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Relationship between Financial and ESG Performance on the publicly traded Technology Companies.

Special focus: IT Hardware Manufacturing Companies and their risks along the Supply Chain.

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ABSTRACT

Abstract Purpose: The purpose of the research is to examine the correlation between financial and ESG (environmental, social and governance) performance on the publicly traded information technology hardware manufacturing companies, and the risk they are exposed to along their supply chain (i.e. the extent in which they report the risk in their annual reports (10K) and specific reports).

Literature Review: The theories used in this study were based on existing literature and research conducted by past scholars and publishers who wrote about IT hardware manufacturers supply chain risk, sustainability and ESG (environment, social and governance) issues in IT. It was later possible to identify the study gap and develop research questions based on the literature perused.

Methodology: An inductive research methodology was used to investigate the correlation between financial and ESG performance on the publicly traded information technology hardware manufacturing companies, and also educate on their supply chain risk. Primary data was gathered through the SEC website (the 10K report of the individual companies), and specific reports (such as the sustainability, environment social and governance etc) pertinent to the study were collected on the companies websites, and pivot tables was used to analyze the data in order to gain more understanding of the research topic, that helped in identifying key areas of discussion.

Empirical Findings: The empirical results were generated from using pivot tables to analyze the data of the fifteen (15) IT hardware manufacturing companies. The results were discussed in connection to the literature while answering the research questions and fulfilling the purpose of this research. The results indicated that there will be no technology or IT companies without these important minerals, metals, and resources. The results showed that there is a global concern and focus on the mining and usage of these resources, and IT companies are taking positive steps with regards to sustainable practices concerning these resources in order to protect ourselves and our environment.

Keywords: Cobalt, Lithium, Water, E-Waste, Emissions, Copper, Tantalum, Nickel, Silicon.

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List of Acronyms:

ICT: Information & Communication Technology

ESG: Environment Social & Governance

IT: Information Technology

CSR: Corporate Social Responsibility

GHG: Greenhouse Gas Emissions

TCFD: Task Force on Climate-related Financial Disclosures

UNFCCC: United Nations Framework Convention on Climate Change

IPCC: Intergovernmental Panel on Climate Change

C-SCRM: Cybersecurity Supply Chain Risk Management

SCM: Supply Chain Management

FSB: Financial Stability Board, NGO: Non-Governmental Organizations

EPEAT: Electronic Product Environmental Assessment Tool

OEMs: Original Equipment Manufacturers, EEE: Electrical and electronic equipment

CO2: Carbon dioxide

EVs: Electric Vehicles

LCE: Lithium Carbonate Equivalent

DRC: Democratic Republic of Congo

CDM: Congo Dongfang Mining International

TSMC: Taiwan Semiconductor Manufacturing Company

GECAMINES: Generale des Carrières et des Mines

PGE: Platinum Group Element

DoD: Department of Defense

ACTF: AntiCounterfeiting Task Force, CFSI: Conflict-Free Sourcing Initiative

SIA: Semiconductor Industry Association

SBA: Sistema Bibliotecario di Ateneo

SEC: Security and Exchange Commission

3TG: Tin, Tungsten, Tantalum, and Gold

UPS: Uninterruptible Power Supply

LANs: Local Area Networks, WANs: Wide Area Networks

PoE: Power over Ethernet

SSDs: Solid-State Drives, HDDs: Hard Disc Drives

ICs: Integrated circuits, PCBs: Printed Circuit Boards

E-Waste: Electronic Waste, WEEE: Waste Electrical and Electronic Equipment

Chapter 1:

Introduction:

Frequent natural disasters brought on by extreme climatic conditions not only endanger human lives but also have a significant influence on and pose a serious challenge to the world economy. The health, safety, and economic crises brought on by climate change are therefore receiving major attention from governments, businesses, and civil organizations all around the world. To meet the difficulties of the present, they have started debating sustainability-related corporate social responsibility (CSR) and started urgent climate-related initiatives. In recent years, climate change has had an impact on both the environment and industry, disrupting global supply lines, lowering labor productivity, and shutting down company operations. The governance and management of businesses are being put to the test as more and more of them experience financial difficulties and bankruptcy. The manufacturing sector is particularly hard hit, thus it's critical for associated businesses to commit to sustainable development and take action against climate change, (Chen et al, 2022). Global losses from significant natural catastrophes exceeded US$ 166 billion in 2019, before rising to US$ 280 billion in 2021, according to Munich Re Group (2022), a German reinsurance firm. These show that the frequency and severity of extreme climate events brought on by climate change have increased, (Chen et al, 2022). The economic development of nations around the world is negatively impacted by climate change, according to Kahn et al. (2019). Global GDP will decrease by 7.2% as a result of climate change if it is not addressed, which will have a negative impact on firm profits (Javadi and Masum, 2021). According to Pankratz et al. (2019), both operating profits and revenue will decrease.

The manufacturing industry now demands sustainability and successful balance of social, environmental, and economic outcomes, (Saberi et al, 2019). Utilizing sustainable manufacturing techniques, businesses may meet rising demand while having little negative influence on the environment and society, (Braccini & Margherita, 2019). Given the significance of sustainable practices, manufacturers have embraced a variety of technologies and methodologies to improve their sustainability performance in the industry 4.0 era, including big data analytics, blockchain, artificial intelligence, lean manufacturing, six sigma, and reverse logistics, (Shaharudin, 2017). Information and communication technology (ICT) items are purchased to support organizational objectives. Each product has a basic set of security criteria in this regard. The environment surrounding security is constantly evolving. Therefore, the organization must realign the product or its processes to bring them back into correct alignment if some part of the evolving product does not match those standards. A real-world ICT product supply chain needs to take into consideration all of these variables as well as any additional ones. Both at the level of the overall supply chain system process and inside the internal workings of any specific member organization within that sourcing chain, accounting should be done. Therefore, any ICT product sourcing system should be built with a clearly defined and thoroughly specified method for managing change, both in the short and long terms, (Sigler et al, 2017).

1.1: Problem Statement:

Humans now enjoy far higher living standards thanks to technological advancement. It is obvious that humans have been effective in making use of new technologies. However, addressing environmental deterioration and climate change presents us with significant obstacles, (Nordhaus, 2019). There were 7348 major weather-related disaster occurrences between 2000 and 2019 that caused 1.23 million fatalities and USD 2.97 trillion in economic losses, (Hou, 2023). Many organizations are too focused on profit maximization that they tend to forget the impact their activities have on the environment and the social well being of the people.

Government agencies, civil groups, and businesses worldwide have started standardizing and putting into practice pertinent backup plans to reduce or adapt to climate change in response to the global systemic threats it has caused, (Chen et al, 2022). The United Nations Framework Convention on Climate Change (UNFCCC) mandated that governments achieve net-zero emissions by the middle of this century and cut their carbon emissions in half by 2030 in order to keep global warming to 1.5 degrees Celsius during the 2021 United Nations Climate Change Conference (commonly known as COP26, 2021). Governments and businesses have responded by implementing a variety of low-carbon transformation plans. The Task Force on Climate-related Financial Disclosures' (TCFD) recommendations were formally published in June 2017 by the Financial Stability Board (FSB). Companies must report their financial measuring methodology as well as the opportunities and hazards associated with climate change (CCR). The goal is for them to have a better understanding of the effects on their finances as a result, leading to operations that are sustainable, (Chen et al, 2022). In accordance with the TCFD framework, 37% and 18% of enterprises in the G250 and N100, respectively, disclosed CCR risks, according to KPMG International Cooperative, 2020. The research will assess the financial and ESG (environment social & governance) performance on the publicly traded ICT hardware manufacturing companies and their supply chain risk inorder to add more knowledge in that research field. Through the analysis of annual reports (10K reports) and specific reports, the research will evaluate the extent the individual companies report on their supply chain risk.

1.2 Research Gap:

There have been quite a number of studies investigating the relationship between financial and ESG performance in an organization as a whole, supply chain risk and supply chain risk management, but there is not enough research focusing on the technology hardware manufacturing companies. The majority of research shows that making disclosures or exhibiting strong ESG performance has a favorable impact on businesses' financial performance, (Chen et al, 2022). The research is conducted to increase the knowledge base on the relationship between financial and ESG performance on the publicly traded information technology hardware manufacturing companies, and also educate the masses on their supply chain risk. The end result we hoped to achieve is to better equip the stakeholders with the above information in their decision making endeavors.

1.3 Research Question:

Due to the fact that there is not much research focusing or examining the relationship between publicly traded IT hardware manufacturing companies financial and ESG performance, and their supply chain risk. This research is ideally suited for this area/field due to the influence technology has on our globe. Financial and ESG have a positive correlation in an organization as many research have revealed that ESG initiatives improves the firm's overall financial performance. The technology sector is among the fastest growing in the world today, people rely a lot on technology as it now becomes indispensable. Governments as well heavily depend on it in the various industries, including communications, entertainment, safety, health care, transportation, and national security. Supply chain is an integral part of an organization's value chain/value creation.

The study hopes to improve the knowledge base or the research gap mentioned above, using the annual reports (10K reports) and specific reports of the technology hardware companies. In light of the aforementioned discussion and the importance of such a study in this technological era, this study addresses the following question:

How do IT hardware manufacturing companies report on sustainability issues, and supply chain risk in their mandatory, voluntary, and supplementary reports.?

1.4 Purpose of Study:

Information technology plays a crucial role in both addressing and escalating sustainability concerns. On one hand, IT may support sustainability initiatives by enabling more effective resource management, lowering energy use, and promoting environmentally responsible behaviors. However, it also presents problems with sustainability, such as the effects of data centers on the environment, how to dispose of electronic waste (e-waste), and how much energy is needed for digital technologies. As previously mentioned, the purpose of the research is to examine the correlation between financial and ESG performance on the publicly traded information technology hardware manufacturing companies, and the risk they are exposed to along their supply chain (i.e. the extent in which they report the risk in their annual reports (10K) and specific reports).

Chapter 2: Literature Review:

2.1 Supply Chain Issues, Environment & Sustainability:

Foreseeable and unexpected events have perpetually exerted influence on supply chains, particularly those of a global nature, jeopardizing their financial viability and operational continuity. Consequently, in an endeavor to mitigate the impact of these associated risks, both professionals and researchers have demonstrated a growing interest in delving into the root causes of such occurrences over the past two decades. This heightened curiosity can be attributed to three primary factors. Firstly, despite the implementation of practices such as just-in-time production, lean management, and streamlined logistics, supply chains remain susceptible to adverse events due to their limited margin for error or adaptability (Snyder et al., 2016). Secondly, the evolving landscape of businesses has witnessed a shift towards greater global diversification and reduced vertical integration, rendering supply chains more intricate and vulnerable to an expanded spectrum of risks (Behzadi et al., 2018). Lastly, a series of high-profile incidents has disrupted international supply chains, capturing global media attention.

Various incidents contribute to supply chain disruptions, with examples ranging from natural disasters like the Thailand floods in 2011, which resulted in a global shortage of hard disk drives (Chopra and Sodhi 2014), to human-made catastrophes like the 9/11 terrorist attacks. Additionally, there are instances causing economic or political instability, such as the Great Recession following the 2008 Global Financial Crisis (World Economic Forum, 2012), and the UK's decision to exit the European Union (Brexit) in 2016 (Matthews 2017). According to Bartol (2014), Cybersecurity Supply Chain Risk Management (C-SCRM) demands the collaboration of multiple distinct professional communities encompassing logistics, system and software engineering, supply chain, and cybersecurity. Each of these domains contributes its unique perspectives, taxonomies, frameworks, and standards. Linton et al. (2014) emphasize that this is a complex discipline integrating traditional cybersecurity with supply chain management to mitigate risks for both information and communications technology (ICT) supply chains and ICT goods and services. They argue that these risks extend throughout the supply chain, potentially leading organizations to lack visibility, understanding, and control over the processes involved in producing and transporting ICT goods. Colicchia et al. (2019) propose a bi-directional approach for projects, encouraging the inclusion of supply chain partners where feasible to overcome the usual isolation in the C-SCRM process. They argue that adopting such an approach promotes controls that extend beyond mere technical solutions and fosters collaboration throughout the entire supply chain. The primary objective of C-SCRM is to attain visibility and governance over an organization's extensive network of partners, encompassing suppliers and customers. This aligns with the need for IT architects, as stated by Boyson (2014), to have effective oversight over the design, construction, and deployment of systems whose hardware and software components are increasingly sourced globally and often lack a clear lineage. Critical functions are frequently hosted on networks with questionable reliability. Furthermore, as Ghadge et al. (2019) point out, supply chains serve as the foundation of evolving technology ecosystems, highlighting the importance of fostering new connections among participants within the supply chain (as cited in Topping et al., 2021).

It is highly disconcerting that manufacturers often possess minimal or no knowledge regarding the components and procedures employed in their supply chains. This lack of transparency is indeed troubling. Another critical aspect that must be unveiled to promote the adoption of renewable energy is the quantity and origin of energy consumed by energy providers. The most formidable obstacle is systemic in nature; it involves not only reducing the volume and speed of resource consumption but also the essential tasks of cleansing and closing material cycles. This necessitates the development of innovative business and marketing strategies in conjunction with advancements in design and technology. The real challenge lies in identifying meaningful indicators that can measure how companies are effectively curbing resource consumption and closing material loops in a manner that is both comprehensible and transparent.

The widespread use of laptops, phones, and tablets is increasingly common worldwide. However, the concerning trend of consumers rapidly purchasing and disposing of these devices is significantly detrimental to our environment. There is a growing demand for electronic gadgets that are both more environmentally friendly and durable, driven by factors such as government regulations, procurement standards like EPEAT (Electronic Product Environmental Assessment Tool), and consumer frustration with planned obsolescence. The electronics industry has already shown some progress in this regard. Positive changes have emerged as businesses leverage their expertise and creativity, focusing on areas such as enhancing energy efficiency in equipment, gradually eliminating hazardous materials, and implementing methods to recover valuable metals from these devices. The creative potential of this industry suggests that it can take further steps to close material loops and enact more substantial reforms to combat overconsumption. Greenpeace has established a strong presence in the IT industry since 2006, primarily by identifying significant environmental impact areas and exerting pressure on international IT corporations to improve their environmental performance. Greenpeace has successfully encouraged major electronics manufacturers to remove hazardous chemicals from their products and introduce voluntary take-back programs in countries lacking such regulations. Since 2010, Greenpeace has achieved the establishment of long-term agreements with more than fifteen international internet corporations, committing them to operate entirely on renewable energy sources. These notable successes were the result of a combination of active involvement, rigorous and continuous performance evaluation, and targeted global public engagement campaigns, as outlined by Cobbing et al. in their 2016 publication. Over the past two decades, original equipment manufacturers (OEMs) have realized cost savings and reduced time-to-market by engaging in international outsourcing within the semiconductor supply chain. However, this practice has rendered printed circuit boards (PCBs) vulnerable to potential global attacks and alterations, as highlighted by Mehta et al. in their 2020 research.

Although the electronics industry has made some progress in enhancing its environmental performance, it has yet to comprehensively tackle the inherent challenges within its current business model. These challenges encompass several vital areas:

Dirty Energy Consumption: The production of electronics relies heavily on substantial amounts of dirty energy, primarily derived from coal sourced from East Asian manufacturers. This contributes to both global warming and air pollution.

Hazardous Substances Usage: The use of hazardous materials is prevalent in both the manufacturing processes and the products themselves. While leading electronics brands have made strides in reducing the presence of these dangerous substances, many other major companies, including emerging global leaders, have been slower to follow suit. For instance, toxic PVC (Polyvinyl Chloride) and associated softeners continue to be used in electrical wires found in computers and televisions, posing long-term environmental and recycling challenges.

Resource Consumption and E-Waste: The rapid growth in smartphone sales, which reached 1.42 billion units in 2015, has resulted in a significant increase in electronic waste (e-waste) volumes. Projections indicate that global e-waste levels could reach 65.4 million metric tons by 2017. Coping with this surge in e-waste is complicated, especially when it is exported to developing nations for recycling, often through unsafe and informal processes, posing health risks to local communities. Despite efforts to expand electronic take-back programs, the collection rates struggle to keep pace with the rate of consumption.

The current unsustainable practices within the electronics sector not only contribute to environmental degradation but also present substantial public health concerns. To effectively address these primary impacts, a transition from a linear to a closed-loop system is imperative. Slowing down the production, use, and disposal of technology is crucial in mitigating these pressing environmental and health challenges, as emphasized in the research conducted by Cobbing et al. in 2016.

Digital technologies (DTs) and their associated artificial intelligence (AI) have undeniable environmental impacts. These impacts encompass a range of factors, including the substantial carbon dioxide emissions resulting from the energy required to process vast amounts of data, the mining of minerals for technological components, and the issue of electronic waste (e-waste). The environmental consequences of DTs are increasingly receiving attention from policymakers and the media in discussions about environmental sustainability. However, it's important to note that the term "sustainability" is multifaceted and can be interpreted in various ways. While stakeholders often possess broad theoretical understandings of sustainability and its connection to the environmental implications of DTs, in practice, environmental sustainability tends to be associated primarily with technology-centered and carbon-focused approaches. While this narrowing of conceptual understandings may seem practical, it can actually obscure more comprehensive sustainability challenges. In light of this, it is crucial for individuals working in this field not to lose sight of the broader "ethos of sustainability," as emphasized by Samuel et al. in their 2022 study. This broader perspective acknowledges that environmental sustainability encompasses a wide array of factors and considerations beyond just technological and carbon-related aspects, highlighting the need for a more holistic approach to address sustainability challenges effectively.

The idea of environmental sustainability has changed into a technocentric and carbon centric strategy that neglects to take into account more comprehensive sustainability challenges as it has been translated from a "regulative ideal" into the practices of the digital sector. This has been problematised in a number of ways. Our intention is not to disparage those engaged in research or working in the industry, since many of them make every effort to guarantee that their operations are sustainable or to advance sustainable practices more generally. Instead, we want to highlight the drawbacks of adopting such a constrained sustainability emphasis and motivate stakeholders to distinguish between constrained activities and a broader sustainability ethos that they incorporate into their practices. The ability to zoom in and out between a focused strategy (such as one based on measurements) and a more general "ethic of sustainability" is essential for stakeholders, especially researchers. The ability to divide the usefulness of the concept into two by using it as a way to drive a "ethos of sustainability" as well as targeted interventions that can have a measurable and impactful change is made possible by seeing the idea and significance of sustainability as having a dual role—both at the higher abstract level and at the more local specific level. This two-pronged strategy fosters culture change by instilling a sustainability ethos across all organizational levels and layers of research, creating a unified message and support for this strategy, and simultaneously focusing on targeted interventions to offer the chance to establish test beds at "pinch points" where sustainability is critically important, (Hunt et al, 2021. cited in Samuel et al, 2022). A business that provides digital commodities to people in low- and middle-income nations is not sustainable if it does not also offer fair compensation for supply chain workers.

Enhancing the involvement of social science and ethical considerations within the research industry is indeed valuable, particularly in a context where sustainability is predominantly approached through techno-scientific methods. To advance sustainability effectively, actors within the digital technology research sector and industry should cultivate coordination skills and a shared understanding of sustainability that encompasses not only the technical aspects but also the broader ethos and ethical dimensions of the concept. However, it's crucial to exercise caution and not place an undue burden on individuals engaged in this field while striving to develop effective sustainability strategies. Instead, the responsibility lies in incorporating the principles and behaviors associated with a sustainability ethos into the policies and regulatory decisions governing the research and industry sectors. In doing so, sustainability becomes a collective endeavor to address the multifaceted challenges within the digital technology industry, as emphasized in the research by Samuel et al. in 2022. In essence, fostering a comprehensive understanding of sustainability, which includes social and ethical considerations, is essential for creating meaningful and lasting changes that promote environmental sustainability in the digital technology sector. This approach ensures that sustainability becomes ingrained in the culture and practices of the industry, rather than being perceived as an additional burden on individual actors.

Despite the benefits that consumers and communities are embracing from these contemporary information and communication technologies, NGO reports and other surveys have shown horrifying environmental and social practices in the mining, manufacturing, and disposal of mobile electronic gadgets. This includes UN reports on warlords funding their operations through mining and trading of "high-tech minerals," reports on destructive practices in the mining of cobalt, tin, gold, palladium, and rare earths, subpar working conditions in manufacturing and assembly, and erratic recycling and disposal in third-world nations. Along with these findings, it is also widely known that various production processes, including the creation of microchips, need enormous amounts of energy, water, and chemicals. Additionally, materials used in electronic gadgets can be harmful to human and environmental health if they are not properly disposed of after the product's lifetime. Over the course of their lifetime, ICT goods have a variety of negative effects on the environment. Among the effects are the potential for global warming, land acidification, freshwater eutrophication, water depletion, cumulative energy demand, fossil resource usage, and many others.

The main contributors to greenhouse gas emissions during production are printed circuit boards (PCBs), displays, and integrated circuits. For the production of tablets, PCBs and integrated circuits account for 41% of the greenhouse gas emissions, whereas display modules produce 39%. A smartphone's overall greenhouse gas emissions are made up of 32% by screens and 36% by PCBs and integrated circuits (including assembly operations). 33% to 85% of all smartphone greenhouse gas emissions come from the manufacturing process. The distribution phase was shown to be responsible for 3% to 17% of the emissions, while the use phase contributed between 10% to 49%. The use phase typically comprises emissions of greenhouse gasses as a result of energy use at end-consumers' premises (for example, for charging cell phones), (Greenpeace, 2016).

Notwithstanding their promises to their biggest clients, such as Apple, Google, and HP, to cut greenhouse gas emissions in their worldwide supply chains, Taiwanese electronics industry behemoths are failing to switch to renewable energy sources. "Up to 80% of a device's lifetime's carbon emissions are produced during production. Chih An Lee, Program Manager at Greenpeace East Asia, warned that the international IT industry will never genuinely go green if Taiwanese businesses do not advance and switch to renewable energy. In a ranking created by Greenpeace East Asia, 10 major Taiwanese electronics producers were graded on transparency, dedication, performance, and advocacy in two key areas that are essential to moving the industry toward sustainability: emissions reduction and the use of renewable energy. The 10 businesses, including TSMC, ASE, Pegatron, Quanta, Compal, Wistron, Inventec, AUO, Innolux, and Hon Hai/Foxconn, are all still taking their time switching to renewable energy sources.

The survey ranks TSMC (Taiwan Semiconductor Manufacturing Company), the world's largest semiconductor producer, at the top position primarily due to its improved information transparency. However, it's worth noting that TSMC only relied on renewable energy for 5.4% of its operations, resulting in an overall grade of B-. On the other end of the spectrum, Hon Hai/Foxconn, Pegatron, and Quanta received the lowest grade, a D-. Although all ten companies included in the survey reported some use of renewable energy in 2017, the percentage of renewable energy in their total electricity consumption ranged from 11.9% to as low as 0.17%. This indicates that there is significant room for improvement in reducing their reliance on fossil fuels. As highlighted by Lee, the Program Manager at Greenpeace East Asia, the Information and Communications Technology (ICT) industry plays a substantial role, accounting for 12% of global electricity consumption. Taiwan, being a hub for electronics production, is particularly significant in this context. To effectively address climate change and transition from inefficient to efficient sources of electricity, it is essential to hold IT corporations and their suppliers accountable for their energy usage and encourage a greater shift towards renewable energy sources. This is crucial not only for environmental sustainability but also for reducing the carbon footprint associated with electronics manufacturing, (Taiwanese, 2019).

2.1.1 Water:

Diseases brought on by inadequate water and sanitation continue to have a significant impact on public health in the developing nations. In 2003, it was estimated that unsanitary water supplies and lack of hygiene contributed to 4% (60.7 million DALYs:Disability-adjusted life years) of the worldwide burden of illness and 1.6 million annual fatalities, (World Health Organization, 2003). In developing countries, there was significant investment made in water supply and sanitation during the 1980s and 1990s. But by 2000, a sizable fraction of the world's population still lacked access to better water and sanitation. Around 40% of the population in Africa, 19% of the population in Asia, and 52% of people in Latin America do not have access to better sanitation and water supplies, respectively, (World Health Organization, 2000).

2.1.2 E-Waste:

By 2050, there will be a 70% increase in global trash compared to 2016 (Schrader-King and Liu, 2018). Plastics have garnered the most attention in relation to the environmental effects of trash because microplastics in the Oceans around the earth already outnumber stars in the Milky Way (UN News, 2017). Electrical and electronic equipment (EEE) is now an indispensable component of daily life. Due to its accessibility and extensive use, many people around the world now enjoy living standards that are higher. However, the way we produce, use, and discard e-waste is not sustainable. Externalities, such as resource consumption, greenhouse gas emissions, and the release of harmful compounds during informal recycling methods, highlight the issue of staying within sustainable limitations due to the slow pace adoption of collecting and recycling. Therefore, the significant environmental and human health concerns of improperly managed Waste Electrical and Electronic Equipment (WEEE), often known as e-waste, provide a challenge for many nations. Even nations with official e-waste management systems must contend with comparatively low rates of collection and recycling. Only 17.4% of the 53.6 million metric tonnes (Mt) produced in 2019 were formally recorded as being adequately collected and recycled. It climbed by 1.8 Mt since 2014, although a total of 9.2 Mt more e-waste was generated. This shows that recycling efforts are not keeping up with the growth of e-waste on a global scale, (Vanessa Forti et al, 2020).

2.1.3 Emissions:

The main contributors to global warming are thought to be greenhouse gas emissions (GHG), particularly carbon dioxide (CO2) emissions. Several nations signed the Kyoto Protocol and pledged to reduce their emissions in order to prevent global warming. As a result, it becomes necessary to clearly identify the sources of CO2 emissions (Hamilton and Turton, 2002). According to estimates, the overall cost of climate change brought on by carbon emissions is comparable to a 5% annual decline in GDP, now and forever, and even a 20% decline if quick action is not taken (Stern, 2007). Near-real-time data show that global CO2 emissions rose by 4.8% in 2021 to reach 34.9 GtCO2, following record-level decreases in 2020. These emissions from 2021 utilized up 8.7% of the carbon budget still available to keep global warming to 1.5 °C, which, if current trends continue, may be depleted in 9.5 years with a 67% probability, (Liu, Z et al, 2022).

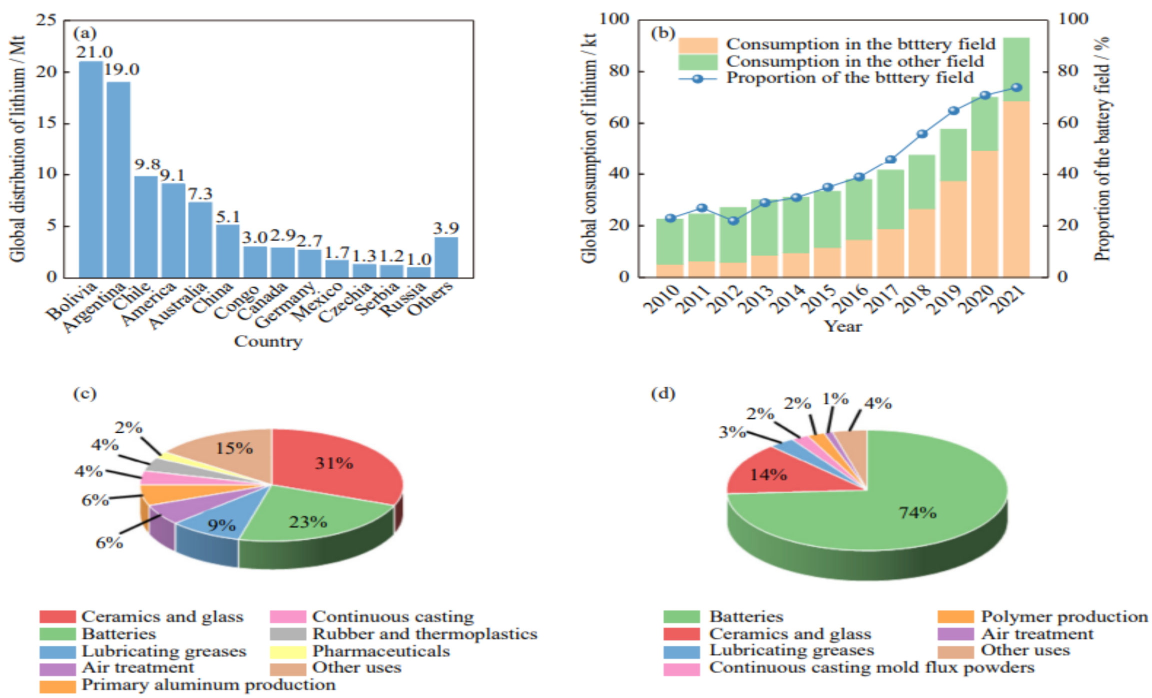
2.2 Rare Minerals used in Manufacturing, and Human Right Issues:

Traditionally, lithium has been utilized as an industrial ingredient in the manufacture of lubricating greases, glassware, ceramics, and other products. In the past, these uses accounted for 40%–50% of the world's lithium consumption (USGS, 2014). Beginning approximately ten years ago, the market expansion of consumer electronics—which have a high need for lithium-ion batteries—led to a significant increase in lithium consumption. From 23% in 2008 to 35% in 2014, lithium was increasingly employed in rechargeable batteries (USGS, 2016). In recent years, lithium has seen widespread use in cutting-edge clean technologies, particularly as the cathode component of batteries for electric vehicles (EVs), (Sun et al, 2017). As a result, the world's consumption of lithium increased quickly (USGS, 2014). From 79 kt of lithium carbonate equivalent (LCE) in 2004 to 165 kt of LCE in 2014, there was an increase in the global consumption of lithium, which corresponds to an 8% annual growth rate. Batteries accounted for 35% of the lithium consumed in 2014, followed by ceramics and glasses (32%), lubricating greases (9%), and other uses (24%).

There is growing worry about the security and effectiveness of the usage of lithium resources globally due to the rapid growth of lithium demand, (Sun et al, 2017). In this situation, extensive research has been done to learn more about lithium's flow properties. Three broad categories can be used to categorize existing studies. First, follow the flow of lithium throughout every stage of its life cycle, including resource extraction, chemical synthesis, product manufacturing, product consumption, and waste management. These studies were carried out either at the international or national level, (Sun et al, 2017). A global model of lithium flow that includes production, manufacturing, and use for the year 2007 was created by Ziemann et al. (2012). The findings indicated that there was an imbalance between lithium production and consumption of 4130 tons. Lithium flow for China, the world's largest user of lithium, was examined by Hao et al. (2017) in 2015. Their research showed that the expansion of the EV market would result in China importing more lithium, raising concerns about the security of the supply. Examining the supply and demand for lithium is the second step. The lithium recycling rate must be at least 90% to achieve the supply-demand balance, according to Zeng and Li's (2013) analysis of China's lithium stocks and demand. This is due to the country's rapidly expanding lithium use.

When examining the lithium supply for EVs in the EU, Miedema and Moll (2013) projected that it will exceed 0.5 Mt by 2050. Third, monitoring the flow of energy and materials for lithium items that are nearing the end of their useful lives. A total of 2.8 kt of lithium-ion batteries (LIBs) with a recycle value of $39 million were stockpiled in Taiwan in 2006, according to Chang et al. 's (2009) analysis of Taiwan's LIB flow. In their study of the environmental effects of EVs with lithium batteries, Mellino et al. (2016) discovered that EVs generally had better environmental effects than cars with internal combustion engines. Only 42% of the metal materials in EV LIB waste can be recycled in the United States, according to Richa et al.'s (2014) study on EV LIB waste flows.

Fig.1. (a) Global distribution of lithium in 2021. (b) Global consumption of lithium and proportion of the battery field in 2010–2021. Proportion of lithium consumption in various fields in (c) 2010 and (d) 2021.



Source: Yubo Liu, 2023. p. 210.

The increasing need for cobalt extraction, a critical element in lithium-ion batteries, is propelled by the expanding worldwide demand for portable electronic devices and rechargeable batteries. The Democratic Republic of Congo (DRC) is a significant supplier, contributing over half of the global cobalt supply. Approximately 20% of the cobalt presently obtained is sourced from the DRC. In this area, there exists a community of artisanal miners, often referred to as "creuseurs," numbering between 110,000 to 150,000 individuals. These miners, using basic tools, manually extract rocks from underground tunnels. Shockingly, even children as young as seven years old engage in this labor, searching for cobalt-rich rocks within the discarded materials of industrial mines, performing tasks such as washing and sorting the ore prior to its sale.

In the artisanal mining regions of southern DRC, Amnesty International and Afrewatch conducted research in April and May 2015, during which they visited five mining sites and conducted interviews with approximately 90 individuals, including 17 children, who were either currently working in the mines or had worked there in the past. Prolonged exposure to cobalt-containing dust can lead to a potentially fatal lung condition known as "hard metal lung disease." Additionally, continuous skin contact with cobalt can result in dermatitis, while inhaling cobalt particles may lead to "respiratory hypersensitivity, asthma, shortness of breath, and impaired pulmonary function." Shockingly, despite their daily prolonged exposure to cobalt, most miners lack even the most basic safety equipment, such as gloves, protective clothing, or face masks. Notably, the DRC Mining Law of 2002 and the Regulations of 2003 provide no guidance to artisanal miners regarding protective gear or the handling of potentially harmful substances. Many miners reported frequent coughing and respiratory problems, while female miners who carried heavy loads and faced the physically demanding nature of their work also experienced respiratory issues and bodily discomfort. One woman, for example, stated, "We all struggle with lung problems and discomfort throughout our bodies due to carrying 50-kilogram sacks of cobalt ore."

In 2014, UNICEF estimated that approximately 40,000 boys and girls were engaged in labor within the mines of southern DRC, with many of them involved in the extraction of cobalt. The inquiries made by researchers shed light on the physically demanding nature of their work. These young workers reported carrying heavy loads for up to 12 hours each day in the mines, earning a meager income of one to two dollars daily. Even children attending school were required to toil for extended hours during weekends, school breaks, and both mornings and afternoons. Those who were not enrolled in school spent the entire year laboring in the mines. For instance, Paul, who is now 14 years old, started working in underground tunnel mining at the age of 12. He candidly shared with the researchers that he often "spent 24 hours down in the tunnels, arriving early and leaving the next day." Globally, it is widely recognized as one of the most egregious forms of child labor, which governments are expected to prohibit and eliminate, when children are employed in the mining sector. The research findings underscore the perilous nature of artisanal cobalt mining undertaken by children in the DRC, which poses significant risks to their health and overall well-being.

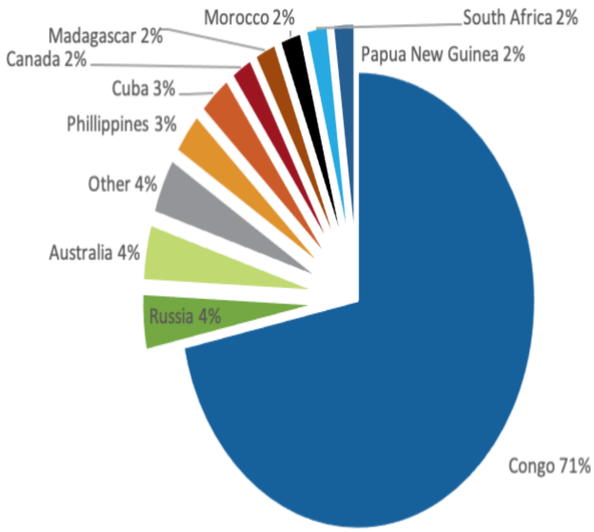
Researchers meticulously tracked the transportation of cobalt ore from artisanal mines in Kolwezi to a marketplace known as "Musompo," where minerals are exchanged, involving miners and traders in the process. Irrespective of its source or mining method, independent traders in Musompo, predominantly of Chinese origin, purchase the ore. Subsequently, these traders distribute the ore to larger enterprises within the DRC, which then undertake the refinement and exportation process. One prominent player in this endeavor is Congo Dongfang Mining International (CDM). Huayou Cobalt, a major global cobalt product producer headquartered in China, owns a fully owned subsidiary of CDM. CDM has been conducting operations in the DRC since 2006, procuring cobalt from dealers who directly acquire it from miners. The ore is then subjected to smelting at CDM's facility in the DRC before being dispatched to China. There, Huayou Cobalt further refines the cobalt and sells it to companies engaged in battery component production in China and South Korea. These companies, in turn, supply battery producers, who ultimately cater to well-recognized consumer brands (Democratic Republic of Congo: “This is what we die for”, 2016).

The demand for cobalt has increased threefold over the past ten years, and the Democratic Republic of the Congo is the world's top producer of the metal. Half of the world's primary cobalt production in 2010 was made possible by cobalt from the Katanga Province. 60 to 90 percent of this cobalt came from artisanal mining over the past ten years. Applications for refined cobalt include metallurgical superalloys and burgeoning chemical uses like batteries for electronic devices and electric vehicles. Tens of thousands of artisanal miners began utilizing heterogenite, a cobalt mineral, in the province of Katanga during a decade of wars and political unrest when industrial output had failed. They supplied the state-owned GECAMINES' (Generale des Carrières et des Mines) smelting plants as well as foreign dealers (mostly Chinese). In the comparatively calm South-East of the country, locals and migrants from other provinces were able to make a living by digging despite the extremely subpar working conditions.

However, the DRC's transitional government started a privatization process of the vast copper, cobalt, and other mineral reserves owned by the GECAMINES in 2002 because it needed to secure financing from multilateral and bilateral donors. To draw in investors, a new mining code was published. Due to foreign investors' desire to protect their assets and their reluctance to be held accountable for artisanal activities carried out under unfavorable working conditions, large tracts of land that artisanal miners could previously exploit were closed to them after the establishment of major mining companies. In addition to violent protests, forced evictions also stoked resentment among local officials, who are well known for disliking mining villages due to their "immoral" reputation. The state, some private companies, and civil society have been working together over the past few years to address the social issues brought on by artisanal mining, but these efforts have only been partially successful due to the threat that 100,000 dissatisfied miners pose to political stability and the pressure of international public opinion. The D.R. Congo will continue to be a crucial supplier of raw cobalt ore even if it now lacks the capacity to process the majority of its output.

When it comes to their working environment, miners are particularly vulnerable to the risk of landslides during the rainy season. Although security measures differ significantly from site to site, annual fatality rates approaching 0.4 to 0.5% of the workforce have been documented in some mines. With contaminated food and drink as well as dust inhalation, miners are exposed to heavy metals. High levels of uranium are present in the mines between Shinkolobwe and Kolwezi. There, miners might receive up to 24 mSv of radiation annually. Furthermore, due to promiscuity, prostitution, and the presence of former soldiers, the unsanitary circumstances in the miner camps encourage epidemics and a higher prevalence of HIV. It is estimated that artisanal miners often work 13 to 20 hours per week, or 35 to 52% more overtime than workers in the formal private sector.

Despite the difficult working conditions and widespread use of children as laborers, no evidence of systematic or explicit forced labor was discovered. It is estimated that between 19,000 and 30,000 children under the age of 15 and 9,000 to 15,000 children between the ages of 15 and 17 work in artisanal cobalt mines. The majority of younger kids perform simple activities like washing and sorting ore. Male teenagers begin working in mines at 15 or 16. Little children, meanwhile, are reportedly also sent to dig in dangerous, constrained spaces because they have better access than adults. Women are frequently prohibited from working in the mining pit, which is the more lucrative occupation, therefore they are instead given the task of sorting and washing the ore. Inequalities may also be caused by latent ethnic sentiments toward migrants from neighboring regions, particularly during bad times economically, (Tsurukawa et al, 2011).



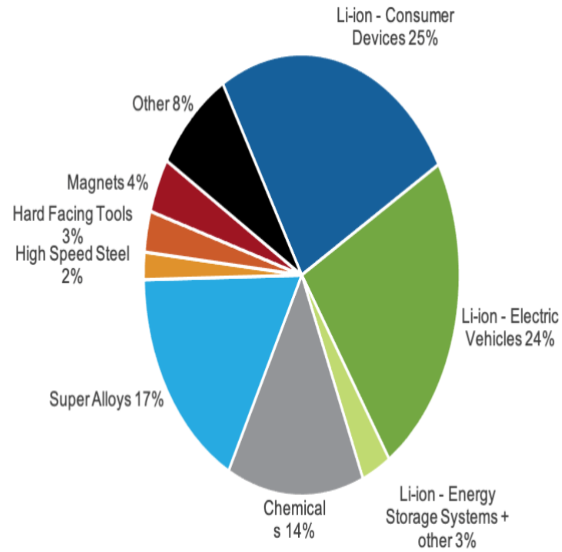


Fig: 2. Global Cobalt Production (2019 Estimates).
Source: USGS

Fig: 3 Cobalt Demand 2021.
Source: Cobalt Institute

The functioning of critical infrastructure in the United States heavily relies on information and communications technology (ICT). The ICT supply chain encompasses a broad spectrum of entities, including third-party vendors, suppliers, service providers, and end users. This supply chain encompasses various components, ranging from cell phones and cloud storage to satellite communication. However, the globally distributed and interconnected nature of ICT also means that any breach or vulnerability in the supply chain can trigger ripple effects throughout other essential infrastructure sectors. The threat to supply chains is further compounded by adversaries seeking to exploit ICT technologies and their associated supply chains for purposes such as espionage, sabotage, and foreign interference. These vulnerabilities within supply chains, whether stemming from inadvertent lapses in security protocols or deliberate malicious actions, pose serious risks. They can result in data and intellectual property theft, erosion of trust in the integrity of the system, or exploitation leading to system or network failures. As a primary avenue of attack, these vulnerabilities are increasingly being targeted by adversaries, notably nations like Russia, China, North Korea, and Iran, (ICT supply chain, 2021).

Vulnerabilities may be introduced at any stage of the ICT life cycle, including design, development, production, distribution, procurement, deployment, maintenance, and disposal, which increases the risk associated with supply chains. These flaws include harmful software and hardware, fake parts, and subpar construction. methods for maintenance, manufacturing, and product designs. Collaboration between the public and private sectors aids in the comprehension of these weaknesses and the sharing of knowledge for creating solutions to the risk associated with the global supply chain, (US DHS Cybersecurity & Infrastructure Security Agency). Supply chain attacks have long been a security risk, but it appears that since 2020, there have been more frequent and well-organized operations. It's possible that attackers have turned their attention to suppliers as a result of the stronger security measures that organizations have implemented. This has allowed them to have a big negative influence on systems downtime, financial losses, and reputational harm, to name just a few. With the SolarWinds attack, the destructive and cascading effects of supply chain attacks were clearly visible. The SolarWinds hack is regarded as one of the biggest supply chain attacks in recent memory, especially when you consider the scope of the targeted entities, which included governmental agencies and significant enterprises. It attracted a lot of media attention and sparked global policy measures. The Kaseya4 assault, which appeared more recently in July 2021, highlighted the necessity for further and focused attention to supply chain attacks affecting managed service providers. Unfortunately, these two instances are not unique, and over the past year, there have been a growing number of supply chain attacks. The necessity for policymakers and the security community to develop and implement unique preventative measures to deal with potential supply chain attacks in the future and to lessen their impact is further highlighted by this trend, (Jessica 2021).

Attackers choose to target a company's supply chain due to the cost of direct attacks on well-defended businesses, as well as the possibility for a significant and international impact. Due to this shift, there have been more supply chain assault cases reported than typical. According to predictions, there will be four times as many supply chain attacks in 2021 as there were in 2020. Current supply networks are inherently global, which amplifies the potential impact of these strikes and widens the attack window for bad actors. This paper discusses a number of documented supply chain attacks, although there may actually be more that go unreported, uninvestigated, or are attributed to other factors. Supply chain attacks, particularly in the software industry, erode public confidence in the software ecosystem. The incidents mentioned emphasize how dangerous actors could infiltrate the software supply chain as early as the development phase. For the supply chain to be designed-insecure, new strategies must be created. New programs like Google SLSA and MITRE D3FEND seem to be making progress in this area. The analysis reveals that there are still a lot of unidentified variables in the instances under investigation. Attack methods used against suppliers still remain unknown in 66% of cases. The trust in the supply chain is seriously threatened by an absence of openness or the capacity for investigation. The first step to enhancing supply chain security and safeguarding ultimate customers is to improve the process of accountability and transparency.

Attacks on the supply chain can be complicated, involve careful planning, and can take months or years to complete. Although APT groups or other well-known attackers are responsible for more than 50% of these attacks, suppliers may become a desirable target in the future due to supply chain attacks due to their effectiveness. Therefore, it is essential that businesses concentrate on supplier security as well as internal security. Recent assaults have highlighted the heightened necessity for cybersecurity safeguards in these industries, especially for cloud service providers and managed service providers, which are the focus of this statement. Attacks on suppliers could have a significant impact due to the rising interdependencies and complexity. This raises concerns for national security or possible geopolitical repercussions in addition to the enormous number of parties affected. This is especially true when sensitive information is leaked, (ENISA, Threat Landscape for Supply Chain Attacks, 2021).

2.2.1 Cobalt:

Because of its ferromagnetism, hardness, and wear resistance when alloyed with other metals, high melting point, multiple valences, low thermal and electrical conductivity, and ability to produce intense blue colors when combined with silica, cobalt is a silvery gray metal with a variety of applications. Cobalt is primarily employed in superalloys for turbine engines in jet aircraft and as cathodes in rechargeable batteries. Around 75,000 metric tons of cobalt were consumed annually globally in 2011, with China, Japan, and the United States being the top three consumers (in terms of quantity consumed).

In 2011, cobalt, copper, nickel, platinum group element (PGE), and zinc operations generated around 109,000 metric tons of recoverable cobalt in ores, concentrates, and intermediate products. The majority (55%) of the world's mined cobalt came from the Democratic Republic of the Congo (Congo, Kinshasa). No cobalt was produced in the United States from mines where cobalt was the main commodity; instead, a tiny amount of byproduct cobalt was generated as an intermediary product from a PGE mining and refining operation in southeast Montana. China was the world's largest cobalt refiner, and a large portion of its cobalt ore, concentrates, and raw materials were imported from Congo (Kinshasa), (Slack et al, 2017).

2.2.2 Lithium:

Since lithium is the primary component of the lithium-ion batteries that will power the next generation of electric cars, it is currently receiving a lot of attention and could in this century be worth as much as gold in terms of value. Lithium has been known for almost two centuries, (Divya et al, 2009). It is also not equally distributed throughout the Earth's crust, which has led to speculation that the Andean South American nations may eventually become the "new Middle East." These elements combine, creating a contentious discussion regarding the available reserves, (Tahil, W., 2007). As well as the expected demands, (Divya et al, 2009): if all automobiles are to be electric over the next 50 years, there are growing concerns about a lithium resource shortage, which might lead to a spectacular price increase similar to what we already experience with fossil fuels. Due to their advantages over alternative battery technologies in terms of energy density, primary lithium and lithium-ion batteries have been the preferred power source in many consumer, industrial, and military applications since the 1990s. Significant research has gone into creating chemistries that are intrinsically safer as well as more efficient heat management and protection systems, (Balakrishnan et al., 2006; Hassoun et al., 2009).

2.2.3 Copper:

Copper's exceptional electrical conductivity makes it a preferred material for wires and cables in IT infrastructure. Its low resistance ensures minimal signal loss, making it indispensable for networking, data centers, and telecommunications (Smith, 2007). Copper interconnects have played a vital role in semiconductor technology. Copper replaced aluminum as the material of choice for interconnecting transistors on integrated circuits, resulting in improved performance and reduced power consumption (Rabaey et al., 2001). Copper mining and production have environmental impacts, prompting efforts to minimize its use in favor of more sustainable alternatives. Recycling copper is gaining traction to reduce its environmental footprint in IT and other industries (Norgate et al., 2017).

2.3 COVID-19 Pandemic, and Globalization:

The COVID-19 pandemic's effects and the ensuing global shortages of essential ICT components have brought to light the flaws in lengthy, internationally concentrated supply chains as well as the effects of their disruption, (U.S. Department of Commerce & U.S. Dept. 2022). These elements have caused supply and demand imbalances that have a negative influence on a number of items that are part of the ICT industrial base or supporting supply chains. A few of these are semiconductors and related parts, (U.S. Department of Commerce & U.S. Dept. 2022).

Electronic communications networks are made up of a variety of network components, many of which are supplied by both new and seasoned equipment manufacturers. In order to enhance their market share by taking advantage of the trend toward convergence in the services given to end-users of ICT devices, network operators have been installing several network technologies in support of different services during the last few years. Due to this tendency, single network operators now have to manage and coordinate a variety of network technologies, some of whose interfaces may not always be based on standardized standards but rather on incompatible software and hardware architectures that are provided by various equipment vendors. Global supply chains exist today. The ICT markets' global reach complicates supply chain organization and emphasizes the value of upholding its integrity. The importance of standardization in helping a community affected by a technology decide how to interact with it cannot be overstated: Standardization may lessen the likelihood that an operator will need to act as a go-between, hence reducing some vulnerabilities. The market is available to new entrants from a wider geographic range when the standards are open and clearly defined, and this could make SC management more challenging.

The utilization of equipment from various vendors (also known as the "multiple vendor strategy") is a typical business model adopted by network operators when outsourcing the deployment, operation, and administration of network(s). This lowers the risk of having one vendor control all aspects of the network while allowing network operators to profit from the competition among equipment providers. The complexity of determining the supply chain's integrity is raised by these market decisions, though. If best practices are not followed and controls are lax, it may also increase the chance of undiscovered vulnerabilities being introduced into the supply chain, but this is true for all forms and components of a supply chain. The onus (or "overhead") for fault isolation, detection, and repair could fall on the network operator in the event that the controls fail. To safeguard their operations, modern network operators have established procedures, guidelines, and standards, (ENISA Supply Chain Integrity, 2015).

Technology is used extensively in developed countries for a wide range of businesses, including communications, entertainment, safety, health care, transportation, and national security. Consumers don't inquire about the origins of the technology used in computers, phones, televisions, or other products since it is so ordinary. Many people around the world are unaware that these devices are made up of multiple components, many of which come from other countries. Devices are susceptible to malware and fake software or hardware when the ICT supplier's identity is unknown, and the acquisition company runs the risk of relying on a dishonest or unqualified service provider. Although the idea of supply chains is not new, the technological boom of the 20th century brought with it a new set of challenges, particularly for the ICT supply chains and the technology businesses that make up these supply chains. Most Technology firms work on a worldwide scale, where development, manufacture, and production are not limited by boundaries or geographical areas. This global ICT supply chain footprint, however, creates new risks for the ICT supply chain. For example, malicious code could be added to ICT software, ICT hardware and firmware could be changed, and ICT networks could be subjected to DoS attacks that would render the entire ICT infrastructure inoperable.

Securing an ICT supply chain may be very challenging and time-consuming. Since computer chips are present in practically all technological equipment, examining the supply chain for a computer chip and the challenges associated with safeguarding it makes for a great supply chain risk case study. Global outsourcing also multiplies the number of workers participating in the chip-making process. In the semiconductor design and production process, outsourcing to third parties is crucial and increases the danger of malware infiltration. The possibility that the ICT product may be threatened while being transported to the customer is enhanced by the use of unsecure supply chain transportation and storage systems. Devices are exposed to the risk of having malware-containing hardware or software installed as well as counterfeit hardware or software installed because of the usage of insecure delivery and storage technologies. The small structure of a chip makes it more challenging to protect it against virus insertion since it makes it more difficult to spot any changes made to the semiconductor throughout the design and production processes, (National CounterIntelligence and Security Center, April, 2022). For instance, the Federal Bureau of Investigation filed a ten-count indictment describing how a

Chinese manufacturer of telecommunications devices broke many confidentiality and non-disclosure agreements with a partner U.S. corporation by stealing trade secrets while the products were being manufactured. Particularly, the Chinese manufacturer discreetly photographed and measured parts while they were being manufactured, and in one case, stole bits of the property so that Chinese engineers could try to copy it, (Department of Justice, 2019).

No government wants to rely on goods and services that can be polluted by an enemy in a world of different and competing economic, political, and military interests. The globalization of the international ICT industry and a greater understanding of the cyber risk environment can be linked to the government's assessment of rising supply chain risk. Manufacturing of ICT gear is mainly outsourced abroad and concentrated in Asia, especially China. Because of this outsourcing, the supply chain for ICT products is overly dependent on China for the production of the hardware needed. In particular, the outsourcing of the hardware increases the likelihood that foreign adversaries may have the chance to introduce phony and/or unreliable components into the system during the production cycle. There is no control of this hardware production process by American agencies. Furthermore, supply chain interruptions from state-sponsored malicious interference might happen when an ICT supply chain is geographically concentrated in a certain nation, like China.

A number of CI hazards are caused by structural weaknesses in ICT supply chains, including the overreliance on single-source and single-region suppliers and the absence of an internal ecosystem for many ICT production segments. The absence of a U.S. ICT production ecosystem allows Asian nations, especially China, to develop their own manufacturing skills and related ICT infrastructure, posing multiple CI supply chain threats. Single-source regions and providers introduce points of failure that can result in the operation as a whole ceasing to function. The United States is overexposed to a number of dangers from the outside world because of the current ICT supply chain, which must be closely monitored to prevent catastrophic disruptions. Particularly, insider threats to the ICT supply chain, software supply chain compromises from cyberattacks, overworked third-party suppliers with insufficient security measures exposing confidential information to malicious actors, and state-sponsored cyber-attacks from nations opposed to America's interests resulting in intellectual property theft or supply chain disruptions, (National Supply Chain Integrity Month, 2022).

An effective supply chain management (SCM) strategy must guarantee a flexible, uninterrupted flow of goods and materials at all stages while keeping costs to a minimum. The organizations operate with a high risk of disruption in environments that are becoming more dynamic as a result of unforeseen and unplanned occurrences like natural disasters, fluctuations in demand, and changes in governmental policy. These occurrences always have an impact on SCs and pose a risk to their continuity, objectives, and profitability. As a result, COVID-19 is a novel kind of environmental disruption that has an effect on the present business environment. It generates a number of risk factors, including supply disruption, material shortages, ambiguous demand, production shutdowns, and lengthened lead times (Dolgui et al., 2018, Ivanov et al., 2014, Rangel et al., 2015). Companies must therefore be ready to continuously and effectively monitor and lower these hazards. Identification, effective assessment, proactive management, and continual monitoring of the advancement of these risks have all received considerable attention. The COVID-19 outbreak highlights the necessity to alter the current SC in order to increase its flexibility, resilience, and robustness against interruptions in this dynamic environment (Dolgui & Ivanov, 2021; Ivanov & Das, 2020).

A pipeline of material and information flows between suppliers and customers can be used to analogize the supply chain notion. From an operational point of view, this pipeline works like a process of activities that are distributed. Therefore, supply chain is not only a linear structure but truly a network (Bhaskar and Lallement 2008). The nature of supply chain networks is that they are a complex network structure made up of suppliers, manufacturers, warehouses, and retailers organized to produce and distribute goods in the correct quantities, to the correct locations, and at the right times in order to reduce total costs while meeting service level requirements, (Simchi-levi et al, 2003). Efficiency is the primary goal that researchers and practitioners in SC network management take into account as a traditional goal. In order to efficiently provide a variety of products and offer value to customers and other stakeholders, modern SC network management can be characterized as the integration of important business activities from end users through original suppliers, (Lambert et al., 1998; Wu and Chuang, 2009). Brand vs brand competition in the global market has given way to SC versus SC competition. Many businesses spent a lot of money on efficient SC network management. Unfortunately, few of them are successful due to the challenging nature and frequently broad scope of SC network management system implementation, (Wu and Chuang, 2009; Tarokh and Soroor, 2006). Such a strategic level system failure is quite expensive and may result in business failure. According to Lambert et al. (1998) and Wu and Chuang (2009), SC network management is the integration of important business activities; as a result, a SC network management system can only be successful if it supports all necessary business operations (Karim et al., 2007). The SCM system's key challenge is to increase performance while cutting expenses (generally in terms of trade-offs). The gap between the order cycle (i.e., the time it takes to complete an order) and the logistical lead-time is a crucial indicator of the SCM system's responsiveness, one of its performance characteristics (including procurement, manufacturing, delivery, etc.). This gap is brought about by ineffective supply management, bottleneck operations, setup times, and interface activity (inventory, transit). Several approaches have been developed and the SCM system has been compared to them, including centralization and decentralization of inventories, focused and distributed factories, outsourcing, partnerships, etc. Yet, they are frequently not justified by taking into consideration the global costs and performance because they are implemented and evaluated for immediate profit.

The SC has become increasingly globalized over the past few years, with few distribution locations and offshore manufacturing/sourcing, meaning that it now spans the entire planet. The finished products are consolidated in a worldwide warehouse for distribution after being built in other nations using components that were purchased from one or two other nations. Lower production costs typically provide as justification for these strategic choices, but the performance outcomes are more susceptible to extended lead times due to transportation needs (inventory activities at least), (Bhaskar and Lallement, 2008).

Although the cybersecurity industry has mainly concentrated on software and network security, supply chain threats and vulnerabilities to hardware devices are becoming bigger concerns. The way that semiconductors and other electronic devices are being used more frequently to support energy distribution, storage, and management at various scales is particularly significant and intriguing in this context. To prevent cyber attacks from affecting energy infrastructure and the societal and economic functions on which they rely, future smart grid supply chains must be secured, (Lambert et al, 2013). “America must also face the rapidly growing threat from cyber-attacks. We know hackers steal people’s identities and infiltrate private email. We know foreign countries and companies swipe our corporate secrets. Now our enemies are also seeking the ability to sabotage our power grid, our financial institutions, and our air traffic control systems.”, (President Barack Obama, State of the Union Address, February 12, 2013).

In recent years, both government and commercial electronic supply lines have frequently been compromised, frequently as a result of fake parts. As many previously used electronics parts are rebranded, repaired, or repackaged and marketed as brand new, counterfeit parts are produced in large quantities as a result of the recycling of electronic waste in foreign nations, (Sood et al. 2011). The effects of this phenomenon are extensive, affecting everything from economics and technological component reliability to energy security. The Department of Defense (DoD) supply chain has seen an increase in counterfeit parts, with 9,356 such instances reported in 2008, according to a recent U.S. Armed Services Committee inquiry, (Defense Industry Daily 2011). According to the Semiconductor Industry Association (SIA), counterfeit semiconductor sales cost the industry $7.5 billion a year and 11,000 jobs, respectively, (Committee on Armed Services, US Senate 2011). To address the issue of counterfeit semiconductors, the SIA (Semiconductor Industry Association) created the AntiCounterfeiting Task Force (ACTF) in 2006. Also impacted by supply chain security issues are rising economies. For instance, worries about intellectual property have effectively deterred major semiconductor makers from locating their advanced front-end production in China, (Yinug 2009). A large portion of China's semiconductor sector is still dependent on lower-value, back-end operations like testing, assembly, and packaging, despite efforts to realign its policies and incentives to draw foreign investment in the high-value, front-end semiconductor wafer design and manufacture.

CHAPTER 3: METHODOLOGY:

3.1 Research Approach:

A study known as inductive research develops theory by observing empirical reality. Because of this, general conclusions are inferred from particular examples, which is the opposite of the deductive method. shifting from the particular to the general is referred to as such because it entails shifting from isolated observations to assertions of generalized patterns or laws (Collis and Hussey, 2021).

In this study, an inductive methodology will be employed, because the goal of the study is to establish a theory by analyzing empirical data (the analysis of research done under the topic/existing literature). With an inductive approach, you can incorporate new data as it becomes available and the researchers can continue to collect new data until the saturation point is reached. The study will use explanatory research. Understanding the relationship between a phenomenon's cause and effect is the aim of an explanatory study. It explains in detail how cause and effect relate to the phenomenon (Saunders, et al., 2016). Based on the study design and methodology, explanatory research will be used to gain more understanding of the subject at hand.

3.2 Literature selection:

The Ca’ Foscari University library system, SBA (Sistema Bibliotecario di Ateneo) was used to find quality articles to be used for literature review. Google scholar was also used to find quality and relevant articles using keyword search of different combinations such as; “IT manufacturing”, “supply chain”, “sustainability”, “risks”, “IT hardware manufacturing”, “supply chain risk management”, and a database of at least 50 relevant articles was created.

A more targeted search based on some specific keywords that emerged from the search was used to find more relevant articles. For example, specific rare minerals that are used in manufacturing of batteries and semiconductors such as, “lithium” and “copper”. Non-academic literature review was also conducted using the same keyword search on Google using only reliable sources of newspaper articles and industry reports that cover the same topic. When choosing an article, the following elements were considered: keywords/title relevance, recency, number of citations ("cited by"), thematic fit of a journal where it was published. The goal of the literature review was to understand which risks exist in IT hardware manufacturers supply chains, using reliable sources of knowledge.

3.3 Research Method:

As previously mentioned, the goal of the study is to establish a theory by analyzing empirical data, as a result an inductive research methodology is used to investigate the correlation between financial and ESG performance on the publicly traded information technology hardware manufacturing companies, and also educate on their supply chain risk. According to Kuper (2008), "qualitative data analysis is largely inductive, allowing meaning to emerge from the data, rather than the more deductive, hypothesis-centered approach preferred by quantitative researchers." Thus, since generalizability is not the main objective of qualitative research, researchers should be mindful of this limitation while employing this study approach. As a result, a qualitative approach is more suitable for inductive research. Due to the research topic and goal, non-numerical data is highly appropriate for the research, where information will be gathered using quality/verifiable data to gain more understanding of the research topic, and as a result improve the knowledge base of the research area.

3.4 Data Collection:

The fifteen (15) companies were chosen on the Nasdaq website, the data was sorted as the ones with market capitalization in the mega (>$200B) and large ($10B - $200B) category, belonging to the technology or telecommunications sector, and manufacturing IT hardware. Data collection, according to (Kabir, 2016), is the method of systematically obtaining and measuring information on variables of interest in order to address research questions, test hypotheses, or assess results. We can better fulfill the purpose of the research and find an answer to the research question by gathering the necessary data.

In order to achieve the research goal, primary data was gathered through the security & exchange commission (SEC) website, the 10K report of the individual companies, and specific reports (such as the sustainability, environment social and governance, corporate social responsibility, supplier responsibility, conflict mineral reports) pertinent to the study were collected on the companies websites. The topic and objectives of the research necessitate the collection and analysis of primary data. The information acquired assisted in responding to the research question.

3.5 Analysis Guide:

A total of fifteen (15) IT hardware manufacturing companies were selected from the Nasdaq website. An Excel template was created for data entry, and the pivot table was used to sort and analyze the data. Keywords related to key issues in the IT hardware manufacturers supply chain that have emerged from the literature review such as “cobalt”, “lithium”, “e-waste”, “water”, “emissions”, “copper”, “tantalum”, “nickel”, and “silicon”, were used as a base for the data analysis, and arranged under columns in the excel template. Several reports of each of the companies, such as the sustainability report, corporate social responsibility report, conflict mineral report, supplier responsibility report, were analyzed. For each report a keyword search was made (involving all keywords, one at a time), and for each mention of a keyword the following steps were carried out:

1. For the first sentence that mentions a keyword, the sentences preceding and following the sentence were read to understand the context.

2. The details were recorded in the excel file, starting with the year, company name, type of report, and “1” was entered in the column corresponding to the exact keyword. Each row in the excel file corresponds to each sentence which uses a keyword.

3. The tone of the sentence was analyzed as:
Positive - “we have taken active steps to prevent human rights violations in the areas of cobalt supply”
Neutral - “cobalt is an important material in our production”
Negative - “human rights violations continue to be an issue in the areas of cobalt supply”

4. The time orientation of the sentence was analyzed as:
Past “we have taken active steps…”
Present “we are taking active steps…”
Future “we are going to/planning to take active steps..”

5. If numeric information/goal is provided in the sentence (e.g, “increase pay to workers by 30%”), “1” was recorded to indicate a yes, and “0” for no.

6. If the time horizon is provided in the sentence, (e.g, “by the end of 2030 improve working conditions….”), “1” was recorded to indicate a yes, and “0” for no.

7. If active or passive voice have been used:
Active “We take action to prevent human rights violations”
Passive “Actions are being taken to prevent human rights violations”, “1” was recorded to indicate active, and “0” for passive.

CHAPTER 4: DATA ANALYSIS AND DISCUSSION

4.1 Data Analysis:

The Security and Exchange Commission (SEC) website was used to access the 10K reports filled by each of the companies. The specific reports were gathered from the companies own websites. An excel template was used for the data entry of the individual reports (CSR, ESG, sustainability, 10K) of all the fifteen (15) companies, and the pivot table was used to sort and analyze the data. Keywords related to key issues that have emerged from the literature review, were searched for, in all the reports of the companies. For each keyword that is mentioned in a report, sentences preceding and after the keyword were read to understand the context of the sentence, and the category it belongs to in the columns of the excel template. The output of the pivot table was used in the interpretation of the results.

4.2 Results:

Cobalt:

- Among all the fifteen companies, Cobalt was mentioned twenty one (21) times in the analysis of the combined reports of the companies. Concerning the tone of the sentences, 16 (76.19%) of those mentions were positive, 5 (23.81%) were neutral. Cobalt got more attention compared to Lithium, and most of the time, it was mentioned in a positive form, which indicated companies efforts to address the sustainability concerns positively. Examples of positive indications from Alphabet are: “In 2019, we joined the Cobalt for Development project, a multi-sector public-private initiative that seeks to promote responsible mining practices and improve conditions at artisanal cobalt mining sites in a southern province of the DRC.” “We are committed to zero child labor everywhere in our supply chain, including in mining. In addition to focusing on tin, tantalum, tungsten, and gold, we are working with peer companies and partners to help ensure zero child labor in cobalt mining and to strengthen cobalt tracing.” And from Apple: “In 2021, all identified cobalt and lithium refiners — key materials used to make batteries for all Apple products — participated in OECD-aligned independent, third-party audits covering labor, human rights, and environmental policies, as well as management systems.” An example of a neutral tone regarding cobalt from Micron Technology: “Because Micron does not produce batteries, we do not use significant amounts of cobalt.”

- In all 21 cases cobalt was mentioned, indicating numeric information or a goal, 16 was in a positive manner, and 5 was in a neutral tone (table under the appendix). An example was a statement from NVIDIA Corp.: “The cobalt program through the RMI is still new and the majority of cobalt refiners in the world have yet to be identified and audited. As the program matures, our goal is to only source from conflict-free cobalt refiners.”. Another one from Intel Corporation: “Intel’s strategy is to maintain the positive progress we’ve made to date on 3TG (tantalum, tin, tungsten, and gold) and cobalt, and to proactively address emerging risks from the expanding scope of materials and geographies.”.

- The entire 21 indications of cobalt, depicting the times it was mentioned in a sentence, have an active voice, 16 in a positive way (76.19%), and 5 in a neutral form (23.81%) (table under the appendix). Example of an active voice indication from Alphabet reads: “In 2020, we funded new research with RMI to investigate the challenges surrounding cobalt and how upstream and downstream parties can work together.” And from Apple: “This marks seven consecutive years of 100 percent compliance for 3TG, six consecutive years for cobalt, and two consecutive years for lithium.”

- The 12 times Cobalt was mentioned indicates that they are working on issues surrounding it currently; 9 indicates in a positive way, and 3 indicates a neutral manner. They dealt with the issue of cobalt in the past 9 times; 7 times in a positive way, and 2 times in a neutral tone (table under the appendix). Most of the positive initiatives the organizations are putting in place are expected to continue for their future operations. An example from Advanced Micro Devices Inc. showed a current undertaking: “Our program will remain focused on mitigating social and environmental risks associated with the raw materials supply chain of AMD products. We have expanded our program beyond 3TG and cobalt, and we continue to identify opportunities to work proactively to map our supply chain and prioritize risk mitigation actions.”.

Fig.4 Cobalt tone and percentages.

Sum of Cobalt	Column Labels			
Row Labels	negative	neutral	positive	Grand Total
Advanced Micro Devices Inc		1	0	1
Alphabet/Google		0	3	3
Apple		0	3	3
Applied Materials Inc		0	1	1
Broadcom Inc		0	0	0
Cisco Systems, Inc		1	0	1
HP Inc.		0	1	1
Intel Corporation		0	2	2
International Business Machines Corporation			1	1
Meta Platforms Inc			0	0
Micron Technology		1	1	2
Microsoft Corp		1	1	2
NVIDIA Corp	0	0	3	3
QUALCOMM Incorporated	0	0	0	0
Texas Instruments Incorporated		1	0	1
Grand Total	**0**	**5**	**16**	**21**

Sum of Cobalt	Column Labels			
Row Labels	negative	neutral	positive	Grand Total
Advanced Micro Devices Inc	0.00%	4.76%	0.00%	4.76%
Alphabet/Google	0.00%	0.00%	14.29%	14.29%
Apple	0.00%	0.00%	14.29%	14.29%
Applied Materials Inc	0.00%	0.00%	4.76%	4.76%
Broadcom Inc	0.00%	0.00%	0.00%	0.00%
Cisco Systems, Inc	0.00%	4.76%	0.00%	4.76%
HP Inc.	0.00%	0.00%	4.76%	4.76%
Intel Corporation	0.00%	0.00%	9.52%	9.52%
International Business Machines Corporation	0.00%	0.00%	4.76%	4.76%
Meta Platforms Inc	0.00%	0.00%	0.00%	0.00%
Micron Technology	0.00%	4.76%	4.76%	9.52%
Microsoft Corp	0.00%	4.76%	4.76%	9.52%
NVIDIA Corp	0.00%	0.00%	14.29%	14.29%
QUALCOMM Incorporated	0.00%	0.00%	0.00%	0.00%
Texas Instruments Incorporated	0.00%	4.76%	0.00%	4.76%
Grand Total	**0.00%**	**23.81%**	**76.19%**	**100.00%**

Lithium:

- Lithium was mentioned 5 times among the combined analysis of the companies, 4 of those mentions were positive (80%), and 1 was neutral (20%). The results from the data analysis of Lithium also showed organizations are undertaking positive initiatives to address concerns relating to the sustainable mining and usage of these elements. A positive indication from Apple’s ESG report reads: “100 percent of the identified tin, tungsten, tantalum, and gold (3TG), cobalt, and lithium smelters and refiners in our supply chain have participated in independent, third-party audits to assess and identify social, environmental, human rights, and governance risks."

- In all the cases lithium was mentioned depicted numeric information/goal, 4 were positive and 1 was neutral (table under the appendix). Another example from Apple showed: "This marks seven consecutive years of 100 percent compliance for 3TG, six consecutive years for cobalt, and two consecutive years for lithium."

- In all 5 cases lithium was mentioned in a sentence had an active voice, 4 was in a positive way (80%), and 1 was in a neutral manner (20%) (table under the appendix). An example from Microsoft's conflict mineral report indicated: "Microsoft also supported the development of an RMI toolkit that provides due diligence guidance for mineral supply chains beyond 3TG and cobalt. This guidance will help suppliers conduct due diligence on a broader range of critical minerals, aligning with Microsoft's expanded supply chain disclosure requirements for aluminum, copper, lithium, magnesium, and nickel."

- The 3 instances lithium was mentioned indicates that they are currently handling the issue, 2 in a positive way, and 1 in a neutral manner (table under the appendix). The 2 remaining mentions indicated that they are dealing with the issue in a positive way for the future operations.

Fig.5 Lithium tone and percentages.

Sum of Lithium	Column Labels			
Row Labels	negative	neutral	positive	Grand Total
Advanced Micro Devices Inc		0	0	0
Alphabet/Google		0	0	0
Apple		0	2	2
Applied Materials Inc		0	0	0
Broadcom Inc		0	0	0
Cisco Systems, Inc		0	0	0
HP Inc.		0	0	0
Intel Corporation		0	0	0
International Business Machines Corporation			0	0
Meta Platforms Inc			0	0
Micron Technology		0	0	0
Microsoft Corp		1	2	3
NVIDIA Corp	0	0	0	0
QUALCOMM Incorporated	0	0	0	0
Texas Instruments Incorporated		0	0	0
Grand Total	**0**	**1**	**4**	**5**

Sum of Lithium	Column Labels			
Row Labels	negative	neutral	positive	Grand Total
Advanced Micro Devices Inc	0.00%	0.00%	0.00%	0.00%
Alphabet/Google	0.00%	0.00%	0.00%	0.00%
Apple	0.00%	0.00%	40.00%	40.00%
Applied Materials Inc	0.00%	0.00%	0.00%	0.00%
Broadcom Inc	0.00%	0.00%	0.00%	0.00%
Cisco Systems, Inc	0.00%	0.00%	0.00%	0.00%
HP Inc.	0.00%	0.00%	0.00%	0.00%
Intel Corporation	0.00%	0.00%	0.00%	0.00%
International Business Machines Corporation	0.00%	0.00%	0.00%	0.00%
Meta Platforms Inc	0.00%	0.00%	0.00%	0.00%
Micron Technology	0.00%	0.00%	0.00%	0.00%
Microsoft Corp	0.00%	20.00%	40.00%	60.00%
NVIDIA Corp	0.00%	0.00%	0.00%	0.00%
QUALCOMM Incorporated	0.00%	0.00%	0.00%	0.00%
Texas Instruments Incorporated	0.00%	0.00%	0.00%	0.00%
Grand Total	**0.00%**	**20.00%**	**80.00%**	**100.00%**

Water:

- Water was mentioned 69 times in the combined analysis of the reports of the companies, 62 of the times it was mentioned in a sentence were positive (89.86%), 5 of those mentions were neutral (7.25%), and there was an indication of 2 negative mentions (2.90%). Like Cobalt, the results showed Water was also mostly mentioned in a positive form, which indicated organizations are taking initiatives to tackle sustainable issues related to water. An indication of a positive initiative from NVIDIA Corp. reads: "In FY21, we installed water-efficient fixtures and automatic faucets at our Shenzhen, China, and Bangalore, India, locations, as well as water-efficient dishwashing equipment in Bangalore." And from QUALCOMM: "In fact, we decreased our freshwater dependency at our San Diego headquarters by 58% from 2016 to 2021 by expanding our recycled water system." Alphabet/Google set a goal to replenish 120% of the water they consume, on average, across their offices and data centers: "To benefit the people and places where we operate, we've set goals to replenish more water than we consume by 2030 and to support water security in communities where we operate.".

- The 65 sentences of water indicates a numeric information/goal, 61 were positive and 4 was neutral. 4 does not indicate a numeric information/goal of which, 1 is positive, 1 is neutral, and 2 is negative (table under the appendix). These are examples from Microsoft: "In FY21, Microsoft invested in replenishment projects that are expected to generate over 1.3 million cubic meters of volumetric benefits." "By 2024, we will reduce water waste in our datacenter operations by 95 percent." Another indication from HP Inc.: "HP withdrew 2,245,000 cubic meters of potable water across global operations in 2021, 30% less than in 2015, and focused reduction efforts on high-risk sites.".

- The 68 times water was mentioned have an active voice; 62 of which were positive (89.86%), 5 in a neutral form (7.25%), and 1 in a negative manner (1.45%). Water was used with a passive voice only once (1) 1.45%, in a negative form (table under the appendix). An example from Apple reads: "We saved 133 million gallons of freshwater this fiscal year due to efficiency projects implemented since 2017. Last year, alternative water sources accounted for 10 percent of our total corporate water usage—primarily from recycled water sources." One from Intel Corp. reads: "In fiscal 2020, we met our first water neutrality target for our campus in Research Triangle Park (RTP), NorthCarolina.” And from Cisco Systems Inc.: “In fiscal 2020, we met our first water neutrality target for our campus in Research Triangle Park (RTP), North Carolina.”.

- 19 of the mentions of water indicated its issue being currently dealt with, 17 in a positive way, 2 shows a negative. The 33 times water was mentioned indicates its issue being addressed in the past, 28 in a positive manner, and 5 in a neutral way. The 17 mentions shows its issue being addressed for the future in a positive form (table under the appendix). An example of a current ongoing project by Microsoft: “Our programs with Water.org account for over 670 million liters of water benefit per year.” Another current project of Advanced Micro Devices Inc stated: “ We continue to utilize rainwater harvesting and reuse gray water at facilities in Austin, Texas and Bengaluru and Hyderabad, India. In 2021, these sites harvested more than 13.75 million liters of rainwater, which is equivalent to over 100 percent of their combined annual water use.” And from the past reads: “In 2021, water use in our operations was 50 percent lower than in 2020. This large reduction was due to transferring our data center operations to a co-located facility (outside of AMD operational control), upgrading cooling units at our Markham, Ontario site and operating with a reduced onsite workforce during COVID-19.”.

Fig.6 Water tone and percentages.

Sum of Water	Column Labels			
Row Labels	negative	neutral	positive	Grand Total
Advanced Micro Devices Inc		0	5	5
Alphabet/Google		1	5	6
Apple		1	1	2
Applied Materials Inc		0	2	2
Broadcom Inc		1	4	5
Cisco Systems, Inc		1	1	2
HP Inc.		0	3	3
Intel Corporation		1	5	6
International Business Machines Corporation			3	3
Meta Platforms Inc			7	7
Micron Technology		0	5	5
Microsoft Corp		0	6	6
NVIDIA Corp	1	0	5	6
QUALCOMM Incorporated	1	0	6	7
Texas Instruments Incorporated		0	4	4
Grand Total	**2**	**5**	**62**	**69**

Sum of Water	Column Labels			
Row Labels	negative	neutral	positive	Grand Total
Advanced Micro Devices Inc	0.00%	0.00%	7.25%	7.25%
Alphabet/Google	0.00%	1.45%	7.25%	8.70%
Apple	0.00%	1.45%	1.45%	2.90%
Applied Materials Inc	0.00%	0.00%	2.90%	2.90%
Broadcom Inc	0.00%	1.45%	5.80%	7.25%
Cisco Systems, Inc	0.00%	1.45%	1.45%	2.90%
HP Inc.	0.00%	0.00%	4.35%	4.35%
Intel Corporation	0.00%	1.45%	7.25%	8.70%
International Business Machines Corporation	0.00%	0.00%	4.35%	4.35%
Meta Platforms Inc	0.00%	0.00%	10.14%	10.14%
Micron Technology	0.00%	0.00%	7.25%	7.25%
Microsoft Corp	0.00%	0.00%	8.70%	8.70%
NVIDIA Corp	1.45%	0.00%	7.25%	8.70%
QUALCOMM Incorporated	1.45%	0.00%	8.70%	10.14%
Texas Instruments Incorporated	0.00%	0.00%	5.80%	5.80%
Grand Total	**2.90%**	**7.25%**	**89.86%**	**100.00%**

E-Waste:

- E-waste was mentioned in a sentence in the combined analysis of all the companies 13 times. In all cases of the times it was mentioned were positive (100%). The results showed IT Hardware manufacturing companies are taking the global sustainability concern regarding e-waste seriously. An example from Broadcom Inc. proved true the results: “In 2021, we recycled nearly 86 metric tons (190,000 lbs) of e-waste from our owned facilities globally.” And from NVIDIA Corp.: “We partner with a global specialist e-waste vendor to ensure proper tracking, decommissioning, and recycling of our e-waste.”.

- The 11 sentences of e-waste all depict a numeric information/goal treated in a positive manner, 2 does not indicate numeric information/goal but treated in a positive form (table under the appendix). A statement from Apple showed: “With the help of customer and employee participation across recycling programs, we directed more than 38,000 metric tons of e-waste to recycling globally in fiscal year 2021.”.

- All the 13 times e-waste was used, had an active voice, and were in a positive tone/manner (100%) (table under the appendix). A statement from Intel Corp. reads: “The consolidated efforts across the supply chain resulted in, 131,000 metric tons in total landfill avoidance, including 5,900 metric tons through the reuse of capital tools. Less than 1% of high-value e-waste went to landfill.” And from HP Inc.: “During 2021, we recycled 108,800 tonnes of hardware, 10,300 tonnes of Original HP and Samsung Toner Cartridges, and 1,500 tonnes of Original HP Ink Cartridges.”.

- The 3 mentions of the e-waste depicts it being treated as a current issue in a positive way, 9 mentions indicates it being treated in the past in a positive way, and 1 mention indicates the issue to be dealt with in a positive manner for the future (table under the appendix). This statement showed an ongoing project from Intel Corp.: “An increase of e-waste collection to 40 countries globally.” This statement from Microsoft Corp. showed a past project: “A critical piece of achieving our zero waste goal is managing e-waste from our growing datacenters. Last year, we piloted a new approach to asset reuse by building a Circular Center within our Amsterdam datacenter campus, which represents 7 percent of our server capacity globally.”.

Fig.7 E-Waste tone and percentages.

Sum of E-waste	Column Labels			
Row Labels	negative	neutral	positive	Grand Total
Advanced Micro Devices Inc		0	1	1
Alphabet/Google		0	0	0
Apple		0	1	1
Applied Materials Inc		0	0	0
Broadcom Inc		0	3	3
Cisco Systems, Inc		0	0	0
HP Inc.		0	1	1
Intel Corporation		0	2	2
International Business Machines Corporation			0	0
Meta Platforms Inc			0	0
Micron Technology		0	0	0
Microsoft Corp		0	3	3
NVIDIA Corp	0	0	2	2
QUALCOMM Incorporated	0	0	0	0
Texas Instruments Incorporated		0	0	0
Grand Total	**0**	**0**	**13**	**13**

Sum of E-waste	Column Labels			
Row Labels	negative	neutral	positive	Grand Total
Advanced Micro Devices Inc	0.00%	0.00%	7.69%	7.69%
Alphabet/Google	0.00%	0.00%	0.00%	0.00%
Apple	0.00%	0.00%	7.69%	7.69%
Applied Materials Inc	0.00%	0.00%	0.00%	0.00%
Broadcom Inc	0.00%	0.00%	23.08%	23.08%
Cisco Systems, Inc	0.00%	0.00%	0.00%	0.00%
HP Inc.	0.00%	0.00%	7.69%	7.69%
Intel Corporation	0.00%	0.00%	15.38%	15.38%
International Business Machines Corporation	0.00%	0.00%	0.00%	0.00%
Meta Platforms Inc	0.00%	0.00%	0.00%	0.00%
Micron Technology	0.00%	0.00%	0.00%	0.00%
Microsoft Corp	0.00%	0.00%	23.08%	23.08%
NVIDIA Corp	0.00%	0.00%	15.38%	15.38%
QUALCOMM Incorporated	0.00%	0.00%	0.00%	0.00%
Texas Instruments Incorporated	0.00%	0.00%	0.00%	0.00%
Grand Total	**0.00%**	**0.00%**	**100.00%**	**100.00%**

Emissions:

- Emissions were mentioned in the analysis of the combined reports of all the companies 79 times, the positive tone of the times it was mentioned was 75 (94.94%), the times the sentence depicts a neutral tone was 4 (5.06%). In almost all cases emission was mentioned in a sentence were positive, depicting organizations are actually taking steps to address sustainability concerns related to it. A statement from Texas Instruments Inc. showed: “We implement more than 200 energy efficiency projects each year to reduce GHG emissions and energy costs.” Another one from Meta Platforms Inc. stated: “As of 2020, our global operations reached net zero emissions and are supported by 100% renewable energy.”.

- All the 79 times emissions were mentioned indicates numeric information or a goal, 75 in a positive manner, and 4 in a neutral (table under the appendix). An example from Alphabet/Google reads: “From 2019 to 2020, we reduced total transportation emissions of Google hardware products by 38% per metric ton shipped.” And from Advanced Micro Devices Inc.: “50% absolute reduction in greenhouse gas emissions from AMD operations (Scope 1 and 2) by 2030 (base year 2020).”.

- The 78 mentions of emissions in a sentence have an active voice, 74 of which were positive (93.67%), and 4 were neutral (5.06%). 1 was indicated in a passive voice, in a positive way (1.27%) (table under the appendix). A statement from Applied Materials Inc. showed: "Scope 1 and Scope 2 CO2 e emissions declined 28% in 2021, contributing to a 31% total reduction from our 2019 baseline." Another one from Cisco Systems Inc. reads: "Reduce total Cisco Scope 1 and 2 GHG emissions worldwide by 60% absolute (FY07 base year).".

- 18 sentences concerning emissions indicates it as a current issue, 16 being treated in a positive manner, and 2 shows a neutral. 30 mentions depicts a past issue, 29 treated in a positive way, and 1 indicates a neutral treatment. 31 indicated a future issue, 30 addressed in a positive form, and 1 neutral (table under the appendix). A statement from the CEO of QUALCOMM Inc. showed an ongoing project: "We set new, ambitious climate goals, including reaching net-zero global greenhouse gas emissions for Scopes 1, 2 and 3 by 2040 and committed to the Science Based Targets initiative's (SBTi) Business Ambition for 1.5°C." Intel Corp. showed a past project: "We have invested in GHG reductions, including chemical substitution, abatement, energy conservation, process optimization, and renewable and alternative electricity. As a result of these actions, we have avoided nearly 75% of our cumulative Scope 1 and 2 emissions over the last decade.".

Fig.8 Emissions tone and percentages.

Sum of Emissions	Column Labels			
Row Labels	negative	neutral	positive	Grand Total
Advanced Micro Devices Inc		0	4	4
Alphabet/Google		0	11	11
Apple		0	3	3
Applied Materials Inc		0	3	3
Broadcom Inc		0	6	6
Cisco Systems, Inc		1	2	3
HP Inc.		1	2	3
Intel Corporation		0	4	4
International Business Machines Corporation			3	3
Meta Platforms Inc			6	6
Micron Technology		0	6	6
Microsoft Corp		1	5	6
NVIDIA Corp	0	1	5	6
QUALCOMM Incorporated	0	0	9	9
Texas Instruments Incorporated		0	6	6
Grand Total	**0**	**4**	**75**	**79**

Sum of Emissions	Column Labels			
Row Labels	negative	neutral	positive	Grand Total
Advanced Micro Devices Inc	0.00%	0.00%	5.06%	5.06%
Alphabet/Google	0.00%	0.00%	13.92%	13.92%
Apple	0.00%	0.00%	3.80%	3.80%
Applied Materials Inc	0.00%	0.00%	3.80%	3.80%
Broadcom Inc	0.00%	0.00%	7.59%	7.59%
Cisco Systems, Inc	0.00%	1.27%	2.53%	3.80%
HP Inc.	0.00%	1.27%	2.53%	3.80%
Intel Corporation	0.00%	0.00%	5.06%	5.06%
International Business Machines Corporation	0.00%	0.00%	3.80%	3.80%
Meta Platforms Inc	0.00%	0.00%	7.59%	7.59%
Micron Technology	0.00%	0.00%	7.59%	7.59%
Microsoft Corp	0.00%	1.27%	6.33%	7.59%
NVIDIA Corp	0.00%	1.27%	6.33%	7.59%
QUALCOMM Incorporated	0.00%	0.00%	11.39%	11.39%
Texas Instruments Incorporated	0.00%	0.00%	7.59%	7.59%
Grand Total	**0.00%**	**5.06%**	**94.94%**	**100.00%**

Copper:

- Copper was mentioned a total of 8 times in the combined reports analysis of all the companies, positive tone of its mention in the analysis of those sentences were 4 (50%), and it was mentioned 4 times in a neutral tone (50%). Results showed that organizations are also making efforts to address the sustainability issues related to most of these rare earth metals and minerals. A statement from Intel Corp. supports this observation: "To contribute to standards and help define and engage in due diligence within the copper supply chain, Intel is an active partner member of The Copper Mark, participating in its Risk Readiness Assessment (RRA) Technical Revision Committee and Technical Working Group.".

- All mentions of copper show a numeric information/goal of which, 4 were positive, and 4 was neutral (table under the appendix). A statement from Applied Materials Inc. stated: "Looking ahead, we intend to expand due diligence to the copper, nickel, lead, zinc, and mica used in our products, consistent with RMI guidance.".

- Copper was indicated in 7 sentences with an active voice , 4 were positive (50%), and 3 was neutral (37.5%). It was mentioned in a passive voice once (1) 12.5%, in a neutral tone (table under the appendix). An example from Apple showed an active voice in a positive form: "We continue to conduct additional due diligence and carry out OECD-aligned independent third-party audits on other battery materials such as graphite, nickel, and copper.".

- 4 sentences indicate copper as a current issue, 2 treated in a positive way, and 2 addressed in a neutral manner. 3 mentions copper as a past matter, 2 treated in a positive way, and 1 shows a neutral. 1 indicates copper as a future issue to be treated positively (table under the appendix).

Fig.9 Copper tone and percentages.

Sum of Coppper	Column Labels			
Row Labels	negative	neutral	positive	Grand Total
Advanced Micro Devices Inc		0	0	0
Alphabet/Google		0	0	0
Apple		0	1	1
Applied Materials Inc		1	0	1
Broadcom Inc		1	0	1
Cisco Systems, Inc		1	0	1
HP Inc.		0	0	0
Intel Corporation		0	2	2
International Business Machines Corporation			0	0
Meta Platforms Inc			0	0
Micron Technology		0	0	0
Microsoft Corp		1	1	2
NVIDIA Corp	0	0	0	0
QUALCOMM Incorporated	0	0	0	0
Texas Instruments Incorporated		0	0	0
Grand Total	**0**	**4**	**4**	**8**

Sum of Coppper	Column Labels			
Row Labels	negative	neutral	positive	Grand Total
Advanced Micro Devices Inc	0.00%	0.00%	0.00%	0.00%
Alphabet/Google	0.00%	0.00%	0.00%	0.00%
Apple	0.00%	0.00%	12.50%	12.50%
Applied Materials Inc	0.00%	12.50%	0.00%	12.50%
Broadcom Inc	0.00%	12.50%	0.00%	12.50%
Cisco Systems, Inc	0.00%	12.50%	0.00%	12.50%
HP Inc.	0.00%	0.00%	0.00%	0.00%
Intel Corporation	0.00%	0.00%	25.00%	25.00%
International Business Machines Corporation	0.00%	0.00%	0.00%	0.00%
Meta Platforms Inc	0.00%	0.00%	0.00%	0.00%
Micron Technology	0.00%	0.00%	0.00%	0.00%
Microsoft Corp	0.00%	12.50%	12.50%	25.00%
NVIDIA Corp	0.00%	0.00%	0.00%	0.00%
QUALCOMM Incorporated	0.00%	0.00%	0.00%	0.00%
Texas Instruments Incorporated	0.00%	0.00%	0.00%	0.00%
Grand Total	**0.00%**	**50.00%**	**50.00%**	**100.00%**

Tantalum:

- In the analysis of the combined reports of all the IT hardware manufacturing companies, Tantalum was mentioned a total of 17 times, it had 15 positive tone indications (88.24%) of the times it was used in those sentences, and 2 neutral indications (11.76%). It is also mostly mentioned in the positive form, which indicates businesses are tackling issues surrounding in a sustainable manner. A statement from Alphabet/Google reads: “We are committed to zero child labor everywhere in our supply chain, including in mining. In addition to focusing on tin, tantalum, tungsten, and gold, we are working with peer companies and partners to help ensure zero child labor in cobalt mining and to strengthen cobalt tracing.” Another one from Texas Instruments Inc. showed: “TI has processes to ensure that its products do not contain minerals derived from sources that finance or benefit armed groups in the Democratic Republic of Congo or adjoining countries. These minerals include tin, tantalum, tungsten and gold.”.

- The 17 mentions of tantalum indicated a numeric information/goal, 15 indicated a positive, and 2 was neutral (table under the appendix). NVIDIA Corp. stated: “Our goal is to use only conflict-free gold, tantalum, tungsten, and tin in our products.”.

- Tantalum was proved 17 times in a sentence with an active voice, 15 of which were positive (88.24%), and 2 was in a neutral manner (11.76%) (table under the appendix). A statement from International Business Machines Corp. showed an active voice in a positive form: “Since the passage of Section 1502 of the Dodd-Frank Financial Reform Act of 2010, IBM’s focus has been to ensure that 3TG minerals (tantalum, tin, tungsten, and gold) used in our products do not contribute directly or indirectly to armed groups in the Democratic Republic of the Congo and adjoining countries. We deploy a multifaceted approach that includes robust policies and practices, as well as external collaboration, to reach these objectives.”.

- 12 instances indicated tantalum as a current matter, 10 being treated in a positive manner and 2 showing a neutral. 5 indicated a past issue dealt in a positive way (table under the appendix).

Fig.10 Tantalum tone and percentages.

Sum of Tantalum	Column Labels			
Row Labels	negative	neutral	positive	Grand Total
Advanced Micro Devices Inc		0	1	1
Alphabet/Google		0	1	1
Apple		0	1	1
Applied Materials Inc		0	1	1
Broadcom Inc		0	1	1
Cisco Systems, Inc		1	0	1
HP Inc.		1	0	1
Intel Corporation		0	1	1
International Business Machines Corporation			1	1
Meta Platforms Inc			1	1
Micron Technology		0	1	1
Microsoft Corp		0	2	2
NVIDIA Corp	0	0	3	3
QUALCOMM Incorporated	0	0	0	0
Texas Instruments Incorporated		0	1	1
Grand Total	**0**	**2**	**15**	**17**

Sum of Tantalum	Column Labels			
Row Labels	negative	neutral	positive	Grand Total
Advanced Micro Devices Inc	0.00%	0.00%	5.88%	5.88%
Alphabet/Google	0.00%	0.00%	5.88%	5.88%
Apple	0.00%	0.00%	5.88%	5.88%
Applied Materials Inc	0.00%	0.00%	5.88%	5.88%
Broadcom Inc	0.00%	0.00%	5.88%	5.88%
Cisco Systems, Inc	0.00%	5.88%	0.00%	5.88%
HP Inc.	0.00%	5.88%	0.00%	5.88%
Intel Corporation	0.00%	0.00%	5.88%	5.88%
International Business Machines Corporation	0.00%	0.00%	5.88%	5.88%
Meta Platforms Inc	0.00%	0.00%	5.88%	5.88%
Micron Technology	0.00%	0.00%	5.88%	5.88%
Microsoft Corp	0.00%	0.00%	11.76%	11.76%
NVIDIA Corp	0.00%	0.00%	17.65%	17.65%
QUALCOMM Incorporated	0.00%	0.00%	0.00%	0.00%
Texas Instruments Incorporated	0.00%	0.00%	5.88%	5.88%
Grand Total	**0.00%**	**11.76%**	**88.24%**	**100.00%**

Nickel:

- Nickel was mentioned 5 times in the combined analysis of all the companies reports, it has 3 positive tone mentions (60%), it was mentioned 2 times in those sentences in a neutral tone (40%). Nickel was mentioned the same number of times like lithium, and it was also mostly in a positive form. A statement from Apple indicated: “We continue to conduct additional due diligence and carry out OECD-aligned independent, third-party audits on other battery materials such as graphite, nickel, and copper.”.

- All the 5 mentions of nickel depicted a numeric information/goal of which, 3 were treated positively, and 2 was neutral (table under the appendix). This statement from Intel Corp. showed a goal they want to achieve: “In 2021, we sent our first expanded minerals survey for aluminum, copper, nickel, and silver to suppliers contributing these materials in our Intel-manufactured microprocessors. This is an important step in our RISE strategy, as we begin mapping our supply chains for our highest priority minerals. Although sourcing of these minerals is not yet widely reported, we received a response from 89% of relevant suppliers. Additionally, we continue to partner with industry associations to ensure standards are in place to enable our ultimate goal of responsible sourcing for all the minerals in our supply chain.”.

- Nickel was proved in 4 sentences with an active voice, 3 mentions were positive (60%), 1 was neutral (20%). It was indicated in a passive voice once (1) 20%, and in a neutral form (table under the appendix). Mcrosofts’s statement showed an active voice in a positive tone: “Microsoft also supported the development of an RMI toolkit that provides due diligence guidance for mineral supply chains beyond 3TG and cobalt. This guidance will help suppliers conduct due diligence on a broader range of critical minerals, aligning with Microsoft’s expanded supply chain disclosure requirements for aluminum, copper, lithium, magnesium, and nickel.”.

- 3 nickel mentions shows a present matter, 2 addressed in a positive manner, and 1 in a neutral form. 1 indicates it as a past matter treated in a positive way. 1 shows it being addressed as a future issue to be treated positively (table under the appendix).

Fig.11 Nickel tone and percentages.

Sum of Nickel	Column Labels			
Row Labels	negative	neutral	positive	Grand Total
Advanced Micro Devices Inc		0	0	0
Alphabet/Google		0	0	0
Apple		0	1	1
Applied Materials Inc		1	0	1
Broadcom Inc		0	0	0
Cisco Systems, Inc		0	0	0
HP Inc.		0	0	0
Intel Corporation		0	1	1
International Business Machines Corporation			0	0
Meta Platforms Inc			0	0
Micron Technology		0	0	0
Microsoft Corp		1	1	2
NVIDIA Corp	0	0	0	0
QUALCOMM Incorporated	0	0	0	0
Texas Instruments Incorporated		0	0	0
Grand Total	**0**	**2**	**3**	**5**

Sum of Nickel	Column Labels			
Row Labels	negative	neutral	positive	Grand Total
Advanced Micro Devices Inc	0.00%	0.00%	0.00%	0.00%
Alphabet/Google	0.00%	0.00%	0.00%	0.00%
Apple	0.00%	0.00%	20.00%	20.00%
Applied Materials Inc	0.00%	20.00%	0.00%	20.00%
Broadcom Inc	0.00%	0.00%	0.00%	0.00%
Cisco Systems, Inc	0.00%	0.00%	0.00%	0.00%
HP Inc.	0.00%	0.00%	0.00%	0.00%
Intel Corporation	0.00%	0.00%	20.00%	20.00%
International Business Machines Corporation	0.00%	0.00%	0.00%	0.00%
Meta Platforms Inc	0.00%	0.00%	0.00%	0.00%
Micron Technology	0.00%	0.00%	0.00%	0.00%
Microsoft Corp	0.00%	20.00%	20.00%	40.00%
NVIDIA Corp	0.00%	0.00%	0.00%	0.00%
QUALCOMM Incorporated	0.00%	0.00%	0.00%	0.00%
Texas Instruments Incorporated	0.00%	0.00%	0.00%	0.00%
Grand Total	**0.00%**	**40.00%**	**60.00%**	**100.00%**

Silicon:

- Among all the reports of the fifteen IT hardware manufacturing companies, silicon was mentioned 6 times, it has 3 positive mentions (50%), and 3 neutral tone indications (50%). The results showed companies are making positive gradual efforts to address its issues. A statement from Advanced Micro Devices Inc. stated: “We are steadfast in our commitment to environmental sustainability, and that includes working with our manufacturing suppliers to evaluate and continuously improve performance. Given the amount of energy and water needed in the wafer fabrication process, silicon wafer manufacturing represents the bulk of our environmental footprint in our supply chain. We have set 2025 performance metrics for our wafer foundry suppliers, and track progress each quarter.”.

- The 3 mentions of silicon indicated a numeric information/goal, 2 were positive, and 1 was neutral. The other 3 indicated no numeric information/goal, 1 addressed positively, and 2 in a neutral manner (table under the appendix).

- All the 6 indications of silicon in a sentence were with an active voice, 3 were positive (50%), and the other 3 were in a neutral form (50%) (table under the appendix). Advanced M. Devices Inc. showed a statement in an active voice positively: “Since 2014 we have partnered with our wafer suppliers to establish best-in-class environmental, health and safety (EHS) performance for AMD silicon wafer production.”.

- 5 sentences indicate silicon as a current matter, 2 treated in a positive manner, and 3 in a neutral form. 1 shows it as a past issue treated in a positive way (table under the appendix).

Fig.12 Silicon tone and percentages.

Sum of Silicon	Column Labels			
Row Labels	negative	neutral	positive	Grand Total
Advanced Micro Devices Inc		0	3	3
Alphabet/Google		0	0	0
Apple		0	0	0
Applied Materials Inc		0	0	0
Broadcom Inc		0	0	0
Cisco Systems, Inc		0	0	0
HP Inc.		0	0	0
Intel Corporation		0	0	0
International Business Machines Corporation			0	0
Meta Platforms Inc			0	0
Micron Technology		0	0	0
Microsoft Corp		0	0	0
NVIDIA Corp	0	1	0	1
QUALCOMM Incorporated	0	2	0	2
Texas Instruments Incorporated		0	0	0
Grand Total	**0**	**3**	**3**	**6**

Sum of Silicon	Column Labels			
Row Labels	negative	neutral	positive	Grand Total
Advanced Micro Devices Inc	0.00%	0.00%	50.00%	50.00%
Alphabet/Google	0.00%	0.00%	0.00%	0.00%
Apple	0.00%	0.00%	0.00%	0.00%
Applied Materials Inc	0.00%	0.00%	0.00%	0.00%
Broadcom Inc	0.00%	0.00%	0.00%	0.00%
Cisco Systems, Inc	0.00%	0.00%	0.00%	0.00%
HP Inc.	0.00%	0.00%	0.00%	0.00%
Intel Corporation	0.00%	0.00%	0.00%	0.00%
International Business Machines Corporation	0.00%	0.00%	0.00%	0.00%
Meta Platforms Inc	0.00%	0.00%	0.00%	0.00%
Micron Technology	0.00%	0.00%	0.00%	0.00%
Microsoft Corp	0.00%	0.00%	0.00%	0.00%
NVIDIA Corp	0.00%	16.67%	0.00%	16.67%
QUALCOMM Incorporated	0.00%	33.33%	0.00%	33.33%
Texas Instruments Incorporated	0.00%	0.00%	0.00%	0.00%
Grand Total	**0.00%**	**50.00%**	**50.00%**	**100.00%**

4.3 Discussion:

The results or the findings of this study are timely and relevant to the increasing digitisation of the globe. It comes at a time when technology is being used in almost all human activities. As a result, it is crucially vital to investigate this sector from the perspective of the component/equipment manufacturers; IT hardware manufacturers on their activities in this hugely important sector. Climate change is now a global concern, as it is taking its toll on our planet. The activities of component manufacturers especially in the technology sector has contributed to a larger portion of the climate crisis we are currently facing.

This study, therefore, provides an insight into the activities of IT hardware manufacturers. The activities investigated are the risk associated with their supply chain, and how they are performing with regards to sustainable practices in their operations, and how they are responding towards the society and the environment in which they operate in (in addressing the effects of their operations). In general, the main focus of the study is to investigate the relationship between the financial and ESG (environment, social and governance) performance of the publicly traded IT hardware manufacturing companies, and the risk they encounter along their supply chain. The findings of the research were interesting and it has answered the research question. The findings of the results are discussed below:

Cobalt:

- Cobalt is among the most important earth metals, the demand for cobalt has increased threefold over the past ten years, it is primarily used in lithium-ion batteries, the Democratic Republic of the Congo is by far the largest cobalt producer in the world, with more than 50% of global production; according to reports DRC will continue to be a crucial supplier of raw cobalt ore even if it now lacks the capacity to process the majority of its output. It is a valuable commodity because of its wide range of applicability. Cobalt is used in the production of semiconductors, an integral component of virtually all electronic devices. It helps improve the conductivity and thermal stability of materials used in microchips, making our computers, smartphones, and other gadgets faster and more efficient. While its magnetic qualities find usage in electronics, including smartphones and hard drives, cobalt alloys are extensively used in the aerospace and healthcare industries. The result of the combined analysis of the 15 companies showed that companies are taking sustainable initiatives with regards to cobalt; from its extraction/mining to processing, and the toll this metal has on our environment and the well being of humans. It showed companies making active statements in a positive tone/way 76.19% of the times cobalt has been mentioned, signifying that they are/did take action to positively address its matter. The results showed businesses have positively tackled its issue in the past, and are taking current initiatives to address its sustainability concerns which would continue into their future operations.

Cobalt mining in the DRC has been linked to unethical problems, such as child labour and dangerous working conditions. The impact of cobalt mining on the environment also raises questions regarding sustainability. Rising cobalt demand has sparked questions about the ethical aspects of the supply chain and its effects on the environment. The UN reports that warlords fund their operation through the mining of cobalt. Child labour, the poor and unsafe working conditions of artisanal miners (who dig out the rocks from subterranean tunnels by hand; produced 20% of the cobalt exported, according to government estimates); that impose physical and health risk are among the situations that need to be addressed with regards to cobalt mining. Prolonged exposure to cobalt can cause lethal lung disease, asthma and shortness of breath. The electric vehicle (EV) industry is responsible for the biggest recent increase in demand for cobalt. Cobalt is essential for the cathodes of lithium-ion batteries, which are frequently found in EVs. Longer driving distances and quicker charging periods are made possible by cobalt's ability to maintain consistent performance and high energy density in these batteries.

Researchers and businesses are working to lessen cobalt dependence in battery technology in response to ethical and environmental concerns. One strategy is to increase the amount of nickel in batteries, which can enhance sustainability and performance. We can lessen some of the difficulties in cobalt extraction by using it less.
Another approach to the cobalt supply problem is recycling. The requirement for fresh mining can be decreased by recovering cobalt from discarded batteries. Additionally, research is being done to create cobalt free battery technologies such as solid-state batteries, which promise to offer better energy storage options without the drawbacks of cobalt.

Lithium:

- The market for consumer electronics, which has a high demand for lithium-ion batteries, expanded about ten years ago, which resulted in a major rise in lithium demand and consumption. In the past, lithium has been used as an industrial ingredient to create lubricating greases, glass, ceramics, and other goods. Today's world depends heavily on lithium, a tiny, adaptable metal that powers everything from our cellphones to electric cars. Due to its special qualities, current batteries require it as a fundamental component, accelerating the transition to greener, more sustainable energy sources. The reason lithium is so well-liked as a battery component is due to its exceptional qualities. Since it is the lightest metal in the periodic table, it is a great material for electric cars and portable gadgets. The most popular kind of rechargeable batteries, lithium-ion batteries, use lithium as a key component for their cathodes, enabling high energy density and prolonged charge cycles. This results in batteries for our gadgets and electric cars that are stronger and last longer. The combined analysis of the companies have proven that organizations are taking proactive steps to address the sustainability issues with the extraction and usage of lithium in IT hardware manufacturing. The results showed that 80% of the lithium mentions have an active voice/tone indicated in a positive way, depicting that real actions have or are being taken to address its sustainability concerns. The results showed organizations have committed themselves to positively address the concerns with regards to the mining and usage of lithium in their current operations, and also for their future business activities.

  Lithium's contribution to the clean energy revolution is one of its most notable advantages. Lithium-ion batteries are crucial for storing renewable energy produced by sources like solar and wind as the globe works to lessen its reliance on fossil fuels and fight climate change. The excess energy produced during times of high renewable output can be stored in these batteries and discharged when necessary, maintaining a consistent supply of clean electricity. Electric vehicles (EVs) are propelled by lithium-ion batteries, which have revolutionized the automobile industry. These batteries overcome the main drawbacks of older battery technologies with their high energy density and quick charging capabilities. The popularity of EVs decreases our dependency on oil while simultaneously reducing greenhouse gas emissions. With improvements in lithium battery technology, more people are now able to purchase and use electric vehicles, opening up sustainable mobility to a wider market. Because of its small weight and great energy density, lithium has revolutionized the portable electronics industry. Lithium-ion batteries have improved the size and performance of all of our electronic devices, from smartphones to laptops to wearables. They improve our daily lives and productivity by offering longer battery life and quicker charging.

Renewable energy sources like solar and wind are becoming increasingly important in the pursuit of sustainable IT practices. Lithium-ion batteries are at the forefront of energy storage solutions, enabling the efficient capture and utilization of clean energy. This not only reduces carbon footprints but also enhances the reliability of renewable energy sources, ensuring a stable power supply for IT infrastructure. Behind every online service and digital platform lie vast server farms and data centers, collectively consuming enormous amounts of energy. In these facilities, lithium-ion batteries act as backup power sources to ensure continuous operation in the event of power interruptions. This reliability is critical in maintaining the seamless functioning of online services, reinforcing lithium's significance in IT infrastructure. Moreover, lithium-ion batteries are used for uninterruptible power supply (UPS) systems, which protect sensitive IT equipment from voltage fluctuations and power surges. These systems guarantee data integrity and prevent costly downtime, underscoring the vital role of lithium in safeguarding digital assets. Despite its many benefits, the lithium industry faces challenges, such as concern about the effects of mining and extraction on the environment and the scarcity of lithium supplies. To address these problems and enhance sustainability, researchers are actively investigating alternate materials and battery technologies.

Water:

- ❖ Unquestionably, one of the most crucial components for life as we know it, is water. The transparent, flavorless, and odorless fluid that covers more than 70% of the surface of our globe. It is a subject worth investigating due to its special qualities and importance to all living things. Because it can dissolve a variety of things, water is frequently referred to as the "universal solvent". This feature is essential for the movement of nutrients in biological systems and for the formation of solutions that are necessary for the activities of life. Many chemical reactions vital to life would be severely constrained without the solvent properties of water. Additionally, water is essential for controlling Earth's temperature. As a result of its high specific heat capacity, it can absorb and release a lot of heat without significantly changing its temperature. This characteristic plays a critical role in maintaining the Earth's temperature and providing a habitat for a wide variety of organisms. Water is abundant on Earth, but many people still have serious concerns about access to clean, safe water. The need for appropriate water management and conservation is highlighted by the fact that water scarcity is a developing global problem. It's imperative that we all contribute to protecting and preserving this invaluable resource. Water is a resource that all organizations use no matter the nature of the business operations or types of products manufactured. In the combined analysis of all the reports of the companies, 89.86% of the times water was mentioned was done with an active voice, in a positive tone. The results proved that businesses are actually taking proactive steps to solve the global concern regarding water scarcity, addressing sustainability of the usage of water in their operations. The results indicated organizations took steps in the past to address water sustainability issues, positively. And are currently taking dynamic/proactive sustainable initiatives in the usage of water for current and future operations.

Managing the heat produced by electrical devices is one of the biggest issues in information technology. Technology development leads to smaller, more powerful components, which increases heat generation. Data centers and electronic gadgets need effective cooling systems to prevent overheating. In this aspect, water has shown to be a great coolant. Water is an effective medium for transporting heat away from electronic components due to its high heat capacity and thermal conductivity. In data centers, water-cooled systems are used to maintain optimal operating temperatures, ensuring that servers and networking equipment run smoothly. Modern data centers now include liquid cooling technologies like heat exchangers and water blocks as essential parts because they increase energy efficiency and extend the life of vital IT infrastructure. Water also contributes to energy efficiency in information technology. Many data centers are located close to water bodies, which enables them to use natural water sources for cooling. This method, often referred to as free cooling or aquatic cooling, significantly reduces the amount of energy used by traditional air conditioning systems. Data centers can reduce their carbon footprint and operating expenses by using water from the surrounding area. Businesses gain from this, and it also lessens the impact data processing has on the environment, aligning with the global trend towards sustainability. Hydropower, a clean and renewable energy source, relies on the movement of water to generate electricity. Data centers are increasingly being designed and located near hydropower facilities to take advantage of this green energy source. The combination of water-cooled data centers and renewable hydropower creates a symbiotic relationship, where information technology benefits from eco-friendly energy sources, reducing its overall environmental impact.

E-Waste:

❖ Electronic devices are now a necessary component of our daily lives in our quickly evolving digital society. We place a great deal of reliance on these devices for convenience, communication, and entertainment, from cellphones and laptops to televisions and kitchen appliances. The biggest drawback of this technological advancement is that electronic garbage, or e-waste, is now a major issue on a global scale. Electronic garbage, or "e-waste," is the term used to describe abandoned electrical and electronic equipment, ranging from small appliances like outdated cell phones to bigger appliances like refrigerators and washing machines. The manufacturing and disposal of these gadgets have increased significantly due to the continuous pace of technological advancement. As a result, e-waste is now the waste stream with the fastest rate of growth worldwide. As the world is ready to tackle the growing e-waste problem, as a result of the increase in the usage and the need for technology products. The results of the analysis of the companies showed businesses are responding positively to the global concern.There was an indication of proactive actions taken in the past, some are currently initiated for present day operations, and positive steps for the future operations to address the global sustainable e-waste management worry, to protect the environment and the well being of humans. There was a 100% indication in an active manner/voice of all the instances e-waste was highlighted in a sentence, and were all in a positive manner/tone.

There are numerous environmental and health dangers associated with incorrect e-waste disposal. Hazardous substances like lead, mercury, and brominated flame retardants are frequently found in electronic gadgets. These poisonous materials can seep into the land and water if they are not managed and disposed of properly, polluting ecosystems and harming both human and animal life. Burning electronic waste also disperses dangerous toxins into the atmosphere, which worsens air pollution and accelerates climate change. The electronic waste recycling industry often operates in developing countries with lax regulations, and has been linked to hazardous working conditions that put employees at risk for health problems. E-waste poses significant risks to the environment and human health, but it also offers business opportunities. By properly recycling and refurbishing electronic gadgets, valuable materials like gold, silver, and copper can be recovered, minimizing the need for mining and promoting resource conservation. Additionally, promoting appropriate e-waste management can boost local economies and create jobs.

Emissions:

❖ The assessment from the Intergovernmental Panel on Climate Change (IPCC) of the United Nations warns that time is running out to keep global warming far below 2° Celsius in pursuit of 1.5°, and that the trajectory of global emissions reductions currently in place would not allow for this. Information technology (IT) is essential to changing our lives, revolutionizing industries, and enabling worldwide connectedness in today's increasingly digital world. However, one often-overlooked side effect of this digital change is carbon Emissions. Understanding the environmental impact of our digital activities and looking at measures to reduce emissions are vital as IT infrastructure expands. Although information technology does not by itself have a high carbon footprint, the extensive infrastructure needed to power and operate digital services does. Data centers, network infrastructure, as well as the production and disposal of IT equipment, are the main sources of emissions in the IT industry. These enormous buildings, known as data centers, are home to innumerable servers that process and store data for various web businesses. Massive amounts of energy are needed to run data centers and keep temperatures at ideal levels, which generates a lot of carbon emissions. Global warming has put the world at edge in recent times and as a result, governments and international bodies have intensified efforts in order to address this global challenge. The rate of global warming is presently higher than it has ever been. Global warming and climate change is as a result of the Earth being covered in greenhouse gas emissions, which traps the sun's heat. The results showed businesses are taking positive actions to address emissions in information technology, in a sustainable way. There was a 93.67% indication with an active voice, in a positive tone, of all the times emissions were mentioned in a sentence. The results indicated organizations have taken positive proactive steps to address the emissions in their current operations. It also proved that businesses have taken positive steps in the past to mitigate emissions in their IT operations, and proactive steps for their future operations in order to address sustainability concerns regarding emissions.

The network infrastructure, the extensive system of cables and data transmission tools that links our gadgets to the internet also uses a lot of energy and produces emissions. The production and disposal of IT equipment, including computers, smartphones, and data storage devices, has a consequence on the environment. Emissions are a result of the production process, raw material extraction, and disposal of electronic waste. All of our regular digital engagements, such as streaming videos, writing emails, and browsing the internet, need energy. Fossil fuels are a common source of this energy, which results in greenhouse gas emissions. Particularly energy-intensive are cloud services, streaming platforms, and data-intensive applications.

Copper:

- ❖ Copper continues to be an unsung hero in the rapidly evolving landscape of information technology, quietly enabling the smooth transfer of data between networks and devices. Copper still has a significant impact on the IT industry, despite the increased emphasis given to more recent technologies like fiber optics and wireless communication. Copper has been a fundamental component of networking for decades, serving as the primary medium for transmitting data within local area networks (LANs) and wide area networks (WANs). Copper Ethernet cables are widely used for connecting computers, switches, routers, and other network devices. Their affordability, reliability, and ease of installation make them a preferred choice for many IT professionals. The results from the data analysis proved that organizations are gradually taking positive actions to address the mining and usage of copper in their operations, in mitigating its sustainability related concerns. Copper was mentioned 7 times out of 8 in total with an active voice, 50% in a positive way, depicting the efforts of the organizations in positively tackling its issues. The results proved businesses have committed themselves to tackle its sustainable concerns both in their past and current operations, and in their future operations as well.

One of the key advantages of copper in IT is its ability to transmit data at high speeds. Copper cables are suitable for a variety of applications, from office networks to data centers, as they can support Gigabit Ethernet and even 10 Gigabit Ethernet connections. Businesses that depend on effective data connection need copper's reliable performance in delivering high-speed data transfers. Copper's significance extends beyond data transmission; it is also instrumental in providing power to devices over Ethernet cables. Power over Ethernet (PoE) technology allows devices like IP cameras, VoIP phones, and wireless access points to receive both data and power through a single copper cable. This simplifies installation and reduces the need for additional power sources, making copper-based PoE a cost-effective solution for many IT applications. Copper is a dependable material for IT infrastructure because of its resistance to a variety of environmental factors. Because copper cables can survive changes in temperature, moisture, and physical stress, their performance stays constant over time. This durability is particularly valuable in scenarios where cables may be exposed to harsh conditions or frequent handling. Copper is compatible with existing infrastructure. Many organizations have invested in copper-based networking solutions over the years, and copper cables remain a valuable resource for extending or upgrading networks without a complete overhaul. Copper interfaces and connectors are also widely used in IT equipment, ensuring compatibility with a variety of devices and components.

Tantalum:

Over time, information technology (IT) has quickly developed, and its constituent parts have shrunk, accelerated, and improved. Tantalum, a rare metal, is one component that has quietly played an essential role in this transition. Tantalum, a transition metal with distinct qualities, has made its way into a variety of IT devices and improved their performance. Its scarcity and valuable properties make it an ideal choice for a range of electronic components. The high melting point of tantalum, which exceeds 3,000 degrees Celsius, is one of the main characteristics that contribute to its popularity. Due to this characteristic, tantalum capacitors can endure wide temperature swings, which is essential for the durability and dependability of IT hardware. Tantalum capacitors are widely used in IT devices. These capacitors have a compact design and high capacitance, making them suitable for electronic components like smartphones, laptops, and tablets. Their high energy density and consistent electrical performance provide a steady supply of power and less electromagnetic interference, which improves device efficiency. The results of the analysis of the combined reports of all the companies proved very promising, it has shown that organizations are taking responsibility to mitigate the concerns raised as a result of these elements they use in their operations.

Tantalum has a 88.24% active voice indication in a positive tone/way, depicting that businesses are tackling sustainability issues with regards to the mining, usage and the toll this metal has on our environment in a positive way. The results proved organizations have positively tackled its issue in the past, and are taking current initiatives to address its sustainability concerns which would last/continue into their future operations.

Storage devices like solid-state drives (SSDs) and hard disc drives (HDDs) are made with the help of tantalum. These resistors provide precise resistance values and exceptional stability, which are essential for accurate data storage and retrieval. Tantalum resistors help storage devices function better as their capacity and speed continue to grow. Tantalum is also used in semiconductor manufacturing, enabling them to function at high temperatures while maintaining optimal performance. Tantalum is increasingly being used in mobile phones and wearables due to consumer demand for smaller, lighter, and more energy-efficient products. It is the perfect material for these applications due to its strong heat conductivity and resistance to corrosion. Despite its significant contributions to information technology, tantalum mining has faced criticism due to ethical concerns surrounding conflict minerals. To address these issues, companies have increasingly sought responsibly sourced tantalum to ensure ethical and sustainable production practices.

Nickel:

- ❖ While the majority of us associate IT with cutting-edge hardware and sophisticated software, nickel also plays a significant part in enabling our digital world. Although this understated metal may not be in the forefront, it is a crucial part of many IT systems. Ethernet cables, USB cables, and HDMI connectors are just a few of the cables and connectors that are produced using nickel. Nickel is a great option because these parts require materials that can survive frequent bending, corrosion resistance, and superior electrical conductivity. The nickel plating on connectors ensures a reliable electrical connection and prevents corrosion, which is essential for data transmission and power delivery. Nickel is a key component in the batteries that power our laptops, smartphones, and other portable devices. Its ability to store energy efficiently has made nickel indispensable in IT for years. Nickel-plated hard drive discs play a crucial role in the field of data storage. The nickel plating protects the drive's surface from corrosion and ensures that data can be reliably read and written to the disk. Hard drives' durability and functionality could suffer without nickel.

Nickel was also mentioned most of the times in a positive tone, with a 60% percentage indication. The results also proved organizations have taken sustainable steps in the past, and have current initiatives, as well as future ones to address its related concerns in their operations. Integrated circuits (ICs), and various microelectronic components in computers and other IT equipment often contain small amounts of nickel. Nickel is also used in some cooling systems for IT equipment. Nickel-plated heat sinks and cooling pipes are employed to dissipate heat efficiently, preventing devices from overheating and ensuring their optimal performance.

Silicon:

- ❖ Silicon has become a key component driving the digital revolution in the rapidly evolving field of information technology (IT). The chemical element silicon, which is widely known for being present in large quantities in the Earth's crust, has become linked with the microelectronics sector. Silicon is the unsung hero that powers everything from the tiny transistors on smartphones to the massive data centers that power the internet. The silicon chip, commonly referred to as the integrated circuit (IC) or microchip, is at the core of almost every electronic device. The importance of silicon in IT goes beyond microchips. It is also very important for data storage technology. Solid-state drives (SSDs) and other non-volatile memory products are created using silicon-based materials. These storage solutions offer faster data access times and greater durability compared to traditional mechanical hard drives. Silicon-based materials are used in the healthcare sector for various applications, including in medical implants, as they are biocompatible and resistant to bodily fluids.

The results showed businesses have current initiatives in place to tackle the sustainability concerns associated with silicon in their operations, which they expect to last into their future operations as well. And have taken actions in the past to positively address some of the concerns. As shown under the results, in all 6 cases silicon was mentioned, it was done with an active voice, and 50% was in a positive way. It indicated companies taking proactive steps to address its related concerns. Silicon is faced with certain challenges despite playing a crucial part in information technology. As microelectronics continue to miniaturize, researchers are approaching the physical limits of silicon's capabilities. Engineers are working on novel architectures to extend the life and capabilities of silicon-based devices. Due to its versatility and abundance, silicon will continue to play a crucial role in IT for the foreseeable future.

CHAPTER 5: CONCLUSION, RECOMMENDATION, LIMITATIONS OF THE STUDY AND FURTHER STUDIES:

5.1 Conclusion:

Cobalt: From powering our devices with long-lasting batteries to preserving and accessing vast amounts of data, cobalt quietly but significantly contributes to the seamless functioning of the IT world. Cobalt's importance in modern technology cannot be understated, particularly in the context of the electric vehicle revolution. However, as the industry strives for sustainability, it's crucial to address the environmental and ethical concerns associated with cobalt mining and usage. The ethical and environmental concerns surrounding its extraction necessitate a shift towards more sustainable practices and alternative materials. As industries and researchers continue to innovate and explore greener battery technologies, the role of cobalt in our world may evolve, ensuring a more responsible and eco-friendly supply chain for this precious element.

Lithium: Due to its exceptional qualities, lithium has emerged as a key component in the search for greener, more sustainable energy sources. Lithium-ion batteries are at the vanguard of the clean energy revolution, powering everything from electric automobiles to storing renewable energy. While challenges exist, ongoing research and innovation promise to make lithium batteries even more efficient and eco-friendly. Lithium plays a diverse and crucial role in defining the digital age through its use to power portable devices, guarantee the dependability of data centers, and promote sustainability. As we continue to transition towards a greener future, lithium will undoubtedly play a crucial role in powering the world.

Water: Water is a miraculous substance that sustains life on Earth in myriad ways. It is known as the elixir of life because of its special abilities as a solvent, temperature regulator, and essential component of organisms. As we continue to study and understand water's significance, we must also take active steps to safeguard and ensure its availability for generations to come. Often underestimated in its role within information technology, water is unquestionably essential for the effective operation and sustainability of the modern digital world. It is an unsung hero in the IT industry because of its cooling capabilities, energy efficiency, and contribution to the production of renewable energy. As technology continues to advance, so too will the importance of water in ensuring the reliable and sustainable operation of our digital infrastructure.

E-Waste: E-waste is a pressing issue that requires collective action at the individual, community, corporate, and governmental levels. We must collectively work towards more sustainable practices, from responsible manufacturing to recycling and consumer awareness. As consumers, we must be mindful of the environmental impact of our electronic consumption and take steps to reduce, reuse, and recycle electronic devices. Only through these concerted efforts can we reduce the environmental and health consequences associated with the growing pile of discarded electronic devices.

Emissions: As information technology continues to advance, addressing emissions in the IT sector becomes paramount. By adopting sustainable practices, transitioning to renewable energy sources, and promoting user awareness, we can reduce the carbon footprint of our digital world. Recognizing the environmental impact of our digital activities is a crucial step toward building a more sustainable future, and addressing emissions is a global challenge that requires concerted efforts from individuals, businesses, and governments.

Copper: While newer technologies continue to push the boundaries of information technology, copper remains a steadfast and indispensable element of IT infrastructure. It is a popular option for networking and data transmission in a variety of applications due to its affordability, reliability, speed, and compatibility. In a world where data is the lifeblood of businesses and individuals, copper quietly plays a vital role in keeping the digital ecosystem connected and thriving.

Tantalum: Tantalum is a versatile and invaluable element that has transformed numerous industries, thanks to its exceptional properties. Tantalum continues to fuel innovation and influence our contemporary environment in fields ranging from electronics to aerospace and medicinal uses. It is an essential material for technological advancement due to its biocompatibility, high heat tolerance, and corrosion resistance. As we move forward, it is crucial to maintain ethical practices in tantalum mining to ensure a sustainable and responsible supply chain. Due to its special characteristics, tantalum is a crucial element in the field of information technology. Its role in capacitors, semiconductors, and various electronic components ensures the reliability and performance of the devices we rely on daily. Tantalum will likely remain a cornerstone of innovation as technology advances, supporting the growth and development of the digital age.

Nickel: Nickel is an essential element in our modern world because of its versatility, durability, and resistance to corrosion, its unique properties make it an unsung hero in the world of information technology. From the stainless steel in our kitchens, cables, and connectors to the batteries in our electronic devices, nickel plays a significant role in enhancing our lives, and ensuring the reliability and longevity of IT equipment. Powering devices with long-lasting batteries, and ensuring data integrity in magnetic storage, nickel plays a crucial role in various IT applications. As technology continues to advance, we can expect nickel to remain a fundamental element, quietly powering the systems and devices that have become indispensable to our daily lives. However, as we continue to rely on this valuable metal, it is crucial to ensure that its extraction and usage are conducted in an environmentally responsible manner.

Silicon: Silicon is a versatile and abundant element that underpins our modern way of life. It is a vital component in electronics, energy production, building, and many other industries due to its special semiconductor qualities and prevalence in nature. This remarkable element serves as the foundation of modern computing, from the silicon chip that powers laptops to the silicon-based memory in your smartphone. Silicon's significance is undeniable, and as technology continues to advance, so too will our reliance on this remarkable element; driving innovation and shaping the digital world as we know it.

5.2 Recommendations:

Cobalt:

Cobalt is a vital element in IT and is required for various applications including batteries, hard drives, and aerospace technology. The use of cobalt in information technology (IT) with sustainability in mind offers a chance to promote ethical and favorable environmental outcomes while maintaining technological advancement. Sustainability in cobalt usage is not only an ethical imperative but also a strategic move that aligns with the growing demand for environmentally conscious technology solutions.. This recommendation outlines the sustainable use of cobalt in IT and emphasizes the importance of responsible sourcing and recycling practices:

Responsible Sourcing: IT companies should give preference to buying cobalt from ethically and environmentally responsible suppliers and mines. This includes supporting initiatives that promote fair labor conditions, reduce environmental impact, and ensure traceability in the supply chain.

Battery Recycling: Since batteries account for a sizable amount of the cobalt used in IT, businesses should fund battery recycling initiatives. This reduces the demand for newly mined cobalt and minimizes the environmental footprint associated with extraction and processing.

Research and Development: Encourage research into alternative materials and technologies that reduce or eliminate the reliance on cobalt, especially in batteries. Advancements in battery chemistry, such as cobalt-free cathodes, can lead to more sustainable energy storage solutions.

Efficiency Optimization: Continuously strive for improved energy efficiency in IT equipment and infrastructure. Efficient systems require fewer resources, including cobalt, to operate, reducing the overall environmental impact.

End-of-Life Management: Implement responsible end-of-life management practices for IT equipment. Promote the refurbishment and recycling of devices, ensuring that cobalt-containing components are properly recovered and reused.

Lithium:

Sustainability has become a key priority for businesses and organizations worldwide, in today's fast-paced digital world. One of the most promising elements in this pursuit of sustainability within the realm of information technology is lithium. This versatile and abundant element plays a pivotal role in enhancing the eco-friendliness of IT systems, making it a compelling choice for companies committed to reducing their environmental footprint. By incorporating lithium-based solutions and adhering to environmentally responsible practices, businesses and organizations can contribute to a greener and more sustainable future while also reaping economic benefits. Embracing lithium in information technology is a step towards a more sustainable, energy-efficient, and eco-conscious IT landscape. Recommendations for Sustainable IT Practices:

Adopt Lithium-ion Batteries: Consider replacing lithium-ion batteries instead of conventional ones in laptops, mobile devices, and other portable equipment to improve energy efficiency and reduce waste.

Implement Energy Storage Solutions: Invest in lithium-based energy storage systems to efficiently harness renewable energy sources and encourage the use of sustainable energy.

Upgrade Data Center Infrastructure: Upgrade the infrastructure of data centers by using lithium-based uninterruptible power supply (UPS) systems to enhance reliability, cut down on energy use, and lower operating costs.

Battery Recycling Programs: Establish or participate in battery recycling programs to ensure the responsible disposal and recycling of lithium batteries, reducing environmental impact.

Invest in Research: Encourage the advancement of lithium battery technology through research and development with a focus on sustainability and safety.

Water:

The rapid technological advancement comes with a significant environmental footprint, particularly concerning energy consumption and resource utilization. The IT sector must be proactive in managing its water usage responsibly in order to promote sustainability. Companies may reduce expenses, strengthen their image as environmentally responsible organizations, and help the world's efforts to address water scarcity challenges by reducing their water consumption. These recommendations align with broader sustainability goals and are a crucial step towards a more environmentally responsible IT industry:

Efficient Cooling Systems: Data centers, which are the foundation of IT operations, are infamous for their energy-intensive cooling systems. By utilizing cutting-edge cooling techniques such as liquid cooling, hot/cold aisle containment, and direct evaporative cooling, water consumption can be significantly reduced while maintaining ideal operating temperatures.

Data Center Location: Selecting data center locations in regions with abundant water resources or utilizing natural sources like lakes and rivers for cooling can minimize the need for freshwater consumption.

Reuse and Recycling: Invest in water treatment and recycling systems within data centers to reuse water for non-potable purposes like cooling. Implementing closed-loop cooling systems can help reduce water wastage.

Energy Efficiency: Improve the energy efficiency of IT infrastructure to dramatically cut down on water use. Water usage for electricity generation in power plants can be reduced by using energy-efficient hardware, virtualization, and cloud computing.

Eco-friendly Hardware: Encourage the creation and usage of environmentally friendly IT hardware, which uses fewer resources, such as water, during manufacturing.

Monitoring and Reporting: Implement real-time monitoring and reporting tools to keep tabs on water usage throughout IT processes. This information can be used to spot inefficiencies and guide attempts at continuous improvement.

Education and Awareness: Foster a culture of water-consciousness within the IT industry through employee training and awareness campaigns. Engaged employees are more likely to actively participate in water conservation initiatives.

Collaboration: Work together with water utilities, local administrations, and environmental groups to explore creative approaches and incentives for water conservation in IT operations.

Regulatory Compliance: Stay informed about water-related regulations and compliance requirements to ensure that IT operations align with environmental laws and standards.

Sustainable Sourcing: Collaborate with vendors who place a high priority on sustainable water management techniques throughout their supply chains and business operations.

E-Waste:

The responsible management of electronic waste (e-waste) has become imperative for both individuals and organizations involved in Information Technology (IT). Adopting sustainable e-waste management practices is not only morally required, but also a crucial first step in reducing the negative environmental effects of the digital era. It is crucial to consider the environmental impact of IT practices and equipment as we work towards technological innovation and advancement. E-waste management is not just a compliance requirement; it is a fundamental pillar of sustainability that can positively impact our planet and ensure a better future for generations to come:

Inventory and Assessment: Perform a complete inventory of your IT assets to spot any hardware that is outdated or towards the end of its useful life. This assessment will help you understand the scale of your e-waste challenge.

Reuse and Recycling: Prioritize the reuse of IT equipment whenever possible. Devices can have their useful lives extended by being refurbished and redeployed. Partner with accredited e-waste recycling facilities when disposal is required to ensure safe and ethical recycling.

Data Security: To safeguard privacy and adhere to data protection requirements, ensure any sensitive data is safely deleted or destroyed before disposing of any IT equipment.

Education and Awareness: Promote e-waste awareness and best practices among your employees. Encourage responsible e-waste disposal in their personal lives as well.

Circular Economy: Explore opportunities to participate in the circular economy by considering eco-design principles, repairability, and the use of recycled materials in your IT products and services.

Supplier Engagement: Work with those who prioritize sustainability and provide take-back programmes to promote ethical disposal and recycling.

Emissions:

In the fast-paced world of Information Technology, where efficiency and innovation are of utmost importance, it is imperative to address the environmental impact of business operations. Businesses in the IT sector must be proactive in reducing emissions and promoting a more sustainable future as the world struggles with climate change and its far-reaching consequences. It is our collective responsibility to lead the way in addressing emissions and ensuring a sustainable planet for future generations. By implementing these recommendations, IT organizations can reduce their carbon footprint, minimize environmental impact, and contribute to a greener, more sustainable future:

Adopt Energy-Efficient Hardware and Infrastructure: Investing in energy-efficient hardware and infrastructure is one of the most efficient strategies to lower emissions in the IT industry. Choose servers, data centers, and networking equipment that are designed for optimal energy consumption. The use of virtualization and cloud computing can also significantly reduce energy use and, as a result, emissions.

Promote Remote Work and Telecommuting: The COVID-19 pandemic has shown that remote work is both feasible and beneficial. Encouragement of telecommuting and remote work reduces the carbon footprint associated with travel while also enabling more flexible work schedules, increasing employee retention and satisfaction.

Embrace Renewable Energy Sources: Data centers and IT facilities that switch to renewable energy sources, such solar or wind power, can significantly reduce emissions. Many governments and organizations offer incentives and support for this transition.

Optimize Software and Application Development: Efficient software and application development practices can significantly reduce energy consumption and emissions. Encourage developers to write efficient code, minimize resource-intensive processes, and employ energy-efficient algorithms.

Regularly Update and Maintain Equipment: Outdated hardware and software often consume more energy and emit more emissions than their newer counterparts. Maintain IT equipment with regular updates to ensure optimal performance.

Educate and Engage Employees: Raise awareness among employees about the importance of sustainability in IT. Encourage them to incorporate energy-saving techniques into their regular work, such shutting off devices when not in use and practicing responsible printing techniques.

Collaborate with Suppliers and Partners: Work together with suppliers and partners to make sustainability a shared objective along the whole supply chain. Select suppliers who place a high priority on sustainable practices and products.

Measure and Report Emissions: Establish reliable procedures for measuring and reporting emissions to monitor progress towards sustainability objectives. Transparency in reporting emissions is crucial for accountability and improvement. Establish clear and ambitious emissions reduction goals for your IT department or organization as a whole. Regularly assess progress and adjust strategies to meet these goals.

Copper:

Leveraging copper's unique properties and its ethical sourcing can result in reduced environmental impacts, increased energy efficiency, and extended product life cycles, embracing copper in information technology for sustainability purposes is a prudent choice. By prioritizing copper's sustainable use, IT professionals can contribute to a greener and more environmentally responsible future for the industry:

Energy Efficiency: Copper is an excellent heat and electricity conductor, making it an ideal material for IT component electrical wiring. IT equipment can run more effectively, lowering energy consumption and greenhouse gas emissions, by utilizing copper-based wiring and heat sinks. This promotes energy conservation and lowers the carbon footprint of IT systems.

Longevity and Durability: Copper is highly corrosion-resistant and durable, extending the life of IT infrastructure. By incorporating copper components in IT hardware, businesses can reduce the frequency of replacements and upgrades, ultimately decreasing electronic waste generation and the associated environmental impact.

Responsible Sourcing: To maximize the sustainability benefits of copper, it's crucial to prioritize responsible sourcing practices. Ensure that the copper used in IT products is mined in a way that has little impact on the environment and on society. Supporting certified mines and adhering to responsible sourcing standards such as those established by the Responsible Copper Initiative can help maintain copper's sustainability credentials.

Recycling Potential: Copper is one of the most recycled materials globally. Encourage the recycling of obsolete IT equipment containing copper components to recover valuable resources and reduce the demand for virgin materials. Increase awareness among IT users and implement recycling programmes to advance the circular economy concept.

Tantalum:

Tantalum, a rare metal often used in the production of electronic components. It has a number of advantages that make it a desirable choice for organizations and IT professionals that are concerned about sustainability. Tantalum is a promising material for improving sustainability in information technology because of its ethical sourcing, recyclability, durability, and energy efficiency. IT professionals and organizations should consider integrating tantalum into their supply chains and product designs as part of their commitment to reducing the industry's environmental impact:

Recycling Potential: Tantalum has a significant potential for recycling. Given the finite nature of tantalum resources, recycling can play a pivotal role in reducing the environmental impact associated with mining and extraction. We can conserve resources and lower electronic waste by integrating tantalum recycling practices into IT supply chains.

Conflict-Free Sourcing: Tantalum's ethical aspect is worth highlighting. Unlike some other minerals used in IT products, tantalum has made significant progress in terms of responsible sourcing. Initiatives like the Conflict-Free Sourcing Initiative (CFSI) have been established, to ensure that tantalum is sourced from conflict-free areas and thereby reduce the risk of fueling armed conflicts and violating human rights.

Extended Product Life Cycles: Tantalum capacitors are known for their reliability and durability and are frequently used in electronics. Tantalum components allow IT manufacturers to make products with longer life cycles, reducing the need for frequent replacements and lowering overall electronic waste generation.

Miniaturization: Tantalum capacitors are compact and lightweight, making them ideal for miniaturized electronic devices. By enabling the development of smaller, more energy-efficient IT products, the environmental impact is further diminished. Tantalum capacitors perform very well in terms of power management and energy efficiency.

Nickel:

Nickel, a versatile metal widely used in various industries, including information technology, plays a crucial role in advancing sustainability efforts within the IT sector. It is critical to take into account the environmental and social effects related to the materials used in these devices, as society increasingly relies on digital technologies. It is essential to manage its use responsibly by focusing on resource efficiency, energy efficiency, recyclability, responsible sourcing, and ongoing research and innovation. It is highly recommended to manage it efficiently, as nickel can make a substantial contribution to information technology sustainability goals:

Supply Chain Responsibility: It's essential for IT manufacturers to source nickel responsibly, taking into account social and environmental considerations. Ethical sourcing practices can help to mitigate the negative effects of nickel mining, including habitat disruption and abuses of human rights.

Energy Efficiency: Nickel plays a crucial role in the batteries that power numerous IT devices. Longer battery life and greater energy efficiency have been made possible by advancements in nickel-based battery technology, including lithium-ion batteries. This directly contributes to reduced energy consumption and the carbon footprint of IT products.

Recyclability: Nickel is highly recyclable, making it an environmentally friendly choice. Incorporating recycling programs for nickel-containing IT components ensures that valuable resources are not lost, and it reduces the demand for newly mined nickel, which can have adverse environmental impacts. Innovation in this field can lead to reduced environmental impacts while maintaining the performance and functionality of IT devices.

Resource Efficiency: The durability and corrosion resistance of nickel helps electronic products like servers, laptops, and smartphones last longer. By enhancing the longevity of IT equipment, it reduces the need for frequent replacements, conserving resources and minimizing electronic waste.

Silicon:

To ensure a sustainable future in information technology, it is imperative that industry leaders, researchers, and policymakers continue to prioritize and invest in silicon-based technologies. By doing so, we can harness silicon's incredible power to improve renewable energy technologies, enhance electronic waste reduction, and promote energy efficiency. Its unique properties and versatile applications contribute significantly to advancing eco-friendly practices and achieving sustainability goals. Collaboration across sectors and the adoption of best practices in silicon manufacturing and recycling will be key to realizing these sustainability benefits:

Recycling: Silicon-based electronic components are highly recyclable. The environmental impact of disposing of electronic waste can be reduced by using appropriate recycling procedures to recover valuable elements from outdated devices, including silicon.

Energy Efficiency: Silicon manufacturing processes have continuously evolved to reduce power consumption while maintaining performance. This directly translates into less energy being used by data centers and personal electronics, contributing to reduced carbon emissions.

Longevity and Durability: Silicon-based components are known for their durability and long lifespan. This means that electronic devices built with silicon tend to last longer, reducing the need for frequent replacements and thereby reducing electronic waste, a significant sustainability concern. The technology industry continually invests in research to improve the sustainability of silicon-based technologies.

Renewable Energy Technologies: Silicon is a crucial component in the production of solar panels, a crucial technology for switching to renewable energy sources. As the world strives to lessen its dependency on fossil fuels, silicon plays a crucial role in harnessing solar energy efficiently.

5.3 Limitation of the Study:

Research focusing on the financial and ESG performance on the publicly traded IT hardware manufacturing companies is limited, and that in a way limits a researcher's ability to capture more academic articles as he/she wishes, specifically focusing on the research topic.

5.4 Further Studies:

Future research on the subject is advised in order to improve on the most crucial areas and increase the availability of data due to the aforementioned study's limitations.

It is also advised that future research be done in the area, with a particular emphasis on the recommendations noted in the study, with more articles, specific reports of organizations and industry reports.

REFERENCES:

Braccini, Alessio Maria, and Emanuele Gabriel Margherita. 2019. "Exploring Organizational Sustainability of Industry 4.0 under the Triple Bottom Line: The Case of a Manufacturing Company" Sustainability 11, no. 1: 36.

Baryannis, G., Validi, S., Dani, S., & Antoniou, G. (2018). Supply chain risk management and artificial intelligence: state of the art and future research directions. International Journal of Production Research, 1–24. doi:10.1080/00207543.2018.1530476.

Behzadi, G., M. J. O'Sullivan, T. L. Olsen, and A. Zhang. 2018. "Agribusiness Supply Chain Risk Management: A Review of Quantitative Decision Models." Omega 79: 21–42.

Bhaskar, V., & Lallement, P. (2008). Activity routing in a distributed supply chain: Performance evaluation with two inputs. Journal of Network and Computer Applications, 31(4), 402–428.

Balakrishnan, P.G., Ramesh, R., Prem Kumar, T., 2006. Safety mechanisms in lithium-ion batteries. J. Power Sources 155, 401–414

Committee on Armed Services, US Senate (2011) Investigation into counterfeit electronic parts in the Department of Defense Supply Chain.

Chopra, S., and M. S. Sodhi. 2014. "Reducing the Risk of Supply Chain Disruptions." MIT Sloan Management Review Spring (3): 73–80.

Chen, H.M., Kuo, T.C. and Chen, J.L., Impacts on the ESG and financial performances of companies in the manufacturing industry based on the climate change related risks, Journal of Cleaner Production, Volume 380, Part 1, 2022, 134951, ISSN 0959-6526, https://www.sciencedirect.com/science/article/pii/S0959652622045243

Chang, T.C., You, S.J., Yu, B.S., Yao, K.F., 2009. A material flow of lithium batteries in Taiwan. J. Hazard. Mater. 163 (2–3), 910–915.

Collis, J., & Hussey, R. (2021). Business research: A practical guide for undergraduate and postgraduate students. 5th edition. United Kingdom: Palgrave Macmillan.

COP26, 2021. Glasgow climate pact COP26. Glasgow.

Cobbing, Maddy & Cook, Gary & Kruszewska, Iza & Lee, Chih An & Santen, Manfred & Shinn, Melissa. (2016). Cleaning, closing and slowing the loop: the environmental imperative for innovation in the IT Sector.

Democratic Republic of Congo: “This is what we die for”: Human rights abuses in the Democratic Republic of the Congo power the global trade in cobalt. January 19, 2016, Index Number: AFR 62/3183/2016. Amnesty International.
https://www.amnesty.org/en/documents/afr62/3183/2016/en/

D.A. Simchi-Levi, P.A. Kaminsky and E. Simchi-Levi McGraw-Hill, Irwin (2003). Designing and managing the supply chain: concepts, strategies, and case studies.

Department of Justice, Chinese Telecommunications Device Manufacturer and its U.S. Affiliate Indicted for Theft of Trade Secrets, Wire Fraud, and Obstruction Of Justice, (January 28, 2019).

Dhwani Mehta, Hangwei Lu, Olivia P. Paradis, Mukhil Azhagan M. S., M. Tanjidur Rahman, Yousef Iskander, Praveen Chawla, Damon L. Woodard, Mark Tehranipoor, and Navid Asadizanjani. October 2020. The Big Hack Explained: Detection and Prevention of PCB Supply Chain Implants. J. Emerg. Technol. Comput. Syst. 16, 4, Article 42, 25 pages.

Divya, K.C. and Østergaard, J., 2009. Battery energy storage technology for power systems—An overview. Electric power systems research, 79(4), pp.511-520.

Dolgui, A., & Ivanov, D. (2021). Ripple effect and supply chain disruption management: New trends and research directions. International Journal of Production Research, 59 (1), 102–109.

Dolgui, A., Ivanov, D., & Sokolov, B. (2018). Ripple effect in the supply chain: An analysis and recent literature. International Journal of Production Research, 56(1–2), 414–430.

European Union Agency for Cybersecurity. Supply Chain Integrity, An overview of the ICT supply chain risks and challenges, and vision for the way forward. VERSION 1.1, AUGUST 2015. https://www.enisa.europa.eu/publications/sci-2015

European Union Agency for Cybersecurity, THREAT LANDSCAPE FOR SUPPLY CHAIN ATTACKS, JULY 2021.
file:///C:/Users/Pc/Downloads/ENISA%20Threat%20Landscape%20for%20Supply%20Chain%20Attacks%20(3).pdf

GREENPEACE, Resource Efficiency in the ICT Sector. Final Report, November 2016.
https://www.greenpeace.org/static/planet4-international-stateless/2017/10/952ef054-20161109_oeko_resource_efficency_final_full-report.pdf

George Baryannis, Sahar Validi, Samir Dani and Grigoris Antoniou, 2018. Supply Chain Risk Management and Artificial Intelligence: State of the Art and Future Research Directions.
https://pure.hud.ac.uk/ws/files/14514165/2018_IJPR.pdf

Gartner, Gartner Says Worldwide Smartphone Sales Grew 9.7 Percent in Fourth Quarter of 2015 - Global Smartphone Sales Exhibited Slowest Growth Since 2008, February 18, 2016.

Hou, H.; Zhu, Y.; Wang, J.; Zhang, M. 2023. Will Green Financial Policy Help Improve China's Environmental Quality? The Role of Digital Finance and Green Technology Innovation. Environ. Sci. Pollut. Res. 2023, 30, 10527–10539.

Hassoun, J., Panero, S., Reale, P., Scrosati, B., 2009. A new, safe, high-rate and high-energy polymer lithium-ion battery. Adv. Mater. 21, 4807–4810.

Hao, H., Liu, Z., Zhao, F., Geng, Y., Sarkis, J., 2017. Material flow analysis of lithium in China. Resour. Policy 51, 100–106.

Hamilton, C., Turton, H., 2002. Determinants of emissions growth in OECD countries. Energy Policy 30, 63–71

ICT SUPPLY CHAIN RISK MANAGEMENT, cybersecurity and infrastructure security agency, https://www.cisa.gov/sites/default/files/publications/factsheet_ict-scrm_508_1.pdf

Ivanov, D. (2020). Predicting the impacts of epidemic outbreaks on global supply chains: A simulation-based analysis on the coronavirus outbreak (COVID-19/SARS-CoV-2) case. Transportation Research Part E: Logistics and Transportation Review, 136, 101922.

ICT SUPPLY CHAIN RISK MANAGEMENT, 2021. Cybersecurity & Infrastructure Security Agency.
https://www.cisa.gov/sites/default/files/publications/ict-scrm_factsheet_Dec-2021_508.pdf#:~:text=Coordination

Ivanov, D., Sokolov, B., & Dolgui, A. (2014). The Ripple effect in supply chains: Trade-off 'efficiency-flexibility-resilience' in disruption management. International Journal of Production Research, 52(7), 2154–2172

Ivanov, D., Rozhkov, M. Coordination of production and ordering policies under capacity disruption and product write-off risk: an analytical study with real-data based simulations of a fast moving consumer goods company. Ann Oper Res 291, 387–407 (2020).

Javadi, S., Masum, A.-A., 2021. The impact of climate change on the cost of bank loans. J. Corp. Finance 69, 102019.

Jessica Haworth, August 2021. Four-fold increase in software supply chain attacks predicted in 2021 – report
https://portswigger.net/daily-swig/four-fold-increase-in-software-supply-chain-attacks-predicted-in-2021-report

J. Karim, T. Somers and A. Bhattacherjee (2007). The impact of ERP implementation on business process outcomes: a factor-based study, Journal of Management Information Systems, 24, pp. 101-134.

KPMG International Cooperative, 2020. The KPMG Survey of Sustainability Reporting
2020. KPMG Publishing. Me-has-come-survey-of-sustainability-reporting.html.

Kuper, A., Lingard, L., & Levinson, W. (2008). Critically appraising qualitative research. BMJ, 337(aug 07 3), a1035–a1035.

Kahn, M.E., Mohaddes, K., Ng, R.N., Pesaran, M.H., Raissi, M., Yang, J.-C., 2019. Long Term Macroeconomic Effects of Climate Change: A Cross-Country Analysis (0898-2937).

Ken Sigler, Dan Shoemaker, Anne Kohnke, 2017. “Control Sustainment and Operational Assurance”, Supply Chain Risk Management, Applying Secure Acquisition Principles to Ensure a Trusted Technology Product. 1st ed. Vol. 1. United Kingdom: 203-38. Web.

Liu, Z., Deng, Z., Davis, S.J. et al. Monitoring global carbon emissions in 2021. Nat Rev Earth Environ 3, 217–219 (2022).

Lambert, J. H., Keisler, J. M., Wheeler, W. E., Collier, Z. A., & Linkov, I. (2013). Multiscale approach to the security of hardware supply chains for energy systems. Environment Systems and Decisions, 33(3), 326–334. doi:10.1007/s10669-013-9465-2

Lambert, D.M., Cooper, M.C. and Pagh, J.D. (1998), "Supply Chain Management: Implementation Issues and Research Opportunities", The International Journal of Logistics Management, Vol. 9 No. 2, pp. 1-20.

Matthews, A. 2017. “Brexit Impacts on Irish Agri-food Exports to the UK.” EuroChoices 16 (2): 26–32.

Mohd Rizaimy Shaharudin, Kannan Govindan, Suhaiza Zailani, Keah Choon Tan, Mohammad Iranmanesh, 2017. Product return management: Linking product returns, closed-loop supply chain activities and the effectiveness of the reverse supply chains. J. Clean. Prod. 149, 1144–1156.

Miedema, J.H., Moll, H.C., 2013. Lithium availability in the EU27 for battery-driven vehicles: the impact of recycling and substitution on the confrontation between supply. Resour. Policy 38 (2), 211.

Maheshwari, P., Kamble, S., Belhadi, A. et al. Responsive strategies for new normal cold supply chain using greenfield, network optimization, and simulation analysis. Ann Oper Res (2023).

Mellino, S., Petrillo, A., Cigolotti, V., Autorino, C., Jannelli, E., Ulgiati, S., 2017. A Life Cycle Assessment of lithium battery and hydrogen-FC powered electric bicycles: searching for cleaner solutions to urban mobility. Int. J. Hydrogen Energy 42 (3), 1830–1840.

Munich Re Group, 2022. Hurricanes, Cold Waves, Tornadoes: Weather Disasters in USA Dominate Natural Disaster Losses in 2021. Reinsurance. Munich Re Group Publishing.

National Supply Chain Integrity Month, A Spotlight on ICT Supply Chains, April 2022. https://www.dni.gov/files/NCSC/documents/supplychain/ict-supply-chain-spotlight-2022-AB12873B-.pdf

Noudeng, Vongdala, Nguyen Van Quan, and Tran Dang Xuan. 2022. "A Future Perspective on Waste Management of Lithium-Ion Batteries for Electric Vehicles in Lao PDR: Current Status and Challenges" International Journal of Environmental Research and Public Health 19, no. 23: 16169. https://doi.org/10.3390/ijerph192316169

National CounterIntelligence and Security Center, Information and Communications Technology and the Supply Chain Risk, April, 2022. https://www.dni.gov/files/NCSC/documents/supplychain/ict-supply-chain-risk-2022-5BE169B1-.pdf

Nordhaus, W. 2019. Climate Change: The Ultimate Challenge for Economics. Am. Econ. Rev. 2019, 109, 1991–2014.

Nicolas Tsurukawa, Siddharth Prakash, Andreas Manhart. Social impacts of artisanal cobalt mining in Katanga, Democratic Republic of Congo. Freiburg, November, 2011. Institut fur angewandte Okologie institute for applied ecology, https://www.oeko.de/oekodoc/1294/2011-419-en.pdf

Pankratz, N., Bauer, R., Derwall, J., 2019. Climate change, firm performance, and investor surprises. Firm Performance, and Investor Surprises 1–76.

Risk Response Network. 2012. New Models for Addressing Supply Chain and Transport Risk. Geneva: World Economic Forum. Industry Agenda.

Rangel, D. A., de Oliveira, T. K., & Leite, M. S. A. (2015). Supply chain risk classification: Discussion and proposal. International Journal of Production Research, 53(22), 6868–6887.

Richa, K., Babbitt, C.W., Gaustad, G., Wang, X., 2014. A future perspective on lithium-ion battery waste flows from electric vehicles. Resour. Conserv. Recycl. 83, 63–76.

Saunders, M., Lewis, P., & Thornhill, A. (2019). Research methods for business students 8th edition. Pearson Education.

Sara Saberi, Mahtab Kouhizadeh, Joseph Sarkis & Lejia Shen (2019). Blockchain technology and its relationships to sustainable supply chain management, International Journal of Production Research, 57:7, 2117-2135.

Samuel, Gabrielle, Federica Lucivero, and Lucas Somavilla. 2022. "The Environmental Sustainability of Digital Technologies: Stakeholder Practices and Perspectives" Sustainability 14, no. 7: 3791.

Snyder, L. V., Z. Atan, P. Peng, Y. Rong, A. J. Schmitt, and B. Sinsoysal. 2016. “OR/MS Models for Supply Chain Disruptions: A Review.” IIE Transactions (Institute of Industrial Engineers) 48 (2): 89–109. Cited By 41.

Sun, X., Hao, H., Zhao, F., & Liu, Z. (2017). Tracing global lithium flow: A trade-linked material flow analysis. Resources, Conservation and Recycling, 124, 50–61.

Slack, J.F., Kimball, B.E., and Shedd, K.B., 2017, Cobalt, chap. F of Schulz, K.J., DeYoung, J.H., Jr., Seal, R.R., II, and Bradley, D.C., eds., Critical mineral resources of the United States—Economic and environmental geology and prospects for future supply: U.S. Geological Survey Professional Paper 1802, p. F1–F40.

Stern, N., 2007. The Economics of Climate Change: The Stern Review. Cambridge University Press, UK

Saunders M., Lewis P. & Thornhill, A. (2016). Research Methods for Business Students. 7th edition. Essex: Pearson Education Limited. E-book.

Sood B, Das D, Pecht M (2011) Screening for counterfeit electronic parts. J Mater Sci: Mater Electron 22:1511–1522

Tarokh MJ, Soroor J. (2006). Supply chain management information systems critical failure factors. In: IEEE international conference on service operations and logistics, and informatics. SOLI ‘06, p. 425–31.

Tahil, W., 2007. The trouble with lithium. Implications of Future PHEV Production for Lithium Demand. Martainville: Meridian International Research.

Ta-Ping Lu, Amy J.C. Trappey, Yi-Kuang Chen, Yu-Da Chang, Collaborative design and analysis of supply chain network management key processes model, Journal of Network and Computer Applications, Volume 36, Issue 6, 2013, Pages 1503-1511, ISSN 1084-8045, https://www.sciencedirect.com/science/article/pii/S1084804513001021

Taiwanese suppliers for Apple, HP, Google failing in renewable energy ranking. 30 May 2019. Greenpeace International. https://www.greenpeace.org/international/press-release/22139/taiwanese-suppliers-for-apple-hp-google-failing-in-renewable-energy-ranking/

Topping, C., Dwyer, A., Michalec, O., Craggs, B., & Rashid, A. (2021). Beware suppliers bearing gifts!: Analysing coverage of supply chain cyber security in critical national infrastructure sectorial and cross-sectorial frameworks. Computers & Security, 108, 102324.

U.S. DEPARTMENT OF COMMERCE AND U.S. DEPARTMENT OF HOMELAND SECURITY FEBRUARY 24, 2022, ASSESSMENT OF THE CRITICAL SUPPLY CHAINS SUPPORTING THE U.S. INFORMATION AND COMMUNICATIONS TECHNOLOGY INDUSTRY. https://www.dhs.gov/sites/default/files/2022-02/ICT%20Supply%20Chain%20Report_2.pdf

US Department of Homeland Security, Cybersecurity & Infrastructure Security Agency, ICT SUPPLY CHAIN RISK MANAGEMENT.
https://www.cisa.gov/sites/default/files/publications/factsheet_ict-scrm_508_1.pdf

USGS, 2014. Minerals Yearbook Lithium. United States Geological Survey.
https://minerals.usgs.gov/minerals/pubs/commodity/lithium/

USGS, 2016. Mineral Commodity Summaries 2016. United States Geological Survey. https://minerals.usgs.gov/minerals/pubs/commodity/lithium/

Vanessa Forti, Cornelis Peter Baldé, Ruediger Kuehr, Garam Bel, 2020. The Global E-waste Monitor. Quantities, flows, and the circular economy potential.

World Health Organization, World Health Report. 2003, Geneva.

World Health Organization, United Nations Children's Fund, and Water Supply and Sanitation Collaborative Council, Global Water Supply and Sanitation Assessment 2000 Report. 2000.

Wu, I.-L., & Chuang, C.-H. (2009). Analyzing contextual antecedents for the stage-based diffusion of electronic supply chain management. Electronic Commerce Research and Applications, 8(6), 302–314. doi:10.1016/j.elerap.2009.04.013

Yubo Liu, Baozhong Ma, Yingwei Lü, Chengyan Wang, and Yongqiang Chen, A review of lithium extraction from natural resources, Int. J. Miner. Metall. Mater., 30(2023), No. 2, pp. 209-224.

Yinug F (2009) Challenges to foreign investment in high-tech semiconductor production in China. J Int Commer Econ 2:197–226

Zeng, X., Li, J., 2013. Implications for the carrying capacity of lithium reserve in China. Resour. Conserv. Recycl. 80, 58–63.

Ziemann, S., Weil, M., Schebek, L., 2012. Tracing the fate of lithium-the development of a material flow model. Resou. Conserv. Recycl. 63, 26–34.

Appendix:

Fig.4 Cobalt tone and percentages.

Sum of Cobalt	Column Labels			
Row Labels	negative	neutral	positive	Grand Total
Advanced Micro Devices Inc		1	0	1
Alphabet/Google		0	3	3
Apple		0	3	3
Applied Materials Inc		0	1	1
Broadcom Inc		0	0	0
Cisco Systems, Inc		1	0	1
HP Inc.		0	1	1
Intel Corporation		0	2	2
International Business Machines Corporation			1	1
Meta Platforms Inc			0	0
Micron Technology		1	1	2
Microsoft Corp		1	1	2
NVIDIA Corp	0	0	3	3
QUALCOMM Incorporated	0	0	0	0
Texas Instruments Incorporated		1	0	1
Grand Total	**0**	**5**	**16**	**21**

Sum of Cobalt	Column Labels			
Row Labels	negative	neutral	positive	Grand Total
Advanced Micro Devices Inc	0.00%	4.76%	0.00%	4.76%
Alphabet/Google	0.00%	0.00%	14.29%	14.29%
Apple	0.00%	0.00%	14.29%	14.29%
Applied Materials Inc	0.00%	0.00%	4.76%	4.76%
Broadcom Inc	0.00%	0.00%	0.00%	0.00%
Cisco Systems, Inc	0.00%	4.76%	0.00%	4.76%
HP Inc.	0.00%	0.00%	4.76%	4.76%
Intel Corporation	0.00%	0.00%	9.52%	9.52%
International Business Machines Corporation	0.00%	0.00%	4.76%	4.76%
Meta Platforms Inc	0.00%	0.00%	0.00%	0.00%
Micron Technology	0.00%	4.76%	4.76%	9.52%
Microsoft Corp	0.00%	4.76%	4.76%	9.52%
NVIDIA Corp	0.00%	0.00%	14.29%	14.29%
QUALCOMM Incorporated	0.00%	0.00%	0.00%	0.00%
Texas Instruments Incorporated	0.00%	4.76%	0.00%	4.76%
Grand Total	**0.00%**	**23.81%**	**76.19%**	**100.00%**

Fig.13 Numeric info./goal

Sum of Cobalt	Column Labels		
Row Labels	neutral	positive	Grand Total
Advanced Micro Devices Inc	1	0	1
Alphabet/Google		3	3
Apple	0	3	3
Applied Materials Inc	0	1	1
Broadcom Inc	0	0	0
Cisco Systems, Inc	1	0	1
HP Inc.	0	1	1
Intel Corporation	0	2	2
International Business Machines Corporation		1	1
Meta Platforms Inc		0	0
Micron Technology	1	1	2
Microsoft Corp	1	1	2
NVIDIA Corp	0	3	3
QUALCOMM Incorporated		0	0
Texas Instruments Incorporated	1	0	1
Grand Total	**5**	**16**	**21**

numeric info./goal

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Fig.14 Active voice

Sum of Cobalt	Column Labels			
Row Labels	negative	neutral	positive	Grand Total
Advanced Micro Devices Inc		1	0	1
Alphabet/Google		0	3	3
Apple		0	3	3
Applied Materials Inc			1	1
Broadcom Inc		0	0	0
Cisco Systems, Inc		1	0	1
HP Inc.		0	1	1
Intel Corporation		0	2	2
International Business Machines Corporation			1	1
Meta Platforms Inc			0	0
Micron Technology		1	1	2
Microsoft Corp		1	1	2
NVIDIA Corp		0	3	3
QUALCOMM Incorporated	0	0	0	0
Texas Instruments Incorporated		1	0	1
Grand Total	**0**	**5**	**16**	**21**

active/passive v...

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Fig.15 Time orientation

Sum of Cobalt	Column Labels									
	future		future Total	past		past Total	present			present Total
Row Labels	neutral	positive		neutral	positive		negative	neutral	positive	
Advanced Micro Devices Inc		0	0		0	0		1	0	1
Alphabet/Google		0	0	0	2	2			1	1
Apple		0	0	0	2	2			1	1
Applied Materials Inc	0	0	0		0	0			1	1
Broadcom Inc		0	0	0	0	0		0	0	0
Cisco Systems, Inc				1		1		0	0	0
HP Inc.	0	0	0		0	0		0	1	1
Intel Corporation		0	0	0	1	1			1	1
International Business Machines Corp.		0	0		0	0			1	1
Meta Platforms Inc		0	0		0	0			0	0
Micron Technology		0	0	1	0	1			1	1
Microsoft Corp		0	0	0	0	0		1	1	2
NVIDIA Corp		0	0		2	2	0	0	1	1
QUALCOMM Incorporated		0	0		0	0	0	0	0	0
Texas Instruments Incorporated		0	0		0	0		1	0	1
Grand Total	**0**	**0**	**0**	**2**	**7**	**9**	**0**	**3**	**9**	**12**

Fig.5 Lithium tone and percentages

Sum of Lithium	Column Labels			
Row Labels	negative	neutral	positive	Grand Total
Advanced Micro Devices Inc		0	0	0
Alphabet/Google		0	0	0
Apple		0	2	2
Applied Materials Inc		0	0	0
Broadcom Inc		0	0	0
Cisco Systems, Inc		0	0	0
HP Inc.		0	0	0
Intel Corporation		0	0	0
International Business Machines Corporation			0	0
Meta Platforms Inc			0	0
Micron Technology		0	0	0
Microsoft Corp		1	2	3
NVIDIA Corp	0	0	0	0
QUALCOMM Incorporated	0	0	0	0
Texas Instruments Incorporated		0	0	0
Grand Total	**0**	**1**	**4**	**5**

Sum of Lithium	Column Labels			
Row Labels	negative	neutral	positive	Grand Total
Advanced Micro Devices Inc	0.00%	0.00%	0.00%	0.00%
Alphabet/Google	0.00%	0.00%	0.00%	0.00%
Apple	0.00%	0.00%	40.00%	40.00%
Applied Materials Inc	0.00%	0.00%	0.00%	0.00%
Broadcom Inc	0.00%	0.00%	0.00%	0.00%
Cisco Systems, Inc	0.00%	0.00%	0.00%	0.00%
HP Inc.	0.00%	0.00%	0.00%	0.00%
Intel Corporation	0.00%	0.00%	0.00%	0.00%
International Business Machines Corporation	0.00%	0.00%	0.00%	0.00%
Meta Platforms Inc	0.00%	0.00%	0.00%	0.00%
Micron Technology	0.00%	0.00%	0.00%	0.00%
Microsoft Corp	0.00%	20.00%	40.00%	60.00%
NVIDIA Corp	0.00%	0.00%	0.00%	0.00%
QUALCOMM Incorporated	0.00%	0.00%	0.00%	0.00%
Texas Instruments Incorporated	0.00%	0.00%	0.00%	0.00%
Grand Total	**0.00%**	**20.00%**	**80.00%**	**100.00%**

Fig.13 Numeric info./goal

Sum of Lithium	Column Labels		
Row Labels	neutral	positive	Grand Total
Advanced Micro Devices Inc	0	0	0
Alphabet/Google		0	0
Apple	0	2	2
Applied Materials Inc	0	0	0
Broadcom Inc	0	0	0
Cisco Systems, Inc	0	0	0
HP Inc.	0	0	0
Intel Corporation	0	0	0
International Business Machines Corporation		0	0
Meta Platforms Inc		0	0
Micron Technology	0	0	0
Microsoft Corp	1	2	3
NVIDIA Corp	0	0	0
QUALCOMM Incorporated		0	0
Texas Instruments Incorporated	0	0	0
Grand Total	**1**	**4**	**5**

numeric info./goal
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Fig.14 Active voice

Sum of Lithium	Column Labels			
Row Labels	negative	neutral	positive	Grand Total
Advanced Micro Devices Inc		0	0	0
Alphabet/Google		0	0	0
Apple		0	2	2
Applied Materials Inc			0	0
Broadcom Inc		0	0	0
Cisco Systems, Inc		0	0	0
HP Inc.		0	0	0
Intel Corporation		0	0	0
International Business Machines Corporation			0	0
Meta Platforms Inc			0	0
Micron Technology		0	0	0
Microsoft Corp		1	2	3
NVIDIA Corp		0	0	0
QUALCOMM Incorporated	0	0	0	0
Texas Instruments Incorporated		0	0	0
Grand Total	**0**	**1**	**4**	**5**

active/passive v...
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Fig.15 Time orientation

Sum of Lithium	Column Labels									
	future		future Total	past		past Total	present			present Total
Row Labels	neutral	positive		neutral	positive		negative	neutral	positive	
Advanced Micro Devices Inc		0	0		0	0		0	0	0
Alphabet/Google		0	0	0	0	0			0	0
Apple		1	1	0	0	0			1	1
Applied Materials Inc	0	0	0		0	0			0	0
Broadcom Inc		0	0	0	0	0		0	0	0
Cisco Systems, Inc				0		0		0	0	0
HP Inc.	0	0	0		0	0		0	0	0
Intel Corporation		0	0	0	0	0			0	0
International Business Machines Corp.		0	0		0	0			0	0
Meta Platforms Inc		0	0		0	0			0	0
Micron Technology		0	0	0	0	0			0	0
Microsoft Corp		1	1	0	0	0		1	1	2
NVIDIA Corp		0	0		0	0	0	0	0	0
QUALCOMM Incorporated		0	0		0	0	0	0	0	0
Texas Instruments Incorporated		0	0		0	0		0	0	0
Grand Total	**0**	**2**	**2**	**0**	**0**	**0**	**0**	**1**	**2**	**3**

Fig.6 Water tone and percentages

Sum of Water	Column Labels			
Row Labels	negative	neutral	positive	Grand Total
Advanced Micro Devices Inc		0	5	5
Alphabet/Google		1	5	6
Apple		1	1	2
Applied Materials Inc		0	2	2
Broadcom Inc		1	4	5
Cisco Systems, Inc		1	1	2
HP Inc.		0	3	3
Intel Corporation		1	5	6
International Business Machines Corporation			3	3
Meta Platforms Inc			7	7
Micron Technology		0	5	5
Microsoft Corp		0	6	6
NVIDIA Corp	1	0	5	6
QUALCOMM Incorporated	1	0	6	7
Texas Instruments Incorporated		0	4	4
Grand Total	**2**	**5**	**62**	**69**

Sum of Water	Column Labels			
Row Labels	negative	neutral	positive	Grand Total
Advanced Micro Devices Inc	0.00%	0.00%	7.25%	7.25%
Alphabet/Google	0.00%	1.45%	7.25%	8.70%
Apple	0.00%	1.45%	1.45%	2.90%
Applied Materials Inc	0.00%	0.00%	2.90%	2.90%
Broadcom Inc	0.00%	1.45%	5.80%	7.25%
Cisco Systems, Inc	0.00%	1.45%	1.45%	2.90%
HP Inc.	0.00%	0.00%	4.35%	4.35%
Intel Corporation	0.00%	1.45%	7.25%	8.70%
International Business Machines Corporation	0.00%	0.00%	4.35%	4.35%
Meta Platforms Inc	0.00%	0.00%	10.14%	10.14%
Micron Technology	0.00%	0.00%	7.25%	7.25%
Microsoft Corp	0.00%	0.00%	8.70%	8.70%
NVIDIA Corp	1.45%	0.00%	7.25%	8.70%
QUALCOMM Incorporated	1.45%	0.00%	8.70%	10.14%
Texas Instruments Incorporated	0.00%	0.00%	5.80%	5.80%
Grand Total	**2.90%**	**7.25%**	**89.86%**	**100.00%**

Fig.13 Numeric info./goal

Sum of Water	Column Labels		
Row Labels	neutral	positive	Grand Total
Advanced Micro Devices Inc	0	4	4
Alphabet/Google		5	5
Apple	1	1	2
Applied Materials Inc	0	2	2
Broadcom Inc	1	4	5
Cisco Systems, Inc	1	1	2
HP Inc.	0	3	3
Intel Corporation	1	5	6
International Business Machines Corporation		3	3
Meta Platforms Inc		7	7
Micron Technology	0	5	5
Microsoft Corp	0	6	6
NVIDIA Corp	0	5	5
QUALCOMM Incorporated		6	6
Texas Instruments Incorporated	0	4	4
Grand Total	**4**	**61**	**65**

numeric info./goal
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Fig.16 Non numeric info./goal

Sum of Water	Column Labels			
Row Labels	negative	neutral	positive	Grand Total
Advanced Micro Devices Inc			1	1
Alphabet/Google		1		1
Microsoft Corp			0	0
NVIDIA Corp	1			1
QUALCOMM Incorporated	1	0		1
Grand Total	**2**	**1**	**1**	**4**

numeric info./goal

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Fig.14 Active voice

Sum of Water	Column Labels			
Row Labels	negative	neutral	positive	Grand Total
Advanced Micro Devices Inc		0	5	5
Alphabet/Google		1	5	6
Apple		1	1	2
Applied Materials Inc			2	2
Broadcom Inc		1	4	5
Cisco Systems, Inc		1	1	2
HP Inc.		0	3	3
Intel Corporation		1	5	6
International Business Machines Corporation			3	3
Meta Platforms Inc			7	7
Micron Technology		0	5	5
Microsoft Corp		0	6	6
NVIDIA Corp		0	5	5
QUALCOMM Incorporated	1	0	6	7
Texas Instruments Incorporated		0	4	4
Grand Total	**1**	**5**	**62**	**68**

active/passive v...

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Fig.17 passive voice

Sum of Water	Column Labels			
Row Labels	negative	neutral	positive	Grand Total
Applied Materials Inc		0		0
NVIDIA Corp	1		0	1
Grand Total	**1**	**0**	**0**	**1**

active/passive v...

0

1

Fig.15 Time orientation

Sum of Water	Column Labels									
	future		future Total	past		past Total	present			present Total
Row Labels	neutral	positive		neutral	positive		negative	neutral	positive	
Advanced Micro Devices Inc		1	1		4	4		0	0	0
Alphabet/Google		3	3	1	1	2			1	1
Apple		0	0	1	0	1			1	1
Applied Materials Inc	0	0	0		1	1			1	1
Broadcom Inc		0	0	1	2	3		0	2	2
Cisco Systems, Inc				1		1		0	1	1
HP Inc.	0	0	0		2	2		0	1	1
Intel Corporation		2	2	1	3	4			0	0
International Business Machines Corp.		0	0		3	3			0	0
Meta Platforms Inc		2	2		3	3			2	2
Micron Technology		3	3	0	1	1			1	1
Microsoft Corp		3	3	0	2	2		0	1	1
NVIDIA Corp		1	1		2	2	1	0	2	3
QUALCOMM Incorporated		1	1		2	2	1	0	3	4
Texas Instruments Incorporated		1	1		2	2		0	1	1
Grand Total	**0**	**17**	**17**	**5**	**28**	**33**	**2**	**0**	**17**	**19**

Fig.7 E-Waste tone and percentages

Sum of E-waste Row Labels	Column Labels negative	neutral	positive	Grand Total
Advanced Micro Devices Inc		0	1	1
Alphabet/Google		0	0	0
Apple		0	1	1
Applied Materials Inc		0	0	0
Broadcom Inc		0	3	3
Cisco Systems, Inc		0	0	0
HP Inc.		0	1	1
Intel Corporation		0	2	2
International Business Machines Corporation			0	0
Meta Platforms Inc			0	0
Micron Technology		0	0	0
Microsoft Corp		0	3	3
NVIDIA Corp	0	0	2	2
QUALCOMM Incorporated	0	0	0	0
Texas Instruments Incorporated		0	0	0
Grand Total	**0**	**0**	**13**	**13**

Sum of E-waste Row Labels	Column Labels negative	neutral	positive	Grand Total
Advanced Micro Devices Inc	0.00%	0.00%	7.69%	7.69%
Alphabet/Google	0.00%	0.00%	0.00%	0.00%
Apple	0.00%	0.00%	7.69%	7.69%
Applied Materials Inc	0.00%	0.00%	0.00%	0.00%
Broadcom Inc	0.00%	0.00%	23.08%	23.08%
Cisco Systems, Inc	0.00%	0.00%	0.00%	0.00%
HP Inc.	0.00%	0.00%	7.69%	7.69%
Intel Corporation	0.00%	0.00%	15.38%	15.38%
International Business Machines Corporation	0.00%	0.00%	0.00%	0.00%
Meta Platforms Inc	0.00%	0.00%	0.00%	0.00%
Micron Technology	0.00%	0.00%	0.00%	0.00%
Microsoft Corp	0.00%	0.00%	23.08%	23.08%
NVIDIA Corp	0.00%	0.00%	15.38%	15.38%
QUALCOMM Incorporated	0.00%	0.00%	0.00%	0.00%
Texas Instruments Incorporated	0.00%	0.00%	0.00%	0.00%
Grand Total	**0.00%**	**0.00%**	**100.00%**	**100.00%**

Fig.13 Numeric info./goal

Sum of E-waste Row Labels	Column Labels neutral	positive	Grand Total
Advanced Micro Devices Inc	0	0	0
Alphabet/Google		0	0
Apple	0	1	1
Applied Materials Inc	0	0	0
Broadcom Inc	0	3	3
Cisco Systems, Inc	0	0	0
HP Inc.	0	1	1
Intel Corporation	0	2	2
International Business Machines Corporation		0	0
Meta Platforms Inc		0	0
Micron Technology	0	0	0
Microsoft Corp	0	2	2
NVIDIA Corp	0	2	2
QUALCOMM Incorporated		0	0
Texas Instruments Incorporated	0	0	0
Grand Total	**0**	**11**	**11**

numeric info./goal
- 0
- 1
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Fig.16 Non numeric info./goal

Sum of E-waste Row Labels	Column Labels negative	neutral	positive	Grand Total
Advanced Micro Devices Inc			1	1
Alphabet/Google		0		0
Microsoft Corp			1	1
NVIDIA Corp	0			0
QUALCOMM Incorporated	0	0		0
Grand Total	**0**	**0**	**2**	**2**

numeric info./goal
- 0
- 1
- (blank)

Fig.14 Active voice

Sum of E-waste	Column Labels			
Row Labels	negative	neutral	positive	Grand Total
Advanced Micro Devices Inc		0	1	1
Alphabet/Google		0	0	0
Apple		0	1	1
Applied Materials Inc			0	0
Broadcom Inc		0	3	3
Cisco Systems, Inc		0	0	0
HP Inc.		0	1	1
Intel Corporation		0	2	2
International Business Machines Corporation			0	0
Meta Platforms Inc			0	0
Micron Technology		0	0	0
Microsoft Corp		0	3	3
NVIDIA Corp		0	2	2
QUALCOMM Incorporated	0	0	0	0
Texas Instruments Incorporated		0	0	0
Grand Total	**0**	**0**	**13**	**13**

active/passive v...
- 0
- 1
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Fig.15 Time orientation

Sum of E-waste	Column Labels									
	future		future Total	past		past Total	present			present Total
Row Labels	neutral	positive		neutral	positive		negative	neutral	positive	
Advanced Micro Devices Inc		0	0		1	1		0	0	0
Alphabet/Google		0	0	0	0	0			0	0
Apple		0	0	0	1	1			0	0
Applied Materials Inc	0	0	0		0	0			0	0
Broadcom Inc		0	0	0	2	2		0	1	1
Cisco Systems, Inc				0		0		0	0	0
HP Inc.	0	0	0		1	1		0	0	0
Intel Corporation		0	0	0	1	1			1	1
International Business Machines Corp.		0	0		0	0			0	0
Meta Platforms Inc		0	0		0	0			0	0
Micron Technology		0	0	0	0	0			0	0
Microsoft Corp		1	1	0	2	2		0	0	0
NVIDIA Corp		0	0		1	1	0	0	1	1
QUALCOMM Incorporated		0	0		0	0	0	0	0	0
Texas Instruments Incorporated		0	0		0	0		0	0	0
Grand Total	**0**	**1**	**1**	**0**	**9**	**9**	**0**	**0**	**3**	**3**

Fig.8 Emissions tone and percentages

Sum of Emissions	Column Labels			
Row Labels	negative	neutral	positive	Grand Total
Advanced Micro Devices Inc		0	4	4
Alphabet/Google		0	11	11
Apple		0	3	3
Applied Materials Inc		0	3	3
Broadcom Inc		0	6	6
Cisco Systems, Inc		1	2	3
HP Inc.		1	2	3
Intel Corporation		0	4	4
International Business Machines Corporation			3	3
Meta Platforms Inc			6	6
Micron Technology		0	6	6
Microsoft Corp		1	5	6
NVIDIA Corp	0	1	5	6
QUALCOMM Incorporated	0	0	9	9
Texas Instruments Incorporated		0	6	6
Grand Total	**0**	**4**	**75**	**79**

Sum of Emissions	Column Labels			
Row Labels	negative	neutral	positive	Grand Total
Advanced Micro Devices Inc	0.00%	0.00%	5.06%	5.06%
Alphabet/Google	0.00%	0.00%	13.92%	13.92%
Apple	0.00%	0.00%	3.80%	3.80%
Applied Materials Inc	0.00%	0.00%	3.80%	3.80%
Broadcom Inc	0.00%	0.00%	7.59%	7.59%
Cisco Systems, Inc	0.00%	1.27%	2.53%	3.80%
HP Inc.	0.00%	1.27%	2.53%	3.80%
Intel Corporation	0.00%	0.00%	5.06%	5.06%
International Business Machines Corporation	0.00%	0.00%	3.80%	3.80%
Meta Platforms Inc	0.00%	0.00%	7.59%	7.59%
Micron Technology	0.00%	0.00%	7.59%	7.59%
Microsoft Corp	0.00%	1.27%	6.33%	7.59%
NVIDIA Corp	0.00%	1.27%	6.33%	7.59%
QUALCOMM Incorporated	0.00%	0.00%	11.39%	11.39%
Texas Instruments Incorporated	0.00%	0.00%	7.59%	7.59%
Grand Total	**0.00%**	**5.06%**	**94.94%**	**100.00%**

Fig.13 Numeric info./goal

Sum of Emissions	Column Labels		
Row Labels	neutral	positive	Grand Total
Advanced Micro Devices Inc	0	4	4
Alphabet/Google		11	11
Apple	0	3	3
Applied Materials Inc	0	3	3
Broadcom Inc	0	6	6
Cisco Systems, Inc	1	2	3
HP Inc.	1	2	3
Intel Corporation	0	4	4
International Business Machines Corporation		3	3
Meta Platforms Inc		6	6
Micron Technology	0	6	6
Microsoft Corp	1	5	6
NVIDIA Corp	1	5	6
QUALCOMM Incorporated		9	9
Texas Instruments Incorporated	0	6	6
Grand Total	**4**	**75**	**79**

numeric info./goal
0
1
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Fig.14 Active voice

Sum of Emissions	Column Labels			
Row Labels	negative	neutral	positive	Grand Total
Advanced Micro Devices Inc		0	4	4
Alphabet/Google		0	11	11
Apple		0	3	3
Applied Materials Inc			3	3
Broadcom Inc		0	6	6
Cisco Systems, Inc		1	2	3
HP Inc.		1	2	3
Intel Corporation		0	4	4
International Business Machines Corporation			3	3
Meta Platforms Inc			6	6
Micron Technology		0	6	6
Microsoft Corp		1	5	6
NVIDIA Corp		1	4	5
QUALCOMM Incorporated	0	0	9	9
Texas Instruments Incorporated		0	6	6
Grand Total	**0**	**4**	**74**	**78**

active/passive v...
0
1
(blank)

Fig.17 passive voice

Sum of Emissions	Column Labels			
Row Labels	negative	neutral	positive	Grand Total
Applied Materials Inc		0		0
NVIDIA Corp	0		1	1
Grand Total	**0**	**0**	**1**	**1**

active/passive v...
0
1

Fig.15 Time orientation

Sum of Emissions	Column Labels									
	future		future Total	past		past Total	present			present Total
Row Labels	neutral	positive		neutral	positive		negative	neutral	positive	
Advanced Micro Devices Inc		2	2		2	2		0	0	0
Alphabet/Google		5	5	0	4	4			2	2
Apple		1	1	0	1	1			1	1
Applied Materials Inc	0	1	1		2	2			0	0
Broadcom Inc		1	1	0	3	3		0	2	2
Cisco Systems, Inc				0		0		1	2	3
HP Inc.	1	1	2		1	1		0	0	0
Intel Corporation		2	2	0	2	2			0	0
International Business Machines Corp.		2	2		1	1			0	0
Meta Platforms Inc		2	2		2	2			2	2
Micron Technology		2	2	0	3	3			1	1
Microsoft Corp		2	2	1	2	3		0	1	1
NVIDIA Corp		2	2		2	2	0	1	1	2
QUALCOMM Incorporated		5	5		1	1	0	0	3	3
Texas Instruments Incorporated		2	2		3	3		0	1	1
Grand Total	**1**	**30**	**31**	**1**	**29**	**30**	**0**	**2**	**16**	**18**

Fig.9 Copper tone and percentages

Sum of Coppper	Column Labels			
Row Labels	negative	neutral	positive	Grand Total
Advanced Micro Devices Inc		0	0	0
Alphabet/Google		0	0	0
Apple		0	1	1
Applied Materials Inc		1	0	1
Broadcom Inc		1	0	1
Cisco Systems, Inc		1	0	1
HP Inc.		0	0	0
Intel Corporation		0	2	2
International Business Machines Corporation			0	0
Meta Platforms Inc			0	0
Micron Technology		0	0	0
Microsoft Corp		1	1	2
NVIDIA Corp	0	0	0	0
QUALCOMM Incorporated	0	0	0	0
Texas Instruments Incorporated		0	0	0
Grand Total	**0**	**4**	**4**	**8**

Sum of Coppper	Column Labels			
Row Labels	negative	neutral	positive	Grand Total
Advanced Micro Devices Inc	0.00%	0.00%	0.00%	0.00%
Alphabet/Google	0.00%	0.00%	0.00%	0.00%
Apple	0.00%	0.00%	12.50%	12.50%
Applied Materials Inc	0.00%	12.50%	0.00%	12.50%
Broadcom Inc	0.00%	12.50%	0.00%	12.50%
Cisco Systems, Inc	0.00%	12.50%	0.00%	12.50%
HP Inc.	0.00%	0.00%	0.00%	0.00%
Intel Corporation	0.00%	0.00%	25.00%	25.00%
International Business Machines Corporation	0.00%	0.00%	0.00%	0.00%
Meta Platforms Inc	0.00%	0.00%	0.00%	0.00%
Micron Technology	0.00%	0.00%	0.00%	0.00%
Microsoft Corp	0.00%	12.50%	12.50%	25.00%
NVIDIA Corp	0.00%	0.00%	0.00%	0.00%
QUALCOMM Incorporated	0.00%	0.00%	0.00%	0.00%
Texas Instruments Incorporated	0.00%	0.00%	0.00%	0.00%
Grand Total	**0.00%**	**50.00%**	**50.00%**	**100.00%**

Fig.13 Numeric info./goal

Sum of Coppper	Column Labels		
Row Labels	neutral	positive	Grand Total
Advanced Micro Devices Inc	0	0	0
Alphabet/Google		0	0
Apple	0	1	1
Applied Materials Inc	1	0	1
Broadcom Inc	1	0	1
Cisco Systems, Inc	1	0	1
HP Inc.	0	0	0
Intel Corporation	0	2	2
International Business Machines Corporation		0	0
Meta Platforms Inc		0	0
Micron Technology	0	0	0
Microsoft Corp	1	1	2
NVIDIA Corp	0	0	0
QUALCOMM Incorporated		0	0
Texas Instruments Incorporated	0	0	0
Grand Total	**4**	**4**	**8**

numeric info./goal

- 0
- 1
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Fig.14 Active voice

Sum of Coppper Row Labels	Column Labels negative	neutral	positive	Grand Total
Advanced Micro Devices Inc		0	0	0
Alphabet/Google		0	0	0
Apple		0	1	1
Applied Materials Inc			0	0
Broadcom Inc		1	0	1
Cisco Systems, Inc		1	0	1
HP Inc.		0	0	0
Intel Corporation		0	2	2
International Business Machines Corporation			0	0
Meta Platforms Inc			0	0
Micron Technology		0	0	0
Microsoft Corp		1	1	2
NVIDIA Corp		0	0	0
QUALCOMM Incorporated	0	0	0	0
Texas Instruments Incorporated		0	0	0
Grand Total	**0**	**3**	**4**	**7**

active/passive v...
0
1
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Fig.17 passive voice

Sum of Coppper Row Labels	Column Labels negative	neutral	positive	Grand Total
Applied Materials Inc		1		1
NVIDIA Corp	0		0	0
Grand Total	**0**	**1**	**0**	**1**

active/passive v...
0
1

Fig.15 Time orientation

Sum of Coppper	Column Labels future			past			present			
Row Labels	neutral	positive	future Total	neutral	positive	past Total	negative	neutral	positive	present Total
Advanced Micro Devices Inc		0	0		0	0		0	0	0
Alphabet/Google		0	0	0	0	0			0	0
Apple		0	0	0	0	0			1	1
Applied Materials Inc	1	0	1		0	0			0	0
Broadcom Inc		0	0	0	0	0		1	0	1
Cisco Systems, Inc				1		1		0	0	0
HP Inc.	0	0	0		0	0		0	0	0
Intel Corporation		0	0	0	2	2			0	0
International Business Machines Corp.		0	0		0	0			0	0
Meta Platforms Inc		0	0		0	0			0	0
Micron Technology		0	0	0	0	0			0	0
Microsoft Corp		0	0	0	0	0		1	1	2
NVIDIA Corp		0	0		0	0	0	0	0	0
QUALCOMM Incorporated		0	0		0	0	0	0	0	0
Texas Instruments Incorporated		0	0		0	0		0	0	0
Grand Total	**1**	**0**	**1**	**1**	**2**	**3**	**0**	**2**	**2**	**4**

Fig.10 Tantalum tone and percentages

Sum of Tantalum	Column Labels			
Row Labels	negative	neutral	positive	Grand Total
Advanced Micro Devices Inc		0	1	1
Alphabet/Google		0	1	1
Apple		0	1	1
Applied Materials Inc		0	1	1
Broadcom Inc		0	1	1
Cisco Systems, Inc		1	0	1
HP Inc.		1	0	1
Intel Corporation		0	1	1
International Business Machines Corporation			1	1
Meta Platforms Inc			1	1
Micron Technology		0	1	1
Microsoft Corp		0	2	2
NVIDIA Corp	0	0	3	3
QUALCOMM Incorporated	0	0	0	0
Texas Instruments Incorporated		0	1	1
Grand Total	**0**	**2**	**15**	**17**

Sum of Tantalum	Column Labels			
Row Labels	negative	neutral	positive	Grand Total
Advanced Micro Devices Inc	0.00%	0.00%	5.88%	5.88%
Alphabet/Google	0.00%	0.00%	5.88%	5.88%
Apple	0.00%	0.00%	5.88%	5.88%
Applied Materials Inc	0.00%	0.00%	5.88%	5.88%
Broadcom Inc	0.00%	0.00%	5.88%	5.88%
Cisco Systems, Inc	0.00%	5.88%	0.00%	5.88%
HP Inc.	0.00%	5.88%	0.00%	5.88%
Intel Corporation	0.00%	0.00%	5.88%	5.88%
International Business Machines Corporation	0.00%	0.00%	5.88%	5.88%
Meta Platforms Inc	0.00%	0.00%	5.88%	5.88%
Micron Technology	0.00%	0.00%	5.88%	5.88%
Microsoft Corp	0.00%	0.00%	11.76%	11.76%
NVIDIA Corp	0.00%	0.00%	17.65%	17.65%
QUALCOMM Incorporated	0.00%	0.00%	0.00%	0.00%
Texas Instruments Incorporated	0.00%	0.00%	5.88%	5.88%
Grand Total	**0.00%**	**11.76%**	**88.24%**	**100.00%**

Fig.13 Numeric info./goal

Sum of Tantalum	Column Labels		
Row Labels	neutral	positive	Grand Total
Advanced Micro Devices Inc	0	1	1
Alphabet/Google		1	1
Apple	0	1	1
Applied Materials Inc	0	1	1
Broadcom Inc	0	1	1
Cisco Systems, Inc	1	0	1
HP Inc.	1	0	1
Intel Corporation	0	1	1
International Business Machines Corporation		1	1
Meta Platforms Inc		1	1
Micron Technology	0	1	1
Microsoft Corp	0	2	2
NVIDIA Corp	0	3	3
QUALCOMM Incorporated		0	0
Texas Instruments Incorporated	0	1	1
Grand Total	**2**	**15**	**17**

numeric info./goal

- 0
- 1
- (blank)

Fig.14 Active voice

Sum of Tantalum	Column Labels			
Row Labels	negative	neutral	positive	Grand Total
Advanced Micro Devices Inc		0	1	1
Alphabet/Google		0	1	1
Apple		0	1	1
Applied Materials Inc			1	1
Broadcom Inc		0	1	1
Cisco Systems, Inc		1	0	1
HP Inc.		1	0	1
Intel Corporation		0	1	1
International Business Machines Corporation			1	1
Meta Platforms Inc			1	1
Micron Technology		0	1	1
Microsoft Corp		0	2	2
NVIDIA Corp		0	3	3
QUALCOMM Incorporated	0	0	0	0
Texas Instruments Incorporated		0	1	1
Grand Total	**0**	**2**	**15**	**17**

active/passive v...

- 0
- 1
- (blank)

Fig.15 Time orientation

Sum of Tantalum	Column Labels									
	future		future Total	past		past Total	present			present Total
Row Labels	neutral	positive		neutral	positive		negative	neutral	positive	
Advanced Micro Devices Inc		0	0		0	0		0	1	1
Alphabet/Google		0	0	0	1	1			0	0
Apple		0	0	0	0	0			1	1
Applied Materials Inc	0	0	0		0	0			1	1
Broadcom Inc		0	0	0	0	0		0	1	1
Cisco Systems, Inc				0		0		1	0	1
HP Inc.	0	0	0		0	0		1	0	1
Intel Corporation		0	0	0	0	0			1	1
International Business Machines Corp.		0	0		1	1			0	0
Meta Platforms Inc		0	0		0	0			1	1
Micron Technology		0	0	0	0	0			1	1
Microsoft Corp		0	0	0	1	1		0	1	1
NVIDIA Corp		0	0		2	2	0	0	1	1
QUALCOMM Incorporated		0	0		0	0	0	0	0	0
Texas Instruments Incorporated		0	0		0	0		0	1	1
Grand Total	**0**	**0**	**0**	**0**	**5**	**5**	**0**	**2**	**10**	**12**

Fig.11 Nickel tone and percentages

Sum of Nickel	Column Labels			
Row Labels	negative	neutral	positive	Grand Total
Advanced Micro Devices Inc		0	0	0
Alphabet/Google		0	0	0
Apple		0	1	1
Applied Materials Inc		1	0	1
Broadcom Inc		0	0	0
Cisco Systems, Inc		0	0	0
HP Inc.		0	0	0
Intel Corporation		0	1	1
International Business Machines Corporation			0	0
Meta Platforms Inc			0	0
Micron Technology		0	0	0
Microsoft Corp		1	1	2
NVIDIA Corp	0	0	0	0
QUALCOMM Incorporated	0	0	0	0
Texas Instruments Incorporated		0	0	0
Grand Total	**0**	**2**	**3**	**5**

Sum of Nickel	Column Labels			
Row Labels	negative	neutral	positive	Grand Total
Advanced Micro Devices Inc	0.00%	0.00%	0.00%	0.00%
Alphabet/Google	0.00%	0.00%	0.00%	0.00%
Apple	0.00%	0.00%	20.00%	20.00%
Applied Materials Inc	0.00%	20.00%	0.00%	20.00%
Broadcom Inc	0.00%	0.00%	0.00%	0.00%
Cisco Systems, Inc	0.00%	0.00%	0.00%	0.00%
HP Inc.	0.00%	0.00%	0.00%	0.00%
Intel Corporation	0.00%	0.00%	20.00%	20.00%
International Business Machines Corporation	0.00%	0.00%	0.00%	0.00%
Meta Platforms Inc	0.00%	0.00%	0.00%	0.00%
Micron Technology	0.00%	0.00%	0.00%	0.00%
Microsoft Corp	0.00%	20.00%	20.00%	40.00%
NVIDIA Corp	0.00%	0.00%	0.00%	0.00%
QUALCOMM Incorporated	0.00%	0.00%	0.00%	0.00%
Texas Instruments Incorporated	0.00%	0.00%	0.00%	0.00%
Grand Total	**0.00%**	**40.00%**	**60.00%**	**100.00%**

Fig.13 Numeric info./goal

Sum of Nickel	Column Labels		
Row Labels	neutral	positive	Grand Total
Advanced Micro Devices Inc	0	0	0
Alphabet/Google		0	0
Apple	0	1	1
Applied Materials Inc	1	0	1
Broadcom Inc	0	0	0
Cisco Systems, Inc	0	0	0
HP Inc.	0	0	0
Intel Corporation	0	1	1
International Business Machines Corporation		0	0
Meta Platforms Inc		0	0
Micron Technology	0	0	0
Microsoft Corp	1	1	2
NVIDIA Corp	0	0	0
QUALCOMM Incorporated		0	0
Texas Instruments Incorporated	0	0	0
Grand Total	**2**	**3**	**5**

numeric info./goal

- 0
- 1
- (blank)

Fig.14 Active voice

Sum of Nickel	Column Labels			
Row Labels	negative	neutral	positive	Grand Total
Advanced Micro Devices Inc		0	0	0
Alphabet/Google		0	0	0
Apple		0	1	1
Applied Materials Inc			0	0
Broadcom Inc		0	0	0
Cisco Systems, Inc		0	0	0
HP Inc.		0	0	0
Intel Corporation		0	1	1
International Business Machines Corporation			0	0
Meta Platforms Inc			0	0
Micron Technology		0	0	0
Microsoft Corp		1	1	2
NVIDIA Corp		0	0	0
QUALCOMM Incorporated	0	0	0	0
Texas Instruments Incorporated		0	0	0
Grand Total	**0**	**1**	**3**	**4**

active/passive v...
0
1
(blank)

Fig.17 passive voice

Sum of Nickel	Column Labels			
Row Labels	negative	neutral	positive	Grand Total
Applied Materials Inc		1		1
NVIDIA Corp	0		0	0
Grand Total	**0**	**1**	**0**	**1**

active/passive v...
0
1

Fig.15 Time orientation

Sum of Nickel	Column Labels									
	future		future Total	past		past Total	present			present Total
Row Labels	neutral	positive		neutral	positive		negative	neutral	positive	
Advanced Micro Devices Inc		0	0		0	0		0	0	0
Alphabet/Google		0	0	0	0	0			0	0
Apple		0	0	0	0	0			1	1
Applied Materials Inc	1	0	1		0	0			0	0
Broadcom Inc		0	0	0	0	0		0	0	0
Cisco Systems, Inc				0		0		0	0	0
HP Inc.	0	0	0		0	0		0	0	0
Intel Corporation		0	0	0	1	1			0	0
International Business Machines Corp.		0	0		0	0			0	0
Meta Platforms Inc		0	0		0	0			0	0
Micron Technology		0	0	0	0	0			0	0
Microsoft Corp		0	0	0	0	0		1	1	2
NVIDIA Corp		0	0		0	0	0	0	0	0
QUALCOMM Incorporated		0	0		0	0	0	0	0	0
Texas Instruments Incorporated		0	0		0	0		0	0	0
Grand Total	**1**	**0**	**1**	**0**	**1**	**1**	**0**	**1**	**2**	**3**

Fig.12 Silicon tone and percentages

Sum of Silicon	Column Labels			
Row Labels	negative	neutral	positive	Grand Total
Advanced Micro Devices Inc		0	3	3
Alphabet/Google		0	0	0
Apple		0	0	0
Applied Materials Inc		0	0	0
Broadcom Inc		0	0	0
Cisco Systems, Inc		0	0	0
HP Inc.		0	0	0
Intel Corporation		0	0	0
International Business Machines Corporation			0	0
Meta Platforms Inc			0	0
Micron Technology		0	0	0
Microsoft Corp		0	0	0
NVIDIA Corp	0	1	0	1
QUALCOMM Incorporated	0	2	0	2
Texas Instruments Incorporated		0	0	0
Grand Total	**0**	**3**	**3**	**6**

Sum of Silicon	Column Labels			
Row Labels	negative	neutral	positive	Grand Total
Advanced Micro Devices Inc	0.00%	0.00%	50.00%	50.00%
Alphabet/Google	0.00%	0.00%	0.00%	0.00%
Apple	0.00%	0.00%	0.00%	0.00%
Applied Materials Inc	0.00%	0.00%	0.00%	0.00%
Broadcom Inc	0.00%	0.00%	0.00%	0.00%
Cisco Systems, Inc	0.00%	0.00%	0.00%	0.00%
HP Inc.	0.00%	0.00%	0.00%	0.00%
Intel Corporation	0.00%	0.00%	0.00%	0.00%
International Business Machines Corporation	0.00%	0.00%	0.00%	0.00%
Meta Platforms Inc	0.00%	0.00%	0.00%	0.00%
Micron Technology	0.00%	0.00%	0.00%	0.00%
Microsoft Corp	0.00%	0.00%	0.00%	0.00%
NVIDIA Corp	0.00%	16.67%	0.00%	16.67%
QUALCOMM Incorporated	0.00%	33.33%	0.00%	33.33%
Texas Instruments Incorporated	0.00%	0.00%	0.00%	0.00%
Grand Total	**0.00%**	**50.00%**	**50.00%**	**100.00%**

Fig.13 Numeric info./goal

Sum of Silicon	Column Labels		
Row Labels	neutral	positive	Grand Total
Advanced Micro Devices Inc	0	2	2
Alphabet/Google		0	0
Apple	0	0	0
Applied Materials Inc	0	0	0
Broadcom Inc	0	0	0
Cisco Systems, Inc	0	0	0
HP Inc.	0	0	0
Intel Corporation	0	0	0
International Business Machines Corporation		0	0
Meta Platforms Inc		0	0
Micron Technology	0	0	0
Microsoft Corp	0	0	0
NVIDIA Corp	1	0	1
QUALCOMM Incorporated		0	0
Texas Instruments Incorporated	0	0	0
Grand Total	**1**	**2**	**3**

numeric info./goal

0

1

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Fig.16 Non numeric info./goal

Sum of Silicon	Column Labels			
Row Labels	negative	neutral	positive	Grand Total
Advanced Micro Devices Inc			1	1
Alphabet/Google		0		0
Microsoft Corp			0	0
NVIDIA Corp	0			0
QUALCOMM Incorporated	0	2		2
Grand Total	**0**	**2**	**1**	**3**

numeric info./goal

0

1

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Fig.14 Active voice

Sum of Silicon	Column Labels			
Row Labels	negative	neutral	positive	Grand Total
Advanced Micro Devices Inc		0	3	3
Alphabet/Google		0	0	0
Apple		0	0	0
Applied Materials Inc			0	0
Broadcom Inc		0	0	0
Cisco Systems, Inc		0	0	0
HP Inc.		0	0	0
Intel Corporation		0	0	0
International Business Machines Corporation			0	0
Meta Platforms Inc			0	0
Micron Technology		0	0	0
Microsoft Corp		0	0	0
NVIDIA Corp		1	0	1
QUALCOMM Incorporated	0	2	0	2
Texas Instruments Incorporated		0	0	0
Grand Total	**0**	**3**	**3**	**6**

active/passive v...
0
1
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Fig.15 Time orientation

Sum of Silicon	Column Labels									
	future		future Total	past		past Total	present			present Total
Row Labels	neutral	positive		neutral	positive		negative	neutral	positive	
Advanced Micro Devices Inc		0	0		1	1		0	2	2
Alphabet/Google		0	0	0	0	0			0	0
Apple		0	0	0	0	0			0	0
Applied Materials Inc	0	0	0		0	0			0	0
Broadcom Inc		0	0	0	0	0		0	0	0
Cisco Systems, Inc				0		0		0	0	0
HP Inc.	0	0	0		0	0		0	0	0
Intel Corporation		0	0	0	0	0			0	0
International Business Machines Corp.		0	0		0	0			0	0
Meta Platforms Inc		0	0		0	0			0	0
Micron Technology		0	0	0	0	0			0	0
Microsoft Corp		0	0	0	0	0		0	0	0
NVIDIA Corp		0	0		0	0	0	1	0	1
QUALCOMM Incorporated		0	0		0	0	0	2	0	2
Texas Instruments Incorporated		0	0		0	0		0	0	0
Grand Total	**0**	**0**	**0**	**0**	**1**	**1**	**0**	**3**	**2**	**5**