LUISS

AI & SUSTAINABILITY

"The XXII century trends"

Course: Artificial Intelligence and Machine Learning

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CHAPTER 1

INTRODUCTION TO THE PROBLEM

One of the most significant issues confronting the world today is the impact that human beings are having on the planet.
We are slowly destroying the world around us, and the effects that we are starting to face might soon become irreversible. The world, as we were used to knowing it is disappearing, suffers from all the damage we are causing. Daily human activities have showed to cause substantially dreadful impacts in many ways and fields, such as pollution, deforestation, climate change, soil erosion, poor air quality, undrinkable water, and animal extinction. The spread of one of these phenomena often leads to the rise and creation of others.
If we want to cohabit with this planet, we should start appreciating what we have and rapidly readapt our habits to respect the species around us.

Acting in a sustainable way, in most of the cases, can result in not being so straightforward. The dynamics that govern the planet are complex, and the effects on our actions sometimes are not immediately visible. To better understand how to mitigate the damages that humans are causing to nature, research needs to be done.
As you will see, following your reading, I conducted a research implementing a code that tries to explain some sustainable behaviors within the IT industries.

I. What is Sustainability?

Throughout the research, the term “Sustainability” will be frequently referenced. As such, it is prudent to provide a clear definition of this concept, as it will serve as a fundamental component of the ensuing discourse.
Sustainability can be explained as a societal aim that refers to people's ability to coexist on earth for an extended period of time. Specific definitions of this phrase are challenging to come to terms with, since they have evolved, and will still evolve in response to literature, context, and time.

Sustainability has been a concept that has existed for many centuries. In fact, the earliest mentions of it can be traced back to ancient authors in the early 5th century BC who expressed concerns about the detrimental effects of human activities on the environment and advocated for the use of less harmful practices. However, it wasn't until the 1970s that the term "sustainability" was first used in the same manner as it is now, referring to humanity's future. Since then, the concept of sustainability has expanded to include ideas like social justice, environmental conservation, and globalism.

Sustainability is commonly described by experts as consisting of three key dimensions or pillars. These pillars are significant because they form the basis for the United Nations' Sustainable Development Goals (SDGs). Let's delve into a deeper understanding of each of these pillars:

- The environmental pillar of sustainable development comprises rules, laws, and other tools used to address environmental realities and issues such as land, oceans, air, energy consumption, natural resources, and wildlife management. This pillar involves a comprehensive approach to environmental management that includes both direct action, such as planting and protecting trees that produce oxygen, as well as addressing the issue of human consumption.
- The social pillar refers to public policy and regulatory actions that support social issues. These include objectives such as tackling poverty, social justice, peace, diversity promotion, quality of life, access to healthcare, and education.
- The economic pillar focuses on promoting economic growth, development, and stability while also ensuring that resources are used in a sustainable manner and that the benefits of economic activity are shared equitably among all members of society. It is of utmost importance to remember that our planet's resources are finite and limited, especially given that the current economic paradigm is still based on the assumption of "infinite" exponential growth. The problem with this approach is that if all accessible natural resources are depleted, long-term economic expansion will be impossible. Therefore, it is imperative to transition towards a sustainable financial model that considers our planet's finite resources. Many firms prioritize short-term profits over long-term sustainability, and as a result, they often overlook the environmental and social impacts of their actions.

  Moreover, companies may face additional expenses and logistical challenges in today's highly competitive market when transitioning towards more sustainable practices.

These changes can be complex and time-consuming, which may discourage businesses from adopting more sustainable practices.

As has been observed in recent years, sustainability is swiftly becoming an integral aspect of our daily lives and is gaining prominence in every sector where it can be implemented. We expect it to become one of the major trends in the upcoming years.

II. What is Artificial Intelligence?

There is a vast amount of information pertaining to the topic of Artificial Intelligence that cannot be adequately addressed within the confines of this brief introduction. However, the purpose of this section is to provide an overview of fundamental concepts that may prove useful in comprehending the research presented herein.

Artificial Intelligence (AI) pertains to the capability of digital computers (or computer-controlled robots) to perform tasks commonly associated with intelligent beings. The term "AI" is frequently applied to creating systems endowed with human-like cognitive processes, such as the capacity to reason, comprehend meaning, generalize, or learn from past experiences.
Since the introduction of the digital computer in the 1940s, it has been shown that computers can be programmed to perform extremely complicated tasks with accuracy and high speed. Such tasks may encompass the discovery of proofs for mathematical theorems or even playing games (chess was the first example, around 1950).
Moreover, some programs have achieved performance levels comparable to those of human experts and professionals in specific tasks. As such, artificial intelligence can be found in applications as diverse as medical diagnosis, computer search engines, and voice or handwriting recognition. Typically, these systems acquire the ability to perform such tasks by processing vast quantities of data and identifying patterns to emulate in their decision-making processes, relying on mathematical models, such as Linear Regression to predict future values.

However, despite the ongoing advancements in computer processing speed and memory capacity, no program has yet been able to match human adaptability across a wide range of domains or in activities requiring extensive everyday knowledge. Consequently, rather than

replacing human expertise and judgment, AI should be viewed as a complementary instrument and enhance human decision-making. It is important to recognize that "AI is only as good as the data it is trained" on, and biases and limitations in the data can lead to unintended consequences and negative environmental impacts.

As a result, transparency and accountability must be prioritized in the development and implementation of AI for environmental sustainability, ensuring that the underlying algorithms and data are open to scrutiny, and that the potential impacts of AI are carefully assessed and mitigated.

III. Can AI help achieve environmental sustainability?

It has been observed that Enhancing sustainability practices can prove to be challenging, given the intricacy of various systems that govern ecological processes. Ecosystems, in particular, are highly complex and interdependent systems, where every component interacts with others, and the consequences of actions are often not immediately visible.

Artificial Intelligence holds significant potential in promoting environmental sustainability by facilitating a better understanding of complex environmental systems and processes, predicting environmental impacts and risks, and devising more effective and efficient solutions to mitigate and adapt to environmental challenges.

Through the analysis of vast amounts of environmental data from sensors, satellites, and other sources, AI can identify patterns and trends, supporting the development of models for forecasting and monitoring potential natural events.

Here are some recent AI developments that improved a sustainable aspect of a warding situation:

- AI contributed to biodiversity conservation by monitoring and managing ecosystems, tracking endangered species, and identifying and mitigating threats to biodiversity. A recent study published in “Nature Communications Biology” employed machine learning algorithms to accurately forecast species' potential extinction risk or recovery

status[1]. AI is also being used to stop illegal wildlife trafficking, which impacts more than 7,000 species of animals and plants[2].

- AI technology has been instrumental in natural resource management, allowing for the analysis of satellite images to identify areas where the flora is at risk and take preventive measures. AI can also help track and restore damaged land and soil. Using neural networks and objective-oriented techniques, AI can improve the classification of vegetation cover types in remote satellite images. This technology can be used to identify trends in desertification over large areas, aid in environmental planning and decision-making, and help reverse desertification by identifying the factors causing it.
- AI can enable smart and low-carbon cities by bringing together a variety of interconnected technologies, such as electric self-driving cars and intelligent devices that can enable demand fulfillment in the electricity sector, all of which are required to combat climate change.
- In the last few years, AI's presence in the healthcare industry has grown significantly. AI can be used in healthcare systems to identify a patient's likelihood of specific diseases and to recommend preventive measures. AI can also help hospitals and healthcare systems operate more efficiently and decrease patient wait times.
- AI can also aid in the interoperability of variable renewable energies by enabling smart grids in order to match electrical demand to times when the sun shines, and the wind blows.

Overall, artificial intelligence presents a valuable toolset for supporting environmental sustainability through its ability to provide insights, tools, and solutions that reduce our impact on the environment and facilitate a transition to a more sustainable future.

IV. Potential contradictions between AI and Sustainability

Artificial Intelligence (AI) is undoubtedly a game changer on a global scale. However, the potential for beneficial change that AI delivers also carries the potential for detrimental

[1] https://www.nature.com/articles/s42003-022-03638-9
[2] https://news.microsoft.com/en-gb/2021/11/18/first-of-its-kind-multispecies-ai-model-to-detect-illegal-wildlife-trafficking-is-ready-to-roll-out-to-airports/

consequences for society and the environment. While AI can facilitate sustainability by improving efficiency and reducing resource consumption, there may be inconsistencies in how those goals are met. When implementing AI in sustainability initiatives, it is essential to consider these potential contradictions carefully.

It is undeniable that Artificial Intelligence has now become an indispensable part of our way of life, and it will continue to shape our future. Therefore, it is important to recognize that many of its current implementations are moving in the opposite direction of the Sustainable Development Goals (SDG).

One of the main contradictions of artificial intelligence (AI) is that it requires a significant amount of energy to operate, which can lead to increased greenhouse gas emissions, contributing to climate change. AI systems are powered by massive computing resources, which consume vast amounts of electricity, generating carbon emissions in the process. Furthermore, as the demand for AI continues to grow, so does the energy required to operate and maintain these systems, exacerbating the problem of energy consumption.To address this issue, researchers are exploring different ways to reduce the energy consumption of AI systems. One approach is to optimize the algorithms used in AI to reduce the computation required, allowing the systems to run more efficiently. Another solution could be to use renewable energy sources to power AI systems.

Overall, the goal is to find a balance between the benefits of AI and the environmental impact of its energy consumption.

AI could be seen as contradicting in the field of equality, since machine learning has developed algorithms that try to divide into clusters, detecting weaknesses to be exploited. Therefore, the use of Artificial Intelligence in under debate in fields that uses AI tool for hiring employees and lendings, which due to the bias of model, can lead to severe descriminations.

The term "Big Nudging" refers to the merging of big data and nudging. *Nudging* is a behavioral economics phenomenon that proposes small environmental changes that are simple and inexpensive to implement in order to influence the behavior and decision-making of individuals or communities. The concept behind "Big Nudging" is to use the vast amounts of data available to more efficiently nudge people towards certain actions, exploiting their psychological weaknesses — potentially causing problems such as harming social stability, democratic values, and even human rights.

This kind of situations are possible due to a lack of information received by the citizens on the type of analyzed data, and the consequences that this may have on their lives (GDPR in EU deals with protection. of personal data from 2016).

It is also known that machine-learning algorithms, when uncritically trained on regular media articles, will unconsciously learn and replicate the societal biases against women and girls that are embedded in contemporary languages. A famous example of AI failure in this field, is the Microsoft Tay case, which is about an artificial intelligence chatbot that Microsoft Corporation released on Twitter on March 23, 2016. The chatbot was designed to gain knowledge from interactions with real users on Twitter. Unfortunately, less than 24 hours after its release, Tay began sending inflammatory and offensive tweets via its Twitter account. Microsoft later apologized for creating the chatbot and explained that Tay was the victim of a "coordinated attack by a subset of people" after it was launched.

Furthermore, another difficulty that AI is still struggling with, is the accountability and security aspect. Who should be held liable if an AI system causes harm? The users, Who should be held accountable if an AI system causes harm? The development team, the users, or the AI itself? Some theories propose to configure the responsibility for the damage caused by the choice of an algorithm as «culpa in eligendo»: the fault derives from having blindly trusted the machine; instead, «culpa in vigilando» would, be excluded, since its functioning was not understandable to man.

To conclude, AI can lead to job loss by automating tasks that humans traditionally perform. This is known as technological unemployment. While AI can increase labor productivity and create new jobs in fields such as AI research and development, it can also displace workers in industries where tasks can be automated. This can lead to economic insecurity and increased poverty for those who lose their jobs and are unable to find new employment. There have been several studies and analyses on the potential impact of AI on jobs. A Zippia report claims that over the course of the next ten years, AI could eliminate 375 million jobs and displace up to one billion people worldwide. At present, various measures are being undertaken to address the challenges associated with the implementation of AI technology. It is expected that imminent advancements in areas such as energy efficiency and regulatory frameworks will effectively mitigate these concerns. Consequently, it is advisable for AI initiatives aimed at

advancing the Sustainable Development Goals (SDGs) to explicitly conform to established ethical standards and demonstrate compliance with relevant guidelines.

CHAPTER 2

SUSTAINABLE DEVELOPMENT GOALS (SDG)

i. What are the SDGs and why are so important?

The Sustainable Development Goals (SDGs) are a set of 17 global goals established by the United Nations in 2015 as part of the 2030 Agenda for Sustainable Development. These goals aim to eradicate poverty, protect the environment, and promote peace and prosperity for all individuals. The SDGs comprise:

1. No Poverty: This goal seeks to end poverty in all of its forms by guaranteeing that everyone will have access to basic necessities such as food, water, healthcare, and an appropriate place to live.
2. Zero Hunger: It aims to end hunger and malnutrition by increasing access to nutritious food and encouraging sustainable agriculture.
3. Good Health and Well-being: It focuses on ensuring that everyone has equal access to quality healthcare and that people can live healthy lives, free from preventable illnesses and diseases.
4. Quality Education: This goal tries to ensure that everyone has access to quality education, from early childhood to tertiary level, and that education is inclusive and equitable.
5. Gender Equality: This goal aims to eliminate gender discrimination and empower women and girls by promoting equal rights and opportunities in a variety of areas.
6. Clean Water and Sanitation: This goal seeks to provide everyone with universal and equitable access to safe and affordable drinking water. In addition, all people should have access to sanitation and hygiene, and open defecation should be eliminated, with particular attention paid to the necessities of women, girls, and those in vulnerable situations.
7. Affordable and Clean Energy: This goal focuses on increasing access to affordable, reliable, and sustainable energy and promoting renewable energy sources.

8. Decent Work and Economic Growth: This goal promotes sustainable economic growth and decent work by creating more jobs, supporting entrepreneurship, and promoting fair labor practices.
9. Industry, Innovation, and Infrastructure: This goal promotes sustainable industrialization and innovation by investing in infrastructure, technology, research, and development.
10. Reduced Inequalities: This goal aims to reduce inequality within and among countries by promoting social, economic, and political inclusion and empowerment.
11. Sustainable Cities and Communities: This goal promotes sustainable urbanization by creating safe, inclusive, and resilient cities and communities.
12. Responsible Consumption and Production: This goal aims to promote sustainable consumption and production patterns by reducing waste, promoting resource efficiency, and minimizing the environmental impact of production and consumption.
13. Climate Action: This goal aims to take immediate action to fight climate change and its consequences., by promoting mitigation and adaptation strategies and supporting international cooperation.
14. Life Below Water: This goal aims to conserve oceans, seas, and aquatic species in a sustainable manner for long-term development.
15. Life On Land: By combating desertification, land degradation, and biodiversity loss, this goal aims to protect, recover, and encourage the sustainable use of terrestrial ecosystems.
16. Peace, Justice, and Strong Institutions: This goal promotes peaceful and inclusive societies by facilitating access to justice, reducing violence and corruption, and strengthening governance and institutions.
17. Partnerships for the Goals: This goal aims to strengthen global partnerships for sustainable development by promoting cooperation and collaboration among governments, civil society, and the private sector.

The Sustainable Development Goals (SDGs) represent a universal agenda that applies to all countries, irrespective of their developmental stage. The SDGs strive to ensure that no one is left behind and that progress is evaluated not only in economic aspects but also in terms of social and environmental sustainability. The SDGs provide a blueprint for transformative change, advocating a transition towards more sustainable and inclusive societies. They

underscore the necessity for collaboration and partnership among governments, civil society, the private sector, and other stakeholders in order to achieve the goals.

The SDGs recognize that the world's challenges are interconnected and cannot be addressed in isolation because many of the issues are interrelated and have a domino effect on one another. Poverty, for instance, is defined as a lack of access to essential public services, such as healthcare, education, and potable water. Addressing poverty requires addressing these underlying issues as well. Similarly, climate change affects food security, health, and economic growth, among other things. By recognizing the interconnectedness of these challenges, the SDGs aim to address the root causes of global problems and create sustainable solutions.

Finally, the SDGs are essential because they reflect the aspirations and needs of people around the world. By working to achieve the SDGs, we can create a more just, equitable, and sustainable world for current and future generations. (https://sdgs.un.org/goals).

ii. What people thought before SDGs?

The Sustainable Development Goals (SDGs) were built upon the foundation of the Millennium Development Goals (MDGs). The MDGs were established in 2000 with the goal of reducing poverty and improving health and education in developing countries by 2015. The eight objectives were the following:

1. *Eradicate extreme poverty and hunger*: The goal was to reduce by half the proportion of people living with less than $1.25 a day and the percentage of people who suffer from hunger.
2. *Achieve universal primary education*: Its focuses was to ensure that all children, regardless of gender or economic status, complete primary education.
3. *Promote gender equality and empower women*: The aim was to remove gender disparity in primary and secondary education and increase the proportion of women in non-agricultural employment.
4. *Reduce child mortality*: The goal was to decrease by two-thirds the mortality rate among children under five.

5. *Improve maternal health*: The focus was to reduce by three-quarters the maternal mortality ratio and achieve universal access to reproductive health.
6. *Combat HIV/AIDS, malaria, and other diseases*: The goal was to halt and begin to reverse the spread of HIV/AIDS, achieve universal access to treatment for HIV/AIDS, and reduce the incidence of malaria and other major diseases.
7. *Ensure environmental sustainability*: The objective was to merge the principles of sustainable development into national policies and initiatives, reduce biodiversity loss, increase access to safe drinking water and basic sanitation, and improve the lives of slum dwellers.
8. *Develop a global partnership for development:* The goal was to develop an open, rule-based, predictable, and non-discriminatory trading and financial system, that addresses the special needs of least developed countries, landlocked developing countries, and small island developing states, and provides access to affordable essential drugs and new technologies. The goal also aimed to improve the coordination and cooperation of international aid and debt relief to support the achievement of the other MDGs.

Even if, the SDGs and the MDGs were both established by the United Nations to address global challenges, there are however several significant differences between the two.
Firstly the SDGs are more comprehensive than the MDGs. In fact, the MDGs were a set of goals with the aim of solving pressing situations, focusing only on developing countries. Conversely, the SDGs consist of 17 goals that address a more comprehensive range of issues, including economic growth, injustice, climate change, and peace and justice.
Secondly, the SDGs place a greater emphasis on sustainability and the interconnectedness of global challenges. The goals recognize that economic growth must be balanced with social and environmental sustainability and that progress in one area cannot be achieved at the expense of another. SDGs recognize that global challenges require collective action from all countries.

While significant progress was made toward achieving the MDGs, it was recognized that more must be done to address global challenges. Some of the events and trends starting to occur after the establishment of the MDGs, made it urgent to create a new set of goals, which finally included:

1. *Rising inequality*: Despite progress in reducing poverty, inequality within and among countries increased. As a result, the new sustainable goals consider individual inequalities (SDG.10), while also fighting for gender equality (SDG.5).

2. *Climate change*: Climate change, especially in the last few years, has been recognized as an urgent global challenge that requires immediate action.
3. *Environmental degradation*: The loss of biodiversity, deforestation, and pollution threaten the health of the planet and its inhabitants. Therefore goals regarding life on land (SDG.15), life below water (SDG.14), and Affordable and Clean Energy (SDG.7), have been introduced.
4. *Conflict and instability of Institutions*: Goal 16 of the SDGs, which focuses on promoting peace, justice, and strong institutions, was established to create inclusivity and ensure that everyone has access to justice, and accountable institutions at all levels. Regardless of their race, religion, or sexual orientation, everyone should be safe from all forms of violence and feel secure as they go about their daily lives. The foundation of this procedure is enhancing the rule of law and advancing human rights, in countries where freedom is not taken for granted.

iii. What can we say about SDGs so far?

Since their introduction in 2015, the Sustainable Development Goals (SDGs) have advanced in many areas.

However, in the last few years, attaining Sustainable Development Goals has been impeded by a series of recent interrelated crises, including the COVID-19 pandemic, climate change, and global conflicts. These events have exacerbated the challenges associated with achieving the SDGs and have resulted in a decline in progress toward numerous targets. However, the impact of COVID-19 has varied across the SDGs; while its impact on many prosperity-related SDGs was negative, its impact on many planet-related SDGs has been positive. The upheavals caused by the COVID-19 crisis, therefore, create the opportunity for recognizing this conflict in a more profound way.

The Sustainable Development Goals Report is an annual report published by the United Nations that gives a global overview of how the SDGs' implementation under the 2030 Agenda is going. The report details the change in the direction of years of progress in the SDGs fields and emphasizes the seriousness and complexity of the challenges we face. The article

highlighted areas that require immediate action to save the SDGs and produce significant progress for environmental sustainability by 2030.

Some key findings from *The Sustainable Development Goals Report 2022*[3] include:

1. No poverty- The COVID-19 pandemic wiped out more than four years of progress. The working poverty rate rose for the first time in two decades, pushing an additional eight million workers into poverty. Moreover, rising inflation and the impacts of war in Ukraine further derail progress.
2. Zero hunger- COVID-19 and climate change are converging to undermine food supply. Food shortages have also been caused by the Ukraine crisis for the world's poorest people.
3. Good health and well-being- Covid is threatening decades of progress in global health. Tuberculosis deaths have risen for the first time since 2005.
4. Quality education- A global learning crisis has worsened due to the COVID-19 pandemic. One hundred forty-seven million kids missed more than half of their in-person class time. In the chaos of war, 3 million children in Ukraine are offered remote learning.
5. Gender equality-According to the UN, at the current rate, it would take another 40 years for women and men to be equally represented in national political leadership.
6. Clean water and sanitation- To meet drinking water, sanitation, and hygiene goals by 2030, progress must be made at a 4x faster rate.
7. Affordable and Clean Energy-To meet the goals for the global climate, progress in energy efficiency must be accelerated. There are still 2.4 billion people who cook using ineffective and harmful methods. Furthermore, international financial flows to developing countries for renewables decreased for the second year in a row. Only 17.7% of all final energy consumption is made up of renewable sources.
8. Decent Work and Economic Growth- Global economic recovery is still further set back by the Ukraine crisis and Russia's gasoline stops.
9. Industry, Innovation, and Infrastructure- Global manufacturing has rebounded from the pandemic, but least developed countries need to be included.
10. Reduced Inequalities- pandemic has caused the first rise in between-country income inequality in a generation.
11. Sustainable Cities and Communities- "Leaving no one behind" project will require an intensified focus on 1 billion slum dwellers.

[3] https://unstats.un.org/sdgs/report/2022/The-Sustainable-Development-Goals-Report-2022.pdf

12. Responsible Consumption and Production- Unsustainable consumption and production patterns are the root cause of the Triple Planetary Crisis: climate change, biodiversity loss, and pollution.
13. Climate Action- Climate change is humanity's window to avoid climate catastrophe is closing rapidly. Energy-related CO2 emissions increased by 6% in 2021, reaching the highest level ever.
14. Life Below Water- Plastic pollution is choking the ocean; over 17 million metric tons of plastic entered the sea in 2021.
15. Life On Land- 10 Million hectares of forest are destroyed every year. Almost 90% of global deforestation is due to agricultural expansion.
16. Peace, Justice, and Strong Institutions- a quarter of the population lives in conflict-affected countries (end 2022).
17. Partnerships for the Goals- rising debt burdens threaten developing countries' pandemic recovery.

In summary, progress toward achieving the Sustainable Development Goals (SDGs) has been characterized by a combination of advances and shortfalls. While certain areas have made noteworthy strides, others have yet to keep pace.
Consequently, it remains a substantial amount of work to be done to ensure that individuals across the globe are able to live in dignity and enjoy a sustainable future.

iv. What can be done according to the SDGs

Imagine a world where no one goes hungry, where every child has access to education, where clean water and sanitation are basic human rights, and where our planet is protected for future generations; well...the current reality falls short of this vision. Despite the criticality of attaining these objectives, global focus and effort towards the Sustainable Development Goals are still inadequate .
To work towards achieving the SDGs, governments, organizations, and individuals can take a variety of actions. Several illustrations comprise:

1) Raising awareness about the SDGs and their importance, encouraging others to take actions. In fact, despite the SDGs' importance, the general population's awareness about them is still low today. People may not know what the SDGs are, but they are aware of the topics and problems related to them. This demonstrates the need for awareness-raising education and communication campaigns about the SDGs and their significance. This information can be delivered through various channels, such as schools, public campaigns, social media, and community events.

   Raising awareness about the United Nations' Sustainable Development Goals (SDGs) is crucial for several reasons, and therefore it has the capacity to change the world in numerous ways.

   a) By increasing awareness of the Sustainable Development Goals, we can foster a deeper understanding of the challenges they address and inspire individuals and organizations to take action. Those who lack sufficient education on environmental threats may find it difficult to identify theirs harmful practices. Moreover, comprehending the factors that contribute to environmental degradation can enhance public engagement in efforts to implement positive change. For instance, issues such as climate change are not comprehensively understood by the majority of the population, which can result in a lack of awareness about the negative consequences of activities such as consuming meat or traveling by airplane.
   b) Education about the SDGs can help students better understand global challenges, such as poverty, inequality, climate change, and environmental degradation. This can inspire them to become in the future global citizens committed to addressing these challenges. Furthermore, the study of SDGs can encourage critical thinking and problem-solving skills among students. They can learn to analyze complex issues, evaluate evidence, and develop creative solutions to real-world problems.
   c) Moreover, the SDGs provide a framework for action relevant to all societal sectors, including governments, businesses, civil society organizations, and individuals. Promoting awareness of the SDGs can encourage greater collaboration and partnerships across industries, leading to more effective and sustainable solutions.

2) Supporting sustainable business practices is an essential aspect of corporate responsibility in the modern era. Adopting such practices benefits the environment and can enhance a company's reputation, increase customer loyalty, and boost profitability.

a) One crucial sustainable business practice is to reduce waste and carbon emissions, which could be achieved by promoting sustainable supply chains. Companies should optimize their production processes by implementing energy-efficient technologies, adopting renewable energy sources, and using eco-friendly packaging. For example, Walmart has set a goal to become a zero-waste company by 2025, and they have already reduced their carbon emissions by 18% over the past decade.
b) Companies should also pay more attention to the equality of gender and the salary of their workers. *Fairtrade* is a global movement that promotes sustainable and ethical trading practices, particularly for small-scale farmers and workers in developing countries. It aims to ensure that these producers receive fair prices for their products, which can help to improve their living standards, promote sustainable farming practices, and protect their rights. The fair trade movement operates through a system of certification and labeling. By choosing fair trade products, consumers can support sustainable and ethical trading practices and help to create a more just and equitable global economy.

3) Generating and implementing programs and policies One solution to incentivize firms to become more sustainable, is to employ government laws to include the cost of environmental damage in the pricing. This can be accomplished through taxation and incentives: the government can levy a tax on unsustainable operations, such as emissions or excessive trash discharged into the environment, while subsidizing more virtuous firms.

4) Adopting sustainable lifestyle practices is a critical step toward achieving the Sustainable Development Goals (SDGs) of the United Nations and attempting to create a more sustainable future for all. Inducting people to adopt sustainable lifestyle practices can involve a range of strategies and approaches, depending on the context and target audience.
a) Governments can establish incentives to encourage businesses and individuals to adopt sustainable lifestyle practices. For example, some countries provide subsidies or grants to companies that develop environmentally sustainable technologies. Others may offer tax breaks for individuals who purchase electric cars or install solar panels on their homes. Incentives can also be used to encourage the adoption of sustainable practices in agriculture, such as crop rotation or reduced use of pesticides. For instance, the Indian government offers subsidies to farmers who switch to organic farming practices.

b) As mentioned above, awareness-raising and policies can also play a role in inducing people to adopt sustainable lifestyle practices.
c) By promoting sustainable behaviors as the social norm and creating a culture of sustainability, individuals may be more likely to adopt sustainable practices themselves. Peer influence can also be a powerful motivator, as individuals are often more likely to adopt behaviors that are endorsed by their social networks.

In conclusion, achieving the SDGs requires collaboration and effort from all sectors of society. Governments, the private sector, and individuals must work together to implement strategies that align with the SDGs and promote sustainable development. This can involve raising awareness about the SDGs, incorporating them into business models, and using sub-indicators to track progress toward the goals. By taking these steps, we can move closer to a sustainable future for all.

v. My contribution to the SDGs

In today's global landscape, where sustainable development is of paramount importance, raising awareness about the Sustainable Development Goals (SDGs) has become a critical endeavor. Governments and companies play a pivotal role in championing these goals and ensuring widespread adoption.

In particular, fims that boast a substantial following on social media platforms possess a unique opportunity to make a lasting impact by drawing attention to the pressing challenges our world faces. By communicating about the SDGs and sharing insights into their sustainability practices, these companies can inspire and empower their followers to embrace sustainable behaviors and actively contribute to the achievement of the goals.

To this end, companies and governments should invest in targeted campaigns that employ compelling storytelling, engaging content, and innovative communication techniques to educate, motivate, and mobilize individuals towards sustainable practices. By leveraging the influential reach of social media and other communication channels, companies can effectively disseminate information, raise awareness, and foster meaningful conversations around the SDGs.

In this regard, my contribution to the SDGs focuses on the communicational aspect of their essential topics. To this end, I have developed a model capable of assessing how effectively a company communicates its sustainability practices on its website and social media.
This model offers valuable assistance to firms and authorities seeking an official assessment of the effectiveness of their communications regarding specific sectors of the Sustainable Development Goals (SDGs). By utilizing this model, they can gain insights into their communication performance and easily identify any SDG fields that have not yet received sufficient attention.
Looking ahead, it is worth considering the possibility that such analyses may become mandatory in the future. As the importance of sustainability continues to grow, there is an increasing demand for transparency and accountability in corporate sustainability efforts. It is conceivable that one day, companies will be required to publicly disclose ratings or evaluations of their sustainability initiatives, including their communication practices.

Therefore, this model serves two key purposes that contribute to the advancement of the Sustainable Development Goals (SDGs).
Firstly, it functions as a valuable general assessment tool. It enables individuals to efficiently filter and identify companies that actively communicate about specific SDG-related topics. With this model, stakeholders can quickly evaluate a company's commitment and engagement towards a particular SDG, fostering informed decision-making and encouraging support for businesses that align with their values and sustainability goals.
Secondly, the assessment generated by this model has the potential to enhance transparency within companies. By utilizing the model, organizations can evaluate and analyze their own communication practices in relation to the SDGs. The results of this assessment can serve as a source of pride and recognition for companies that prioritize effective communication on these vital issues. It can also inspire healthy competition among firms, as they strive to improve their sustainability practices and communication efforts, leading to a positive impact on the SDGs.
By leveraging this model for both external and internal purposes, it becomes a catalyst for promoting awareness, accountability, and positive change. It

During my research, I focused on assessing the involvement of the IT field in addressing the Sustainable Development Goals (SDGs). As emphasized in the introduction of my thesis, technology, particularly Artificial Intelligence (AI), plays an immensely significant role in our lives. Its potential for addressing complex challenges, including those related to the SDGs, is

substantial. Therefore, it was imperative to delve into the attention and contribution of the IT industry to these urgent global issues.

To gain a comprehensive understanding of the current landscape, I selected and analyzed eight prominent firms operating in the IT industry. Through a meticulous comparative assessment, I examined their approaches, actions, and individual contributions towards the SDGs. The aim was to paint a comprehensive picture of the IT industry's involvement in addressing the SDGs and identify areas where improvements or further attention are required.

By studying these select firms, I aimed to uncover insights into the IT industry's commitment to sustainable development. This analysis shed light on the extent to which these companies integrate the SDGs into their strategies, operations, and communication practices. Through this research, I aimed to provide valuable insights into the current state of SDG implementation within the IT industry.

The findings of this research not only contribute to the existing body of knowledge but also provide a platform for further discussions and actions. Understanding the attention and contribution of the IT industry to the SDGs can drive future advancements, collaborations, and innovations in addressing these urgent global challenges. It serves as a starting point for identifying best practices, fostering knowledge-sharing, and inspiring collective efforts towards achieving the SDGs.

In conclusion, the model that I'm going to present has the potential to be a valuable tool in promoting the SDGs by helping to assess and improve the communication efforts of companies. Raising awareness of the SDGs and promoting sustainable practices, creating a more equitable and sustainable world for future generations.

CHAPTER 3

FAIR INDEX MODEL OVERVIEW

Certainly, there are already thousands of AI models in place trying to address the vast issues of the SDGs. As you might understand at this point, the SDGs deal with so many fields, and can be analyzed for so many purposes.

The research that I have been conducting and analyzing over the past few months pertains to the implementation of Sustainable Development Goals (SDGs) at an organizational level. The business problem that this analysis aims to address is the effectiveness of communication regarding SDGs by various firms.

Specifically, the study was conducted utilizing machine learning models, implemented with Python as the programming language. The objective was to classify unstructured textual data obtained from the websites and social media platforms of target firms and determine whether such data relates to the topic of SDGs. If so, the data was further categorized accordingly.

This model, will allow for a more objective evaluation of how well different firms are performing in terms of SDG communication.

Therefore, the two steps that the algorithm will follow in order to make the assessments, are to:

Initially, filter from the amount of textual data collected and select only those that concern the sphere of the SDGs.

Subsequently, classify them into a or more Sustainable Development Goals categories.

The problem will be addressed as a combination of two tasks: the first of binary classification and the second of multi-label classification.

When the code finishes its run, the results will comprise all the SDGs classified data, indicating the specific category of all the posts published by the firm. Based on these results, later in the research, graphs displaying data will help us drawing various deductions about the communication practices of firms, and what they deem essential to communicate to the public.

i) What it is the goal?

The FAIR INDEX MODEL is a novel approach to better understanding how firms communicate their commitment to Sustainable Development Goals (SDGs) on their web and social media platforms.
The model can help companies better understand their competitors' commitment toward SDGs and identify areas that can benchmark their efforts against those.
By using this model, companies can evaluate their progress, measure their performance, and identify gaps in their communication. This kind of information can drive positive change within companies.

Moreover, the proposed model can be a valuable tool for evaluating potential partners in future collaborations. By leveraging the capabilities of the machine learning algorithms, the model can analyze vast amounts of textual data, coming from various sources related to firms' communication. The ability to quickly assess the potential partner's commitment to SDGs efficiently ensures that they cooperate only with partners that share their commitment to sustainable development. This can help in fostering long-term partnerships built on shared values and goals.

Furthermore, the final output that the model will produce is an index based on the firm's commitment to SDG divulgation. The index will be used to rank firms according to their engagement. Hopefully, this kind of assessment, once published, could create some healthy competition among the firms participating in the analysis, which will ultimately benefit the SDGs.

As will be shortly illustrated, my research on the FAIR INDEX MODEL, was conducted using data from eight technology industry firms. These companies were selected to evaluate the extent to which IT brands promote sustainability in their online activities. The strength of running this model on data coming from a specific industry, can be extremely efficient to provide valuable insights into the specific areas, which might be almost imperceptible if only one firm was analyzed. By analyzing the communication strategies of various firms, the model can identify which sustainable development goals (SDGs) are most commonly addressed and which may be less emphasized or overlooked altogether.

This kind of assessment can be helpful for firms seeking to align their sustainability initiatives with the broader goals of the industry, as well as for those looking to differentiate themselves from their competitors by focusing on underrepresented SDGs.
Overall, the model provides a comprehensive framework for assessing and improving sustainability communication efforts within the IT industry.

To conclude, given the increasing importance of the SDGs in the global development agenda, it is not unlikely that one-day such assessments could be required by the law. In this case scenario, The FAIR INDEX MODEL will provide an excellent tool for companies to stay ahead of regulatory requirements and to demonstrate their commitment to the SDGs.

ii) Dataset

Since the introduction of my thesis, I have emphasized how Technology nowadays can be a powerful tool to make substantial differences toward sustainability. In this regard, I believe it is essential to have a look at the IT industry, to determine how firms are addressing SDG issues, and identifying those that have not yet benefited from technology interventions.
Therefore, the dataset that the research will use will be constructed by gathering all data pertaining online communication, coming from eight different firms:

1. Almaviva
2. Almawave
3. Capgemini
4. Engineering
5. Everis
6. Expert Systems
7. Reply
8. TopNetwork

It is worth noting that these firms are all Italian companies. This decision was influenced by the nature of text mining, which relies on detecting common words used in categories. Performing this process in more than one language (in the case of considering international firms) would have required significantly more work and time, potentially compromising the model's accuracy.

The data collected from the respective websites and social media of the firms was not randomly selected. This non-random selection was designed to facilitate the subsequent step: labeling. The fact that data was not selected equally among firms will be a crucial concept to consider once we discuss the model's results across different firms.

After all the necessary data have been stored in a dataset, **Data labeling** is the next essential step that has to be done to prepare the model to perform text mining. It involves the process of annotating textual data with predefined labels (SDGs) to create a labeled datasets. Unfortunately, this technique still requires human effort and thus demands a considerable amount of time and precision. In this research, annotation was performed in Excel by selecting the corresponding category for each collected sentence, resulting in approximately 5000 labeled examples. Labeled data serves as the foundation for training and assessing the performance of machine learning models in text mining. By providing labeled examples, models can learn patterns, relationships, and classifications necessary for accurate predictions on new, unlabeled data.

Data augmentation becomes necessary given the limited amount of data that can be labeled within a feasible timeframe for this research. Data augmentation is a technique used to increase the size and diversity of a training dataset by generating additional artificially created examples. It is commonly employed to improve model performance and generalization.
To give you a general idea of how it usually works, commonly used data augmentation techniques for text include:

1. Synonym Replacement: Replacing certain words with their synonyms to introduce variation in the text while maintaining a similar semantic context.
2. Random Deletion: Randomly removing words from the text to simulate noisy or incomplete data, forcing the model to rely on the remaining context.
3. Random Swap: Randomly swapping the positions of words within a sentence to create new sentence structures.

In the Fair Index model, WordNet was used as a word embedding technique, along with a BERT model.

- WordNet, is a lexical database that organizes words based on their semantic relationships. It provides a vast collection of words and their synonyms, antonyms, hypernyms (superordinate terms), hyponyms (subordinate terms), and more. WordNet

is often used in natural language processing tasks, including this case as a word embedding.

  - Word embedding is a technique used to represent words or phrases as vectors in a high-dimensional space. These vectors capture the semantic and syntactic relationships between words, enabling machine learning models to process and understand natural language more effectively. WordNet can be used as a resource to enhance word embedding by incorporating semantic relationships between words into the vector representations.

- On the other hand, BERT (Bidirectional Encoder Representations from Transformers) is a pre-trained language model based on a transformer architecture. It is designed to understand the contextual meaning of words within sentences or documents. BERT captures intricate relationships between words and generates contextualized word embeddings. These embeddings are more representative of the meaning and context of individual words, allowing downstream tasks to benefit from this rich contextual information.

  In summary, thanks to data augmentation, the database passes from 5000 to 15000 annotated phrases.

Given the potential for future reuse of the "skeleton" (code) of the Index model for purposes beyond SDGs, it is important to acknowledge that all the efforts invested in the database will be forfeited. The research has generated significant value through the meticulous preparation of the database, including the processes of

1. data collection,
2. labeling,
3. augmentation.

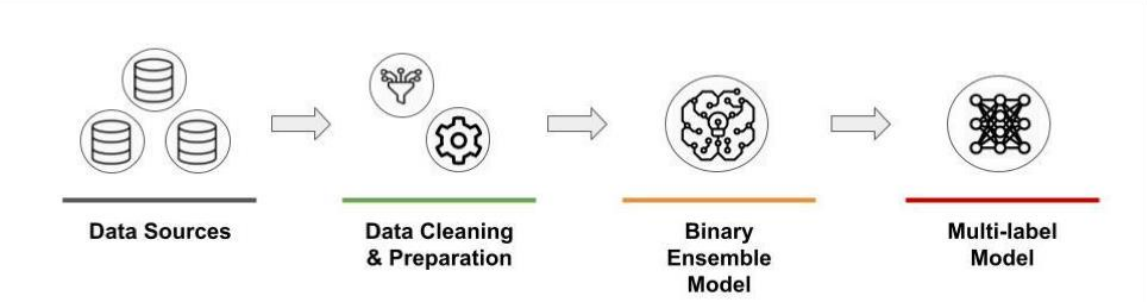
Should the model be employed for other text-mining applications in the future, these three fundamental steps, along with the training process, would need to be re-executed, as they are intrinsic to the model's functionality and effectiveness.

CHAPTER 4

FAIR INDEX MODEL (in details)

The fair index model, which we will examine, employs text mining classification to categorize text data into predefined categories, SDGs. As introduced in the previous chapter, the model encompasses the following steps:

1. Data Source: Gathering data from relevant sources.
2. Data Labeling: Manually assigning appropriate labels to the collected data.
3. Text Pre-processing: Cleaning and transforming the text data to ensure its suitability for analysis.
4. Text Vectorization: Converting the text data into a numerical representation, such as one-hot encoding or bag-of-words representation.
5. Classification Model: The computer will classify text into different categories. In our case, the classification step involves two distinct models:
    i. Ensemble Model (SDG, SVM, LR): Determining if text data pertains to SDG fields.
    ii. Multilabel Model (SVM): Classifying the specific categories to which the text data belongs.
6. Model Evaluation: Assessing the model's performance using metrics such as precision, recall, f1-score, or area under the ROC curve. Additionally, the model generates a final ranking of the analyzed firms.



The model was intentionally designed to exhibit the following characteristics:

- Generalizability: The model possesses the capability to generalize its learnings to unseen data during the training phase.
- Scalability: The model should be able to handle large amounts of text in a reasonable amount of time.
- Interpretability: The model should be interpretable, meaning that developers and end-users should be able to understand how the model is making its classification decisions.

I. Text Pre-processing

Before developing the Machine Learning models, a crucial preliminary phase of Data Cleaning and Data Preparation is necessary. The quality of the input data greatly influences the trustworthiness of the machine learning model's output. The Data Cleaning and Data Preparation process encompasses several key steps:

- Step 1: Removal of unwanted characters- This involves eliminating undesirable elements such as URLs, HTTP/HTTPS references, and punctuation marks (@, #, *, etc.) from the text data.
- Step 2: Encoding the text- The text is encoded in the appropriate format to ensure consistent and accurate processing.
- Step 3: Text tokenization- This step involves breaking down the text into individual tokens, each representing a meaningful semantic unit within a specific document. Tokenization enables effective processing of the text.
- Step 4: Capitalization / De-capitalization- Depending on the specific requirements, the text may be converted to either uppercase or lowercase to ensure uniformity and facilitate analysis.
- Step 5: Removal of stop words- Stop words, such as common words like "and," "are," "at," "be," "of," "that," and so on, which contribute little value in matching user needs, are eliminated from the vocabulary. This helps to enhance the relevance and accuracy of the analysis.

- Step 6: Lemmatization- It involves reducing inflected word forms to their canonical or base form. For example, words like "change," "changing," and "changer" would all be reduced to their base form, "change." Lemmatization aids in standardizing the text and improving semantic understanding.
- Step 7: Stemming- It refers to the process of reducing the inflected form of a word in its root form (change, changer, changing… → chang) There are many ways to approach it:
    - build a database of words and their stems (eg. play, play-er,…). The advantage of doing this is that the machine will be able to detect exceptions (eg. child and children), but the disavandage is that it will not be able to handle new words that are not in the database.
    - or write a rule-base algorithm (porter stemming algorithm). The pro is that it will be able to handle new/unknown words, but the con is that it will miss many words with exceptions. This was the technique adopted by the model.
    - other options will include machine learning (train algorithms to recognize the root of words).
- Step 8: Calculation of the TF-IDF, a function used to measure the importance of a term with respect to a document or a collection of documents. This function increases proportionally to the number of times the term is contained in the document, but grows inversely proportional to the frequency of the term in the collection. The idea behind this behaviour is to give more importance to terms that appear in the document, but which are generally infrequent.

Once the textual data has undergone these preparatory steps, it can be divided into a training set (data used for machine learning model training) and a test set (data used to evaluate the model's classification performance). This division allows for effective model assessment and validation.

II. Binary Classification (Ensemble Model)

Once the data cleaning and data preparation steps were completed, the analysis proceeded by building a machine learning model for binary classification of the text. The two categories that this first model has to detect are SDG from the non-SDG texts.

To identify the best performing model for this task, several tests were conducted using different algorithms, including: Neural Networks, Support Vector Machines, Logistic Regression, Random Forest, and Naive Bayes. After experimenting, an optimal solution was founded by constructing an Ensemble Machine Learning model.

An ensemble model combines multiple models to achieve better predictive performance compared to individual models used in isolation; it leverages the collective intelligence of the base models to improve overall performance and generalization.

We employed the following machine learning algorithms to construct the ensemble model:

- Support Vector Machine (SVM) the basic idea behind it is to find a hyperplane (a decision boundary) that separates the data into different categories with the maximum margin, meaning that it maximizes the distance between the closest data points of different categories, known as support vectors.

  The text data is first pre-processed and vectorized, and then the resulting feature vectors are used as input to the SVM model. The model learns to identify the optimal hyperplane based on the training data and uses it to predict new text data, performing a non-probability binary classification.

  SVM has been found to be effective in text classification problems due to its ability to handle non-linear decision boundaries, deal with high-dimensional data. However, SVM can be computationally intensive and may require a long time to train on large datasets, especially when using complex kernel functions. However, this is not our case because we opted for a liner kernel.
- Logistic Regression (LR) is a statistical method that can be used in text mining to predict a binary outcome (e.g., SDG vs no-SDG) based on one or more independent variables (e.g., words in a text). It is a type of supervised learning algorithm that uses an equation to model the relationship between the dependent variable and one or more

independent variables. The output of the equation is transformed into a probability that the dependent variable belongs to a specific class (e.g., 60% is an SDG).

- Stochastic Gradient Descent (SGD) is an optimization algorithm used to minimize an objective function by updating the model parameters in small steps. In the context of text mining, the SGD classifier can be used to train a linear classifier, such as Support Vector Machines (SVM) or Logistic Regression, on large text datasets. The stochastic nature of SGD allows it to efficiently handle high-dimensional data, such as text, and quickly converge to a good solution, even for large-scale problems. Additionally, SGD classifiers can be easily updated online, making them well-suited for streaming text data.

Once the three ML models have been trained, the output of the ensemble model is defined as the majority vote of the predictions of the three individual models. The underlying idea is that the ensemble of three models can circumvent misclassification in cases where the input text is either too short or with an ambiguous meaning. Therefore, an ensemble model of this type manages to maximize the f-measure score at the same time as the recall and accuracy of the forecasts.

III. Multi-Labelled Classification Model

In the second phase of the analysis, the labeled data generated by the ensemble model will be utilized to further refine the categorization process. This subsequent model aims to provide more detailed categorization by assigning specific labels indicating which of the Sustainable Development Goals (SDGs) the text refers to.

In order to accurately classify the new de-structured textual data related to the Sustainable Development Goals (SDGs), and determine the specific categories they belong to, the analysis initially considered the 17 global goals outlined by the United Nations.
However, during the first categorization processes, it became apparent that certain Sustainable Development Goals (SDGs) shared significant similarities in their field and terminology, leading to frequent confusion. Notably, the goals of "No Poverty" and "Zero Hunger" were often misclassified due to their close relationship and intricacy. In light of this challenge, a

deliberate decision was made to consolidate these similar goals into the same cluster to mitigate confusion and enhance accuracy.

The identification of an appropriate number of clusters is a critical aspect of clustering analysis, as it necessitates the selection of a balance between the granularity of the partition and the accuracy of the resultant model. While the decision to merge these categories reduces the overall granularity of the classification, it ensures that the resulting clusters align with the shared area of interest and reflect the holistic nature of the SDGs. Consequently, this adjustment maintains the integrity of the categorization process and facilitates a more comprehensive analysis of textual data concerning the SDGs.

The new categories will be the following:

Peace, Justice and Strong Institution	Cluster 1
Quality Education	Cluster 2
Good Health and Well-being Clean water and sanitation	Cluster 3
Climate Action Life Below Water Life On Land	Cluster 4
Industry, Innovation and Infrastructure Responsible Consumption and Production Affordable and Clean Energy	Cluster 5
No Poverty Zero Hunger	Cluster 6
Gender Equality Decent Work and Economic Growth Reduced Inequalities	Cluster 7
Sustainable cities and communities	Cluster 8
Partnerships for the Goals	Cluster 9

Reducing the categories will not alter the result, since they will be grouped according to the same area of interest, just slightly broader than before.

In the context of constructing a multi-label classification task, extensive experimentation was conducted on various algorithms to identify the optimal solution. The most effective approach was found to be the utilization of a machine learning model from the Support Vector Machines (SVM) family, specifically a Linear Support Vector Classifier (SVC). The distinctive characteristic of an SVC model lies in its ability to fit the provided data and determine an optimal hyperplane that effectively separates or classifies the data.

In the case of the specific multi-label classification task, the SVC model generates a set of probabilities as its prediction output, indicating the likelihood of the input sentence belonging to each of the SDG clusters. These probabilities serve as valuable scores, enabling the identification of an ideal probability threshold (best cut-off) for each cluster. By comparing the model's predicted probability with the threshold, the classification decision for each cluster can be made accurately and efficiently

IV. Assessment of the performance of the model

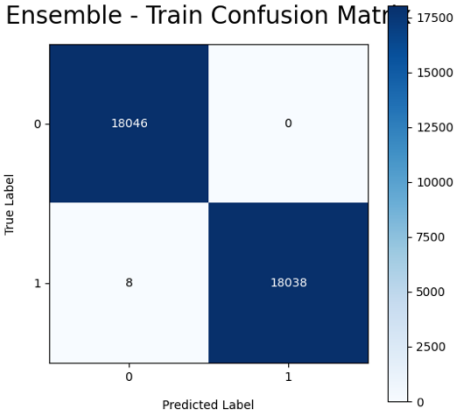
By the end of the analysis, both models have demonstrated commendable performance, yielding accurate and reliable results in their respective tasks.

The binary model exhibits an accuracy exceeding 0.95 (95%) on the test set, indicating its strong capability to correctly label data into SDG versus NO-SDG.

On the other hand, the multilabel model achieves an accuracy of 0.7 on the test set, suggesting its proficiency in accurately assigning each SDG labels to the given data instances. While an accuracy score of 0.7 may appear relatively low, it is normal for a more challenging task to result in a lower accuracy compared to a relatively simpler task. The difficulty of a classification task is based on factors such as the number of labels to be assigned, class imbalance, and inherent ambiguity in the labeling process.

Overall, these strong performance outcomes reinforce the reliability and effectiveness of the models; both models have effectively learned and captured the underlying patterns and relationships within the data, instilling confidence in their predictive capabilities.

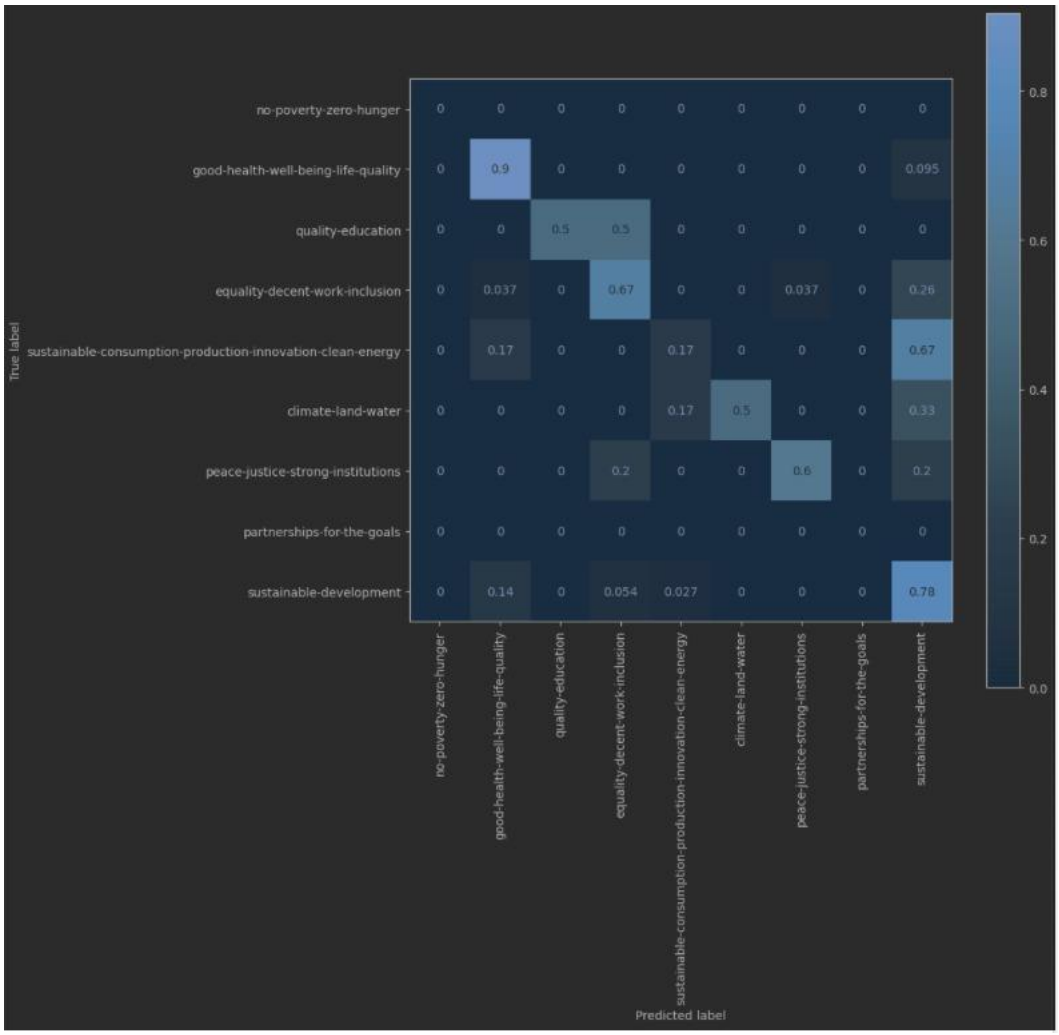
Confusion matrix of the binary model.



From the image we can easily see that there have been only 8 misclassified text data. More specifically, there were 8 posts pertain to the SDG, that have not been detected.

On the other hand, there were no no-SDG that have been classified as such.

Confusion matrix of the multiclass model



The confusion matrix of the multiclass model provides valuable insights into the classification performance, with the numbers inside the squares indicating the percentage of instances assigned to each category. For example, the value of 0.9 in the top-left corner signifies that 90% of cases belonging to the "good-health" category were correctly classified as such; looking at its right, we can see that the remaining were erroneously classified as "Sustainable development."
The diagonal represents all the correct classified instances, while the numbers outside the diagonal represent the percentages of misclassifications, where data was assigned to the wrong categories.

A notable observation in the confusion matrix is the tendency for misclassification between the "sustainable consumption" and "sustainable development" categories. Specifically, 67% of instances belonging to the "sustainable consumption" category were erroneously classified as "sustainable development." It is important to highlight that although these two concepts share close associations, they do possess distinct differences. Across various clusters, it is evident that the model frequently misclassifies a portion of instances as "sustainable development," which can be attributed to the broad and encompassing nature of this category.

Another intriguing finding is that the most frequently used SDGs identified by the model (frequency table shown in the next section), such as "Good-Healt, Well-Being, Life-Quality" and "Sustainable Developments," exhibit the highest accuracy in their classification.
This observation serves as a reminder of the significance of exposing machine learning algorithms to substantial volumes of data, as it is through such exposure that they acquire the capacity to learn and improve their classification performance.
As observed, it is apparent that certain clusters are devoid of any instances. While we will address this issue in detail later, it is worth mentioning that one contributing factor to this occurrence is the limited number of examples available to the computer during its training phase. The scarcity of training data for specific clusters can result in their emptiness within the model's classification framework.

Additionally, it is important to mention that during the manual annotation process of the textual data utilized by the model, certain instances exhibited vagueness. As a result, I made the decision to label these instances as "sustainable development," which could have potentially introduced some confusion to the algorithm's learning process.

Overall, the provided confusion matrix offers valuable insights into the classification performance, shedding light on the accurate classification of commonly used SDGs on the dataset while highlighting the challenges in distinguishing between closely related concepts.
Among the clusters analyzed, there were several that did not exhibit satisfactory performance, specifically:

- "Quality education"- which cluster was frequently confused with the "Equality, Decent work, Inclusion" cluster, resulting in a misclassification rate of 50%.
- "Sustainable consumption, Affordable and clean energy"- which was correctly classified only 17% of the time.
- "Climate, Land, Water"- which demonstrated a moderate level of accuracy, with correct classifications achieved only half of the time.

By identifying the clusters that exhibited lower accuracy or frequent misclassifications, it becomes possible to focus on refining the model's performance in those specific areas. These findings provide valuable insights for guiding future enhancements and fine-tuning the classification model to achieve better accuracy and more reliable res

CHAPTER 5

RESULTS

After executing the final multi-label classification model, we have obtained data classified with their corresponding Sustainable Development Goals (SDGs). To gain insights into the overall communication of SDGs across different firms, we can visualize the classification results using various graphs. In the following sections, you will find a pivot table and several radar plots. These visualizations will enable us to make preliminary statements about the performance of the selected IT companies in their communication regarding SDGs.

PIVOT TABLE

FIRM	CLIMATE, LAND, WATER	EQUALITY, DECENT WORK, INCLUSION	GOOD-HELTH, WELL-BEING, LIFE-QUALITY	NO-POVERTY ZERO-HUNGER	PEACE JUSTICE STONG INSTITUTION	QUALITY EDUCATION	SUSTAINABLE COSUMPTION, PRODUCT INNOVATION, CLEAN ENERGY	SUSTAINABLE DEVELOPMENT	PARTNERS HIP FOR GOALS	SUM
Almaviava	14	21	64	0	4	0	6	87	0	196
Almawave	0	12	18	0	1	0	2	22	0	55
Capgemini	0	25	28	1	1	1	3	33	0	92
Engineering	5	24	51	0	7	4	10	82	0	183
Everis	2	39	39	0	5	2	3	51	0	141
ExpertSystem	0	3	3	0	0	0	0	4	0	10
Reply	0	4	14	0	2	0	5	11	0	36
TopNetwork	0	14	41	0	5	2	7	38	0	107
Grand total	21	142	258	1	25	0	36	328	0	820

The pivot table displays the frequency outputs (number of instances) generated by the multi-labeled model, which classified the data according to their respective SDGs. Zeros in the table indicate that no mentions of those particular SDGs were found in the disclosures of the analyzed firms, or the model was unable to detect them.

As the number of retrieved data instances varies across companies due to the non-randomness of the extraction process, it is not appropriate to compare the companies' rows directly. To ensure a fair comparison, adjustments need to be made to calibrate the results. Normalizing the data is necessary as it accounts for the different value ranges observed.

In this regard, to facilitate the forthcoming data interpretation, it would be helpful to have a look at the normalized pivot table as well.

NORMALIZED PIVOT TABLE

FIRM	CLIMATE, LAND, WATER	EQUALITY, DECENT WORK, INCLUSION	GOOD-HELTH, WELL-BEING, LIFE-QUALITY	NO-POVERTY ZERO-HUNGER	PEACE JUSTICE STONG INSTITUTION	QUALITY EDUCATION	SUSTAINABLE COSUMPTION , PRODUCT INNOVATION, CLEAN ENERGY	SUSTAINABLE DEVELOPMENT	PARTNER SHIP FOR GOALS	SUM
Almaviava	7.14%	10.71%	32.65%	-	2.04%	-	3.06%	44.39%	-	100%
Almawave	-	21.82%	32.73%	-	1.82%	-	3.64%	40.00%	-	100%
Capgemini	-	27.17%	30.43%	1.09%	1.09%	1.09%	3.36%	35.87%	-	100%
Engineering	2.73%	13.11%	27.87%	-	3.83%	2.19%	5.46%	44.81%	-	100%
Everis	1.42%	27.66%	27.66%	-	3.55%	1.42%	2.13%	36.17%	-	100%
ExpertSystem	-	30.00%	30.00%	-	0	-	-	40.00%	-	100%
Reply	-	11.11%	38.89%	-	5.56%	-	13.89%	30.56%	-	100%
TopNetwork	-	13.08%	38.32%	-	4.67%	1.87%	6.54%	35.51%	-	100%
Grand total	2.56%	17.32%	31.46%	0.12%	3.05%	1.10%	4.39%	40.00%	0.00%	100%

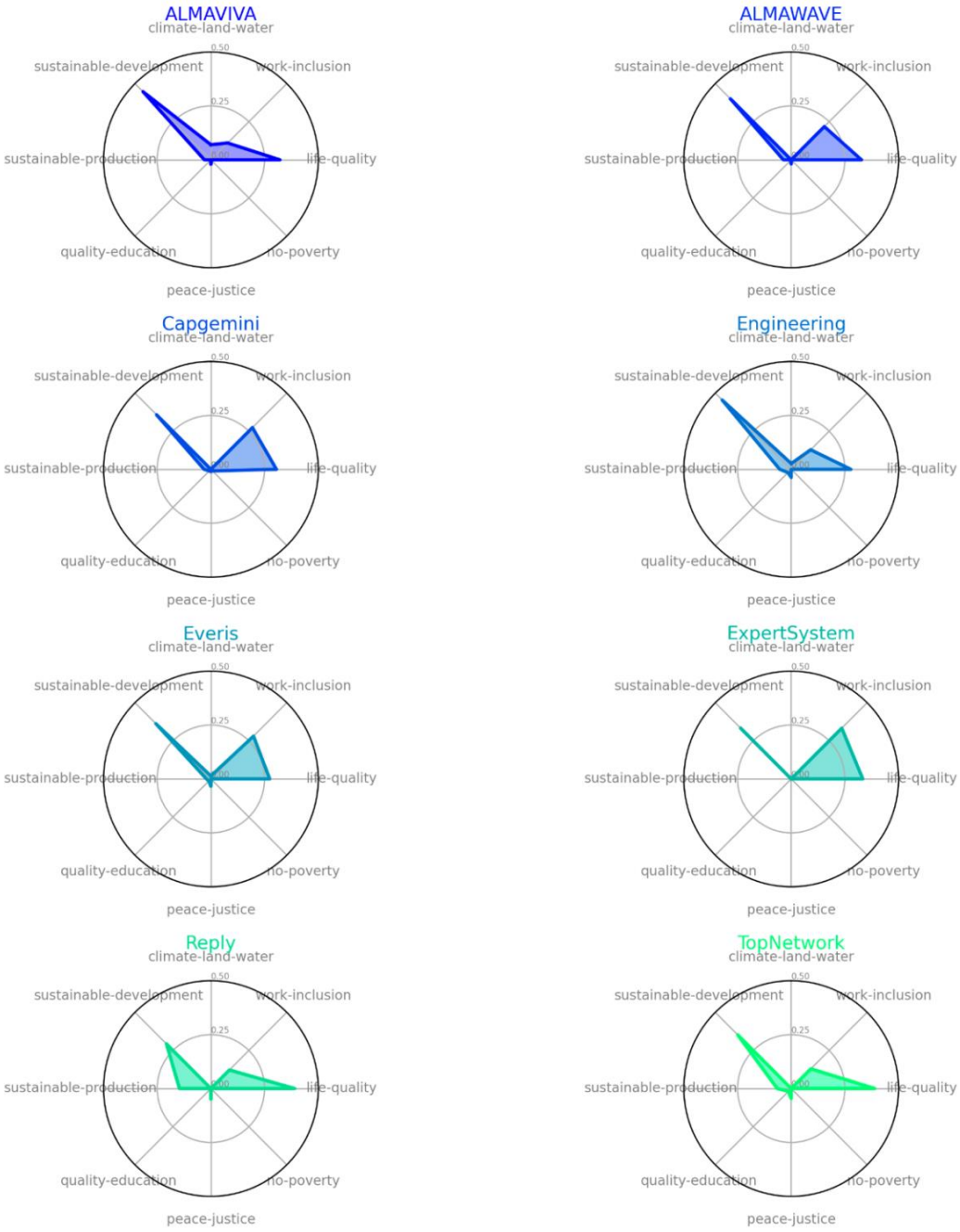
Normalizing a table (horizontally) means scaling the values within each row to a common range or standard. By applying row-wise normalization, each value the table is substituted by:

Normalized Value = Value / Sum of Row Values

The reason for normalizing the table horizontally is to account for the uneven distribution of data among the firms and to ensure a fair comparison. Without normalization, the analysis of the raw frequency counts may be biased towards firms that have a larger number of instances or disclosures overall. By normalizing, we can focus on the relative distribution of SDGs within each firm, allowing for a more accurate comparison of their performance in communicating about the SDGs.

Upon comparing the two tables, we can observe significant differences that demonstrate how the non-normalized table could have potentially misled our understanding of the firms' performance. For instance, without normalization, it might have been easy to assume that "Almaviva" excelled in every category. However, upon examining the normalized percentages, we realize that this assumption is far from accurate.

RADAR PLOTS



Radar plots are highly effective in providing a quick overview of the performance of all firms. They serve as graphical representations of the normalized pivot table mentioned earlier, where each radar plot displays colored sections representing the percentage of communication in specific fields relative to the total number of Sustainable Development Goals associated with each firm. These plots offer a visual snapshot and an intuitive understanding of how firms prioritize and communicate their efforts across different SDGs.

i. Data interpretation

Upon analyzing the radar plots and pivot table, it is evident that certain categories of the Sustainable Development Goals (SDGs) receive minimal to no discussion, indicating potential gaps in communication within the IT industry. These categories include:

1. Partnership for goals: None of the firms have discussed this category, indicating a notable absence of communication regarding collaborative efforts within the IT industry.
2. No poverty and zero hunger: Only Capgemini has addressed these issues in their communications, indicating that the rest of the firms may not consider them relevant. In fact, this category constituted only 0.12% of the overall communication about SDGs across firms.
3. Climate, land, water, and quality education: Only half of the firms have engaged in discussions related to these topics, suggesting room for improvement, especially for those that didn't participate in divulging this urgent global issue.

On the other hand, three topics demonstrated widespread adoption and discussion across all the firms:

1. Sustainable development: This category exhibits extensive adoption and is prominently discussed by multiple firms, representing 40% of the overall communication about SDGs
2. Good health, well-being, and life quality: This topic exhibits a high level of homogeneity in adoption across firms, indicating its significance and the industry's recognition of the importance of promoting health, well-being, and life quality.
3. Equality, decent work, and inclusion: This category also garners substantial discussion, highlighting the firms' focus on promoting equality, ensuring decent working conditions, and fostering inclusivity within their operations.

Overall, the radar plots and pivot table have greatly facilitated the comprehension of the data, providing a clear understanding of areas of emphasis and potential gaps in the firms' communication and actions regarding the SDGs.

Why are there some Sustainable Goals not taken in consideration by firms?

With a more in-depth look at the radar plots and the pivot table, we can see that approximately, every firm follows the same trend in deciding which Sustainable Goals are the most important to include in their public online communication.

I remind you that the firms selected for this analysis operate in the same Industry; therefore, these results may tell us something about companies' behavior in this business environment and, in turn, which SDGs they found to be more in line with the rest of their communication and their brand image.

Moreover, it is not just a coincident, that the most frequently used SDGs in their communications, are those that are more closely related to the economic activity they perform, in fact, looking at the top three most common SDGs, some important considerations can be drawn:

1. Sustainable development: The broad meaning of this goal allows it to encompass a wide range of initiatives, making it more adaptable and applicable across different projects and activities. As sustainability becomes increasingly important, firms are incorporating it into their operations, contributing to its high adoption rate.
2. Good health, well-being, and life quality: The high adoption of this SDG can be attributed to the fact that all the firms operate in the technology industry, which is inherently linked to improving efficiency and security. Moreover, technology plays an increasingly important role in the health sector, enabling advancements in telemedicine, remote patient monitoring, and personalized healthcare solutions.
3. Equality, decent work, and inclusion: Despite not constituting the core activity of a business, the conditions of work exert a strong influence on its overall operations and impact. In the present context, there is considerable emphasis placed on this particular topic, as firms recognize the importance of communicating their initiatives aimed at promoting equality, ensuring favorable working conditions, and fostering inclusivity within their organizational frameworks. Moreover, by actively communicating their commitment to these values, companies can garner respect and bolster their reputation among both their workforce and clientele.

Conversely, the Sustainable Development Goals (SDGs) that received less attention were those that posed greater challenges in terms of their contextualization within the IT industry. An example of this is the category of "No poverty", which exhibited minimal engagement with almost zero posts addressing the issue. This suggests that leveraging technology to directly tackle poverty-related challenges may present inherent difficulties within the IT sector.

Similarly, the SDG category of "Partnership for goals" was not discussed by any of the selected firms, indicating a lack of emphasis on collaborations and partnerships to achieve sustainable goals within the Industry. This finding highlights an area that presents opportunities for improvement in the future, as partnerships are crucial in a fast-paced world where knowledge is dispersed across different firms and individuals.

In conclusion, the analysis of the radar plots and pivot table offers valuable insights into the firms' communication strategies concerning SDGs. The observed alignment of communication efforts with their respective economic activities underscores the firms' recognition of the relevance of sustainability within their Industry. Moreover, the prominence given to SDGs closely related to the Industry's capabilities, such as sustainable development and promoting good health, well-being, and life quality, reflect the strategic focus on areas where technology can make a significant impact. However, the gaps observed in certain SDG categories indicate areas that require attention and improvement in future sustainability initiatives.
By considering the findings from the radar plots and pivot table, firms can refine their communication strategies, address existing gaps, and explore opportunities for collaboration to better align their actions with the broader objectives of sustainable development.

ii. How could we rank firms according to their communication on SDGs?

The normalization of frequencies in the previous radar plots provides a standardized basis for comparing the performances of different categories across firms. However, to evaluate the overall performance of companies on Sustainable Development Goals (SDGs) in a ranking format, several steps need to be followed.

1. The first step involves computing the percentage of communication dedicated to each category of the SDGs by each company. This computation allows us to gauge the extent to which firms invest their communication efforts in each specific SDG field. By determining the proportion of communication devoted to each category, we obtain a quantitative measure of their commitment to addressing the respective SDGs.
2. The second step entails ranking the companies for each category of the SDGs individually. In this process, firms are assigned rankings or points based on their relative positions within each category. The company with the highest percentage of communication in a particular category will receive the highest score, while the one with the lowest percentage will obtain the lowest score. This ranking procedure is repeated for each category, resulting in a series of individual rankings for each firm.
3. The final step involves computing an overall rank that takes into consideration the singular rankings obtained in the previous step. To derive the overall rank, the scores assigned to each firm in the individual category rankings are aggregated. By summing up the scores across all SDG categories, a comprehensive assessment of the firms' overall performance in addressing the SDGs can be obtained. The firm with the highest overall score will be ranked at the top, indicating their exemplary commitment to SDGs, while the firm with the lowest overall score will be placed at the bottom.

For privacy reasons, the final ranking of firm's performance will not be disclosed. However, the analysis aims to provide a fair evaluation of firms' efforts and contributions to sustainable development, taking into account their performance across multiple SDG categories.

CHAPTER 6

RESEARCH CONCLUSION

i) What could be improved

In light of the comprehensive analysis conducted in this research, it can be concluded that the overall outcomes align with the initial expectations, yielding easily interpretable and meaningful results. However, the study also revealed areas that warrant further attention and improvement in future iterations of this model, particularly in relation to the accurate categorization of multiple SDG fields. Imperfections are evident in the examination of the correlation matrix, where certain categories exhibited confusion and overlapping interpretations.

To address the future improvements of the multi-labeled process, two mutually reinforcing approaches can be adopted:

Firstly, merging categories that share closely related fields could enhance the clarity of the results. For instance, the distinction between "Sustainable consumption" and "Sustainable development" was often blurred, suggesting that treating them as a single category might yield more meaningful insights. The analysis could benefit from a more cohesive and unified representation of the underlying concepts by further combining related categories.

Secondly, to enhance the accuracy of the model's predictions for categories where it struggled due to limited training examples, acquiring additional data specific to those fields becomes crucial. By expanding the dataset and incorporating more diverse instances and variations within these challenging categories, the algorithm can learn to recognize and identify common features more effectively, ultimately improving its classification performance.

By implementing these strategies in future iterations of the model,
will contribute to refining the model's predictive capabilities, reducing confusion, and enhancing the overall accuracy and reliability of the analysis.It is worth emphasizing that these proposed strategies should be gradually implemented with careful consideration and evaluation, ensuring that the integrity and validity of the research findings are maintained.

In conclusion, while the research outcomes indicate success and alignment with expectations, the study also highlights opportunities for improvement in future iterations. By merging related categories and augmenting the dataset with additional training examples, the model's accuracy and comprehensiveness can be further enhanced. These advancements will ultimately contribute to a deeper understanding of the intricate relationship between firms' communication on SDGs and their contributions to sustainable development, empowering organizations to develop more informed and impactful strategies in pursuit of a more sustainable future.

ii) For what can the model be useful?

The development of this model stemmed from the desire to gain deeper insights into various aspects of SDG communication. The following objectives were pursued in its creation:

1. Understanding Brands' Communication on SDGs: Thanks to the first model that performs a binary classification (SDG vs. NO-SDG), it will be almost immediate for the algorithm to retrieve all the sentences about the SDGs theme. Following the multi-labeled analysis, the themes and messages communicated by brands in relation to the SDGs.
2. Assessing Performance Compared to Competitors: The model, thanks to the implementation of a ranking algorithm, can be utilized to assess how a firm is performing on the SDGs relative to its competitors. By analyzing the communication strategies of multiple companies within the same industry, it becomes possible to gauge their respective efforts and contributions towards the SDGs, allowing for benchmarking and performance evaluation.
3. Evaluating Partner Alignment with SDGs: The model serves as a valuable tool in understanding potential collaboration partners and their commitment to the SDGs. By extracting information on their communication regarding sustainability goals, organizations can assess the degree to which their potential partners prioritize and align with the SDGs, aiding in informed decision-making and fostering collaborations with like-minded entities.
4. Enhancing Understanding of Various Fields: This model not only provides insights into how specific firms are addressing the SDGs but also facilitates a better understanding

of how different industries (in this analysis, the IT industry was analyzed) are dealing with sustainability challenges. By investigating the communication patterns across industries, researchers and practitioners can gain valuable insights into the unique approaches, priorities, and challenges faced by different sectors in integrating sustainability practices.

Additionally, the applicability of this model extends beyond the realm of SDGs. Despite being trained exclusively on SDG-related data, the algorithm's ability to learn from the provided information without any pre-existing knowledge of sustainability makes it a potentially valuable tool for conducting analysis in other fields. The model's capabilities can be harnessed to explore and understand diverse topics, leveraging its data-driven insights to uncover patterns and trends specific to other domains.

In summary, the development of this model was driven by the desire to delve into the realm of SDG communication, with specific goals in mind. From examining brands' communication to assessing Performance, evaluating collaboration partners, and gaining insights into various fields, this model offers a versatile and valuable resource. Furthermore, it is not unlikely that the law could require one-day such analysis. In this case scenario, The FAIR INDEX MODEL will provide an excellent tool for companies to stay ahead of regulatory requirements and to demonstrate their commitment to the SDGs.

iii) What can be deduced from the research?

The research findings highlight the significance of creating awareness and fostering sustainable business practices to achieve the Sustainable Development Goals (SDGs). It emphasizes the shared responsibility of governments, organizations, and individuals in working together toward SDG implementation. This collaborative effort is crucial, as the successful realization of the SDGs necessitates the active participation of all sectors of society.

The core focus of this research revolves around the role of Artificial Intelligence (AI) in promoting environmental sustainability and facilitating the effective integration of SDGs into companies' communication practices. By leveraging AI technologies, organizations can

harness the power of data analytics to gain valuable insights and drive informed decision-making in support of sustainability initiatives.

The analysis conducted in this research project has proven to be successful, providing a comprehensive understanding of how AI can contribute to environmental sustainability and enhance SDG implementation. It demonstrates the capacity of AI to efficiently process and analyze vast amounts of complex data, ultimately providing clear and actionable insights.
One notable contribution of this research is the introduction of the FAIR INDEX MODEL, which represents an innovative approach to assessing a company's communication effectiveness in relation to its sustainability practices. This model holds the potential as a valuable tool for organizations, enabling them to identify areas for improvement, align their practices with the SDGs, and measure their progress. Moreover, it can foster healthy competition among companies, motivating them to continuously enhance their sustainability practices.

In conclusion, this thesis offers a comprehensive and insightful analysis of the IT industry's role in promoting environmental sustainability. It provides valuable recommendations for future actions, emphasizing the need for immediate attention to specific fields that are currently not receiving sufficient focus. By shedding light on these areas, the research prompts further exploration and action to address sustainability challenges within the IT industry and beyond.

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