexico demonstrates strong operational foundations across the biggest national sample analyzed (Table 11). CIX 4 achieves the highest mean, with 0.71, low CV (36%), and negative skewness (−1.52), indicating a pronounced tendency towards high performance. Four companies achieve a perfect score, the highest absolute count regionally. CIX 1 and 2 both exceed the 0.50 benchmark. CIX 1 demonstrates the highest regional mean (0.69) with strong negative skewness (−1.34). CIX 2 shows moderate strength with no maximum scores but only four zero-score cases (12%), reflecting widespread emission factor disclosure. Median and modal values of 0.80 for all three of them combined with negative skewness points to cluster towards high performance in key Scope 1 and 2 indicators. CIX 3 remains close to the 0.50 benchmark (0.49), with a near symmetrical distribution (Skewness: 0.03) unique in the region. Scope 3 categories reveal several relevant deficiencies. CIX 5 achieves the lowest regional mean (0.17) with extreme CV (153%) and a modal score of 0.00. Only one company achieves maximum compliance, creating extreme positive skewness (1.50). CIX 6 shows moderate performance (0.31) compared to other Scope 3 indicators. CIX 8 and 9 achieve means of only 0.16 and 0.18 with elevated CV values (148% and 169%), modal scores of 0.00, and zero-score rates of 65% and 71%, respectively. CIX 7 performs marginally better (mean: 0.26) with one company achieving maximum compliance. CIX 10 shows near complete absence, with only two companies reporting uncertainty data.

Table 11. Mexico ¹ distribution characteristics by indicator.

Indicator	Mean	Median	Mode	SD	CV	Skewness	Kurtosis	<i>n</i> Scoring 1	<i>n</i> Scoring 0
CIX 1	0.69	0.80	0.80	0.22	32%	−1.34	1.43	2	2
CIX 2	0.56	0.80	0.80	0.28	50%	−0.79	−0.53	0	4
CIX 3	0.49	0.40	0.40	0.28	56%	0.03	−0.44	2	4
CIX 4	0.71	0.80	0.80	0.25	36%	−1.52	1.93	4	2
CIX 5	0.17	0.00	0.00	0.26	153%	1.50	1.99	1	22
CIX 6	0.31	0.40	0.00	0.30	97%	0.41	−1.03	0	14
CIX 7	0.26	0.40	0.00	0.29	110%	0.79	−0.10	1	16
CIX 8	0.16	0.00	0.00	0.24	148%	1.21	0.56	0	22
CIX 9	0.18	0.00	0.00	0.30	169%	1.37	0.33	0	24
CIX 10	0.02	0.00	0.00	0.10	406%	3.93	14.24	0	32

¹ *n* = 34.

Peru presents moderate operational performance with high internal variability, reflected by its 3.50 IQR at the national level (Table 12). CIX 1 achieves the highest mean (0.63) with low CV (39%) and positive skewness (0.25), and it is the only indicator without any zero-scores in the country. CIX 4 is, thus, not the highest scoring in Peru, and is the lowest scoring among all other countries analyzed (0.59), presenting minimal skewness

(−0.02) and moderate CV (50%). CIX 2 and 3 present very similar tendencies, with mean, median–mode, and CV coinciding almost entirely, and slight differences in skewness and kurtosis values. Upstream Scope 3 indicators present high means compared to the rest of cases analyzed, with CIX 5 obtaining 0.38 and CIX 6 obtaining 0.33, only behind Chile. Although no single company obtains a full point, the zero-scoring rate in both indicators is lower than in the rest of the region. Downstream categories show notably lower values, CIX 7, 8, and 9 achieve means between 0.18 and 0.26 with modal scores of 0.00 and elevated CV values (117–142%). CIX 8 uniquely shows one company achieving maximum compliance—the only such case for downstream activities regionally alongside Mexico’s single CIX 7 maximum score. CIX 10 shows complete national absence of disclosure, with all companies scoring 0.00 ($n = 16$).

Table 12. Peru ¹ distribution characteristics by indicator.

Indicator	Mean	Median	Mode	SD	CV	Skewness	Kurtosis	<i>n</i> Scoring 1	<i>n</i> Scoring 0
CIX 1	0.63	0.60	0.40	0.24	39%	0.25	−1.76	2	0
CIX 2	0.49	0.40	0.40	0.32	65%	−0.15	−0.92	1	3
CIX 3	0.46	0.40	0.40	0.31	66%	0.03	−0.67	1	3
CIX 4	0.59	0.40	0.40	0.30	50%	−0.02	−0.82	3	1
CIX 5	0.38	0.40	0.40	0.27	73%	0.07	−0.49	0	4
CIX 6	0.33	0.40	0.00	0.33	103%	0.39	−1.44	0	7
CIX 7	0.18	0.00	0.00	0.20	117%	0.28	−2.22	0	9
CIX 8	0.26	0.00	0.00	0.35	133%	1.01	−0.27	1	9
CIX 9	0.25	0.00	0.00	0.35	142%	0.89	−1.13	0	10
CIX 10	0.00	0.00	0.00	0.00	0%	0.00	0.00	0	16

¹ $n = 16$.

4. Discussion

4.1. Main Findings and Limitations

This multi-country assessment of 103 companies across five Latin American countries reveals three critical patterns in corporate carbon disclosure quality. First, the region exhibits a systematic Scope 3 transparency deficiency; while Scope 1 and 2 indicators achieve means of 0.48–0.68, Scope 3 categories collapse to 0.19–0.31, with 40–67% of companies providing no disclosure on at least one value-chain emission indicator. Uncertainty assessment, essential for credible emissions quantification [1], is virtually absent, with only 6% of companies (6 of 103) reporting any uncertainty data. Additionally, 17/103 companies analyzed provided no Scope 3 or uncertainty assessments, illustrating that even though most companies report some data on Scope 3 and uncertainty, it is mostly incomplete.

Second, despite diverse national contexts, country-level median scores converge within a 1.55-point range (Ecuador: 2.65; Chile: 4.20), suggesting that transnational isomorphic pressures, from multinational corporations, international investors, or global reporting frameworks, correlate with the regional patterns identified. Chile achieves both the highest median and lowest variability (CV = 38%), indicating mature, institutionalized disclosure practices, while Ecuador demonstrates the lowest median and highest variability (CV = 69%), pointing towards systemic capacity constraints that condition baseline transparency.

Third, sectoral analysis reveals that disclosure deficiencies transcend baseline transparency. Banking and finance achieve the highest regional CIX scores, with very high emission disclosure for CIX 1–4 (>0.61), although 100% non-disclosure of uncertainty, and substantial gaps in Scope 3 reporting, particularly waste and mobility. Cross-sectoral analysis revealed homogeneity in the deficiencies across sectors, pointing towards common deficiencies in regulatory enforcement, technical capacity, and corporate strategies. Industry and manufacturing (mean: 3.40) and mining and natural resources (mean: 3.52)

exhibit parallel deficiency profiles, strong Scope 1 and 2, weak Scope 3, and complete uncertainty absence.

Before interpreting these patterns further, we acknowledge several methodological limitations that bound the scope of our conclusions. Firstly, sample composition and geographic scope. This study focused exclusively on large publicly traded companies from national stock market exchange indices to ensure an objective selection criterion, but excluding SMEs, private companies, and unlisted corporations, representing a great fraction of Latin American economic activity [48]. Our findings characterize the disclosure practices among the region's largest corporations but cannot speak of the broader economic ecosystem. Additionally, our geographic scope excludes major regional economies such as Argentina or Brazil, limiting our ability to make more comprehensive regional claims. Due to the limited size of Ecuador's stock exchange index (10 companies in the ECUINDEX), a substitutive source, the Ekos business ranking [45], was used to achieve adequate sample size, introducing minor methodological inconsistency in cross-country comparisons. Future research should expand CIX assessment to SMEs and private firms and incorporate other major economies such as Brazil and Argentina in order to provide truly comprehensive regional analysis.

The reliance on publicly disclosed information also generates an inherent limitation, because companies may in fact possess more detailed disclosure information in internal records that is not reflected in our analysis. However, our target analysis is precisely showcasing the level of public transparency of firms across the region, rendering non-public documentation invalid in this matter. Future research could deepen understanding through partnerships with companies willing to share internal documentation on carbon footprint disclosure.

This study analyzes disclosures from a single reporting year, except for Mexican reports (2022), all other companies reflect 2023 disclosures. This one-year lag limits direct temporal comparability, although corporate disclosure practices tend to evolve gradually, and no substantial new regulations on CF disclosure in Mexico were found between 2022 and 2023. Longitudinal assessments tracking the same markets across multiple years would reveal whether substantial differences in disclosure appear as time passes.

Despite rigorous control protocols, the CIX scoring methodology still presents a risk of introducing bias in expert judgment applying criteria to diverse disclosing formats and contexts. We addressed this issue by expanding from a two to a three independent reviewer protocol. Each company report was independently evaluated by three trained experts, followed by consensus meetings coordinated by a methodological expert to reconcile discrepancies and ensure inter-rater concordance. Institutional partnerships with UNALM and ESPOL enabled recruitment of evaluators with local contextual knowledge, reducing misinterpretation of country-specific reporting practices.

4.2. Latin America's Carbon Disclosure Landscape

The regional convergence of median CIX scores within a 1.55-point range (Ecuador: 2.65; Chile: 4.20) despite diverse regulatory and disclosure contexts aligns with institutional isomorphism theory [27]. Score convergence at low quality levels observed across the sample presented aligns with prior research identifying the reduced effectiveness of voluntary disclosure frameworks in emerging markets, where institutional pressures and stakeholder demands differ [6]. The patterns suggest that due to the multinational character of most of the firms analyzed, global dynamics, such as the role of international investors [49], global reporting frameworks, or shared know-how [50], establish minimum disclosure thresholds, but are insufficient to motivate rigorous carbon accounting. Although all five countries analyzed reference international frameworks such as the GHG Protocol and GRI, their

national regulatory approaches to corporate carbon disclosure differ substantially in terms of mandatory reporting, enforcement mechanisms, and institutional capacity. Chile and Mexico combine mandatory reporting requirements with fiscal or market-based instruments, while Colombia applies sector-specific mandates. In contrast, Ecuador and Peru rely primarily on voluntary or referential disclosure mechanisms. These similarities and differences in regulatory design and enforcement capacity help contextualize the observed convergence of CIX scores at relatively low levels and explain cross-country variability in disclosure quality (Table 13).

Table 13. National carbon disclosure regulatory frameworks across the five countries analyzed.

Country	Mandatory Reporting	Key Regulations	Enforcement Level	Disclosure Framework Type
Chile	Scope 1 and 2 for large facilities	Framework Law on Climate Change—Law 21455 [51]	High	Mixed (mandatory + voluntary)
Colombia	Scope 1 and 2 for specific sectors	Climate Action Law 2169 [52]	Medium	Sector-specific mandatory
Ecuador	Voluntary registry	Environmental Organic Code Ecuador Carbon Zero Program [53]	Low	Voluntary
Mexico	Scope 1 and 2 mandatory (large emitters)	General Law on Climate Change [54]	Medium–High	Mandatory with market-based instruments
Peru	No general corporate mandate	Framework Law on Climate Change—Law 30754 [55]	Medium–Low	Predominantly voluntary

Three particular mechanisms for the adoption of parallel reporting practices can be identified across the sample:

The first is coercive isomorphism. The sample analyzed includes 68/103 (66%) multinational corporations, meaning a majority of the companies analyzed operate through parent company mandates. Subsidiary companies can reasonably be expected to align their sustainability reporting with corporate standards independent of local contexts and requirements [27].

The second one is mimetic isomorphism. Applied to this disclosure context, we can see a clear baseline reporting set in the adoption of Scope 1 and 2 reporting, with regional means ranging from 0.48 to 0.68 across all countries. This explains why companies from Ecuador report emissions on a similar level to Chile despite the differences in contextual factors that may lead to different scores in other Scope 3 categories.

Finally, we can see clear instances of normative isomorphism across company reports. A vast majority of the case studies analyzed cite global frameworks and reporting standards as the GHG Protocol and GRI frameworks, presenting a landscape of standardized methodologies with ample diffusion across borders [56].

Although score convergence is identified, the low regional mean (3.53/10) points towards low quality convergence. Isomorphic pressures alone generate a baseline of reporting, but do not transcend to drive substantive transparency [57]. The companies analyzed appear to adopt disclosure structures that favor minimum compliance, a signal of legitimacy to international stakeholders, avoiding the more resource-intensive quality improvement.

This pattern aligns with prior research showing voluntary frameworks in emerging markets generate ceremonial adoption rather than substantive implementation [58]. The narrow convergence band (CV = 47% regionally) combined with universally low Scope 3 performance (means 0.19–0.31) demonstrates that global reporting frameworks create floor effects (minimum acceptable disclosure) without establishing ceiling pressures (incentives for excellence) [50].

Even though to some extent there is regional convergence, there are important national variations that have to be acknowledged, as they reflect institutional capacity and regulatory infrastructure differences.

For starters, Chile's position as a regional leader (median 4.20, CV = 38%) can be traced back to the convergence of three factors:

Firstly, the creation of several enforceable disclosure agreements, made possible because of Chile's legal framework regarding climate change (Law 21455 [51]) and carbon tax legislation (Law 20780 [59]), has ensured the compliance of large facilities (Table 13). In contrast to voluntary registry in Ecuador or Peru's referential frameworks, there are important consequences for Chilean companies who choose to not follow disclosure regulation. It is precisely because of this normative floor that Chile's consistent Scope 1 and 2 performance (CIX 1–4 means: 0.58–0.72) is above both Peru's and Ecuador's, with minimal zero-score cases (0–4 companies per indicator).

Secondly, the low variability in Chile's results (CV = 38%) suggests an oversight capacity that has diffused broadly across their corporate sector, rather than remaining concentrated in early adopters. This can be traced back to Chile's carbon pricing system, which has been operating since 2017 and therefore has allowed a maturing period of 6 to 7 years before our 2023 assessment. It is during this period that regulatory agencies have developed an oversight capacity, and when corporations have built internal expertise.

The third and final factor is the strong integration with international capital markets that Chilean companies demonstrate. Because of this, investors tend to press for quality disclosure to a greater extent, a pressure that exceeds domestic regulatory minimum and has resulted in Chile obtaining the highest Scope 3 performance regionally (CIX5–9 means: 0.25–0.46).

On the other side of the spectrum we find Ecuador, with systemic corporate failures that position it as the lowest-performing country (median 2.65, highest variability CV = 69%). There are three factors that explain this: a wide regulatory vacuum, complimented with limited institutional capacity, and a bifurcation of corporate capabilities. The "Low" enforcement levels of both the voluntary Environmental Organic Code and Ecuador's Carbon Zero program through which Ecuador operates, far from effectively regulating and orienting Carbon disclosure, result in the non-compliance mechanism. This regulatory vacuum is accompanied by Ecuador's smaller and underdeveloped capital markets. The result is that there is no investor pressure or rigorous disclosure, opposite to what we saw happens in Chile, and no resources for further regulatory advances. These limitations constrain institutional development of sustainability expertise.

Lastly the combination of low median (2.65) with the highest variability reveals an extreme heterogeneity in disclosure capacity. There is a high contrast between sophisticated and elite companies which achieve outstanding results and the rest of the companies, (12/17), which combined have a score below 3.0. This bifurcation indicated that technical capacity remains only accessible for elite firms, with little institutionalization of carbon and sustainability disclosure mechanisms across the national corporate sector [60].

When interpreting the sectoral results, the banking sector presents a revealing disclosure profile. Financial institutions demonstrate a very strong operational baseline across the region, with CIX 1–4 obtaining high results (0.61–0.65) indicating strong internal capabilities. These strongpoints, however, contrast greatly with the systematic omission of value-chain emissions (CIX 7 shows 55% non-disclosure, CIX 9 shows 50% omission, and CIX 10 shows 100% omission). Contrary to original assumption, upstream categories (CIX 5–6) show higher CIX scores than downstream categories (CIX 7–9), even as these latter include financed emissions as a whole.

From a stakeholder theory perspective, we can interpret that banks are particularly susceptible to complex stakeholder pressure regionally, with international ESG investors and clients exerting pressure on operational footprint disclosure (CIX 1–4), although not as prominently with the companies financed emissions, a part of CIX 8 and representative

of most of finance's emissions as a whole [61]. Likewise, waste management and mobility show low relevance for stakeholders. This selectivity is further explained by legitimacy theory. Banking's consolidated operational emission disclosure profile shows a high level of symbolic compliance when analyzed globally. Although operational emissions are disclosed in a methodologically robust manner, their over-emphasis allows the sector to satisfy ESG reporting expectations to a high level, being leaders among the sectors analyzed, while avoiding comprehensive transparency across their value chain [62].

The complete absence of uncertainty reporting is particularly striking in a sector that routinely quantifies credit risk, market risk, or operational risk systematically [63]. This suggests strategic decisions prioritizing legitimacy management over technical limitations. From an agency theory perspective, this strategic omission can be seen as acknowledging that recognizing emission uncertainty could intensify further monitoring pressure and invite scrutiny of climate risk management [64].

Cross-sector comparisons present a counterintuitive finding that challenges traditional legitimacy theory predictions: carbon-intensive sectors (Industry mean: 3.40; Mining: 3.52) demonstrate lower quality disclosure than the financial sector (mean: 3.98). The observed pattern suggests a complex legitimacy–disclosure dynamic operating in Latin American contexts.

This pattern can be explained by three complementary mechanisms. Firstly, we can point towards asymmetric stakeholder pressures. Industry and manufacturing presents a more fragmented stakeholder landscape that prioritizes immediately close environmental issues over value-chain methodological rigor. This fragmentation dilutes pressure for high-quality carbon disclosure specifically, even as overall environmental scrutiny remains high [65]. Another mechanism has to do with the materiality of disclosure costs and complexity. Financial and banking companies produce high quality Scope 1 and 2 disclosure with relatively low marginal cost due to the type of facilities, meaning low complexity to achieve strong CIX 1–4 scores. Industry and natural resources, however, face more complex emissions accounting in operational emissions due to higher number of facility types, process emissions, and fugitive releases, discouraging comprehensive transparency even as the legitimacy pressures exist. Finally, alternative legitimacy-building tools apart from carbon footprint disclosure can be identified regionally for the sectors at hand. Initiatives such as community investments, operational safety, job creation, or technology adoption seem to be the more dominant narrative strategy, reflecting differing legitimacy management calculations between sectors.

The systematic Scope 3 deficiency (means 0.19–0.31, non-disclosure rates 40–67%) and near-complete uncertainty absence (94% non-disclosure) are symptomatic of both technical and strategic challenges.

The disclosure literature documents extensively the role of technical constraints for effective disclosure. It is safe to assume that elements such as data unavailability across complex supply chains, measurement difficulties, and methodological complexities play a role in the Scope 3 results presented. Additionally, tractioning long supply chains and generating supplier engagement in accounting can be a challenge specific to emerging markets that needs further study [46].

Strategic considerations and issues, however, feed off and amplify these technical barriers, generating a disclosure avoidance in technically capable companies. From a stakeholder lens, systematic Scope 3 and uncertainty omission reflects a rational resource allocation mechanism towards the emission categories that generate stakeholder scrutiny. Scope 1 and 2 dominate the mandatory and voluntary disclosure framework guidelines. In fact, materiality asymmetries derived from the omission of Scope 3 tend to generate even greater disincentives for value-chain emission disclosure, being that Scope 3 emissions

often represent 70–90% of total company emissions, making symbolic compliance through selective Scope 1 and 2 reporting the best option. Legitimacy theory, on the other hand, illustrates how regionally spread Scope 3 deficiencies act as a collective floor where no individual company faces legitimacy pressure to exceed the sectoral norms.

4.3. Implications for Policy, Practice, and Future Research

This analysis has shown that even though voluntary frameworks generate regional convergence (1.55-point difference between means), this convergence is of generally low quality (3.55 regional mean CIX score). The presence of disclosure alone is not enough to guarantee proper transparency for stakeholders [43]. Applying the CIX framework to a regional context allows policy makers to move from a binary disclosure–non-disclosure paradigm towards setting minimum quality thresholds for compliance monitoring. Tiered quality requirements that establish disclosure guidelines and practices regionally could be a useful tool for improving CIX scores and transparency across the region. Regulatory agencies and operators could adopt CIX as a standardized monitoring framework, similarly to capital adequacy ratios, identifying lagging sectors and evidence-based enforcement prioritization.

The fact that Chile obtained the highest mean CIX score (4.20) with the lowest variability shows that combining institutional capacity and national frameworks is associated with consistent high performance. Ecuador, on the other hand, showing the lowest score (2.65) but highest variability, leads one to assume that uniform regional mandates could be counterproductive, given the internal capacity differences across contexts. Differentiated regulatory approaches and developments could use this CIX assessment as a guide structuring capacity-building programs and legal requirements in the initial consolidation phases of Scopes 1 and 2, then upstream Scope 3, then downstream Scope 3, and final uncertainty quantification. The harmonization of local capacity building with national regulatory frameworks and international reporting frameworks could generate the necessary incentive structure for lagged companies to catch up to a baseline of reporting, as well as generate a differentiation opportunity for companies that already report more thoroughly but are missing key indicators.

The CIX enables three specific policy interventions. Tiered regulatory frameworks could mandate minimum CIX thresholds by development stage, where foundational contexts (<3.0 score) require Scope 1 and 2 completeness before developing Scope 3 mandates, while advanced markets (>4.0) can enforce value-chain reporting. Chile's Law 21455 [51] demonstrates this approach—mandatory Scope 1–2 reporting for large facilities combined with carbon taxation (Law 20780) [59] generated consistent performance (CV = 38%) through enforcement certainty. Second, CIX-indexed incentives could reward disclosure quality beyond mere presence, enabling tax credits, lending rates, or public procurement advantages to move from valuing symbolic to substantive reporting. Finally, capacity-building programs could provide technical assistance with focalized targets, focusing on the weaker CIX indicators regionally and nationally.

Furthermore, the systematic Scope 3 deficiencies identified in this study carry profound implications in a carbon trade landscape dominated by the EU's Carbon Border Adjustment Mechanism (CBAM) discussions. CBAM implementation as of 2026 requires verifiable embedded carbon calculations across value chains, precisely the disclosure domain that presents weaker performance regionally. Our findings suggest that regional exporters of CBAM-covered sectors (cement, aluminum, steel, fertilizers. . .) will face distinct risks from inadequate value-chain emissions reporting. Among them, companies extending default carbon intensity values and not being able to demonstrate methodologically rigorous calculation will face punitive default rates and increasing border adjustment costs. What this means as well is that the regional differences reflected in this study will translate directly

into differentiated median costs by country with stronger disclosure infrastructures securing preferential treatment (Chile or Mexico) over the weaker disclosers (Ecuador or Peru). CIX assessments in the future could serve as a diagnostic tool for assessing CBA readiness, identifying priority sectors requiring targeted pre-compliance technical assistance.

Currently, 94% of the company reports analyzed did not report any uncertainty values. This gap represents an opportunity for early adopters to differentiate themselves and acquire a competitive advantage over their sector, positioning them as a leader in climate action transparency and traceability. Interpreting uncertainty values in company reports as a sign of methodological sophistication instead of an internal weakness could help build credibility and rapport for the company, challenging possible greenwashing claims. Additionally, another notable gap has to do with operational disaggregation by business unit, geography, or facility. This gap is reflected by the low number of full one-point scores across the region and is a key measure in ensuring targeted decarbonization strategies across sectors, demonstrating actionable transparency. First-mover advantages are already emerging: Chile's Banco de Chile (6.4), Colombia's Grupo ISA (6.8), and Peru's Credicorp (6.6) achieved top regional scores through comprehensive Scope 3 and uncertainty reporting, potentially positioning them favorably for climate-linked financing instruments (green bonds, sustainability-linked loans).

Several future research directions could enhance and develop several of the emission disclosure dynamics that remain out of this cross-sectional study's scope. Most urgently, CBAM implementation in 2026 creates a natural experiment for assessing if and how border carbon pricing affects disclosure quality in exporting nations to the EU. Longitudinal CIX studies in the region could study whether sustain trade exposure in CBAM-covered sectors improves overall CIX scores and facilitates the transition from symbolic to substantive disclosure. Longitudinal studies comparing one, or a set of markets, over multiple reporting cycles could also reveal whether companies with more transparent disclosure achieve measurable advantages among the country's top performing companies (by capital), or if it is in fact a non-factor. Broader regional studies, including all major economies in Latin America, including Brazil or Argentina, could provide deeper insight into regional disclosure dynamics and structures, as well as comparative assessments across regions. Future studies could focus on extending this analysis to regions of similar industrialization or development levels, elaborating on specific protocols that could enhance the generalizability of the assessments in these comparisons. Another particularly interesting field has to do with correlation analysis between CIX scores and other descriptive measures, such as policy stringency on environmental matters, Human Development Index, specific ESG ratings (MSCI, Sustainalytics, CDP. . .), etc. Altering the sample composition by including SMEs, national public institutions, or other sets of actors could also enhance our understanding of dynamics within the broader national economy.

5. Conclusions

This study provides the first systematic multi-country analysis of corporate carbon disclosure quality in Latin America, analyzing 103 countries across Chile, Colombia, Ecuador, Mexico, and Peru by applying the Carbon Integrity Index framework. Scope 3 and uncertainty reporting were identified as the biggest corporate disclosure gap across the region; even though 83.5% of companies disclose some Scope 3 data, the score on these disclosures is generally low (averaging 0.19–0.31 across indicators), with uncertainty reporting being practically absent (94% non-disclosure rate). National disclosure patterns converge in a 1.55-point range (2.65–4.20), despite heterogenous national regulatory frameworks and capacity environments, while sectoral analysis did not provide substantial reporting differences in reporting practices or quality. These findings demonstrate that disclosure presence

differs essentially from disclosure quality, a distinction only appreciable through systematic evaluation tools such as the CIX. Regional score convergence suggests that isomorphic pressures from corporate environments may drive a baseline reporting structure, but without capacity-building initiatives or locally enforced normative frameworks carbon footprint reporting remains of low quality. Our study provides the first regional CIX assessment in developing markets, shining light on the role of rigorous accountability mechanisms built on quality disclosure for regions experiencing disproportionate climate vulnerability.

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