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Pathway to Sustainability in the Mining Industry: A Case Study of Alcoa and Rio Tinto

Prasanna Shrivastava and Rachana Vidhi *

Harvard Extension School, Harvard University, Cambridge, MA 02138, USA; prs695@g.harvard.edu

* Correspondence: rav394@g.harvard.edu

Received: 27 May 2020; Accepted: 4 June 2020; Published: 7 June 2020



Abstract: Sustainability for the mining companies is a critical requirement for their ongoing operations. Regulations and licenses generally depend on the companies' sustainability practices, forcing them to focus on environmental impact and social welfare. While the mining industry has historically been associated with poor working conditions and their unsustainable practices, closer review of the industry suggests that the last few decades have seen improved performance and heightened focus on doing the right thing for the environment and the society. This research is focused on reviewing the sustainability strategy and initiatives of Alcoa and Rio Tinto, two Fortune-500 mining companies. It was found that these companies had started focusing on sustainability a few decades ago, but developed a holistic sustainability strategy as part of their core business only over the last few years. While there are many controversies still facing the companies, particularly around environmental pollution, their continued focus on sustainability will be beneficial for their employees as well as the communities they operate in.

Keywords: mining; sustainability; Alcoa; Rio Tinto; footprint; strategy; stakeholder engagement

1. Introduction

The mining industry has always faced an ethics and sustainability challenge; on one hand, their products and services are vital for the growth of humankind and the global economy; on the other hand, this industry has been known for high fatalities, human right violations, exploitation of miners and other unsustainable practices [1]. As the stakeholders of the mining businesses are becoming more aware of these challenges, they are demanding for these companies to focus on sustainable ways to extract and deliver their products. Additionally, the last few decades have experienced increased scrutiny and regulations, resulting in a reduction in fatalities of miners [2]. Therefore, in the 21st century, mining companies have had to include sustainable practices as part of their core business in order to obtain licenses and certifications to operate.

As the regulations around sustainability practices are getting more stringent, and the Social License to Operate is becoming increasingly important in most countries where the mining companies operate [1], strategies have been adapted to include sustainability practices. Researchers have also been studying the impact of improved sustainability practices on companies' technical and financial performance. Some of them have focused on stakeholder concerns related to sustainability [3–6], some of them have focused on specific issues [7,8] while some others have attempted to perform more detailed studies based on multi-criteria metrics reported by the industry [9–12]. Vintro et al. examined the extent of sustainability adoption by mining companies in the Catalonia, Spain region [13]. Their study was based on survey responses obtained from 60 mining companies in that region on about 41 different sustainability topics and found that most companies do claim to adopt sustainability practices. Fuisz-Kehrbachn presented a three-dimensional framework for evaluating the sustainability strategies used by mining companies based on the types of activities, issues addressed and the step of

the value chain concerned [14]. These studies suggest that mining companies have been looking at environmental and social sustainability as necessary components of their business. However, there is a need for these companies to integrate sustainability in their core business, and not treat it as a mandatory compliance nuisance only. Some of the large corporations have already started proposing holistic integrated sustainability strategies. A holistic strategy accounts for a corporation's social, economic and environmental impact [15]. It also provides a framework to establish practices for areas that overlap the boundaries of society, the economy and the environment, as well as to develop strategies that can integrated local, national and global sustainability concerns. In this paper, case studies for two large mining companies, Alcoa and Rio Tinto, have been performed to investigate their sustainability strategies and initiatives. Selection of the companies was based on their size, ownership as well as historical information. Not only are these among the largest mining companies, they are also publicly listed, and have been in operation for over a century. As they are publicly listed, they have to abide by the globally accepted accounting and sustainability reporting standards. How they have incorporated sustainability practices as part of their core business has been explored, and recommendations for further improvements have been made.

2. Companies and Business Case

2.1. Alcoa's Sustainability Initiatives

Alcoa is the world's eighth largest producer of Aluminum, with operations in 10 countries [16] and has a 100+ years of history in bauxite mining and aluminum production. It is headquartered in Pittsburgh, Pennsylvania, and invented the aluminum industry in 1886 [17]. It was founded by Charles Martin Hall, when he started the Pittsburgh Reduction Company with an experimental smelting plant in Pittsburgh, Pennsylvania. The company expanded through the 1900s and became one of the largest producers of aluminum in the world. For a certain period, it was the only company legally permitted to produce aluminum in the United States.

Today, Alcoa is a Fortune 500 (Ranked 236) company with greater than ~\$10 billion of revenue from a product line comprising of bauxite, alumina and aluminum [17]. These products are used in several industries including the aerospace, packaging, automotive, building & construction, electrical and electronics industries [18]. In 2016, Alcoa discontinued its vertically integrated business model and separated into two independent companies named Alcoa and Arconic. The restructured Alcoa comprises of mining, refining and smelting businesses, whereas Arconic comprises of downstream fabrication businesses [19]. Sustainability has been a core part of Alcoa's strategy for several decades. As a part of its Social responsibility strategy, Alcoa chartered "Alcoa Foundation" in 1952. The foundation has been playing a significant role in strengthening sustainability in Alcoa communities worldwide [19], focusing on health and welfare of the society. Currently, the foundation is providing funding for research in climate change and restoration and preservation of biodiversity.

Alcoa has a very strong business case for sustainability. Its primary product, aluminum, is one of the most recyclable minerals found on earth. It is almost 100 percent recyclable and retains its properties indefinitely [20,21]. Additionally, recycling aluminum is cheaper than extracting aluminum from its raw form and uses up to 95% less electricity [21].

From a risk mitigation perspective as well, any increase in aluminum recycling reduces Alcoa's dependence on its mining operation for bauxite and makes the company more resilient to political changes. In its annual sustainability report, Alcoa has identified climate change, air quality and waste management [21] as its most important material issues. In addition, several of Alcoa's mines and refineries are also located in developing countries, where employee welfare and development of the local community can be a big concern. Increased focus on sustainability helps address all these issues as well.

Alcoa's sustainability strategy is based on following three pillars:

- Create sustainable value for the communities where we operate
- Enhance the value of products through differentiation to improve profitability
- Minimize negative environmental impacts and improve health and safety performance to reduce long-term risk exposure.

The three pillars present three different types of growth opportunities for the organization. Working with communities would increase the firm's customer loyalty, local employee base and the supply chain network. Enhancing products helps the firm focus on developing new technologies that provide a long term competitive advantage. Minimizing negative environmental impacts and reducing long-term risk exposure makes the firm more resilient and more likely to survive in the long-term. The three values listed here are like those of Nestle's [22] and encourage the creation of shared value [23] that helps grow profitability while increasing community engagement.

2.2. Rio Tinto's Sustainability Initiatives

Rio Tinto is the world's second largest metals and mining corporation. It was founded in 1873, when a multinational consortium of investors purchased a mine complex on the 'Rio Tinto' river in Spain, from the Spanish government [24]. They have operations and facilities in 36 countries where they employ over 46,000 people. Rio Tinto is headquartered in Melbourne, Australia, and is a global leader in finding, mining and refining the natural minerals such as iron, copper, aluminum, uranium, etc. Their operating facilities include mines, smelters and refineries that produce minerals essential for human progress. Many of their mines are in extreme climates and wild terrains, making it essential to consider environmental impact.

Today, Rio Tinto is a Fortune 500 (Ranked 236) company with greater than ~\$40 billion of revenue from a product line comprising of iron ore, aluminum, copper, borates, diamonds, salt and titanium [25]. Rio Tinto has incorporated sustainability and ethical practices into its strategy for a long time because failing to improve the sustainability of their products, processes and supply chain could damage their business, not just due to regulatory compliance reasons, but also because of the impact climate change can have on the feasibility of their business, which relies heavily on high-risk regions. For example, they obtain minerals from sub-arctic regions and usability of the ice-roads can reduce drastically with increasing global temperatures [26].

Purpose of company is defined as the reason for their existence; it is something that should last for at least 100 years [27]. According to Rio Tinto, their purpose is to produce materials essential to human progress. Although not as clearly articulated earlier, Rio Tinto has been following this purpose for nearly 150 years by mining and refining natural minerals. The countries Rio Tinto operates in have varying political and social conditions. For example, they operate in Guinea for mining iron ore deposits, which has faced dictatorship and political unrest, with no clear regulations around sustainability for last several decades [28], while also operating mines in the USA and refineries in Canada, where the social and regulatory governance requires implementation and reporting of sustainability practices.

To ensure operability in such wide variety of social landscapes, Rio Tinto has included sustainability practices as part of their core business. They may not have seen it as a profit making opportunity at first, but as a loss and penalty minimizing approach, as this is what most researchers observed in 1990s [29]. They started including carbon pricing in their investment decisions in 1998 and have been reporting on sustainability for over a decade. The main drivers in their sustainability strategy and decisions have been regulatory scrutiny and threats to operability. However, while these were the initial driver, Rio Tinto has been able to achieve superior economic and technical performance by implementing sustainability strategies. Some of their recent successes have been summarized in Table 1. As we can see, they have been able to reduce the number of fatal accidents down to zero between 2008 and 2019 by providing safe working conditions to their employees. This is not only

excellent for employee health and well-being and employee engagement, but also provides financial rewards in terms for fewer lawsuits and settlement payments. Additionally, they have been able to reduce their total energy use, as well as CO₂ emissions, and have increased recycling of water used during their operations. Through these improvements in operational efficiency over the last decade, they have been able to shift economic contributions from payments to suppliers to more value-add payments, which include payments to employees, governments and investors.

Table 1. Rio Tinto's performance improvement during 2008–2019 across critical metrics.

Metric	2008	2011	2013	2015	2017	2019
Number of fatal accidents	18	6	3	4	1	0
All injury frequency rates (per 200,000 employee hours)	0.94	0.67	0.65	0.44	0.42	0.42
Total energy use (PJ)	556	516	484	433	440	407
Total greenhouse gas emissions (mt CO ₂)	49.4	43.2	37.4	31.6	30.6	26.4
% of water recycled	28%	29%	33%	34%	34%	37%
Economic contributions—payment to suppliers	51%	57%	45%	49%	37%	38%
Economic contributions—value add	49%	43%	55%	51%	63%	62%

3. Sustainability Footprint and Corporate Strategy

3.1. Footprint Analysis

To develop the sustainability footprint of a company, various tools such as process mapping and lifecycle analysis etc. can be used [30]. For the mining industry, lifecycle of a mine is the most widely used tool [31,32]. The lifecycle of a mine can generally be divided in five stages: Exploration, Planning and Development, Construction, Production and Closure [32].

Each of these steps contribute towards environmental, social and/or economic impact that both Alcoa and Rio Tinto strive to improve. They have identified multiple material issues related to their processes that range from climate change to ethics and integrity [21,33]. These initiatives can be tied directly to many of the stages in the lifecycle of their mines and products [31]. Table 2 shows the environmental, social and economic impact of the various stages in the lifecycle of a mine.

Table 2. Lifecycle environmental, social and economic footprint of a mine.

Stage	Environmental Impact	Social Impact	Economic Impact
Exploration	<ul style="list-style-type: none"> Land disturbance 	<ul style="list-style-type: none"> Mineral Rights Lease Communities Policies 	
Development		<ul style="list-style-type: none"> Communities Permits Policies 	<ul style="list-style-type: none"> Property Tax Access roads
Construction	<ul style="list-style-type: none"> Land disturbance Wildlife displacement Emissions Waste disposal 	<ul style="list-style-type: none"> Employment Communities Health, safety and well-being 	<ul style="list-style-type: none"> Transportation and roads

Table 2. Cont.

Stage	Environmental Impact	Social Impact	Economic Impact
Production	<ul style="list-style-type: none"> • Carbon emissions • Waste disposal • Energy consumption in smelting • Climate change 	<ul style="list-style-type: none"> • Employment • Human Rights • Communities • Health, safety and well being • Ethics and Integrity • Policies and standards 	<ul style="list-style-type: none"> • Operational cost • Income tax
Closure	<ul style="list-style-type: none"> • Land reclamation 	<ul style="list-style-type: none"> • Loss of jobs • Policies and standards 	<ul style="list-style-type: none"> • Loss of jobs

3.2. Alcoa’s Footprint

Alcoa operates seven bauxite mines, six alumina refineries, several aluminum processing plants (smelting, casting and rolling) and some energy generation assets [21]. As seen in Figure 1, the company’s footprint also includes several non-operating assets where it has a minority holding. These assets are dispersed across five continents and managing such a footprint would involve creating several policies relevant to local laws, environment and culture. In the value creation process (Table 3), Alcoa’s environmental footprint includes impact on land, natural resources, water, air quality and biodiversity, whereas its social and economic footprint include impacts on the local economy, employee well-being and the well-being of the communities where its operations are located.

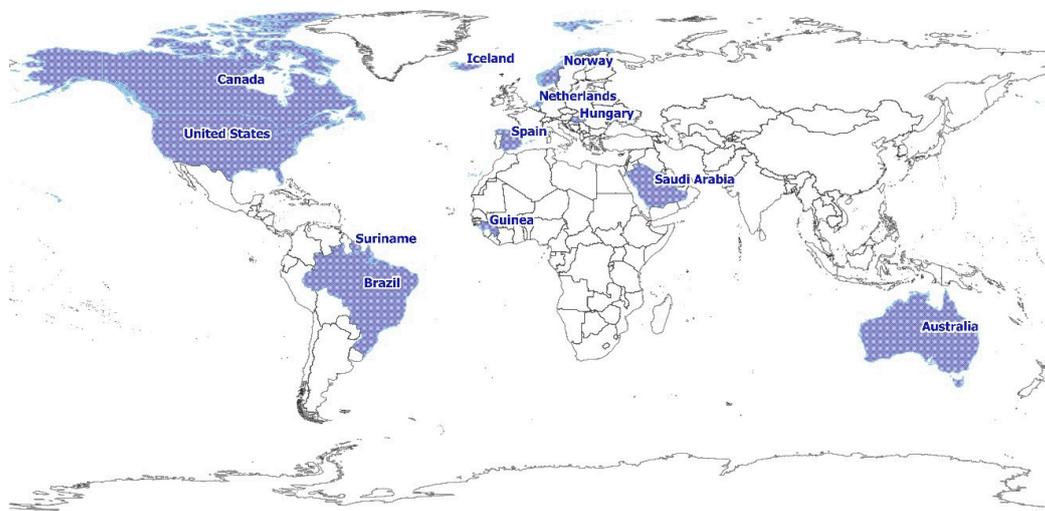


Figure 1. Alcoa operations around the world [21].

In 2019, Alcoa also aligned their sustainability report with United Nations Sustainable Development Goals [21]. They also became a member of International Council on Mining and Metals, which is focused on enhancing the industry’s contribution to the society with safe, fair and sustainable practices.

Table 3. Alcoa’s value addition process [21].

Process	Inputs	Outputs	Sustainability Footprint
Mining	Reserves, water, land, energy	Mineral, wastewater, disturbed land, emissions	Biodiversity and land impact, local community displacement, local employment, GHG emissions, economic development, health & safety
Refining	Mineral, water, energy	Alumina, wastewater, emissions	GHG emissions, local procurement & employment, health & safety
End product	Alumina, other process minerals, water, energy	Aluminum, GHG, NOx & SOx emissions, tailings & residue	Tailings impact on vegetation, emissions & climate change
Energy consumption	Fuel, land, water, infrastructure	Electricity, emissions, disturbed land	Biodiversity and land impact, local community displacement, emissions & climate change

Overall, Alcoa carried out a thorough footprint analysis in 2019 and has adopted most of the best practices. They created high level process maps for their products and have carried out a detailed materiality analysis to identify key focus areas. Their scope 1, scope 2 and scope 3 (seven categories) emission estimates were certified by an independent auditor (DNV GL). The only recommendation in this section would be to carry out the analysis on a regular basis to ensure that their material issues have not changed from one year to another.

3.3. Rio Tinto’s Footprint

Rio Tinto operates mining, refining and processing operations for various minerals. Currently they have 60+ projects across iron, aluminum, copper, borates, diamonds, salts and titanium. They also operate six port terminals and have ~200 contracted ships for transportation. Additionally, Rio Tinto operates seven hydropower plants that provide electricity to its mining, refining and processing operations sites (Table 4). As seen in Figure 2 Rio Tinto’s global operations require the company to create policies that adhere to local laws, environment and culture. Just like Alcoa, Rio Tinto’s environmental footprint also includes its impact on land, natural resources, water, air quality and biodiversity, whereas its social and economic footprint include its impact on local economy, employee well-being and the well-being of the communities where its operations are located.

Table 4. Rio Tinto’s footprint [25].

Product	Mining & Refining	Processing/Production	Energy Generation	Transportation
Iron	16 integrated iron ore mines	5 iron ore products	N/a	4 port terminals
Aluminum	5 bauxite mines, 4 alumina refineries	14 aluminum smelters	7 hydropower plants	2 ports and rail facilities
Copper	5 integrated copper mines	N/a	N/a	N/a
Diamond	2 integrated diamond mines	N/a	N/a	N/a
Other Minerals	6 mining sites for borates, iron ore concentrate, titanium dioxide and Uranium	N/a	N/a	N/a
Other Commercial Operations	N/a	N/a	N/a	200 Contracted ships

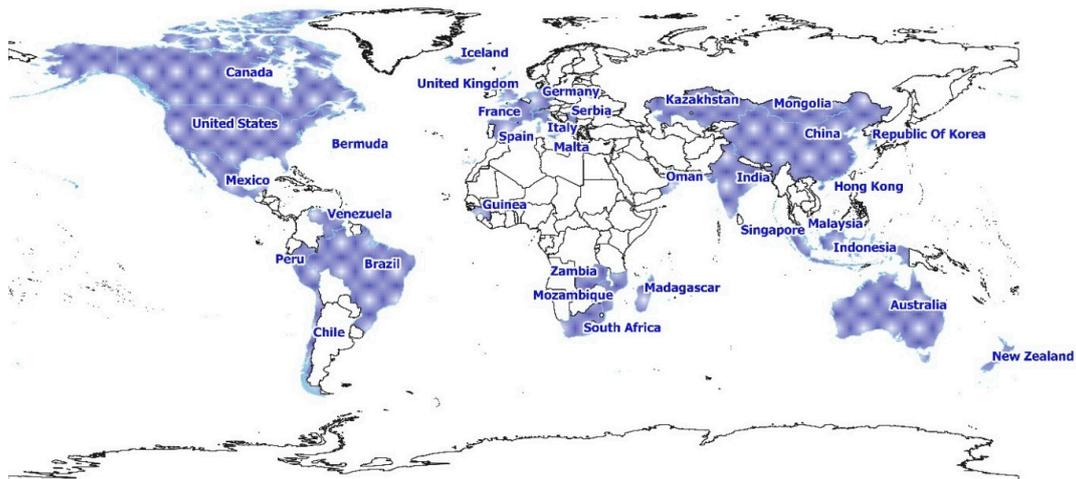


Figure 2. Rio Tinto's footprint [25].

Rio Tinto is also a member of the International Council on Mining and Metals (ICMM), and its sustainability goals are in line with the United Nations Sustainable Development Goals.

They have been working towards minimizing the negative impacts of their mines. They have started reporting on their Scope 1 and Scope 2 emissions as part of sustainability and climate change reports, as well as various metrics listed in Table 2. However, this approach only considers the lifecycle analysis of one of their services: mining. Their products also include aluminum, iron, copper and the variety of minerals they produce. Among their products, they have looked at the lifecycle of aluminum, which was primarily driven by the use of aluminum by the beverage industry [34]. Rio Tinto should start performing lifecycle analysis of other minerals. Additionally, it has been challenging to estimate their Scope 3 emissions because they generally do not have a control on how their products are being used, considering the wide variety of industries that rely on metals.

3.4. Comparison of Alcoa and Rio Tinto's Materiality Analysis

Alcoa and Rio Tinto carried out materiality analysis [21,35] and identified several issues for 2019, which formed the basis for their 2019 sustainability report. Both the companies aligned their 2019 material issues with their respective 10 k filings.

Alcoa's material issues are a subset of the potential issues identified during its value chain mapping exercise shown in Table 3. Alcoa has identified 13 material issues in 2019 whereas Rio Tinto's has identified 16 material issues in 2019. Several of their material issues are similar. Alcoa ranked their material issues in order of priority for 2020 but Rio Tinto plotted them on a chart showing importance for the business and for the stakeholders. 'Air quality and emissions management' is one of Alcoa's material issues, which is missing from Rio Tinto's material issues. However, air pollution has been one of [36] Rio Tinto's challenges in the past. They should think about addressing this in their future and focusing on reducing air pollution from their facilities. Another unique materiality issue identified by Alcoa is 'Economic Performance'. This is more a reflection of the company being in loss a few times in the last several financial years. 'Cyber security' is one of Rio Tinto's material issues that is missing in Alcoa's list of material issues. Additionally, Rio Tinto's material issue recognize employee engagement and well-being as an important part of their strategy in 2020 (Table 5).

Table 5. 2019 Material issues.

Topic	Alcoa's Material Issue (Rank in Bracket)	Rio Tinto's Material Issue (Importance for Stakeholder, Importance for Business)
Corporate governance	Regulatory compliance (1), Ethics, transparency and good governance (6)	Governance (High, Low), Transparency (Medium, Low)
Safety	Occupational health and safety (2)	Safety (Medium, High)
Stakeholder engagement	Human rights (11), Local commitment with communities (3)	Human Rights (Medium, Medium), Communities (High, High), Employee relations (Low, Medium), Health and well-being (Low, Medium), Corporate political behavior (Medium, Low)
Environmental footprint	Climate change (4), Air quality and emissions (5), Tailings management (7), Waste management (8), Water stewardship (9), Facilities closure, soil management and rehabilitation (10), Biodiversity (13)	Climate Change (High, Medium), Tailings and structures (High, High), Waste and circular management (Low, Medium), Water (Medium, High), Operational Environment (Medium, Low), Biodiversity and ecosystems (Low, Medium)
Financial sustainability	Economic performance (12)	Cyber Security (Low, Medium)

3.5. Sustainability Strategy

Most companies realize that they need a holistic sustainability strategy to stay in business and maintain profitability. Both Alcoa and Rio Tinto have corporate sustainability strategies that span environmental, social and economic sustainability. Alcoa defines that its corporate sustainable strategy is based on creating sustainable values for the community, enhancing value of its products through differentiation, and effective risk mitigation to minimize environmental, health and social risk. Similarly, Rio Tinto's integrated sustainability strategy is based on three pillars of running a safe, responsible and profitable business, collaborating to enable long term economic benefits and pioneering materials for human progress.

Alcoa set up its strategic long-term sustainability goals for the first time in 2016 after looking at emerging trends, and reported on them in the 2017 sustainability report (Prior to spinning off Arconic as a separate business in 2016, the joint company also had been focused on sustainability, and was included in the Dow Jones Sustainability Index in 2001 [19]). Several of the goals of the restructured Alcoa were updated from 2017 to 2018 to reflect more appropriate targets [21,37–39] Rio Tinto also has been working on sustainability initiatives for nearly three decades. They received the Tate and Lyle Award for Sustainable Development in 1993, which was given for their work on Rupike Irrigation Scheme, that provided water to regions in south-east Zimbabwe that were poorly affected by the drought of 1991–1992 [40]. Both of these companies have updated their strategic long-term sustainability goals to better align with sustainable development goals identified by the United Nations.

The sustainability strategy of both companies can be divided in three sections:

- **Safety:** Mining companies must prioritize safety above everything, and both Alcoa and Rio Tinto have created robust practices and standards to ensure safety across their business. They focus on health and well-being of their employees, and work towards ensuring that no employee, customer or any related entity experiences human rights violation. They claim that the reason behind prioritizing safe and ethical conditions is because they care for their employees. It must be noted, however, that their license to operate depends on the safe working conditions, ethical treatment and upholding human rights for their employees. So, while they recognize the importance of staying profitable to continue operations, they are also obligated to follow these sustainability principles to stay in business.
- **Collaboration:** They focus on collaborating with local governments and economic development agencies to achieve UN's Sustainable Development Goals [41]. Alcoa's strategy is based on Creating Shared Value (CSV) approach through which they collaborate with local communities

and empower them to be more resilient. Rio Tinto launched the Regional Economic Development (RED) initiative in 2019, which takes a more holistic approach of partnering with local, regional, national and international institutions. These partnerships enable them to create better employment opportunities for the local population as well as to hire better workers with better skills. Both companies recognize that investing in community development not only makes it easier for them to achieve licenses and permits, but also improves employees' skills and engagement, which in turn improves performance and reduces cost. Additionally, they collaborate with other companies to establish uniform sustainability practices. E.g., Alcoa and Rio Tinto have partnered on a joint venture to scale up Alcoa's patented product ELSYS for carbon free aluminum smelting [42], and Rio Tinto has partnered with China Baowu Steel Group and Tsinghua University to develop a joint action plan for improving the supply chain of steel production [43].

- Innovation: Alcoa and Rio Tinto focus on innovation related to all the processes involved in their material production. While Alcoa is mostly focused on lifecycle of aluminum, Rio Tinto's goal is to produce materials essential for human progress. Both companies have been working towards making their mining and refining processes cleaner to reduce their emissions and impact on climate change, e.g., ELSYS to produce carbon free aluminum. They have started performing life cycle analysis (LCA) on their mining facilities, which can provide some useful data to determine basic environmental and social impact [30]. Also, they now include Closure as part of facility level LCA to plan for how they leave a community and a mining facility after they cease operation.

Stakeholder Engagement

Stakeholders are any and all entities that have an interest in the organization, or could be affected by the actions of the organization [30]. These could include employees, suppliers, investors, customers, regulators or the communities. Typically, these could be divided as internal and external stakeholders, and the mode of engaging these stakeholders should vary depending on how they can impact the organization's decisions and how they can get impacted by the organization's decisions. Stakeholder engagement is one of the most important parts of sustainability accountability [44]. A good stakeholder engagement program can help organizations create long term value for the communities they operate in (Porter and Kramer, Creating Shared Value, Feb 2011).

Alcoa and Rio Tinto are large corporations with presence in 10 and 36 countries, respectively; so, the list of their stakeholders is also fairly long. Both have identified stakeholder engagement as one of the key strategic initiatives. One of the highlights in Alcoa's sustainability report is that it clearly lists all the stakeholder grievances that came up in the reporting year, along with the action that the company carried out [21]. Such disclosures help the company build trust not only with local communities and concerned stakeholders, but also with customers and the local suppliers. Openly acknowledging and transparently discussing such issues also emphasizes the company's focus on doing the right thing for the community and helps build a sense of authenticity around their conversation with stakeholders. For example, one of the concerns highlighted in their sustainability report was around collapse of one of the company's tailing dams in Juruti, Brazil. As an action item to this issue, Alcoa increased its dialogue with the stakeholders in the local community and invited the government and community stakeholders to audit its Brazilian operations and policies surrounding tailings management. By acknowledging their critical operational failures in its sustainability report, Alcoa is showing that it is serious about finding a solution. Similarly, Rio Tinto's sustainability report includes a section dedicated to their various stakeholders, in which they describe what their stakeholders' interests are, and what Rio Tinto does to engage the stakeholders. Table 6 shows a summary of the various stakeholders, their interests and modes of engagement. A clear distinction for each stakeholder helps large corporations such as Alcoa and Rio Tinto establish suitable paths for sustainable engagement.

Table 6. Stakeholders of Rio Tinto, their interests and modes of engagement [45].

Stakeholder	Areas of Interest	Mode of Engagement
Employees	<ul style="list-style-type: none"> • Safe work environment • Diversity and inclusion • Wages • Career development • Integrity • Practices and standards • Human rights 	<ul style="list-style-type: none"> • Policies and standards • Contract negotiations • Performance feedback, engagement surveys • Training and development • Townhall meetings • Employee communications
Host Communities	<ul style="list-style-type: none"> • Land access • Indigenous peoples' rights, cultural heritage • Employment opportunities • Community investment • Direct and indirect contributions • Environmental impacts • Access to water 	<ul style="list-style-type: none"> • Policies and standards • Communities and social performance guidance, publications • Community meetings, personal communications • Socio-economic programs, site visits, surveys • Negotiated agreements • Complaints and grievance mechanisms, whistleblowing program
Governments and regulators	<ul style="list-style-type: none"> • Taxes and royalties • Employment and procurement • Regulations, permits and licenses • Legislation • Closure 	<ul style="list-style-type: none"> • Periodic reports and disclosures • Meetings and communications • Regulatory filings • Payment of taxes • Business conformance audits • Site tours
Investors	<ul style="list-style-type: none"> • Financial and operating performance • Reserves and resources • Mergers, acquisitions and divestments • Sustainability disclosures • Governance • Climate change and political risk 	<ul style="list-style-type: none"> • Periodic reports, general meetings • Market announcements • Site tours • Investor seminars • Sustainability reports • Meetings and communications • Benchmarking
Customers & suppliers	<ul style="list-style-type: none"> • Procurement opportunities • Responsible sourcing • Reliability and quality • Pricing and contracts • Research and development 	<ul style="list-style-type: none"> • Contract negotiations • Contractor safety programs, continuous improvement • Local content agreements • Site visits • Meetings and communications

Table 6. Cont.

Stakeholder	Areas of Interest	Mode of Engagement
NGOs, special interest groups, civil society	<ul style="list-style-type: none"> • Safety, health and environment • Human rights • Indigenous peoples' rights • Community relations • Responsible sourcing • Integrity and transparency • Partnerships 	<ul style="list-style-type: none"> • Periodic sustainability reports • Meetings and communications • Civil society roundtables • Conferences, working groups • Partnerships and memberships • Multi-stakeholder initiatives
Peers and industry associations	<ul style="list-style-type: none"> • Technology and innovation • Sharing lessons learned • Regulatory and policy trends • Industry reputation 	<ul style="list-style-type: none"> • Memberships • Meetings and communications • Industry forums, conferences, working groups
Media	<ul style="list-style-type: none"> • Transparency, disclosures • Information sharing 	<ul style="list-style-type: none"> • Press release • Meetings and interviews

4. Environmental, Social and Economic Initiatives

Comprehensive sustainability initiatives span forms of environmental responsibility such as emissions and climate change, social responsibility such as health and well-being as well as economic responsibility such as employment and community investment. Mining companies are held accountable for all these responsibilities in various regions of the world, and must show their commitment in all aspects of sustainability. In this section, Alcoa and Rio Tinto's initiatives across environmental, social and economic responsibility have been reviewed.

4.1. Environmental Responsibility

In the mining industry, particularly for large corporations like Alcoa and Rio Tinto, minimizing the environmental impact of their operations is critical for their existence. Their facilities and products usually cause environmental pollution throughout their lifetime, require a large amount of energy to operate, and can create tremendous waste [46]. Seven out of 13 material issues identified by Alcoa in its latest sustainability report [21] are related to the company's environmental responsibility: climate change, air quality and emissions, tailings management, waste management, water stewardship, soil management rehabilitation and biodiversity. Similarly, Rio Tinto looks at the lifetime environmental impact of their projects and mines, and classifies its environmental focus as including land, water, air, biodiversity, tailings and climate change [33].

4.1.1. Climate Change

Alcoa and Rio Tinto have started noticing the impact of climate change on their operations. Rainfall patterns and water availability in various regions have started changing since the mines were established several decades ago, and they are impacting the economic performance of the mines in addition to hurting the local communities and their employees. As climate change is one of the most material risks, Alcoa has set a target to reduce its total Greenhouse Gas (GHG) emissions by 30% by 2025 and 50% by 2030 versus a 2015 baseline, and Rio Tinto has set a target to achieve net zero emissions by 2050, and to reduce its carbon intensity by 30% by 2030. Rio Tinto is investing \$1 billion in climate related projects, are supporting carbon pricing and have been collaborating with various partners throughout their value chain for climate change innovation. Alcoa also tracks its scope 3

emissions, which is primarily driven (~86%) by processing of alumina to aluminum by its customers, while Rio Tinto only reports on its Scope 1 and Scope 2 emissions.

4.1.2. Energy

Mining, smelting and refining processes are energy intensive. Low emission, low cost energy is critical for economic and environmental sustainability of operations. In total, ~70% of electricity purchased by Alcoa and 76% by Rio Tinto comes from renewable energy resources. By reducing the amount of electricity coming from carbon-based fuels, Alcoa and Rio Tinto will further improve the carbon footprint of their products. Additionally, they should innovate and work towards a technology that does not use carbon-based fuels (natural gas, coal and oil) for smelting and refining processes. Alcoa is collaborating with Rio Tinto on a joint venture to scale up its patented product ELSYS [47], a carbon free smelting technology. Apple and the government of Quebec are investors in the joint venture. Apple is actively buying this carbon free aluminum produced using ELSYS technology [48] or using it in its hardware products. ELSYS was awarded the “Breakthrough Solution of the Year” award by S&P Global Platts in 2019 [47]. To reduce the energy footprint, Alcoa and Rio Tinto should accelerate the commercialization of ELSYS and reduce consumption of carbon fuels in smelting and refining processes.

4.1.3. Land and Waste Management

Land is one of the most important resources for Alcoa and Rio Tinto, as their entire business depends on access to land and resources beneath that land. In the last several years, they have been increasing the rehabilitation of land, particularly in regions that had experienced native population displacements. Additionally, some of their sites have a culture of viewing waste as a product with economic value, and engaging stakeholders—a network of suppliers and customers—to identify potential recycle or reuse opportunity for waste. Carbon dust is an example of a product that one Alcoa site realized could be reused as a raw material in the steel industry and therefore started selling it to local steel mills. In order to improve waste management, they should start tracking types of waste sent to landfill rather than just the total amount of waste sent to landfill.

4.1.4. Water

Mineral mines are located in variety of climates, with wide range of water availability. Some mines experience extreme scarcity of water, and must, therefore, focus heavily on recycling; in addition, some are located below the underground water tables, and hence require removal and disposal of groundwater [33]. Reinjection of clean ground water, while cleaning of any contaminated water prior to disposal or reinjection are generally required by law, and mining processes have had to be updated to abide by such regulations. Alcoa and Rio Tinto have also been building tailing facilities to store the waste slurry before the water can be filtered and injected underground. As commerce in areas with mining and refining facilities typically grows with growth in the companies’ operations, critical stakeholders should be motivated to help them manage water resources to ensure the long-term survival of their operations in the area.

4.1.5. Recycling

Metal recycling is challenging project but has the potential to provide additional source of revenue to the mining companies. Not all metals can be recycled at the same rate or efficiency [49]. Some lose their quality over time, and purifying them to the original strength or capability could be expensive and polluting. While Rio Tinto produces many different types of minerals, Alcoa focuses on aluminum only, which is a unique metal that can be recycled infinitely without losing its properties, making it a sustainable metal of choice in several markets [21]. Both companies identify recycling aluminum as one of their key sustainability opportunities. Alcoa actively uses recycled aluminum in its global aluminum plants, and has also set up several closed-loop processes with customers, where aluminum scrap

from the customer's operations is returned to Alcoa for reuse [21]. The recycling rate of aluminum cans is as high as 95% in Brazil and Japan, and 70% in Europe, while USA has been nearly static at a ~50% recycling rate for the last decade [18]. Aluminum recycling is very profitable, which essentially subsidizes other forms of recycling, and consumers should be engaged to help increase the recycling rates.

Copper is another material that is widely used, and generally recycled. It is an essential component of solar, hydro and wind energy, as well as electric vehicles. Rio Tinto has started incorporating scrap metal recycling into their smelting process, and have recycled over 200,000 lbs. of copper wiring since 2005.

4.2. Social Responsibility

Understanding and addressing social responsibility is a major concern for mining companies. A number of mines are located in some of the poorest communities in the world that lack basic necessities for survival, and the local population frequently suffers from human right violations. Additionally, the working conditions in those facilities are also generally very risky, which makes social responsibility even more critical. They also need to recognize and respect the diversity, cultures, customs and values of the communities they operate in. Alcoa and Rio Tinto's sustainability framework includes human rights, communities and ethics and integrity through which they maintain social responsibility.

As a part of its Social responsibility strategy, Alcoa chartered the "Alcoa Foundation" in 1952. The foundation has been playing a significant role in strengthening sustainability in Alcoa communities worldwide [19], focusing on health and welfare of the society. Rio Tinto, on the other hand, has an approach based on understanding, preventing and managing the impact their business has on the local communities, which they do by working towards their communities and social performance (CSP) targets [50]. In 2019, Rio Tinto measured their performances across various aspects of social responsibility, that are shown in Table 4.

A key concern for mining companies is to effectively collaborate with indigenous people who own or reside in the land used for mining. Alcoa and Rio Tinto have been working closely with indigenous people in their operations regions to ensure that they do not adversely impact local community and culture. One example is Rio Tinto's collaboration with the indigenous communities and tribes in Australia, Canada, the USA [51] and various countries in Africa on programs such as "Uluru Statement from Heart" and the West Pilbara Turtle Program in Australia, and the Indigenous Minerals Program in Canada [51–53].

Companies also need to manage local complaints, reduce the impact of noise and dust, set up appropriate grievance resolution mechanisms, promote local procurement and prioritize diversity and inclusion of the local population. This includes working in line with the United Nations Universal Declaration of Human Rights. Most companies acknowledge that in their business, they are sometimes involved in human rights violations, and in those situations, they must focus on working with multiple stakeholders including suppliers and communities to improve the situation. They must address issues such as modern slavery and human trafficking. Both Alcoa and Rio Tinto have been closely monitoring this extremely sensitive subject for several years, and claim to be working towards eliminating this issue by implementing a modern slavery clause in their contracts with all suppliers, engaging with all stakeholders to implement the government's Modern Slavery Act, providing training to all employees and contractors and building capability within their team to identify and act on any modern slavery conduct [54,55].

In addition to focusing on the communities, companies must also establish internal labor practices that encourage diversity, inclusion and employee experience. Mining companies have historically had very few female employees, and both Alcoa and Rio Tinto have been focusing on increasing the participation of women in its workspace. They also have several programs in place for talent retention and development that includes upskilling employees periodically to help them with their growth

objectives [21]. Their extensive focus on gender diversity and talent development will also help them improve their financial performance [56] in the long-term.

4.3. Economic Responsibility

Any discussion on sustainability is incomplete without discussing economic sustainability. A company needs to stay in business by being economically sustainable [30]. Global Reporting Initiative (GRI) also recommends reporting on environmental, social and economic responsibility to provide a holistic view of a company's sustainability performance [57]. Economic responsibility refers to a company's responsibility to be able to deliver long-term profit to stakeholders, including shareholders, without compromising on the company's environmental and social responsibilities [30].

Alcoa and Rio Tinto claim to provide economic prosperity in the regions where their facilities have been established. These come in various forms such as local employment, procurement, taxes paid and community investments. They spend several billion dollars in taxes and royalties, and several million dollars in community investments. These investments and payments, if properly utilized, could provide great benefits to the communities. They have also started focusing on the economic impact of a mine's closure. A recent example of this is upcoming closure of the Argyle Diamond mine in Australia, owned by Rio Tinto, after more than three decades of operations. After the mine closes, a number of its employees will be looking for new jobs. Rio Tinto is helping them find other opportunities inside the company, and is also supporting them in developing skills that could help them find opportunities elsewhere.

They also have economic responsibility towards the investors and shareholders, and their focus on economic responsibility has been one of the key reasons for their survival for 100+ years. Alcoa has faced financial challenges in the last 5 years, while Rio Tinto has been improving its financial performance during this time. In 2015, the industry was facing low commodity pricing primarily due to the strong supply from China, and slow supply curtailments [58]. The resulting price pressure can be observed in the low stock prices for both Alcoa and Rio Tinto in 2015 (Figure 3). Since then, the metals and minerals market has improved for the industry. Additionally, the price pressure they experienced motivated them to find better cost reduction opportunities, many of which were directly related to their sustainability goals as well (energy, water, recycling etc.). While both companies have been working towards their sustainability goals, Alcoa has experienced challenges in meeting their goals, as described in the previous sections. This may have contributed to their financial losses also, as evident by their stock trend in the last two years. The year 2019 was a financially challenging year for Alcoa and the company finished it with a net loss of ~\$1.1 Billion [59]. Growth in the transportation, construction and packaging sectors [59] are Alcoa's top growth drivers. But, due to Covid 2019 crisis, these sectors are expected to see a reduction in consumer demand in 2020; therefore, Alcoa's revenue is expected to decline further. This is reflected in Alcoa's stock price trend as well, with the company currently trading its lowest level in the last five years. Rio Tinto's stock price, on the other hand, has followed a different trend to Alcoa's since 2017 (Figure 3). This economic sustainability for Rio Tinto aligns with their successes in environmental and social sustainability as well. Alcoa has recognized the challenges, and is working on improving profitability by managing long-term liability, reducing cost through economies of scale, divesting unprofitable plants, and launching more products in its low-carbon product line. Creating differentiated offerings focused on sustainability, and including sustainability as a core part of their corporate strategy should help Alcoa and Rio Tinto to survive in such a complex business environment and improve their financial performance and returns to their investors even further.



Figure 3. Historical stock prices of Alcoa and Rio Tinto [60,61].

4.4. Controversies Surrounding Alcoa and Rio Tinto

Despite all these efforts, there have been claims regarding the lack of their efforts, and how their efforts could be a cover for some of their unethical or unsustainable practices [62]. Greenwashing is the process of creating a false impression of a company's environmental sustainability initiatives or the environmental benefit of its products by disclosing either partially correct or incorrect data as a part of the formal reporting [63]. With increased consumer awareness on sustainability, incidents of greenwashing have increased rapidly in recent years [63]. While both Alcoa and Rio Tinto have sustainability strategies in place, several environmental and social agencies claim that their efforts are nothing more than greenwashing, and that those efforts were taken due to regulatory pressure [62,64–67]. Some examples of the controversies they have been involved in are listed below:

- The Kwinana facility expansion: Alcoa was looking to expand its tailing pond further which could have brought its residue storage area as close as 1.5 km away from residential subdivisions. This was heavily opposed by the residents in the Australian town of Yarloop, who claimed that the dust caused by the residue storage area could cause dry throats and irritated eyes, and this was seen as an unethical move by Alcoa [68].
- Bougainville closure: Rio Tinto was recently accused of multiple human rights violations because their Paguna mine on the island of Bougainville was not closed properly, leading to poisoned water, polluted fields and damage to the river valley [62]. Even though this mine was closed many years ago during a time when sustainability standards were very low, Rio Tinto should still take the responsibility for these damages to the local community and the environment, and attempt to clean up the area.

5. Recommendations

Alcoa and Rio Tinto are parts of an industry that has long suffered from unethical and unsustainable practices. These corporations have managed to understand the importance of sustainability, and are making it a part of their core business. Both companies have a long history in corporate social responsibility and this focus on sustainability has enabled them to survive in the industry for 130+ years. They have been working in the right direction for the last few decades and have made several improvements that make sustainability a part of their core business strategy. Therefore, they have set a high bar for adopting sustainability practices. Even though they have not been successful across

every initiate, they are striving to do the right thing. Based on the research presented here, the other companies can adopt the following best practices from Alcoa and Rio Tinto:

- To align employees, with sustainability goals, companies should prioritize defining their purpose and communicate it to their employees. Rio Tinto strives towards fulfilling their purpose of providing materials essential for human progress. Their board of directors is directly involved in their sustainability strategy through a Sustainability Committee, which ensures appropriate compliance and governance.
- Companies should look to not only serve their shareholders but also engage stakeholders at all levels and ensure that their goals are being met. Both Alcoa and Rio Tinto engage stakeholders at each level of their operations. Alcoa is exploring possibilities of creating shared value for its stakeholders, while Rio Tinto has a unique focus on employee and communities' safety and well-being.
- Companies should develop their sustainability and supply chain management strategy such that it can handle location based complexities, including local politics. Both Alcoa and Rio Tinto have an expansive value chain, spread across various parts of the world, which necessitates defining environmental, social and economic responsibilities such that the local community is engaged.
- Tracking and reporting key sustainability metrics is critical to promoting sustainability mindset in organizations. Both Alcoa and Rio Tinto have conducted extensive reporting on sustainability, climate change, human rights, modern slavery and human trafficking over the last several years, and their efforts have resulted in improvements across most of these metrics.

Additionally, based on the investigations performed here, the following recommendations are made for Alcoa for improved sustainability performance:

- Alcoa has defined its core values and strategic priorities but has not defined its purpose. Without a purpose, Alcoa is getting less alignment in its operations in various parts of the world with its sustainability goals. Alcoa should work towards understanding its social purpose, and communicate it to the team. This would drive the team towards adopting the company's sustainability mindset in their day to day activities.
- Alcoa should work towards bridging the gap between strategy and execution. They have been good about setting up improvement targets for key sustainability metrics (such as emissions reduction) but have not been able to execute on several of them in the last few years. This reflects a gap between their strategy and execution. Alcoa needs to work on creating a roadmap that lays out what they need to do to get them from their current state to the future state defined in their sustainability strategy and diligently work towards accomplishing each milestone.
- Alcoa should work towards further integrating its shared value creation approach into its sustainability initiatives. Several of the metrics that Alcoa could not deliver on in the past were because the stakeholders were not as engaged in their strategy. Alcoa should work towards integrating the shared value creation strategy of stakeholder engagement with its ongoing sustainability initiatives. This would help the company in managing its stakeholders better. For example, in the past Alcoa has pursued projects to increase aluminum recycling, but, as their stakeholders could not be sufficiently engaged, Alcoa could not influence aluminum can recycling rates in the U.S. Approaching this challenge from a shared value creation approach may help them be more successful.

Similarly, the following recommendations can be made for Rio Tinto:

- Even though Rio Tinto has a great stakeholder engagement framework, they need to engage all stakeholders that get impacted by their decisions at every location, including those that Rio Tinto had closed prior to their sustainability strategy implementation. This would help to substantiate their sustainability leadership further. For example, there are regions where Rio Tinto closed

operations before stricter regulations and standards were implemented by local governments. Rio Tinto should consider taking that additional step in such situations and help the communities that they no longer work in but are currently suffering due to Rio Tinto's prior operations.

- Rio Tinto has a goal to achieve total decarbonization by 2050. They have intermediate targets to reduce total emissions by 15% and carbon intensity by 30% by 2030. They should set a clear path and more detailed intermediate goals to ensure transparency throughout this journey.
- Rio Tinto's focus on growth and innovation is limited to existing products and processes. They could be looking for disruptive technologies and work towards accelerating the industry transition towards more sustainable products.

6. Conclusions

The case studies of Alcoa and Rio Tinto's sustainability journey presented in this paper suggests that these companies have been focusing on sustainability for a long time, and have recently started including sustainability as part of their core business. They recognize the impact their business has on the environment, the communities they operate in and on the economy.

Their sustainability footprint spans multiple regions and processes, and they are trying to reduce their footprint by performing lifecycle analysis of their facilities as well as through process improvements. By utilizing such tools, they have been able to develop sustainability strategies and update them as more information became available. By improving their sustainability strategies and engaging the stakeholders, they have determined specific initiatives for environmental, social and economic responsibilities. Their targeted initiatives within each section has provided successful results in terms of reduced emissions and waste, higher use of renewable energy and recycling rates, better working conditions for the employees, protection of human rights and economic welfare of the employees and local communities.

While the success stories presented by these companies are numerous, they have more work to do in the future. They have emissions targets for 2030 and 2050, but their current progress is not on track; ~30% of their energy consumption still comes from fossil fuels and they have been blamed for human rights violations in certain regions through water and land contamination as well as air pollution. Even though the mining industry continues to face criticism for its unsustainable and unethical practices, the efforts made by these companies show that they are on the right path to a sustainable future.

Author Contributions: Conceptualization, methodology, investigation, resources, writing—P.S. and R.V. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

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