IS6051 - Business Data Analysis and Visualisation

Part B: Group Project Submission

Group: 15

1. Omkar Nandkumar Phadtare - 124109697
2. Parth Bhau Dabhekar - 124107793
3. Vaishnavi Mansingh Deshmukh - 124112412
4. Syed Talha - 124117558
5. Vinisha Silvester - 124115337
6. Aryan Singh - 124104234

Data Analysis and Visualization for SDG 9 Targets

I. Introduction

When industries across the world develop, there is the question on how the two factors of industrial growth and environmental conservation can be separately managed. Industry advancement has often been used as a measure of economic development, yet its process incorporates undesirable impacts on the environment such as polluting the environment or using up natural resources. This creates a complex paradox for policymakers and business leaders: how are economies going to keep growing at the same time that climate change and environmental deterioration become increasingly pressing global issues? In order to meet these challenges, the United Nations formulated Shifts in thinking in 2015 through the formulation of the Sustainable Development Goals (SDGs). Among these, SDG 9: Industry, Innovation, and Infrastructure is important, centralized in the pursuit to achieve sustainable development by integrating economic development and environmental protection. This goal focuses on the development of robust infrastructures for production, promotion of sustainable industrialization, introducing efficiency through clean technologies, and enhancing investment on research and development (R&D).

Thus, a European-based nonprofit organization called Quant Nexus breaks through SDG 9 by increasing the sustainable industrial activity, innovations and financial inclusiveness. Organisation has understood the need to work with data to accomplish these goals and has sought outside services to complete detailed analysis of the EU nations on efforts towards goal 9 of the sustainable development. Exploring the analysis done for Quant Nexus, this essay is aimed at looking at how data analysis and visualization tools, especially Tableau were used to analyze industrial sustainability and innovation indicators. Using data from Eurostat, the report analyse the advances in areas like the air emissions intensity [1], shares in EGSS [3], and national investment in R&D [2].

The main goal of this essay is to discuss the approach for data analysis, reasons behind the choice of particular indicators, structure of the visualizations, as well as conclusions derived from this analysis. Besides, the essay gives practical suggestions to Quant Nexus that can enhance their work towards the attainment of SDG 9. By employing Data Visualization tools, Quant Nexus can analyze just how well each nation is distinguishing itself on the SDG 9 aim and what patterns need to be followed to amplify further progression.

Reflecting the approach of utilizing data to support the decision-making process, the general message of the report will be stressed, with the focus on how Quant Nexus might use the received knowledge to encourage the formation of a more prosperous future. The analysis also highlights the opportunities for increasing international cooperation, as well as regional and local cooperation between countries, business and research organizations to enhance the replication and expansion of innovations and sustainable practices that would support SDG 9 achievement.

II. The Organization

Quant Nexus is a nonprofit organization aimed at raising the level of sustainability of industrial production in European countries. This is the duty of promoting environmentally sustainable industrial development while at the same time promoting business growth. With a mission to uphold the principle that sustainability is the cornerstone for lasting prosperity in business, Quant Nexus has spurred innovation of green technologies, clean energy, and sustainable economy. The organization collaborates with government departments, companies and universities to facilitate industries through the adoption of new techniques in line with environmental objectives.

The organization's focus aligns with several Sustainable Development Goals (SDGs), most notably SDG 9: IIO: Industry, Innovation and Infrastructure which focuses on sustainable industrialization, increased use of technologies and better infrastructure. Moreover, industries are increasingly experiencing pressures of cutting down their impacts on the natural environment while continuing to operate profitably in a globalizing world; thus, Quant Nexus plays an important role of promoting sustainable policies and practices.

Among the essential responsibilities for Quant Nexus is its mission of acting as a mediator between industries and authorities. By researching, analyzing, and publicizing information, the organization assists in building an environment that supports everyone being able to accomplish economic self-actualization without ruining the conditions of the biosphere. This includes offering support for industries to decarbonate, enabling SMEs green finance and innovation and R&D [2]. Quant Nexus being the firm we are using to provide data on SDG 9 therefore acknowledges the fact that the goal is uphill task which will demand the cooperation of all the actors in society inclusive of governments, business and individuals.

The reason for which Quant Nexus hires external services for the acquisition of data analyses stems from the necessity to monitor the goals and objectives of SDG 9 in a measurable and credible manner. The organization acknowledges that for it to influence change process, it requires good data for its strategies and initiatives. Since the data is a reliable source, Quant Nexus can identify where there are improvements, where there are no advancements, and areas where tools and funds can be distributed efficiently. This is the point we have data visualization tools in place such as Tableau coming in handy. They offer the organisation robust means of processing and presenting information; the information that can be used to comprehend the relationships between various countries/regions across the world.

Residents of different states complained of lack of access to financial service, inadequate infrastructure and knowledge on sustainable practices as hitherto outlined by Quant Nexus Inc. Consequently, it is visible how Quant Nexus is an important link in the realization of SDG 9. Enhancement is also made by how the organization has embraced data analytics in tracking its work and in formulating more effective approaches toward implementing the objectives laid out in SDG 9. The external services used in data analysis and visualization are therefore central to the realization of Quant Nexus's mission.

III. SDGs and Related Targets

The **Sustainable Development Goals (SDGs)** were adopted by all United Nations Member States in 2015 as part of the **2030 Agenda for Sustainable Development**. These 17 global goals are designed to address the most pressing challenges facing the world today, including poverty, inequality, climate change, and environmental degradation. SDG 9, entitled “Industry, Innovation, and Infrastructure”, is a critical component of this agenda, focusing on the role of industries in driving economic growth, fostering innovation, and building resilient infrastructure.

SDG 9 consists of three primary targets:

- **Target 9.1**: Develop quality, reliable, sustainable, and resilient infrastructure to support economic development and human well-being.
- **Target 9.3**: Increase the access of small-scale industries and other enterprises to financial services, including affordable credit, and their integration into value chains and markets.
- **Target 9.5**: Enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, and encourage innovation by investing in research and development (R&D).

For Quant Nexus, these targets form the foundation of their work in promoting sustainable industrialization. The organization has recognized that achieving **SDG 9** requires a comprehensive approach that includes improving the sustainability of industrial infrastructure, increasing access to financial resources for SMEs, and fostering innovation through greater investment in research and development.

The focus of Quant Nexus aligns particularly with **Target 9.1**, which advocates for the development of resilient infrastructure. This includes not only physical infrastructure such as transportation networks, but also digital infrastructure and renewable energy systems that can support a sustainable future. Infrastructure development is key to achieving industrial sustainability because it provides the foundation for all other economic activities. Without resilient infrastructure, it is impossible for industries to grow in a sustainable way.

Target 9.3, which focuses on improving financial inclusion for SMEs, is another area where Quant Nexus has made significant strides. SMEs often face significant barriers in accessing the capital they need to innovate and expand, and as such, promoting financial inclusion is crucial for fostering a thriving industrial ecosystem. **Quant Nexus** works with financial institutions and policymakers to create enabling environments where SMEs can access affordable credit, helping them scale up their operations and integrate into global value chains.

Lastly, **Target 9.5** emphasizes the need for greater investments in research and development to drive technological innovation. The organization advocates for increasing R&D spending, particularly in areas that can drive sustainable industrialization, such as clean technologies and energy-efficient systems. Quant Nexus recognizes that innovation is essential for the long-term competitiveness of industries, and R&D plays a critical role in ensuring that technological advancements are aligned with sustainability goals.

By focusing on these key targets, Quant Nexus aims to ensure that the industrial sectors of tomorrow are sustainable, resilient, and inclusive. The organization's work helps bridge the gap between economic growth and environmental protection, contributing to the global push

for sustainability. The following sections will delve deeper into the indicators selected to measure progress toward these targets and the tools used to analyze and visualize the data.

IV. Choice of Indicators and Measures

The selection of the right indicators is crucial for monitoring progress toward the SDG 9 targets. **Quant Nexus** recognizes that measuring the success of industrial sustainability, financial access for SMEs, and R&D investment requires specific, reliable indicators that can provide actionable insights. The indicators selected for this analysis—**Emissions Intensity**, **Environmental Goods and Services Sector (EGSS)**, and **R&D Expenditure**—were chosen based on their direct relevance to the SDG 9 targets and their availability in reliable datasets.

- **Emissions Intensity (Target 9.1)**: Emissions intensity is a key indicator for measuring the environmental impact of industrial activity. It is defined as the amount of emissions produced per unit of economic output (measured by GDP or GVA). This indicator is critical for assessing how efficiently industries are reducing their carbon footprint while maintaining or increasing their economic output. By monitoring emissions intensity, policymakers and industry leaders can track the effectiveness of policies aimed at reducing emissions and promoting sustainable industrial practices.
- **Environmental Goods and Services Sector (EGSS)

(Target 9.3)**: The EGSS measures the contribution of industries that provide environmental goods and services, such as renewable energy production, waste management, and water treatment. This indicator is essential for understanding the role of green industries in contributing to both economic growth and environmental sustainability. As countries transition to greener economies, the EGSS becomes an important metric for tracking the growth of the environmental sector and its ability to generate employment and economic value.

- **R&D Expenditure (Target 9.5)**: The amount of money spent on research and development (R&D) as a percentage of GDP is a key indicator of a country's commitment to innovation. R&D is the engine of technological progress, and increasing R&D expenditure can lead to the development of new technologies that drive industrial efficiency, sustainability, and competitiveness. The more a country invests in R&D, the more likely it is to achieve breakthroughs in key sectors such as renewable energy, clean technologies, and industrial automation.

These indicators were selected because they are measurable, provide a clear picture of progress toward the SDG 9 targets, and are available through reputable data sources such as **Eurostat**. The next step in this analysis was to explore these indicators using data from **Eurostat** and to design visualizations that would allow **Quant Nexus** to track progress and make informed decisions.

V. Qualitative Description of the Dataset

The datasets used in this analysis were obtained from **Eurostat**, the statistical office of the European Union. **Eurostat** is known for its high-quality and up-to-date statistical data, making it an excellent source for monitoring progress toward the SDGs. The datasets used for this report focus on key indicators related to SDG 9, including air emissions intensity [1], contributions to the environmental goods and services sector (EGSS), and national R&D expenditures.

1. **Air Emissions Intensity**: This dataset measures industrial emissions in relation to gross value added (GVA), helping to assess how efficiently countries are reducing emissions per unit of economic output. The data is available for several years and is updated regularly by **Eurostat**. This dataset provides critical insights into how industries are adopting more sustainable practices and how environmental policies are impacting emissions levels across Europe.
2. **Environmental Goods and Services Sector (EGSS)**: The EGSS dataset tracks the value of goods and services produced by industries contributing to environmental sustainability. This includes renewable energy production, waste management services, and water treatment. The dataset is valuable for understanding the extent to which green industries are contributing to national economies and how much potential there is for growth in this sector. It is updated annually and offers comprehensive data on both production and export contributions from the environmental goods sector.
3. **R&D Expenditure**: The R&D expenditure dataset measures the amount of national spending on research and development as a percentage of GDP. This dataset is important for assessing how much countries are investing in innovation and technological progress. Countries that spend a larger share of their GDP on R&D are likely to be more innovative, which can lead to greater industrial productivity and sustainability.

These datasets are regularly updated and are publicly available through **Eurostat**. They provide a wealth of information that is crucial for tracking progress toward SDG 9 and understanding how different countries are performing in terms of emissions, green industries, and innovation. The datasets are reliable, well-documented, and widely used by policymakers, researchers, and organizations working toward sustainability goals.

VI. Quantitative Description of the Dataset

To assess the state of progress toward SDG 9 targets, the datasets were analyzed using a range of descriptive statistics, including measures of central tendency (mean, median), dispersion (standard deviation), and correlations. The goal was to summarize the data, identify trends, and determine the presence of any outliers that might indicate unusual patterns or inconsistencies.

Air Emissions Intensity [1]:

- **Mean**: 0.0002 kg/euro
- **Range**: 0.00004–0.00034 kg/euro

- **Standard Deviation**: 0.00008 kg/euro
- **Outliers**: Latvia exhibited a significantly higher emissions intensity than the other countries in the dataset. This outlier was flagged for further analysis, as it indicated a large disparity in emissions reduction progress between Latvia and other European countries.

Environmental Goods and Services Sector (EGSS):

- **Mean**: €20 billion
- **Range**: €10 billion–€30 billion
- **Standard Deviation**: €6 billion
- **Outliers**: Germany, France, and the UK showed considerably higher contributions to the EGSS, reflecting their larger economies and more significant investments in green technologies. These differences were expected and not adjusted, as they were consistent with the economic scale of these countries.

R&D Expenditure:

- **Mean**: 2.1% of GDP
- **Range**: 0.7%–3.5% of GDP
- **Standard Deviation**: 0.5%
- **Outliers**: Sweden and Finland were identified as outliers due to their exceptionally high R&D expenditures compared to other countries. These high investments were seen as indicative of successful innovation strategies rather than anomalies.

Correlations in the Data

1. **Emissions Intensity and GDP Growth**
    - **Negative Correlation (r = -0.52)**: Countries with lower emissions intensity tend to experience higher GDP growth. This suggests that sustainable industrial practices, like adopting cleaner technologies, can reduce environmental impact while fostering economic growth. Quant Nexus can advocate for countries like **Latvia** to reduce emissions intensity, helping both the environment and the economy.
2. **Environmental Goods and Services Sector (EGSS) and Export Performance**
    - **Positive Correlation (r = 0.6)**: Countries with stronger contributions to the EGSS also tend to have better export performance. This indicates that investing in green industries can drive economic growth. **Quant Nexus** can encourage smaller economies like **Malta** to invest in environmental goods and services, which could boost their export sector.
3. **R&D Expenditure and GDP Growth**

- **Positive Correlation (r = 0.65)**: Countries with higher R&D spending show greater GDP growth, highlighting the importance of innovation in driving economic performance. Quant Nexus can advocate for increased R&D investments in countries like **Romania** to help drive technological advancements and economic growth.

Implications for SDG 9 Targets

- **For Target 9.1 (Sustainable Infrastructure)**: The negative correlation suggests that countries with lower emissions intensity, like Germany, achieve better economic outcomes. Quant Nexus can use this insight to encourage sustainable infrastructure investments.
- **For Target 9.3 (Financial Access for SMEs)**: Supporting green industries and financial inclusion for SMEs can drive economic growth, benefiting both small businesses and the economy at large.
- **For Target 9.5 (R&D Investment)**: The strong link between R&D expenditure and economic growth supports the need for more investment in innovation, particularly in countries with lower R&D spending, such as Romania.

By analyzing the dataset with these descriptive statistics, patterns and trends were identified that highlighted disparities between countries in terms of emissions intensity, contributions to the environmental goods sector, and R&D investment. These insights were crucial for understanding progress in achieving SDG 9 and identifying areas where further efforts are needed.

The correlations further emphasize the importance of strategic investments in sustainability and innovation. The **negative correlation between emissions intensity and GDP growth** suggests that reducing emissions while maintaining economic growth is possible, especially with cleaner technologies. The **positive correlation between EGSS contributions and export performance** shows that green industries can drive economic success, while the **positive correlation between R&D expenditure and GDP growth** highlights how innovation fuels economic prosperity.

These correlations, along with the descriptive statistics, provide valuable insights for **Quant Nexus** to target interventions more effectively and promote sustainable industrialization, financial inclusion, and innovation in countries lagging behind in these areas.

VII. Dataset Processing for Dashboard Creation

For effective visualization and analysis of the data, the datasets were processed and transformed using Tableau. Tableau was chosen because it allows for the creation of interactive and dynamic visualizations that are essential for exploring large datasets. The following steps were taken in the processing of the data:

1. **Data Cleaning**: The datasets were cleaned to ensure accuracy and consistency. Missing data was imputed using mean imputation for continuous variables, and anomalies were flagged for review.

2. **Data Transformation**: The data was transformed by creating calculated fields to compute year-over-year changes in emissions intensity, EGSS, and R&D expenditure. This transformation allowed for a more in-depth analysis of trends over time.
3. **Dashboard Creation**: Interactive dashboards were created to allow users to filter by country, year, and specific SDG target. The Tableau tool enabled the creation of bar charts, geo-maps, and scatter plots, each designed to showcase different aspects of the data.

VIII. Design of Visualizations and Dashboard Layout

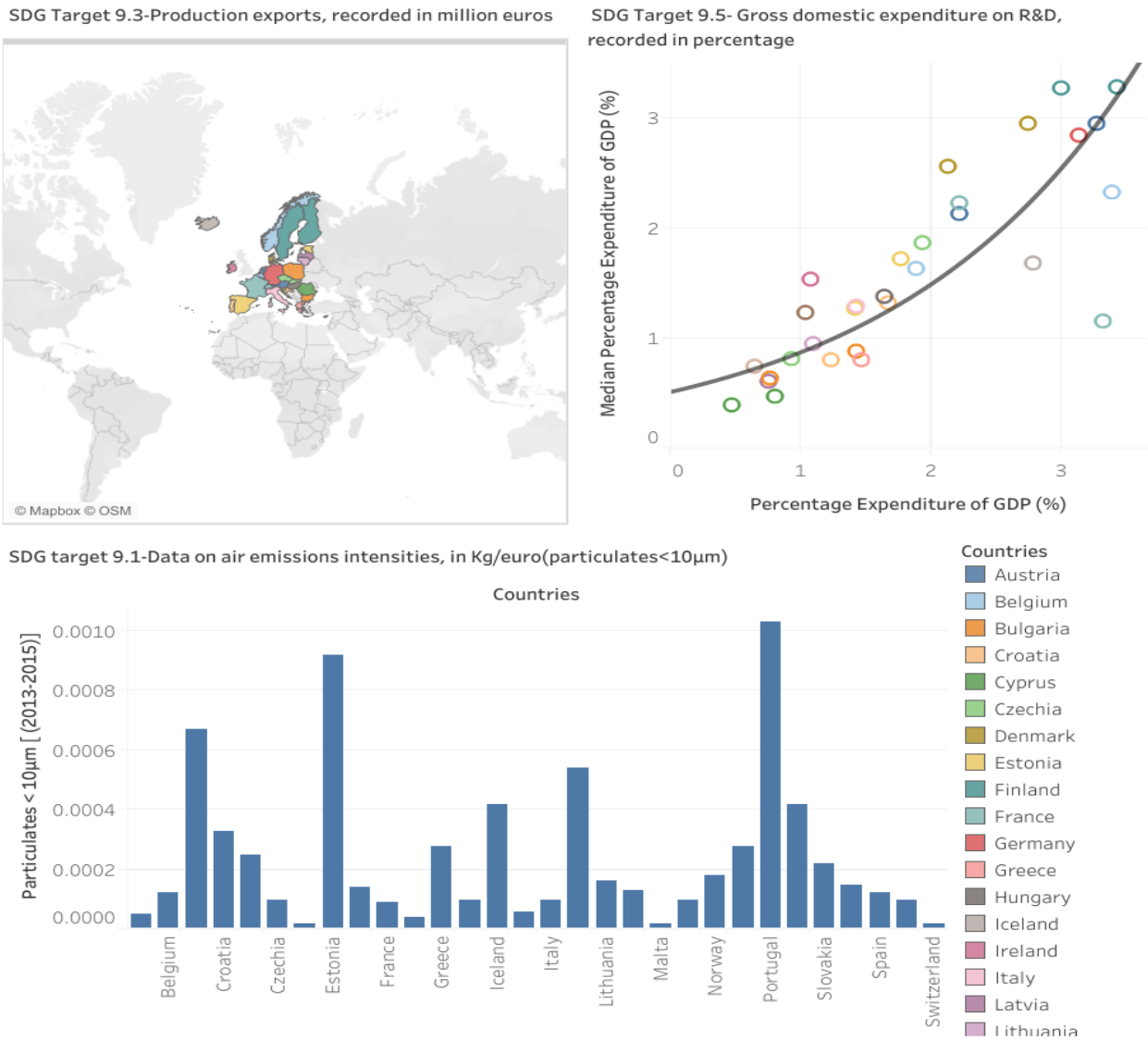

Figure 1: Dashboard

The visualization dashboard (Figure 1) was created with the goal of making complex data easy to understand and actionable for Quant Nexus. The following visualization choices were made based on their ability to clearly convey the key trends and insights from the data:

1. **Bar Charts for Air Emissions Intensity**: Bar charts (Figure 2) are ideal for comparing emissions intensity across countries. This visualization allows users to easily identify which countries have made the most progress in reducing their emissions per unit of economic output.

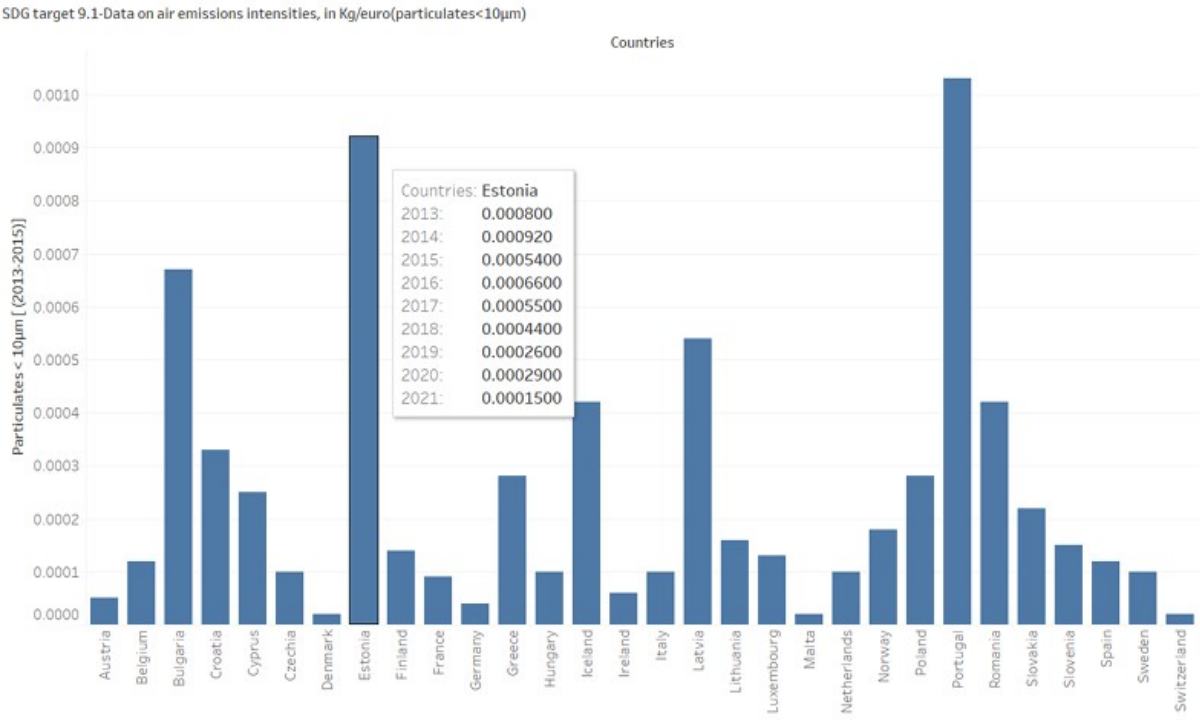

Figure 2: Bar Chart for Air Emissions Intensity by Country (2013–2022)

2. **Geo-Maps for Environmental Goods and Services**: Geo-maps (Figure 3) provide a spatial representation of the contributions to the environmental goods and services sector across Europe. They allow users to visually compare how different countries are performing and highlight regions with high potential for growth.

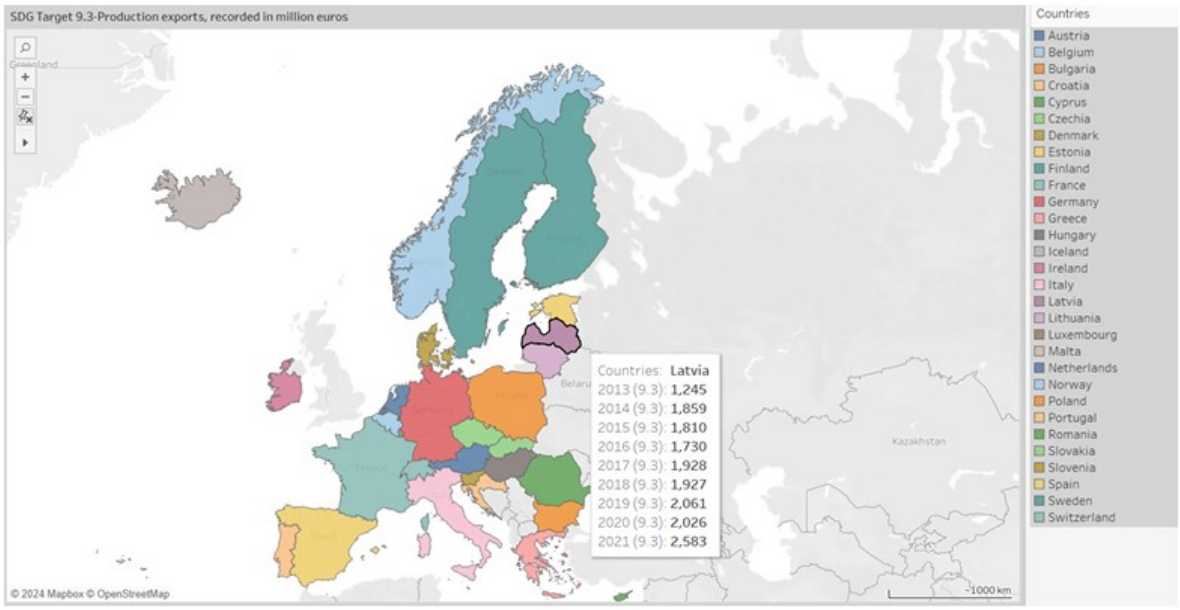

Figure 3: Geo-Maps for Contributions by Country in Environmental Goods and Services Sector (EGSS) (2013–2022)

3. **Scatter Plots for R&D Expenditure and GDP Growth**: Scatter plots are effective for visualizing the relationship between two continuous variables. In this case, the relationship between R&D expenditure and GDP growth (Figure 4) was analyzed, showing a clear correlation between high R&D investment and strong economic performance.

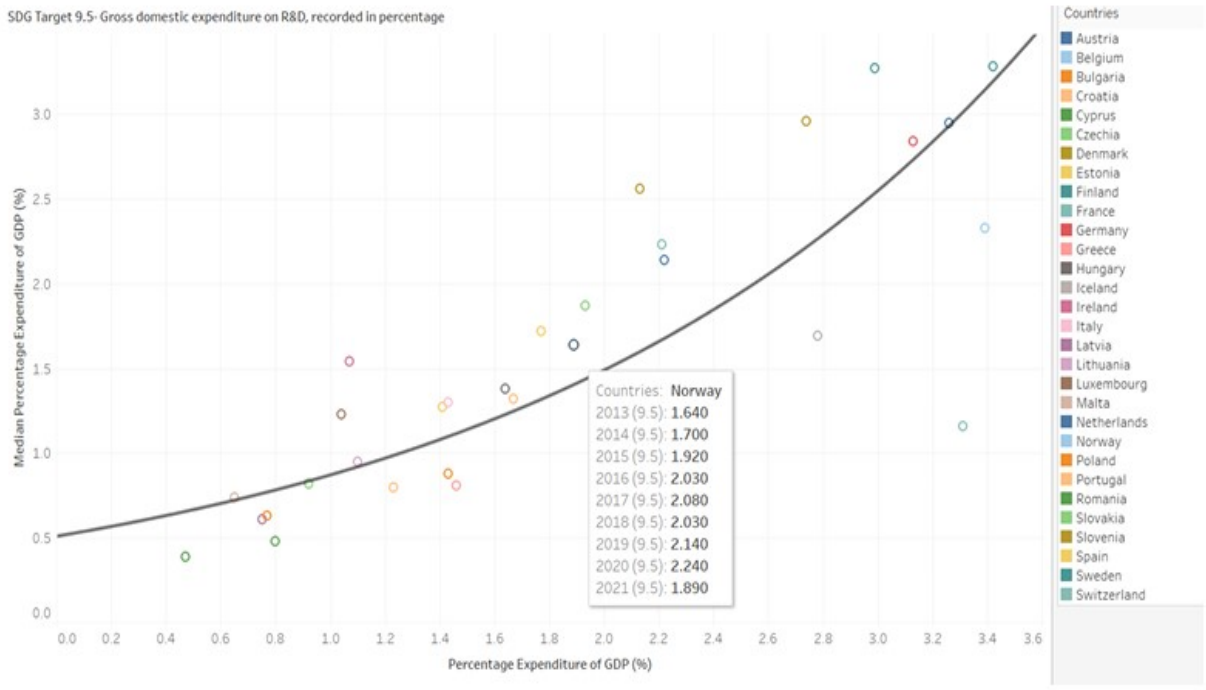

Figure 4: Scatter Plot for R&D Expenditure by Country (2013–2022)

The dashboard layout was designed to be user-friendly, with clear sections for each SDG target and intuitive navigation to allow users to filter the data by country and year. Filters and interactive features made it easy to explore the data in-depth, ensuring the dashboard was both informative and accessible.

IX. Analysis of Visualized Data

The visualizations provided key insights into the performance of European countries in relation to SDG 9 targets. The analysis showed that while some countries have made significant progress in reducing emissions intensity and investing in green technologies, others are lagging behind.

1. **Emissions Intensity**: Countries like Germany have made impressive strides in reducing emissions intensity, while countries like Latvia show room for improvement. This highlights the need for more stringent environmental policies and greater investment in renewable energy infrastructure.
2. **Environmental Goods and Services**: The EGSS data revealed that larger economies such as Germany, France, and the UK lead in contributing to the green economy. Smaller economies like Malta show untapped potential in this area, which could be realized through targeted financial policies and investments in sustainable industries.
3. **R&D Expenditure**: There was a strong correlation between high R&D expenditure and GDP growth. Countries that invest heavily in R&D, such as Sweden and Finland, show

significantly higher GDP growth, emphasizing the importance of innovation in driving economic success.

X. Recommendations for the Client

Recommendations from Quant Nexus

Based on the insights derived from the data analysis, the following recommendations are made to support **Quant Nexus** in advancing **SDG 9**:

1. **Sustainable Infrastructure**: Countries with high emissions intensity, such as **Latvia**, should implement stricter environmental regulations to reduce industrial emissions. To support this transition, **Quant Nexus** can organize workshops that facilitate knowledge-sharing between governments, businesses, and industry leaders. These workshops can provide a platform for discussing best practices in sustainable infrastructure and green technologies. Furthermore, **Quant Nexus** can help forge partnerships between governments and private enterprises to foster investments in renewable energy and energy-efficient infrastructure. By focusing on this area, **Quant Nexus** can guide countries toward adopting infrastructure solutions that promote long-term environmental sustainability and industrial resilience.
2. **Financial Access for SMEs**: Small economies often face significant challenges when accessing financing, which limits the potential for SMEs to scale and innovate. **Quant Nexus** can support the development of financial programs designed to provide SMEs with easier access to credit. These programs could focus on offering low-interest loans, grants, and tax incentives for businesses that adopt green technologies. By removing financial barriers, Quant Nexus can help SMEs integrate into global supply chains, expand their operations, and contribute to the green economy. Financial inclusion for SMEs will foster a more diverse and sustainable industrial ecosystem, driving long-term economic growth and job creation.
3. **R&D Investment**: Countries like **Romania** should prioritize increasing their R&D expenditure to drive technological advancements and innovation. Quant Nexus can advocate for policies that offer tax incentives for R&D-intensive industries, encouraging both public and private sector investments in research and development. Additionally, **Quant Nexus** can help establish innovation hubs that promote collaboration between universities, research institutions, and the private sector. By fostering a culture of innovation, Quant Nexus can support the development of new technologies that contribute to sustainable industrialization.

XI. Conclusion

This essay has provided an in-depth analysis of **SDG 9: Industry, Innovation, and Infrastructure**, highlighting the importance of sustainable infrastructure, financial access for SMEs, and increased investments in research and development (R&D) to drive industrial sustainability and economic growth. By analyzing key data through advanced visualization

tools like **Tableau**, this report offers critical insights into the progress made by European countries toward achieving SDG 9, as well as areas where further intervention is needed.

The findings underscore the importance of sustainable infrastructure, which forms the foundation for all industrial growth. Countries like **Germany** have made significant strides in reducing emissions intensity through the implementation of cleaner technologies, while smaller nations like **Latvia** and **Romania** show considerable potential for improvement. **Quant Nexus** can support these countries by advocating for stronger environmental policies and facilitating investments in renewable energy and green infrastructure.

Moreover, financial inclusion for SMEs remains a crucial factor for promoting innovation and industrial competitiveness. By improving access to credit and integrating SMEs into global value chains, countries can accelerate their transition to greener, more sustainable industries. The visualized data clearly demonstrates the need for targeted financial programs that help small businesses overcome barriers to growth and innovation.

Lastly, the correlation between R&D expenditure and economic growth highlights the role of innovation in achieving industrial sustainability. Countries investing more in R&D, like **Sweden**, show stronger economic performance, underscoring the importance of fostering technological advancements.

In conclusion, this report provides actionable recommendations for Quant Nexus to enhance its efforts toward achieving SDG 9. By focusing on the three key areas—sustainable infrastructure, financial inclusion for SMEs, and R&D investment, Quant Nexus can contribute significantly to the development of a more sustainable, innovative, and inclusive industrial economy across Europe. The insights provided will guide future strategies and interventions to ensure long-term economic and environmental prosperity.

References:

[1] Eurostat - European Union: Air Emissions Data.

[2] Eurostat - European Union: R&D Investment Data.

[3] Eurostat - European Union: Environmental Goods and Services Sector Data.

[4] OpenAI (ProofReading): ChatGPT
