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Assessing corporate social responsibility pressures in lithium mining: a topic modeling analysis approach

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Abstract

Corporate social responsibility (CSR) plays a critical role in mitigating the negative impacts of critical mineral mining. Yet research offers limited insight into how societal pressures shape the responsiveness and effectiveness of CSR in this sector. Empirical study is further constrained by selective corporate disclosure, inconsistent datasets, and unreliable interview evidence. To address these challenges, this study applies topic modeling, a form of natural language processing, to stakeholder communication data. Focusing on the Chilean lithium mining industry from 2010 to 2022, the analysis examines how a leading mining company pursued and operationalized CSR through its annual sustainability reports. The findings show that the company's CSR efforts appear linked to societal pressures, particularly regulatory fines, activism, environmental scrutiny, and investor demands. Persistent drivers included water conflicts, legal actions, and policy changes. The study also demonstrates that topic modeling offers a useful tool for identifying and tracking CSR priorities over time, yielding insights less accessible through conventional research approaches.

1. Introduction

The rapid clean energy transition has intensified demand for minerals like copper, lithium, and nickel (Islam *et al* 2022, Kamran *et al* 2023). However, their extraction often disrupts livelihoods, contaminates land and water, and fuels conflicts between mining companies and stakeholders (Agusdinata *et al* 2022). Balancing economic interests with environmental and social responsibility remains a challenge, causing friction between mining companies, governments, labor groups, and Indigenous communities. Labor groups frequently raise concerns over safety, wages, and mining rights (Min *et al* 2019).

As mining firms face growing scrutiny over their environmental, social, and governance (ESG) impacts, many have adopted corporate social responsibility (CSR) measures to mitigate risks. CSR refers to corporate actions that prioritize social interests beyond economic performance and legal requirements (Orlitzky *et al* 2003). The growing scrutiny may explain why CSR in mining is 'arguably the most extensive of any corporate sector' (Slack 2012, p 180). Companies' public discourses on mining CSR is driven by reputational, operational, and regulatory risks (Jenkins 2004, Frederiksen 2018). However, few studies examine how different societal pressures such as labor concerns, Indigenous rights, or environmental advocacy translate into changes in corporate CSR strategies over time (Lee 2011, Fatima and Elbanna 2023), particularly in critical minerals industries. This gap is particularly relevant because affected communities are often geographically distant from where the final products are consumed (Viveros 2017, Agusdinata *et al* 2023). These communities have limited influence on CSR decisions despite bearing most sustainability impacts. Obtaining reliable data from companies on sustainability practices is challenging (e.g. Torelli *et al* 2020, Ma *et al* 2021, Holtom *et al* 2022). Issues include a lack of standardized datasets, selective corporate disclosures, low survey response rates, and limited access for interviews. Interview data in resource extraction industries are often particularly unreliable

due to opacity, strict regulations, and distrust of outsiders.

Our study examines brine-based lithium extraction in Chile, which holds the world's largest economically extractable lithium reserve and supplies nearly one-third of global production. Lithium mining in Chile, in particular, is controversial because it involves issues concerning water scarcity, Indigenous land rights, and strong environmental activism. Such a combination creates a contested arena for CSR practices. Given this background, Chile provides an appropriate case study to investigate how societal pressures in such high-stakes and conflict-prone contexts are associated with a corporation's sustainability strategies.

Using a case study of a major Chilean lithium producer (CLP), this study examines how societal pressures relate to CLP's CSR strategies and whether these pressures coincide with its actions. To address challenges with traditional data collection methods, we apply topic modeling (Vayansky and Kumar 2020, Isoaho *et al* 2021). The analysis covers CSR activities from 2010 to 2022, using topic modeling to infer the firm's strategic intent from its publicly disclosed sustainability reports (Blei 2012, Ning *et al* 2021). It explores two research questions:

1. What types of societal pressures are associated with how a mining corporation reports on CSR activities?
2. To what extent is topic modeling effective for tracing shifts in CSR discourse in response to societal pressures?

The analysis shows that CLP's reporting appeared to be responsive to societal stakeholder pressures. For policymakers, corporations, and communities, the insights could inform strategies for more accountable and sustainable mining practices. The study also demonstrates the utility of topic modeling as a methodological tool for analyzing corporate sustainability disclosures in contexts where conventional data collection methods are limited.

2. Literature review and research framework

2.1. CSR in the mining industry: contradictions, gaps, and research need

The mining industry faces enduring challenges of environmental degradation, labor conflict, and community opposition, making it what Dashwood (2012) calls 'a contested arena of legitimacy.' CSR has become a central tool for firms to address these pressures, spanning initiatives from community development to compliance with international sustainability standards (Darnall *et al* 2022, Ates 2023). Disclosure has grown particularly important, with frameworks such as the UN Global Compact, OECD guidelines, and the Global Reporting Initiative (GRI) promoting transparency and stakeholder engagement (MacLean and Rebernak 2007, Dilling 2010).

Yet contradictions remain. CSR often functions both as a genuine mechanism for social and environmental improvement and as a reputational tool to deflect scrutiny (Lodhia and Hess 2014, Rolston 2015, CSSN 2021). Firms may adopt CSR to reduce litigation risk (Chakraborty *et al* 2023, Freund *et al* 2023) or selectively disclose information to exaggerate positive impacts (Darnall 2023). Related to corporate CSR reporting, many firms disclose environmental information to cover up their poor environmental performance (Gull *et al* 2022), especially in economically underdeveloped regions (Yun *et al* 2023). Still, research also shows CSR can deliver measurable gains in environmental protection and labor conditions, particularly when sustained community or regulatory pressures drive accountability (Manky 2020, Gobby *et al* 2022, Carvalho *et al* 2023). Moreover, other scholars indicate that CSR reporting on its own can improve their environmental actions (Escamilla-Solano *et al* 2023).

Despite these insights, three research gaps persist. First, most studies of extractive industries focus on gold, coal, or oil, with little systematic attention to critical minerals like lithium, which are central to the clean energy transition (Jenkins 2004, Frederiksen 2018, Islam *et al* 2022, Kamran *et al* 2023). Second, while CSR is known to respond to societal pressures (Lee 2011, Fatima and Elbanna 2023), few studies examine how different types of pressures interact over time to shape corporate strategies. Third, empirical progress remains constrained by limited standardized datasets, selective disclosure, and unreliable interviews (Torelli *et al* 2020, Ma *et al* 2021, Holtom *et al* 2022).

2.2. Theoretical perspectives on CSR

Understanding CSR requires drawing on both stakeholder theory and institutional theory, which explain complementary forces shaping corporate responses. Stakeholder theory emphasizes that long-term success depends on meeting the needs of employees, communities, customers, investors, and other key groups (Freeman 2010, Harrison and Wicks 2013). It highlights direct pressures: unions demanding wages and safety (Alexander 2013), NGOs such as Global Witness exposing unethical practices (Le Billon 2008), and consumer activists pushing for ethical sourcing that reshapes supply chains (Young *et al* 2019). These pressures are transactional and relational, operating mainly at the organizational level as managers identify, prioritize, and respond to stakeholder demands (Freeman 2010, Harrison and Wicks 2013, Behravesh *et al* 2025).

Institutional theory, by contrast, stresses systemic pressures that structure organizational behavior, such as regulatory frameworks, cultural norms, and industry standards (Zucker 1987, Brammer *et al* 2012). Examples include government environmental regulations (Gunningham *et al* 2004), global agreements like the Paris Accord (Baumgartner 2014), industry associations setting best practices (Dashwood 2012), and investors applying ESG criteria (Eccles and Klimenko 2019). Firms conform because legitimacy, social approval, and long-term stability depend on alignment with these norms (Zucker 1987, Brammer *et al* 2012, Scott 2014).

Though distinct, the two theories intersect in important ways. Both view legitimacy as central: firms respond to stakeholders to preserve credibility and conform to institutional norms for societal acceptance (Suchman 1995, Aguilera *et al* 2007). Many actors, such as communities, NGOs, and investors, function simultaneously as stakeholders and carriers of institutional norms. Investor demands for ESG reporting, for instance, both pressure firms instrumentally and reflect institutionalized standards (Campbell 2007). Institutional pressures can also amplify stakeholder activism, as when community protests or NGO campaigns prompt regulators to strengthen environmental rules (Matten and Moon 2008, Brammer *et al* 2012).

Together, these perspectives show CSR as both a strategy for managing stakeholder relationships and an adaptive response to societal norms. In critical mineral mining, firms must simultaneously address conflicts with workers, investors, and communities, while adapting to evolving institutional logics shaped by global agreements, industry associations, and regulatory frameworks (Aguilera *et al* 2007). CSR is thus best understood as a hybrid response that blends instrumental stakeholder management with institutional conformity.

2.3. An integrated framework

When integrated, stakeholder and institutional perspectives reveal that CSR arises from the interaction between firm-level efforts to manage stakeholder relationships and field-level institutional pressures that define legitimate corporate conduct. This combined lens explains why CSR responses vary across contexts: firms adapt practices to address stakeholder demands while aligning with institutional norms, thereby securing both legitimacy and competitive advantage (Lozano 2015, Wang *et al* 2016). It also clarifies why some pressures—such as activist campaigns reinforced by regulatory rulings—produce substantive CSR change, whereas others yield symbolic or delayed responses.

Building on this integration, we apply these perspectives to the CSR activities of the critical minerals sector. We focus on nine aggregated categories of pressure: activist, community, and NGO mobilization; regulatory and legal frameworks; media scrutiny; global agreements; industry associations; scientific research; investors; and supply chain actors. Each reflects both the actor-specific, relational dynamics emphasized by stakeholder theory and the broader societal and normative constraints highlighted by institutional theory. Table 1 outlines these categories in detail, with additional context provided in the Supplementary Information A & B.

2.4. Analytical framework: scope of CSR dimensions

CSR strategies involve a broad scope of activities cutting across multitude of stakeholders (Bhattacharyya 2010). In fact, given its breadth and scope, there is still no proper definition and domains of CSR (Hayat *et al* 2022). The CSR concept means different things to different publics (Alejandra Gonzalez-Perez 2013) and has evolved over the years based on changes in the expectations that societies have about corporations (Latapí Agudelo *et al* 2019). Given this condition, several studies have emphasized the need for systematic operationalization of CSR concepts in text-mining applications. For example, Van der Wiele *et al* (2001) and Carroll (1999) highlighted CSR's multidimensionality, which later syntheses such as Rahman (2011) organized into distinct conceptual dimensions.

In order to capture the scope of CSR activities and strategies that reflects both general CSR theory and the mining sector-specific challenges (i.e. economic, social, environmental, ethical, stakeholder), we adapted the work of Rahman (2011) and synthesized 10 major dimensions of CSR. These categories include

1. Obligation to the society
2. Stakeholders engagement
3. Employee well-being and diversity
4. Economic development
5. Ethical business practice
6. Law-abiding company citizen
7. Philanthropy and charitable giving
8. Human rights and conflict resolution
9. Protection of environment
10. Corporate Governance-Transparency & accountability

On a more practical ground, we believe that the 10 dimensions strike a balance being broad enough to capture the multidimensionality of CSR in mining while still being analytically tractable.

For each CSR dimension, representative keywords and phrases were synthesized for topic modeling analysis. Keywords were identified for each CSR dimension through a structured multi-step process.

Table 1. Integrated Framework: mapping CSR pressures.

Pressure	Stakeholder theory - *Actor-level, relational pressures*	Institutional theory - *Field-level, normative & regulative pressures*
1. Activist, community, and NGO pressures	Communities, Indigenous groups, labor unions, and NGOs directly demand fair wages, safety, land rights, and environmental protections (e.g. Freeman 2010).	Social movements and Indigenous rights discourses become institutionalized in laws and norms, reshaping regulatory frameworks (e.g. Matten and Moon 2008).
2. Labor union and worker pressures	Workers and unions directly negotiate for wages, safety, and conditions; strikes and collective bargaining create immediate economic risks for firms (e.g. Alexander 2013).	Labor laws, ILO conventions, and cultural norms around fair labor institutionalize workers' rights, shaping what counts as legitimate employment practices (e.g. Brammer *et al* 2012).
3. Regulatory and legal pressures	Firms anticipate stakeholder compliance costs and adapt practices to avoid litigation or sanctions (e.g. Gunningham *et al* 2004).	Governments, courts, and international bodies enforce binding rules that define legitimate conduct (e.g. Brammer *et al* 2012).
4. Media scrutiny & public perception	Media acts as watchdog stakeholders, shaping reputational risk and consumer perceptions (e.g. Freeman 2010).	Media channels embed and transmit cultural expectations of corporate legitimacy (e.g. Suchman 1995).
5. Global agreements	Investors and customers use global agreements to evaluate firms' CSR credibility (e.g. Dashwood 2012).	International frameworks (e.g. Paris Accord) institutionalize sustainability norms across industries (e.g. Baumgartner 2014).
6. Industry associations	Firms engage associations strategically to gain peer approval and legitimacy (e.g. Dashwood 2012).	Associations codify norms and diffuse CSR practices across organizational fields (e.g. Zucker 1987).
7. Scientific research	NGOs and communities use scientific findings as evidence to support claims on firms (e.g. Carvalho *et al* 2023).	Scientific knowledge production institutionalizes environmental concerns, shaping regulations and standards (e.g. Lamberton 2005).
8. Investor pressures	Investors exert direct pressure by linking CSR to access to capital, credit ratings, and shareholder value (e.g. Eccles and Klimenko 2019).	ESG frameworks guide investor behavior, embedding institutional logics of sustainability into finance (e.g. Marquis and Qian 2013).
9. Supply chain pressures	Downstream customers (e.g. automakers) demand ethical sourcing to protect their own brand reputations (e.g. Young *et al* 2019).	Ethical sourcing standards diffuse through supply chains, embedding institutional sustainability norms globally (e.g. Pagell and Wu 2009).

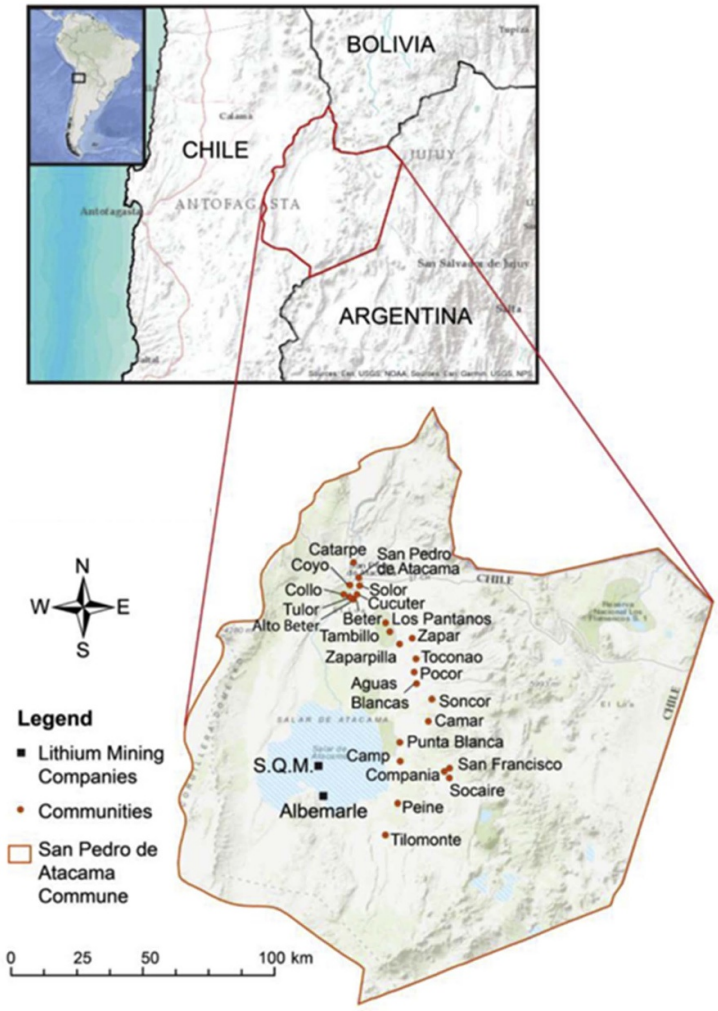
First, foundational CSR scholarships (Carroll 1999, Rahman 2011) were used to delineate conceptual boundaries. Second, we reviewed global reporting standards (GRI, UN Global Compact, ISO 26000, OECD Guidelines) to extract core terminology associated with each dimension. Third, we consulted prior CSR text-mining lexicons (e.g. Liu *et al* 2023, Park *et al* 2023, Liu *et al* 2025) and industry frameworks such as the International Council on Mining and Metals guidelines to capture sector-specific terminology relevant to mining. Fourth, the candidate terms were expanded using synonyms and sustainability glossaries to ensure semantic breadth. Finally, we screened for redundancy and pilot-tested the lists on CSR reports from the mining sector to confirm their contextual relevance. Through this process, 20 representative keywords were selected per dimension.

This size was chosen to capture semantic variation of the terminologies used in the sector while maintaining consistency across dimensions and avoiding overrepresentation. Such an approach is consistent with prior text-mining studies in management and sustainability that adopt comparable keyword ranges (i.e. 15–30 terms per construct) (Park *et al* 2023, Liu *et al* 2025). A complete set of the 20 keywords associated with each CSR dimension can be found in the Supplementary Information C.

3. Materials and methods

3.1. Case study

The case study examines CLP, a major Chilean mining company operating in the Salar de Atacama, one of the world's richest lithium reserves (figure 1).



Note: The blue areas are salt flats. The red dots are human settlements.

Figure 1. Case study area: the Salar de Atacama sub-basin, Chile. Reprinted from Liu and Agusdinata (2020). Copyright (2020), with permission from Elsevier.

CLP's extraction has driven significant profits and global lithium supply but also sparked concerns among stakeholders. Labor groups demand better wages and working conditions, while Indigenous communities highlight environmental risks, particularly water depletion, contamination, and waste management. Supplementary information D details CLP's resource consumption and emissions over the 2010–2022 period.

The Lithium Triangle's unique ecosystems and Indigenous cultures also support tourism, which boosts local economies. Rich in biodiversity, its salares include Ramsar-protected wetlands vital for flamingos, with two species classified as Vulnerable and Near-Threatened (IUCN 2023). Mining relies heavily on water, often obtained through local water rights sales, which also provide income for communities. However, water extraction impacts salinity and quality, affecting both human livelihoods and flamingo population.

3.2. Methods

A topic modeling method, specifically Latent Dirichlet Allocation (LDA) (Blei 2012), was chosen as our primary analytical method for the following reasons. First, it addresses the issue of data scarcity by analyzing a full range of available reports. Second, it enables the identification of latent themes that are embedded in corporate narratives. This allows uncovering of how sensitive issues such as water management or Indigenous engagement are incorporated under broader categories like 'sustainability'. Third, the method facilitates longitudinal analysis that enables tracing of shifts in CLP's discourse between 2010 and 2022 in response to specific societal pressures. Lastly, the method is transparent and reproducible (Boiral *et al* 2019, Marschlich and Hurtado 2025). Although topic modeling has gained traction in ESG and management studies (Vayansky and Kumar 2020, Isoaho *et al* 2021, Gutierrez-Bustamante and Espinosa-Leal 2022, Mohammadrezaei 2024), its application in mining remains limited.

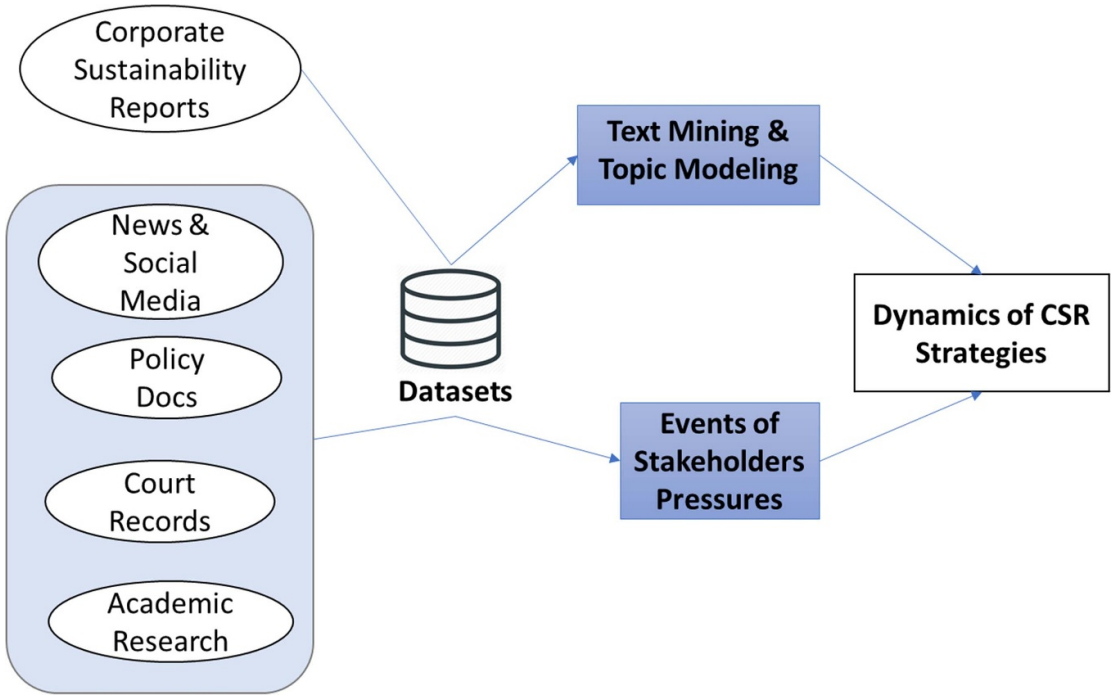


Figure 2. The study data and methods for CSR dynamics analysis.

The approach combined an analysis of events and company's performance and text mining and analytics (figure 2). Using proxy data of CLP's reported CSR activities extracted through topic modeling enabled us to explore the utility of such data as an alternative to primary data collection for assessing stakeholder pressure. First, we scanned the news for relevant CSR issues affecting the company. These news items served as external evidence of societal pressures. Next, we assessed publicly disclosed corporate sustainability reports and other publicly available sources to offer insights into the dynamics of the company's CSR pressures and responses. More specifically, the frequency of keywords mentioned in CLP's CSR documentation was evaluated and then established how the keywords had changed over time. In the absence of alternative datasets, the CSR reports can provide some insight into the evolution of corporate disclosures about CSR practices within a mining company, and the extent to which these practices appear to be responsive to societal pressures. This two-step approach (textual analysis of news media and CSR reports) allowed us to validate the veracity of claims in the report.

3.3. Data

Sustainability reporting has advanced with global initiatives like the EU's CSRD and ISSB, pushing for detailed, auditable disclosures (van Oorschot *et al* 2024). The GRI, for instance, mandates assurance statements to enhance report credibility (Fernández-Feijóo-Souto *et al* 2012). For our CSR analysis, we examined CLP's Sustainability and Annual Reports (2010–2022) alongside major societal events from public sources. These events, covering governance, supply chains, finance, labor, and social movements, were mapped on a timeline to explore relationships between mining expansion, community investment, CSR themes, and societal pressures. Insights were also drawn from our previous studies (e.g. Liu and Agusdinata 2020, Agusdinata and Liu 2023).

To compile societal events, data from news media (Media Cloud) and social media (Twitter/X) were analyzed, supplemented by academic research, legal records, and policy documents. Our broad search aimed to capture key discussions, though some events may have been missed. The search terms included:

> 'Mining' AND ('Governance' OR 'Lithium' OR 'Sustainability' OR 'Critical Minerals' OR 'Chile' OR 'Protest' OR 'CSR' OR 'Energy Transition' OR 'Electric Vehicle').

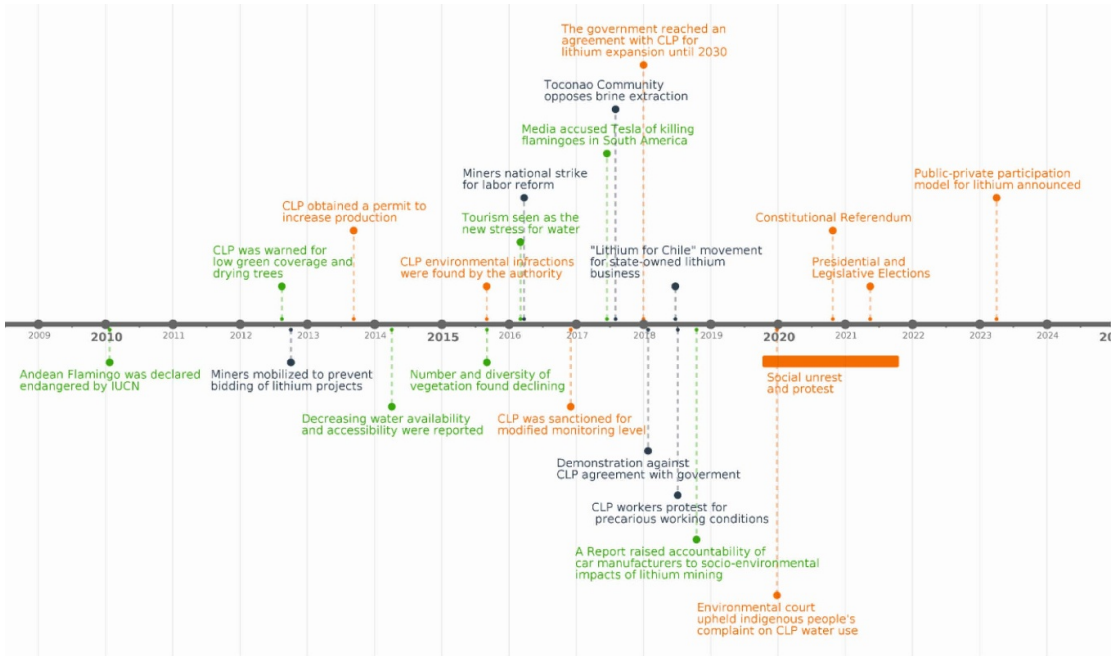
Four researchers identified major events, which were further analyzed based on initiators, significance, impacts, and classification as societal pressures.

4. Results and analysis

4.1. External company developments

4.1.1. External developments at the local-national level

Figure 3 maps the relevant events external to CLP at the local and national level related to lithium mining in Chile. The developments are classified into three



Color code:
orange (governance actions and decisions); black (major social movements), and green (environmental aspect)

Figure 3. Developments related to governance, environmental, and social movements at the local and national level (Chile).

categories related to governance, social movements, and environmental aspects. While not comprehensive, we believe the events capture the range of external pressures faced by CLP.

From the early days of lithium extractions, societal pressures were a concern, stemming from labor issues, ecological and indigenous concerns including scrutiny from media and academics. The declaration by IUCN in 2010 (www.iucnredlist.org/) of the endangered status of the Andean flamingo set the stage for pressure on biodiversity and ecological conservation in the areas where CLP operates. In 2012, conflict with Indigenous populations came to the fore when miners opposed the bidding process for lithium projects due to a perceived conflict of interest and lack of adequate consultation of Indigenous peoples, as required by the Indigenous Law of Chile and ILO Convention 169 (EJ Atlas 2023). Labor interests confronted CLP both in 2012 and 2018 over labor practices and conditions.

Concerns over water scarcity in the Salar de Atacama surfaced in 2014, and by 2016, tourism was recognized as a contributing factor. Later, the media linked these issues to rising EV demand, holding the auto industry partly accountable. CLP faced multiple sanctions for water violations, including a 2020 Chilean court ruling against its remediation plan for excessive brine extraction. The court cited academic research (Liu *et al* 2019) as evidence of environmental harm, underscoring academia's role in regulatory decisions.

Between 1997 and 2017, lithium production from the Salar de Atacama quadrupled. In 2018, CLP secured an extension to mine through 2032, planning a five-fold production increase that will put more pressure on the water issue. This period coincided with growing global scrutiny on mining's human rights and environmental impacts, pushing CLP to adopt CSR measures, including improved safety protocols, sustainability reporting, and stakeholder engagement.

From 2020 to 2022, Chile faced social unrest over mining. The newly elected left-leaning government introduced a public-private mining model, granting the state a controlling stake in lithium extraction while allowing private firms to operate in non-strategic areas. The National Lithium Strategy aims to reduce water use via direct lithium extraction, boost national revenues, and expand lithium production across new salt flats—aligning with broader global sustainability discussions (see next section).

4.1.2. Societal developments-global level

Figure 4 lists some major global developments in relation to critical minerals, social movements, clean technology policies, and corporate accountability initiatives.

Among the global developments were a few specific events that raised awareness internationally about the social and environmental impacts of mining. These included the Mount Polley Mine Tailings Pond Disaster in Canada (2014), Vale's Brumadinho

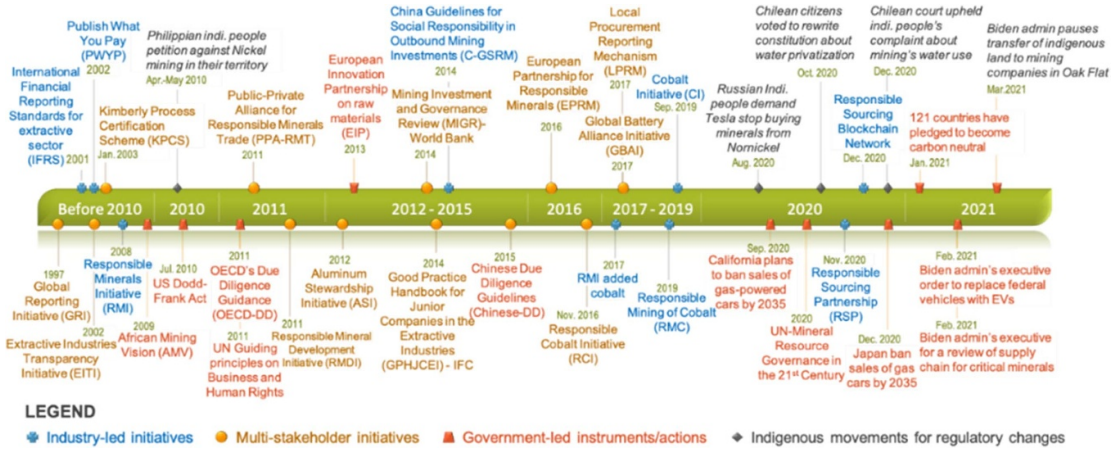
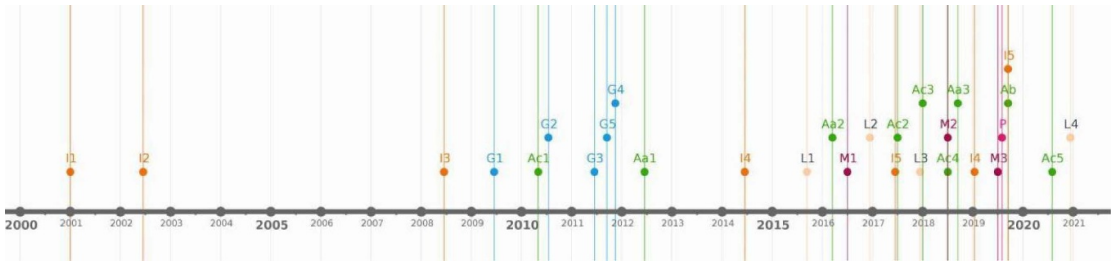


Figure 4. International developments related to industry initiatives, policies, and social movements in the mining industry.



Legend: [Activist (A): Labor (Aa), Investor (Ab), NGOs (Ac)], Regulations (R), Legal Setting (L), Media Scrutiny (M), Global Agreements (G), Industry Association (I), Scientific Publications (P)

Figure 5. Timeline of categories of pressure that include local, national. And global events.

Dam Collapse in Brazil (2019), and Rio Tinto's Juukan Gorge Blasting, a site of significant Aboriginal cultural heritage in Australia (2020) (Oliveri *et al* 2024).

4.1.3. Analysis of CSR pressures

Figure 5 shows the combination of all developments and categorizes them into types of CSR pressures: activist pressure (A), investor influence (I), regulatory pressure (R), legal pressure (L), media scrutiny (M), global initiatives and agreements (G), industry initiatives (I), and scientific publication (P). The timeline is proportionally spaced to give a sense of the intensity of the events. Several patterns can be observed.

Global initiatives and agreements (G) were primarily concentrated between 2009 and 2012, while diverse activist pressures (A) extended through 2020. After 2014, industry initiatives (D) became the dominant source of societal pressure. Legal challenges (L) emerged in mid-2015, mainly addressing water use violations, which were resolved through litigation. Activist pressures (A) came from various groups, including Indigenous communities, mining workers, and NGOs. Between 2019 and 2020, major EV manufacturers like Tesla faced investor pressure to ensure responsible lithium sourcing, prompting stricter sustainability standards for lithium suppliers in Chile and Australia. Media scrutiny (M) played a key role, with Amnesty International highlighting child labor in cobalt mining (2017) and Indigenous NGOs leveraging social media to urge Tesla's CEO to address mining impacts. Regulatory pressures (R) stemmed from national and supranational bodies, such as the EU's stricter anti-pollution policies, which accelerated EV production and pushed manufacturers like Volkswagen and Daimler Benz to improve battery metal sustainability (Di Felice *et al* 2021, Rajaeifar *et al* 2022). In the U.S., the Dodd–Frank Act sought to eliminate illicit mineral trade by enforcing supply chain transparency. Lastly, the combined intensity of pressures increased over time.

4.2. Analysis of CSR-related keywords

4.2.1. Changes in keywords frequencies

Our keyword analysis tracked selected terms as a proxy for their importance over time (figure 6). The top 20 keywords and their frequency are detailed in the supplementary information C (table SI1). These keywords represent key corporate sustainability topics. 'Sustainability' showed fluctuations, peaking

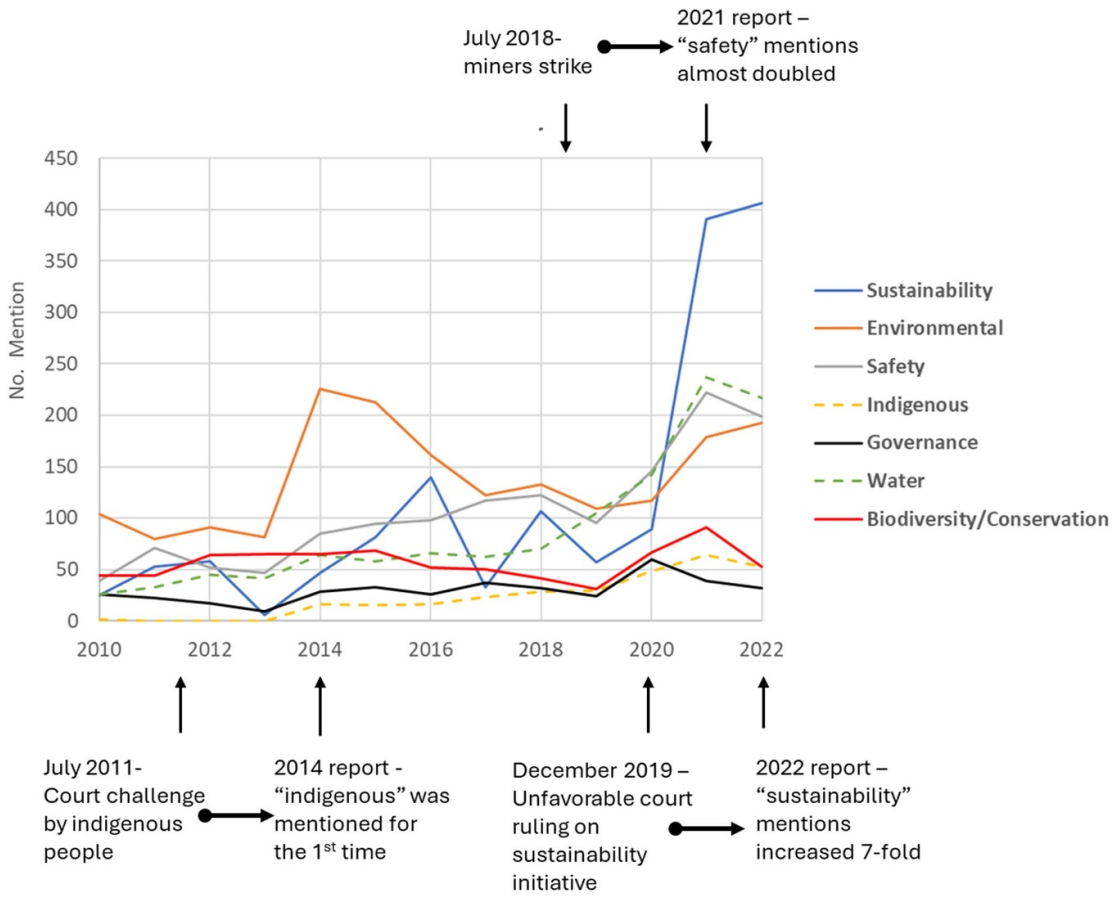


Figure 6. Comparison of a set of selected keywords mentioned in annual CSR reports. Some major events and their suggested effects are added for illustration.

in 2021 and 2022, while 'environmental' peaked in 2014, coinciding with increased production and waste generation. Regulatory action in 2016 also triggered a surge in investment. 'Indigenous' first appeared in 2014 and grew steadily, mirroring rising mentions of 'water' and 'safety.' 'Biodiversity' and conservation-related terms remained stable until 2015, dipped in 2019, peaked in 2021, and then declined. Meanwhile, 'governance' remained relatively constant throughout the period.

The introduction of 'Indigenous' in 2014 and the spike in 'Environmental' discussions that year aligned with both domestic and international shifts. In July 2011, the indigenous people challenged CLP in court over approval of a lithium expansion project in the Salar de Atacama, citing lack of proper consultation of Indigenous communities under the ILO Convention 169, which Chile had ratified in 2008. However, the keyword 'Indigenous' did not appear in CLP's annual sustainability report until 2014.

Globally, multistakeholder initiatives pushed for accountability, leading to guidelines for responsible mining. Between 2012 and 2013, societal pressures and global agreements intensified, reflecting rising concerns over water and labor issues in the Atacama region. In March 2016, Chilean miners launched a strike demanding labor reforms, followed by CLP workers' protests over precarious working conditions in July 2018. Three years later, the frequency of the keyword 'safety' in CLP's 2021 report increased by 2.3 and 1.8 times compared to the 2016 and 2018 reports, respectively. Additionally, following the environmental court ruling in December 2019 that struck down CLP's water use plan, it took two years for mentions of 'sustainability' to rise nearly seven-fold in subsequent reports.

By 2020–2022, these concerns surged amid Chile's social unrest. The shift from environmental to broader sustainability themes seems to mirror global discourse changes. However, apart from labor and Indigenous rights, other social issues did not show clear trends in CLP's documentation. The top 20 keywords for 2010–2022 can be found in the supplementary information C (table SI2).

A correlation analysis was conducted between the number of annual social pressures (see figure 5) and the number of keyword mentions (see figure 6). To account for potential response delays in when a social pressure occurs and a company's potential subsequent response (Emirbayer and Mische 1998, Shipp and Cole 2015) in their CRS report, the analysis incorporated three lag times (1, 2, and 3 years). The average

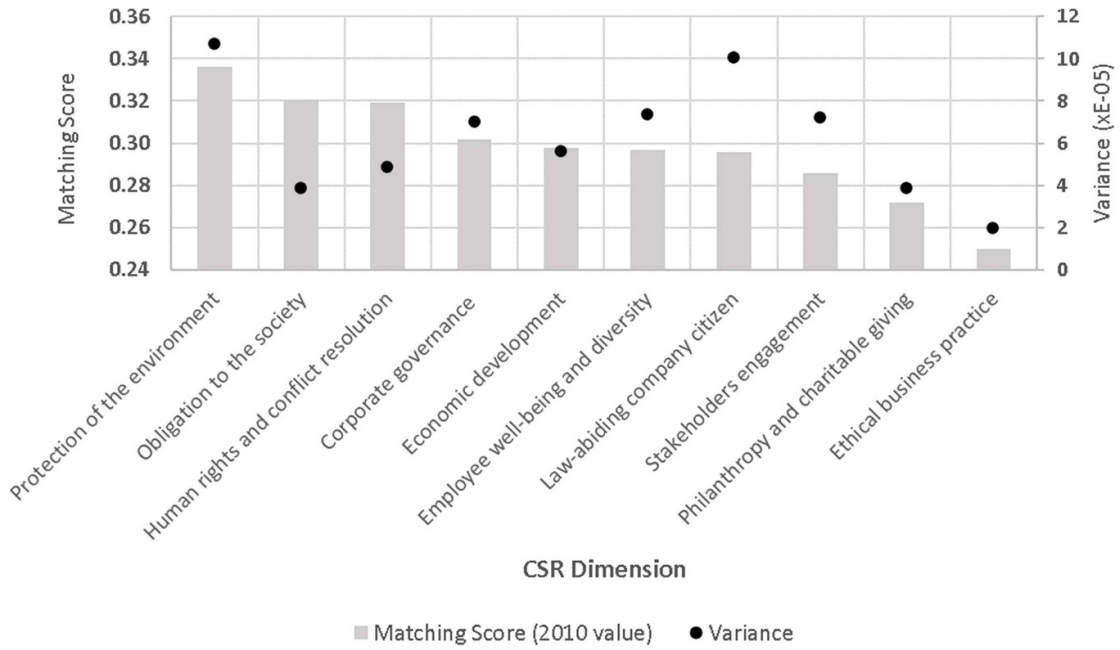


Figure 7. CSR dimension matching score (2010) and variance (2010–2022).

correlation values for one-, two-, and three-year lags were 0.15, 0.39, and 0.61, respectively. The stronger correlation observed at a three-year lag may reflect that companies take several years to adjust the wording of their reports following a social event. Such organizational delays likely arise not only from deliberation over appropriate responses but also from the time required to develop internal capacities to implement change (Emirbayer and Mische 1998, Shipp and Cole 2015).

4.2.2. Rank of CSR dimensions

The extent to which the CLP reports used language that aligns with each of the ten CSR dimensions was analyzed based on the proportion of a document's content that matches the CSR topic's keywords or phrases. A matching score (expressed as a value between 0 and 1) quantifies the association of a document with a particular topic (i.e. CSR dimension) using LDA (Blei 2012). A higher matching score means the document contains more words strongly associated with that topic. The matching score (2010 value) and its variance provide insights into how well each CSR dimension was represented in CLP's sustainability reporting and its variability across the 2010–2022 period (figure 7). The raw time-series data can be found in the supplementary information D (figure SI5).

Overall, the CSR dimension of 'protection of the environment' yields both the highest matching score (2010 value) and variability. The theme consistently holds a dominant position in the reporting, except for the 2017–2019 period, reaching its peak in 2020 with a substantial increase from the previous year. The 'Human rights and conflict resolution' theme consistently ranked higher than the 'Corporate governance-transparency & accountability' theme. Conversely, the 'Ethical business practice' theme consistently ranked the lowest, followed by 'Philanthropy and charitable giving'. This analysis suggests that CSR for CLP is largely focused on environmental measures and human rights concerns, both prominent issues domestically in relation to Indigenous community and labor negotiations and the particularly contentious issues around water management. Other issues pertaining to CSR (e.g. philanthropy and business ethics) were consistently not dominant. This suggests that CSR is largely reactive and outward facing, rather than interpreted as related to in-ward facing corporate structural reform.

4.3. CSR topical areas

The topic modeling method was used to track the evolution of topical areas in CLP's corporate actions (table 2). Initially, in 2010, topics included the 'environment', 'employees', 'community', and 'production'. By 2011, 'safety,' 'energy,' and 'sustainability' gained prominence, while 'water' and 'quality' emerged in 2012 but faded before 'water' reappeared in 2019. Some areas, like 'monitoring,' remained relevant from 2010–2017, while 'school' gained attention from 2017–2020. 'People' became the top topic in 2015 and remained significant, alongside enduring themes like 'development' and 'employees.' In 2022, 'women' and 'men' emerged as key topics, reflecting increased female workforce participation and leadership, coinciding with Chile's social and political changes. 'Sustainability' fluctuated in prominence, while 'GRI' gained attention in 2018 and 2021,

Table 2. Evolution of CSR topical areas.

Drop-out topic	Year	Sustaining topic	New topic	Re-emerged topic
	2010	environmental, employees, production, development, community, organization, work, commitment, monitoring, industry		
organization, commitment, industry	2011	environmental, employees, production, development, community, work, monitoring	safety, energy, sustainability	
community, energy	2012	environmental, employees, production, development, work, monitoring	water, quality	
sustainability	2013	environmental, production, employees, work, development, monitoring		
water, quality	2014	environmental, employees, production, development, monitoring, commitment, work	standard, disclosures	
work	2015	environmental, production, employees, monitoring, development	people	sustainability
	2016	environmental, production, employees, monitoring, development		
	2017	environmental, production, employees, development, monitoring	school	
standard, monitoring	2018	environmental, employees, production, development	GRI, compliance	
GRI, compliance	2019	employees, environmental, production, development		community, work, water
sustainability, environmental, school	2020	employees, production, development	health	
production, safety	2021	employees, development	human, rights	GRI, sustainability
health, GRI, human, rights	2022	development, employees	women, men	safety

aligning with CLP's compliance with updated GRI G4 Sustainability Reporting Guidelines.

5. Discussion

5.1. Stakeholder and institutional pressures associated with CLP's CSR activities

With some lag time, the discourse in CLP's CSR reporting reflected societal pressures including activism, labor strikes, regulatory enforcement, and investor ESG demands. These findings align with research showing that mining CSR tends to be reactive rather than proactive (Dashwood 2012, Kemp and Owen 2013). In relation to **activist, community and NGO pressures,** for example, Indigenous and environmental groups repeatedly challenged CLP over water depletion and contamination in the Atacama. The Chilean Supreme Court acknowledged the importance of prior consultation as a result of a challenge by the Indigenous people over the approval of a lithium expansion project in the Salar de Atacama and its environmental impact on indigenous territories and water resources (July, 2011). A few years later, in 2014, the company's CSR report emphasized more Indigenous engagement. In another event, the communities reported the effect of water scarcity on

drying vegetation (September 2012). Subsequently, the mention of 'water' in the CLP's CSR reports increased by over 90%. These examples illustrate how community resistance may be reflected in a firms' 'social license to operate' (Hilson 2012) and how Indigenous mobilization can be associated with discursive responses (Gobby *et al* 2022). These dynamics appear consistent with institutional accounts of civil society pressure strengthening norms and rules (Campbell 2007).

Labor and union pressures in 2012 and 2018 pushed CLP to address workplace practices, elevating themes such as 'employees,' 'safety,' and 'people' in its CSR reports, which is consistent with prior findings illustrating that labor pressures shape CLP's CSR in ways consistent with unions' economic leverage (Alexander 2013) and with institutionalized labor norms that define legitimate employment practices (Brammer *et al* 2012). These pressures later are associated with CLP's broader human rights discourse, with 'human' and 'rights' gaining prominence after 2020. Similarly, the March 2016 miner strikes and 2018 CLP workers' protests were associated with an 2.3 and 1.8 increase, respectively, in the frequency of 'safety' in CLP's 2021 report. While environmental issues dominated overall, labor activism appears to have kept employee welfare and workplace rights visible in CLP's CSR narrative.

Media scrutiny also appears linked to changes in CSR reporting, with spikes in coverage of environmental controversies followed by more transparent disclosure and community investment. For instance, ABC News—a major U.S. news media outlet—reported a 'water fight' in the region, raising questions about the sustainability of mining operations (October, 2018). The 2021 CLP report contained 3.4 more mentions of 'water' than those in 2018. Similarly, news media reports accusing car manufacturers such as Tesla and GM of killing flamingos due to their lithium sourcing from the region (July, 2016) coincided with an increase in 'biodiversity/conservation' keywords in the CLP report four years later. These findings are consistent with legitimacy theory (Suchman 1995) and evidence that CSR can enhance reputation and risk profiles (Liu and Lu 2021).

Regulatory and legal pressures seemed particularly salient. After receiving fines (December, 2016) and adverse rulings (December, 2020), CLP's reports emphasized water management and ecosystem protection. These outcomes mirror cross-country and U.S. evidence linking enforcement and litigation risk to improved CSR performance (Gunningham *et al* 2004, Jaroenjitrkam *et al* 2022, Freund *et al* 2023) and suggest legal challenges can catalyze strategic reorientation toward 'shared value' initiatives (Porter and Kramer 2006).

In contrast, **global agreements** such as the UN Mineral Resource Governance (IRP 2020), appeared to have little influence, perhaps because they were less immediate than local pressures. Similarly, **industry associations** showed minimal association with changes in reporting, underscoring the primacy of Chile's policy context—consistent with work highlighting domestic policy as decisive in shaping environmental outcomes (Coenen *et al* 2021).

Investor expectations, shaped by institutionalized ESG frameworks (Campbell 2007, Marquis and Qian 2013), also may have influenced CLP. Following ESG concerns raised by investors, including EV manufacturers, reports between 2018 and 2021 increasingly aligned with frameworks such as the GRI. These findings may reinforce research showing firms respond to heightened investor interest in their environmental and social performance (Lambrechts *et al* 2019, Imperiale *et al* 2023). **Supply chain pressures** were less evident in this case, though prior research highlights their role in enforcing responsible sourcing and embedding sustainability norms across value chains (Pagell and Wu 2009).

Finally, CLP's reporting appears linked to sensitivity to **scientific research** outputs (e.g. Liu *et al* 2019). After evidence on water scarcity and biodiversity impacts grew, the company strengthened monitoring and disclosure practices. This offers some support for Carvalho *et al*'s (2023) finding that firms respond to ecosystem evidence with enhanced monitoring and supports the broader view that scientific knowledge shapes reporting priorities (Lamberton 2005).

5.2. Utility of topic modeling in assessing corporate discursive response to societal pressures

Topic modeling proved effective for extracting patterns from unstructured texts such as sustainability reports, addressing persistent challenges in CSR research, including selective disclosure and fragmented data (Blei 2012, Vayansky and Kumar 2020, Isoaho *et al* 2021, Ning *et al* 2021). This approach identified major shifts in CLP's CSR discourse: a stronger focus on water management after 2012, linked to growing water stress, and an increased emphasis on human rights and Indigenous issues after 2014, spurred by labor and community advocacy. It also captured fluctuations in CSR priorities, suggesting reactive responses to external pressures. Matching score analysis indicated that many initiatives were superficial, emphasizing compliance and profit motives over deeper ethical commitments.

Nonetheless, topic modeling has limits: it cannot capture context-specific nuance, and reliance on corporate reports risks narrative management. Future studies should triangulate disclosures with independent evidence, such as NGO assessments, media, audits, satellite monitoring, or community testimony. Emerging AI tools—including sentiment analysis (Krugmann and Hartmann 2024), stance detection (Alturayeif *et al* 2023), and multimodal integration of text, geospatial, and environmental data (Hochmair

et al 2025)—could enrich such work, while qualitative approaches like process tracing (Collier 2011) remain essential for unpacking causal mechanisms across mining practices, policy change, and supply chains.

5.3. Theoretical implications

The nine categories of societal pressures operate through complementary channels: stakeholder theory emphasizes actor-specific relationships, while institutional theory highlights the broader rules and norms that define legitimate conduct. Understanding CSR framing requires recognizing how these channels interact. Reporting shifts were most substantive when pressures converged across levels—for example, Indigenous activism in the Atacama gained momentum after courts rejected weak remediation plans and following scientific studies that confirmed long-term water depletion risks, forcing firms to adopt more rigorous monitoring. Similarly, worker strikes in 2012 and 2018 did more than secure wage settlements; they appear to have helped catalyze reforms to national labor standards, aligning stakeholder demands with institutional change (Manky 2020). These cases illustrate how local claims gain durability when institutional actors codify them into legal and normative frameworks (Campbell 2007, Brammer *et al* 2012). Conversely, fragmented pressures—such as isolated protests without regulatory or scientific reinforcement—appear associated with only symbolic or delayed responses.

Together, these findings clarify our central theoretical contribution: CSR commitments appear to become substantive when stakeholder demands and institutionalized expectations converge, whereas isolated pressures seem to more often produce symbolic compliance. This interplay between stakeholder and institutional theories helps explain how multi-scalar pressures can transform claims into durable corporate commitments.

6. Concluding remarks

This study shows that CSR framing and commitments appear most influenced when stakeholder pressures—activism, labor actions, investor demands, and buyer requirements—converge with institutional reinforcements, such as regulations, scientific evidence, and global standards. Isolated pressures, by contrast, seem to more likely yield a symbolic compliance. Integrating stakeholder and institutional theory may thus help clarify both who applies pressure and how those pressures gain legitimacy and durability, explaining why some catalyze substantive change while others do not (Campbell 2007, Brammer *et al* 2012).

For practitioners, the findings demonstrate that CSR reporting may be shaped by identifiable pressures—fines, activism, legal challenges, and investor demands—rather than abstract commitments. For policymakers, the results underscore the importance of credible enforcement, transparent reporting requirements, and litigation pathways as they may help ensure stakeholder claims translate into measurable corporate change.

Data availability statement

All data that support the findings of this study are included within the article (and any supplementary files).

Supplementary data available at http://doi.org/10.1088/1748-9326/ae2af6/data.

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