

# Financial and ESG Performance Analysis of the Aerospace Industry: A 2020-2024 Outlook

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## 1 ESG Analysis on Aerospace Industry

### 2 Intro

This project will focus into the financial health and ESG performance of major aerospace industry players over the period from 2020 to 2023, utilizing Python packages such as yfinance, pandas, numpy, matplotlib, and seaborn to extract and evaluate comprehensive accounting data.

#### *Summary :*

1. Financial Datas
2. Performance and Ratio Analysis
3. Forecasting
4. ESG Performance

The 4 companies we chose are Airbus; Boeing; Embraer and Bombardier (Even if Bombardier sold its civil fleet to Airbus in 2021, the choice is relevant as Bombardier is the first private/business plane provider). All those companies are referenced under the *SIC code : 3721*.

## 3 I. Financial Datas & relevant infos

### 3.1 A. Income statement

```
[1]: import yfinance as yf
import pandas as pd
import numpy as np
```

```
[2]: companies = {
    "Airbus": "AIR.PA",
    "Boeing": "BA",
    "Embraer": "ERJ",
    "Bombardier": "BBD-B.TO"
}
sic_code="3721"
```

```
[3]: income_statements=pd.DataFrame()
```

**ESG Relevant data:** To get relevant indicators and financial metrics for our esg analysis, the code will use only the most relevant indicators on the income statement, that's why we create a esg condition inside the **loop that will only iterate the esg project focused indicators for the financial analysis**

We can create our first ratios inside the ESG condition with the NI margin =  $\frac{\text{Net Income}}{\text{Total Revenue}}$  and the RD to Revenue ratio =  $\frac{\text{RD}}{\text{Total Revenue}}$  These indicators will be added to our pandas table.

The last step ensure that each row is correctly labeled with the company name and corresponding year then the code finally concatenates the income statements relevant datas with the indicators.

```
[4]: for company, ticker in companies.items():
    ticker_data=yf.Ticker(ticker)
    financials=ticker_data.financials.transpose()

    financials['Company']=company
    financials['Year']=financials.index.year

    esg_relevant_data=financials[['Total Revenue', 'Cost Of Revenue', 'Gross_
    ↪Profit',
                                'Research And Development', 'Operating_
    ↪Income', 'Net Income']].copy()
    #esg_relevant_data['Net Income Margin']=esg_relevant_data['Net Income'] /_
    ↪esg_relevant_data['Total Revenue']
    #esg_relevant_data['R&D to Revenue Ratio']=esg_relevant_data['Research And_
    ↪Development'] / esg_relevant_data['Total Revenue']

    esg_relevant_data['Company']=company
    esg_relevant_data['Year']=esg_relevant_data.index.year

    income_statements=pd.concat([income_statements, esg_relevant_data])
```

```
[5]: income_statements['Index']=income_statements['Company'] + " " +_
    ↪income_statements['Year'].astype(str)
    income_statements.set_index('Index', inplace=True)
```

```
[6]: print(income_statements[['Total Revenue',          'Cost Of Revenue',_
    ↪          'Gross Profit',          'Research And_
    ↪Development',          'Operating Income',          'Net Income']])
```

	Total Revenue	Cost Of Revenue	Gross Profit \
Index			
Airbus 2023	65446000000.0	55402000000.0	10044000000.0
Airbus 2022	58763000000.0	48192000000.0	10571000000.0
Airbus 2021	52149000000.0	42518000000.0	9631000000.0

Airbus 2020	49912000000.0	44250000000.0	56620000000.0
Boeing 2023	77794000000.0	70070000000.0	77240000000.0
Boeing 2022	66608000000.0	63078000000.0	35300000000.0
Boeing 2021	62286000000.0	59237000000.0	30490000000.0
Boeing 2020	58158000000.0	63843000000.0	-56850000000.0
Embraer 2023	52685000000.0	43589000000.0	90960000000.0
Embraer 2022	45404000000.0	36282000000.0	91220000000.0
Embraer 2021	41972000000.0	35376000000.0	65960000000.0
Embraer 2020	37711000000.0	32935000000.0	47760000000.0
Bombardier 2023	80460000000.0	64150000000.0	163100000000.0
Bombardier 2022	69130000000.0	56560000000.0	125700000000.0
Bombardier 2021	60850000000.0	51610000000.0	92400000000.0
Bombardier 2020	64870000000.0	59710000000.0	51600000000.0

	Research And Development	Operating Income	Net Income
Index			
Airbus 2023	32570000000.0	42660000000.0	37890000000.0
Airbus 2022	30790000000.0	52520000000.0	42470000000.0
Airbus 2021	27460000000.0	48330000000.0	42130000000.0
Airbus 2020	28580000000.0	66400000000.0	-11330000000.0
Boeing 2023	33770000000.0	-82100000000.0	-22220000000.0
Boeing 2022	28520000000.0	-35090000000.0	-49350000000.0
Boeing 2021	22490000000.0	-33570000000.0	-42020000000.0
Boeing 2020	24760000000.0	-129780000000.0	-119410000000.0
Embraer 2023	9030000000.0	24480000000.0	16400000000.0
Embraer 2022	11000000000.0	22010000000.0	-18540000000.0
Embraer 2021	4300000000.0	18520000000.0	-4470000000.0
Embraer 2020	2980000000.0	-14770000000.0	-73190000000.0
Bombardier 2023	37300000000.0	78600000000.0	44500000000.0
Bombardier 2022	36000000000.0	47100000000.0	-14800000000.0
Bombardier 2021	33800000000.0	23200000000.0	50410000000.0
Bombardier 2020	32000000000.0	-26900000000.0	-86800000000.0

### 3.2 B. Balance Sheet

```
[7]: balancesheets = pd.DataFrame()
```

```
[8]: for company, ticker in companies.items():
    ticker_data = yf.Ticker(ticker)
    balancesheet = ticker_data.balancesheet.transpose()

    balancesheet['Company'] = company
    balancesheet['Year'] = balancesheet.index.year

    relevant_data = balancesheet[['Inventory', 'Current Assets', 'Current_
↳Liabilities', 'Total Assets', 'Total Liabilities Net Minority Interest',_
↳'Stockholders Equity', 'Long Term Debt', 'Total Debt']].copy()
```

```

relevant_data['Company'] = company
relevant_data['Year'] = relevant_data.index.year

balancesheets = pd.concat([balancesheets, relevant_data])

balancesheets['Index'] = balancesheets['Company'] + " " + balancesheets['Year'].
    .astype(str)
balancesheets.set_index('Index', inplace=True)
print(balancesheets)

```

	Inventory	Current Assets	Current Liabilities \
Index			
Airbus 2023	27740000000.0	64001000000.0	53750000000.0
Airbus 2022	27157000000.0	63002000000.0	52595000000.0
Airbus 2021	25166000000.0	55694000000.0	47807000000.0
Airbus 2020	27286000000.0	58400000000.0	49471000000.0
Boeing 2023	79741000000.0	109275000000.0	95827000000.0
Boeing 2022	78151000000.0	109523000000.0	90052000000.0
Boeing 2021	78823000000.0	108666000000.0	81992000000.0
Boeing 2020	81715000000.0	121642000000.0	87280000000.0
Embraer 2023	2610600000.0	6055400000.0	3665600000.0
Embraer 2022	2295200000.0	5756600000.0	3217300000.0
Embraer 2021	1955200000.0	5875800000.0	2828800000.0
Embraer 2020	2390100000.0	6115700000.0	2428700000.0
Bombardier 2023	3768000000.0	5934000000.0	5938000000.0
Bombardier 2022	3322000000.0	5585000000.0	5437000000.0
Bombardier 2021	3242000000.0	5481000000.0	4768000000.0
Bombardier 2020	3650000000.0	16646000000.0	16827000000.0

	Total Assets	Total Liabilities	Net Minority Interest \
Index			
Airbus 2023	118871000000.0		101141000000.0
Airbus 2022	115944000000.0		102962000000.0
Airbus 2021	107047000000.0		97561000000.0
Airbus 2020	110095000000.0		103639000000.0
Boeing 2023	137012000000.0		154240000000.0
Boeing 2022	137100000000.0		152948000000.0
Boeing 2021	138552000000.0		153398000000.0
Boeing 2020	152136000000.0		170211000000.0
Embraer 2023	10782500000.0		7743200000.0
Embraer 2022	10142100000.0		7317800000.0
Embraer 2021	10155000000.0		7380000000.0
Embraer 2020	10516000000.0		7608500000.0
Bombardier 2023	12458000000.0		14862000000.0
Bombardier 2022	12324000000.0		15086000000.0
Bombardier 2021	12764000000.0		15853000000.0

Bombardier 2020 23090000000.0

29747000000.0

	Stockholders Equity	Long Term Debt	Total Debt	Company \
Index				
Airbus 2023	17695000000.0	8806000000.0	11322000000.0	Airbus
Airbus 2022	12950000000.0	9139000000.0	10983000000.0	Airbus
Airbus 2021	9466000000.0	11603000000.0	13461000000.0	Airbus
Airbus 2020	6445000000.0	12544000000.0	15622000000.0	Airbus
Boeing 2023	-17233000000.0	46927000000.0	52603000000.0	Boeing
Boeing 2022	-15883000000.0	51670000000.0	57277000000.0	Boeing
Boeing 2021	-14999000000.0	56687000000.0	58370000000.0	Boeing
Boeing 2020	-18316000000.0	61752000000.0	63851000000.0	Boeing
Embraer 2023	2786500000.0	2759300000.0	2982400000.0	Embraer
Embraer 2022	2567500000.0	2894700000.0	3274200000.0	Embraer
Embraer 2021	2667900000.0	3452700000.0	4090700000.0	Embraer
Embraer 2020	2794900000.0	4072500000.0	4512700000.0	Embraer
Bombardier 2023	-2404000000.0	5607000000.0	5607000000.0	Bombardier
Bombardier 2022	-2762000000.0	5980000000.0	5980000000.0	Bombardier
Bombardier 2021	-3089000000.0	7047000000.0	7047000000.0	Bombardier
Bombardier 2020	-9325000000.0	8193000000.0	10075000000.0	Bombardier

	Year
Index	
Airbus 2023	2023
Airbus 2022	2022
Airbus 2021	2021
Airbus 2020	2020
Boeing 2023	2023
Boeing 2022	2022
Boeing 2021	2021
Boeing 2020	2020
Embraer 2023	2023
Embraer 2022	2022
Embraer 2021	2021
Embraer 2020	2020
Bombardier 2023	2023
Bombardier 2022	2022
Bombardier 2021	2021
Bombardier 2020	2020

### 3.3 C.Cash Flow

```
[9]: relevant_cash_flows = pd.DataFrame()
```

```
[10]: for company, ticker in companies.items():  
        ticker_data = yf.Ticker(ticker)  
        cashflow = ticker_data.cashflow.transpose()
```

```

cashflow['Company'] = company
cashflow['Year'] = cashflow.index.year

cashflow = cashflow[cashflow['Year'] >= (pd.to_datetime("today").year - 4)]

relevant_data = cashflow[['Operating Cash Flow', 'Investing Cash_
↪Flow', 'Financing Cash Flow', 'End Cash Position', 'Capital Expenditure', 'Free_
↪Cash Flow',
]].copy()

relevant_data['Company'] = company
relevant_data['Year'] = cashflow['Year']
relevant_cash_flows = pd.concat([relevant_cash_flows, relevant_data])

relevant_cash_flows['Index'] = relevant_cash_flows['Company'] + " " +_
↪relevant_cash_flows['Year'].astype(str)
relevant_cash_flows.set_index('Index', inplace=True)

print(relevant_cash_flows)

```

	Operating Cash Flow	Investing Cash Flow	Financing Cash Flow	\
Index				
Airbus 2023	6255000000.0	-4128000000.0	-1276000000.0	
Airbus 2022	6288000000.0	-3113000000.0	-2115000000.0	
Airbus 2021	4639000000.0	-2719000000.0	-2179000000.0	
Airbus 2020	-5420000000.0	4126000000.0	6833000000.0	
Boeing 2023	5960000000.0	-2437000000.0	-5487000000.0	
Boeing 2022	3512000000.0	4370000000.0	-1266000000.0	
Boeing 2021	-3416000000.0	9324000000.0	-5600000000.0	
Boeing 2020	-18410000000.0	-18366000000.0	34955000000.0	
Embraer 2023	617000000.0	-447600000.0	-348700000.0	
Embraer 2022	751300000.0	-109500000.0	-669200000.0	
Embraer 2021	515300000.0	-131600000.0	-430600000.0	
Embraer 2020	-1290200000.0	-105300000.0	1008700000.0	
Bombardier 2023	623000000.0	156000000.0	-438000000.0	
Bombardier 2022	1072000000.0	-304000000.0	-1132000000.0	
Bombardier 2021	332000000.0	-89000000.0	-3205000000.0	
Bombardier 2020	-1672000000.0	1104000000.0	630000000.0	

	End Cash Position	Capital Expenditure	Free Cash Flow	\
Index				
Airbus 2023	16473000000.0	-3051000000.0	3204000000.0	
Airbus 2022	15823000000.0	-2464000000.0	3824000000.0	
Airbus 2021	14572000000.0	-1928000000.0	2711000000.0	
Airbus 2020	14439000000.0	-1759000000.0	-7179000000.0	
Boeing 2023	12691000000.0	-1527000000.0	4433000000.0	

Boeing 2022	14614000000.0	-1222000000.0	2290000000.0
Boeing 2021	8052000000.0	-980000000.0	-4396000000.0
Boeing 2020	7752000000.0	-1303000000.0	-19713000000.0
Embraer 2023	1626300000.0	-430800000.0	186200000.0
Embraer 2022	1815600000.0	-256000000.0	495300000.0
Embraer 2021	1838600000.0	-268200000.0	247100000.0
Embraer 2020	1883100000.0	-223700000.0	-1513900000.0
Bombardier 2023	1594000000.0	-366000000.0	257000000.0
Bombardier 2022	1291000000.0	-355000000.0	717000000.0
Bombardier 2021	1675000000.0	-237000000.0	95000000.0
Bombardier 2020	2450000000.0	-364000000.0	-2036000000.0

	Company	Year
Index		
Airbus 2023	Airbus	2023
Airbus 2022	Airbus	2022
Airbus 2021	Airbus	2021
Airbus 2020	Airbus	2020
Boeing 2023	Boeing	2023
Boeing 2022	Boeing	2022
Boeing 2021	Boeing	2021
Boeing 2020	Boeing	2020
Embraer 2023	Embraer	2023
Embraer 2022	Embraer	2022
Embraer 2021	Embraer	2021
Embraer 2020	Embraer	2020
Bombardier 2023	Bombardier	2023
Bombardier 2022	Bombardier	2022
Bombardier 2021	Bombardier	2021
Bombardier 2020	Bombardier	2020

### 3.4 D. Consolidated Financial Table

To manipulate the datas in order to compute the ratios in the next part, the code creates a consolidated table with all the financial statements computed previously.

```
[11]: financial_data = pd.concat([income_statements, relevant_cash_flows,
    ↪balancesheets], axis=1, join='inner')
print("\nCombined Financial Data:")
print(financial_data)
```

Combined Financial Data:

	Total Revenue	Cost Of Revenue	Gross Profit \
Index			
Airbus 2023	65446000000.0	55402000000.0	10044000000.0
Airbus 2022	58763000000.0	48192000000.0	10571000000.0
Airbus 2021	52149000000.0	42518000000.0	9631000000.0

Airbus 2020	49912000000.0	44250000000.0	56620000000.0
Boeing 2023	77794000000.0	70070000000.0	77240000000.0
Boeing 2022	66608000000.0	63078000000.0	35300000000.0
Boeing 2021	62286000000.0	59237000000.0	30490000000.0
Boeing 2020	58158000000.0	63843000000.0	-56850000000.0
Embraer 2023	52685000000.0	43589000000.0	90960000000.0
Embraer 2022	45404000000.0	36282000000.0	91220000000.0
Embraer 2021	41972000000.0	35376000000.0	65960000000.0
Embraer 2020	37711000000.0	32935000000.0	47760000000.0
Bombardier 2023	80460000000.0	64150000000.0	163100000000.0
Bombardier 2022	69130000000.0	56560000000.0	125700000000.0
Bombardier 2021	60850000000.0	51610000000.0	92400000000.0
Bombardier 2020	64870000000.0	59710000000.0	51600000000.0

	Research And Development	Operating Income	Net Income \
Index			
Airbus 2023	32570000000.0	42660000000.0	37890000000.0
Airbus 2022	30790000000.0	52520000000.0	42470000000.0
Airbus 2021	27460000000.0	48330000000.0	42130000000.0
Airbus 2020	28580000000.0	66400000000.0	-11330000000.0
Boeing 2023	33770000000.0	-8210000000.0	-22220000000.0
Boeing 2022	28520000000.0	-35090000000.0	-49350000000.0
Boeing 2021	22490000000.0	-33570000000.0	-42020000000.0
Boeing 2020	24760000000.0	-129780000000.0	-119410000000.0
Embraer 2023	9030000000.0	24480000000.0	16400000000.0
Embraer 2022	11000000000.0	22010000000.0	-18540000000.0
Embraer 2021	4300000000.0	18520000000.0	-4470000000.0
Embraer 2020	2980000000.0	-14770000000.0	-73190000000.0
Bombardier 2023	37300000000.0	78600000000.0	44500000000.0
Bombardier 2022	36000000000.0	47100000000.0	-14800000000.0
Bombardier 2021	33800000000.0	23200000000.0	50410000000.0
Bombardier 2020	32000000000.0	-26900000000.0	-86800000000.0

	Company	Year	Operating Cash Flow	Investing Cash Flow \
Index				
Airbus 2023	Airbus	2023	62550000000.0	-41280000000.0
Airbus 2022	Airbus	2022	62880000000.0	-31130000000.0
Airbus 2021	Airbus	2021	46390000000.0	-27190000000.0
Airbus 2020	Airbus	2020	-54200000000.0	41260000000.0
Boeing 2023	Boeing	2023	59600000000.0	-24370000000.0
Boeing 2022	Boeing	2022	35120000000.0	43700000000.0
Boeing 2021	Boeing	2021	-34160000000.0	93240000000.0
Boeing 2020	Boeing	2020	-184100000000.0	-183660000000.0
Embraer 2023	Embraer	2023	61700000000.0	-44760000000.0
Embraer 2022	Embraer	2022	75130000000.0	-10950000000.0
Embraer 2021	Embraer	2021	51530000000.0	-13160000000.0
Embraer 2020	Embraer	2020	-129020000000.0	-10530000000.0
Bombardier 2023	Bombardier	2023	62300000000.0	15600000000.0



Bombardier 2022	Bombardier 2022	1072000000.0	-304000000.0
Bombardier 2021	Bombardier 2021	332000000.0	-89000000.0
Bombardier 2020	Bombardier 2020	-1672000000.0	1104000000.0

	...	Inventory	Current Assets	Current Liabilities	\
Index	...				
Airbus 2023	...	27740000000.0	64001000000.0	53750000000.0	
Airbus 2022	...	27157000000.0	63002000000.0	52595000000.0	
Airbus 2021	...	25166000000.0	55694000000.0	47807000000.0	
Airbus 2020	...	27286000000.0	58400000000.0	49471000000.0	
Boeing 2023	...	79741000000.0	109275000000.0	95827000000.0	
Boeing 2022	...	78151000000.0	109523000000.0	90052000000.0	
Boeing 2021	...	78823000000.0	108666000000.0	81992000000.0	
Boeing 2020	...	81715000000.0	121642000000.0	87280000000.0	
Embraer 2023	...	2610600000.0	6055400000.0	3665600000.0	
Embraer 2022	...	2295200000.0	5756600000.0	3217300000.0	
Embraer 2021	...	1955200000.0	5875800000.0	2828800000.0	
Embraer 2020	...	2390100000.0	6115700000.0	2428700000.0	
Bombardier 2023	...	3768000000.0	5934000000.0	5938000000.0	
Bombardier 2022	...	3322000000.0	5585000000.0	5437000000.0	
Bombardier 2021	...	3242000000.0	5481000000.0	4768000000.0	
Bombardier 2020	...	3650000000.0	16646000000.0	16827000000.0	

		Total Assets	Total Liabilities	Net Minority Interest	\
Index					
Airbus 2023	118871000000.0		101141000000.0		
Airbus 2022	115944000000.0		102962000000.0		
Airbus 2021	107047000000.0		97561000000.0		
Airbus 2020	110095000000.0		103639000000.0		
Boeing 2023	137012000000.0		154240000000.0		
Boeing 2022	137100000000.0		152948000000.0		
Boeing 2021	138552000000.0		153398000000.0		
Boeing 2020	152136000000.0		170211000000.0		
Embraer 2023	10782500000.0		7743200000.0		
Embraer 2022	10142100000.0		7317800000.0		
Embraer 2021	10155000000.0		7380000000.0		
Embraer 2020	10516000000.0		7608500000.0		
Bombardier 2023	12458000000.0		14862000000.0		
Bombardier 2022	12324000000.0		15086000000.0		
Bombardier 2021	12764000000.0		15853000000.0		
Bombardier 2020	23090000000.0		29747000000.0		

		Stockholders Equity	Long Term Debt	Total Debt	\
Index					
Airbus 2023	17695000000.0	8806000000.0	11322000000.0		
Airbus 2022	12950000000.0	9139000000.0	10983000000.0		
Airbus 2021	9466000000.0	11603000000.0	13461000000.0		
Airbus 2020	6445000000.0	12544000000.0	15622000000.0		

Boeing 2023	-17233000000.0	46927000000.0	52603000000.0
Boeing 2022	-15883000000.0	51670000000.0	57277000000.0
Boeing 2021	-14999000000.0	56687000000.0	58370000000.0
Boeing 2020	-18316000000.0	61752000000.0	63851000000.0
Embraer 2023	2786500000.0	2759300000.0	2982400000.0
Embraer 2022	2567500000.0	2894700000.0	3274200000.0
Embraer 2021	2667900000.0	3452700000.0	4090700000.0
Embraer 2020	2794900000.0	4072500000.0	4512700000.0
Bombardier 2023	-2404000000.0	5607000000.0	5607000000.0
Bombardier 2022	-2762000000.0	5980000000.0	5980000000.0
Bombardier 2021	-3089000000.0	7047000000.0	7047000000.0
Bombardier 2020	-9325000000.0	8193000000.0	10075000000.0

	Company	Year
Index		
Airbus 2023	Airbus	2023
Airbus 2022	Airbus	2022
Airbus 2021	Airbus	2021
Airbus 2020	Airbus	2020
Boeing 2023	Boeing	2023
Boeing 2022	Boeing	2022
Boeing 2021	Boeing	2021
Boeing 2020	Boeing	2020
Embraer 2023	Embraer	2023
Embraer 2022	Embraer	2022
Embraer 2021	Embraer	2021
Embraer 2020	Embraer	2020
Bombardier 2023	Bombardier	2023
Bombardier 2022	Bombardier	2022
Bombardier 2021	Bombardier	2021
Bombardier 2020	Bombardier	2020

[16 rows x 26 columns]

## 4 II. Performance and Ratio Analysis

In this part we will compute **different financial metrics** using the financial datas we computed before, we will focus on the most relevant ones for the ESG Analysis that follows, that include the classical ratios we use to draw conclusion on a company's financial health.

### 4.1 A. Profitability Analysis

```
[12]: Profitability_ratios = pd.concat([income_statements, relevant_cash_flows,
    ↪balancesheets], axis=1, join='inner')
Profitability_ratios['ROA'] = financial_data['Net Income'] /
    ↪financial_data['Total Assets']
```

```

Profitability_ratios['ROE'] = financial_data['Net Income'] / \
    ↪financial_data['Stockholders Equity']
Profitability_ratios['Gross Margin Ratio'] = financial_data['Gross Profit'] / \
    ↪financial_data['Total Revenue']
Profitability_ratios['Operating Margin Ratio'] = financial_data['Operating \
    ↪Income'] / financial_data['Total Revenue']
Profitability_ratios['Net Profit Margin'] = financial_data['Net Income'] / \
    ↪financial_data['Total Revenue']
Profitability_ratios = Profitability_ratios.loc[:, ~Profitability_ratios.
    ↪columns.duplicated()]#this will delete the duplicate column if there is any

print ("All the ratios are in % : \n" )
print(Profitability_ratios[['ROE', 'ROA', 'Gross Margin Ratio', 'Operating \
    ↪Margin Ratio', 'Net Profit Margin']])

```

All the ratios are in % :

	ROE	ROA	Gross Margin Ratio	Operating Margin Ratio	\
Index					
Airbus 2023	0.214128	0.031875	0.15347	0.065184	
Airbus 2022	0.327954	0.03663	0.179892	0.089376	
Airbus 2021	0.445067	0.039357	0.184682	0.092677	
Airbus 2020	-0.175795	-0.010291	0.11344	0.013303	
Boeing 2023	0.128939	-0.016218	0.099288	-0.010554	
Boeing 2022	0.31071	-0.035996	0.052997	-0.052681	
Boeing 2021	0.280152	-0.030328	0.048952	-0.053897	
Boeing 2020	0.651944	-0.078489	-0.097751	-0.223151	
Embraer 2023	0.058855	0.01521	0.172649	0.046465	
Embraer 2022	-0.07221	-0.01828	0.200907	0.048476	
Embraer 2021	-0.016755	-0.004402	0.157152	0.044125	
Embraer 2020	-0.26187	-0.069599	0.126647	-0.039166	
Bombardier 2023	-0.185108	0.03572	0.202709	0.097688	
Bombardier 2022	0.053584	-0.012009	0.181831	0.068133	
Bombardier 2021	-1.63192	0.394939	0.151849	0.038127	
Bombardier 2020	0.093083	-0.037592	0.079544	-0.041468	

	Net Profit Margin
Index	
Airbus 2023	0.057895
Airbus 2022	0.072273
Airbus 2021	0.080788
Airbus 2020	-0.0227
Boeing 2023	-0.028563
Boeing 2022	-0.07409
Boeing 2021	-0.067463
Boeing 2020	-0.20532
Embraer 2023	0.031128

Embraer 2022	-0.040833
Embraer 2021	-0.01065
Embraer 2020	-0.194081
Bombardier 2023	0.055307
Bombardier 2022	-0.021409
Bombardier 2021	0.828431
Bombardier 2020	-0.133806

The most important ratio among these is the ROE, which reflects whether or not a company is making a profit.

### Comparison of the Profitability ratios with graphs:

```
[13]: import matplotlib.pyplot as plt
import seaborn as sns
```

```
[14]: sns.set_theme(style='darkgrid')

plot_profitability_ratios = ['ROA', 'ROE', 'Gross Margin Ratio', 'Operating_
↳Margin Ratio', 'Net Profit Margin']
fig, axes = plt.subplots(2, 3, figsize=(18, 12))
axes = axes.flatten()

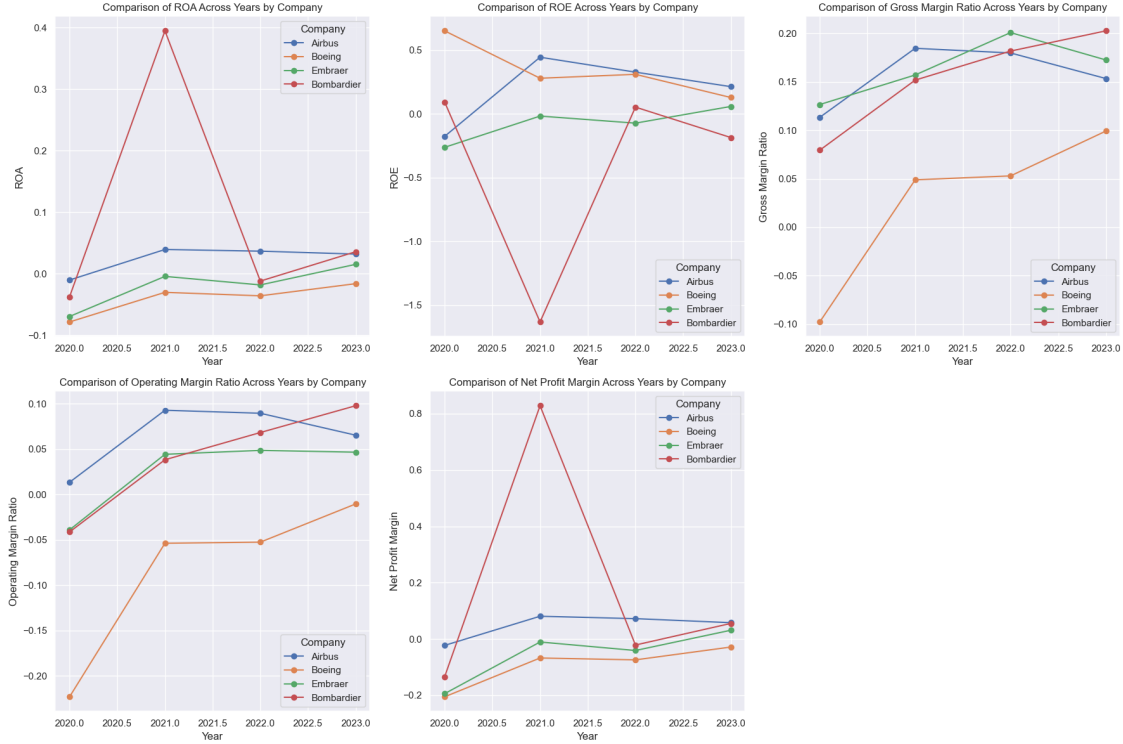
for i, ratio in enumerate(plot_profitability_ratios):
    for company in Profitability_ratios['Company'].drop_duplicates().values:
        subset = Profitability_ratios[Profitability_ratios['Company'] ==
↳company]
        axes[i].plot(subset['Year'], subset[ratio], marker='o', linestyle='-',
↳label=company)

        axes[i].set_title(f'Comparison of {ratio} Across Years by Company')
        axes[i].set_xlabel('Year')
        axes[i].set_ylabel(ratio)
        axes[i].legend(title='Company')
        axes[i].grid(True)

plt.tight_layout()#set automatically space between graphs

if len(plot_profitability_ratios) < len(axes):
    axes[-1].axis('off')

plt.show()
```



#### 4.1.1 Conclusion on time series plot for profitability ratio

The first thing we see is that bombardier has distinctly different curves compared to other companies, which can be attributed to the sale of its commercial aircraft business to Airbus in 2021. This graph shows significant variations in the ratios, justified by this transaction as well as the impact of COVID-19. The other companies display more homogeneous and correlated behavior.

## 4.2 B. Liquidity and Solvency Analysis

The code will compute separately the **Liquidity** from the **Solvency** one.

First, we need to calculate for each company the following liquidity ratios, which will enable us to do the liquidity analysis:

- **Current ratio:**

$$\text{Current ratio} = \frac{\text{Current assets}}{\text{Current liabilities}}$$

- **Quick ratio:**

$$\text{Quick ratio} = \frac{(\text{Current assets} - \text{Inventories})}{\text{Current liabilities}}$$

- **Days sales outstanding (DSO):**

$$\text{DSO} = \frac{\text{Accounts receivable}}{\text{Total credit sales}} \times \text{Number of days in sales}$$

```
[15]: Liquidity_ratios = pd.DataFrame(index=balancesheets.index)
Liquidity_ratios['Current Ratio'] = balancesheets['Current Assets'] /
↳balancesheets['Current Liabilities']
Liquidity_ratios['Quick Ratio'] = (balancesheets['Current Assets'] -
↳balancesheets.get('Inventory', 0)) / balancesheets['Current Liabilities']
Liquidity_ratios['Company'] = balancesheets['Company']
Liquidity_ratios['Year'] = balancesheets['Year']

Solvency_ratios = pd.DataFrame(index=balancesheets.index)
Solvency_ratios['Debt to Equity Ratio'] = balancesheets['Total Debt'] /
↳balancesheets['Stockholders Equity']
Solvency_ratios['Debt to Assets Ratio'] = balancesheets['Total Debt'] /
↳balancesheets['Total Assets']
Solvency_ratios['Company'] = balancesheets['Company']
Solvency_ratios['Year'] = balancesheets['Year']

print ("All the ratios are in % : \n" )

print("Liquidity ratios : \n ")
print(Liquidity_ratios[['Current Ratio','Quick Ratio']])
```

All the ratios are in % :

Liquidity ratios :

	Current Ratio	Quick Ratio
Index		
Airbus 2023	1.190716	0.674623
Airbus 2022	1.197871	0.681529
Airbus 2021	1.164976	0.638568
Airbus 2020	1.18049	0.628934
Boeing 2023	1.140336	0.308201
Boeing 2022	1.21622	0.348376
Boeing 2021	1.325324	0.363975
Boeing 2020	1.393698	0.457459
Embraer 2023	1.651953	0.939764
Embraer 2022	1.789264	1.075871
Embraer 2021	2.077135	1.385959
Embraer 2020	2.518096	1.533989
Bombardier 2023	0.999326	0.364769
Bombardier 2022	1.027221	0.416222
Bombardier 2021	1.149539	0.469589
Bombardier 2020	0.989243	0.77233

To plot the time series, we use again the previous method, by iterating in a for loop the different liquidity ratios in the subplot grid

```
[16]: sns.set_theme(style='darkgrid')

plot_liquidity_ratios = ['Current Ratio', 'Quick Ratio']
fig, axes = plt.subplots(1, 2, figsize=(18, 6))
axes = axes.flatten()

for i, ratio in enumerate(plot_liquidity_ratios):
    for company in Liquidity_ratios['Company'].drop_duplicates().values:
        subset = Liquidity_ratios[Liquidity_ratios['Company'] == company]
        axes[i].plot(subset['Year'], subset[ratio], marker='o', linestyle='-',
            ↪label=company)
        axes[i].set_title(f'Comparison of {ratio} Across Years by Company')
        axes[i].set_xlabel('Year')
        axes[i].set_ylabel(ratio)
        axes[i].legend(title='Company')
        axes[i].grid(True)

plt.tight_layout()
plt.show()
```



```
[17]: print("Solvency ratios : \n")
print(Solvency_ratios[['Debt to Equity Ratio','Debt to Assets Ratio']])
```

Solvency ratios :

	Debt to Equity Ratio	Debt to Assets Ratio
Index		
Airbus 2023	0.639842	0.095246
Airbus 2022	0.848108	0.094727
Airbus 2021	1.422037	0.125749
Airbus 2020	2.423894	0.141896
Boeing 2023	-3.052457	0.38393
Boeing 2022	-3.606183	0.417775
Boeing 2021	-3.891593	0.421286

Boeing 2020	-3.486078	0.419697
Embraer 2023	1.070303	0.276596
Embraer 2022	1.275248	0.322833
Embraer 2021	1.533303	0.402826
Embraer 2020	1.614619	0.429127
Bombardier 2023	-2.332363	0.450072
Bombardier 2022	-2.165098	0.485232
Bombardier 2021	-2.281321	0.5521
Bombardier 2020	-1.080429	0.436336

```
[18]: plot_solvency_ratios = ['Debt to Equity Ratio', 'Debt to Assets Ratio']

fig, axes = plt.subplots(1, 2, figsize=(18, 6))
axes = axes.flatten()

for i, ratio in enumerate(plot_solvency_ratios):
    for company in Solvency_ratios['Company'].drop_duplicates().values:
        subset = Solvency_ratios[Solvency_ratios['Company'] == company]
        axes[i].plot(subset['Year'], subset[ratio], marker='o', linestyle='-',
            label=company)
        axes[i].set_title(f'Comparison of {ratio} Across Years by Company')
        axes[i].set_xlabel('Year')
        axes[i].set_ylabel(ratio)
        axes[i].legend(title='Company')
        axes[i].grid(True)

plt.tight_layout()
plt.show()
```



### 4.3 Conclusion on Financial Analysis

So, according to the graphs, based on the simulated trends for the financial ratios from 2015 to 2020 for Airbus, Boeing, Embraer, and Bombardier we see some trends in these ratios across the



years for each company. Airbus shows improvement in liquidity (current ratio), this could be due to effective management of current assets or reductions in short-term liabilities. An increased focus on cash management and quicker inventory turnover could also contribute.

Airbus might have prioritized debt reduction through refinancing strategies or by allocating more earnings to pay off liabilities, potentially in response to industry norms or economic conditions because it has reduction in debt but Airbus has a slight decline in equity financing.

Boeing's enhancement in liquidity, particularly during a period of intense scrutiny such as **the 737 MAX crisis**, might reflect a strategic initiative to bolster short-term financial health, possibly through asset liquidation or improving operational efficiencies. Boeing has an increase in the debt to assets ratio due to challenging period and a decrease in the equity ratio.

Embraer displays relatively stable but slightly worsening trends in liquidity and equity due to competitive pressure, with a small improvement in lowering debt.

Bombardier stands out with improvements in both solvency ratios, possibly due to selling off less profitable divisions (like the sale of their commercial aviation segment) and focusing on core profitable areas like business jets. Finally, Bombardier appears to be managing its financial structure more effectively compared to others, with improvements in critical solvency ratios and stable liquidity. Boeing, despite its improvements in liquidity, faces challenges with increasing debt levels.

## 5 III. Forecasting

### 5.1 A. Data cleaning

To forecast the datas for 2 years we won't apply forecast method on the ratios directly but on the financial datas, then we will compute the new forecasted ratios and metrics for the 2 years.

Firstly, we create a data frame with only the useful datas that has been used to forecast the metrics.

```
[19]: data_to_forecast = pd.concat([
    income_statements[['Net Income', 'Total Revenue', 'Gross Profit',
    ↪ 'Operating Income']],
    balancesheets[['Current Assets', 'Current Liabilities', 'Total Assets',
    ↪ 'Total Liabilities Net Minority Interest', 'Stockholders Equity', 'Total
    ↪ Debt']],
    relevant_cash_flows[['Operating Cash Flow', 'Investing Cash Flow',
    ↪ 'Financing Cash Flow', 'End Cash Position', 'Capital Expenditure', 'Free
    ↪ Cash Flow']]
    ], axis=1)
```

```
[20]: data_to_forecast = data_to_forecast.loc[:,~data_to_forecast.columns.
    ↪ duplicated()]
```

```
[21]: print(data_to_forecast)
```

	Net Income	Total Revenue	Gross Profit	Operating Income	\
Index					
Airbus 2023	3789000000.0	65446000000.0	10044000000.0	4266000000.0	
Airbus 2022	4247000000.0	58763000000.0	10571000000.0	5252000000.0	

Airbus 2021	4213000000.0	52149000000.0	9631000000.0	4833000000.0
Airbus 2020	-1133000000.0	49912000000.0	5662000000.0	664000000.0
Boeing 2023	-2222000000.0	77794000000.0	7724000000.0	-821000000.0
Boeing 2022	-4935000000.0	66608000000.0	3530000000.0	-3509000000.0
Boeing 2021	-4202000000.0	62286000000.0	3049000000.0	-3357000000.0
Boeing 2020	-11941000000.0	58158000000.0	-5685000000.0	-12978000000.0
Embraer 2023	164000000.0	5268500000.0	909600000.0	244800000.0
Embraer 2022	-185400000.0	4540400000.0	912200000.0	220100000.0
Embraer 2021	-44700000.0	4197200000.0	659600000.0	185200000.0
Embraer 2020	-731900000.0	3771100000.0	477600000.0	-147700000.0
Bombardier 2023	445000000.0	8046000000.0	1631000000.0	786000000.0
Bombardier 2022	-148000000.0	6913000000.0	1257000000.0	471000000.0
Bombardier 2021	5041000000.0	6085000000.0	924000000.0	232000000.0
Bombardier 2020	-868000000.0	6487000000.0	516000000.0	-269000000.0

	Current Assets	Current Liabilities	Total Assets \
Index			
Airbus 2023	64001000000.0	53750000000.0	118871000000.0
Airbus 2022	63002000000.0	52595000000.0	115944000000.0
Airbus 2021	55694000000.0	47807000000.0	107047000000.0
Airbus 2020	58400000000.0	49471000000.0	110095000000.0
Boeing 2023	109275000000.0	95827000000.0	137012000000.0
Boeing 2022	109523000000.0	90052000000.0	137100000000.0
Boeing 2021	108666000000.0	81992000000.0	138552000000.0
Boeing 2020	121642000000.0	87280000000.0	152136000000.0
Embraer 2023	6055400000.0	3665600000.0	10782500000.0
Embraer 2022	5756600000.0	3217300000.0	10142100000.0
Embraer 2021	5875800000.0	2828800000.0	10155000000.0
Embraer 2020	6115700000.0	2428700000.0	10516000000.0
Bombardier 2023	5934000000.0	5938000000.0	12458000000.0
Bombardier 2022	5585000000.0	5437000000.0	12324000000.0
Bombardier 2021	5481000000.0	4768000000.0	12764000000.0
Bombardier 2020	16646000000.0	16827000000.0	23090000000.0

	Total Liabilities	Net Minority Interest	Stockholders Equity \
Index			
Airbus 2023		101141000000.0	17695000000.0
Airbus 2022		102962000000.0	12950000000.0
Airbus 2021		97561000000.0	9466000000.0
Airbus 2020		103639000000.0	6445000000.0
Boeing 2023		154240000000.0	-17233000000.0
Boeing 2022		152948000000.0	-15883000000.0
Boeing 2021		153398000000.0	-14999000000.0
Boeing 2020		170211000000.0	-18316000000.0
Embraer 2023		7743200000.0	2786500000.0
Embraer 2022		7317800000.0	2567500000.0
Embraer 2021		7380000000.0	2667900000.0
Embraer 2020		7608500000.0	2794900000.0

Bombardier 2023	14862000000.0	-2404000000.0
Bombardier 2022	15086000000.0	-2762000000.0
Bombardier 2021	15853000000.0	-3089000000.0
Bombardier 2020	29747000000.0	-9325000000.0

	Total Debt	Operating Cash Flow	Investing Cash Flow \
Index			
Airbus 2023	11322000000.0	6255000000.0	-4128000000.0
Airbus 2022	10983000000.0	6288000000.0	-3113000000.0
Airbus 2021	13461000000.0	4639000000.0	-2719000000.0
Airbus 2020	15622000000.0	-5420000000.0	4126000000.0
Boeing 2023	52603000000.0	5960000000.0	-2437000000.0
Boeing 2022	57277000000.0	3512000000.0	4370000000.0
Boeing 2021	58370000000.0	-3416000000.0	9324000000.0
Boeing 2020	63851000000.0	-18410000000.0	-18366000000.0
Embraer 2023	2982400000.0	617000000.0	-447600000.0
Embraer 2022	3274200000.0	751300000.0	-109500000.0
Embraer 2021	4090700000.0	515300000.0	-131600000.0
Embraer 2020	4512700000.0	-1290200000.0	-105300000.0
Bombardier 2023	5607000000.0	623000000.0	156000000.0
Bombardier 2022	5980000000.0	1072000000.0	-304000000.0
Bombardier 2021	7047000000.0	332000000.0	-89000000.0
Bombardier 2020	10075000000.0	-1672000000.0	1104000000.0

	Financing Cash Flow	End Cash Position	Capital Expenditure \
Index			
Airbus 2023	-1276000000.0	16473000000.0	-3051000000.0
Airbus 2022	-2115000000.0	15823000000.0	-2464000000.0
Airbus 2021	-2179000000.0	14572000000.0	-1928000000.0
Airbus 2020	6833000000.0	14439000000.0	-1759000000.0
Boeing 2023	-5487000000.0	12691000000.0	-1527000000.0
Boeing 2022	-1266000000.0	14614000000.0	-1222000000.0
Boeing 2021	-5600000000.0	8052000000.0	-980000000.0
Boeing 2020	34955000000.0	7752000000.0	-1303000000.0
Embraer 2023	-348700000.0	1626300000.0	-430800000.0
Embraer 2022	-669200000.0	1815600000.0	-256000000.0
Embraer 2021	-430600000.0	1838600000.0	-268200000.0
Embraer 2020	1008700000.0	1883100000.0	-223700000.0
Bombardier 2023	-438000000.0	1594000000.0	-366000000.0
Bombardier 2022	-1132000000.0	1291000000.0	-355000000.0
Bombardier 2021	-3205000000.0	1675000000.0	-237000000.0
Bombardier 2020	630000000.0	2450000000.0	-364000000.0

	Free Cash Flow
Index	
Airbus 2023	3204000000.0
Airbus 2022	3824000000.0
Airbus 2021	2711000000.0

Airbus 2020	-7179000000.0
Boeing 2023	4433000000.0
Boeing 2022	2290000000.0
Boeing 2021	-4396000000.0
Boeing 2020	-19713000000.0
Embraer 2023	186200000.0
Embraer 2022	495300000.0
Embraer 2021	247100000.0
Embraer 2020	-1513900000.0
Bombardier 2023	257000000.0
Bombardier 2022	717000000.0
Bombardier 2021	95000000.0
Bombardier 2020	-2036000000.0

## 5.2 B. Forecasting Method

```
[22]: companies = ['Airbus', 'Boeing', 'Embraer', 'Bombardier']
columns = ['Net Income', 'Total Revenue', 'Gross Profit', 'Operating Income',
           'Current Assets', 'Current Liabilities', 'Total Assets',
           'Total Liabilities Net Minority Interest', 'Stockholders Equity',
           'Total Debt', 'Operating Cash Flow', 'Investing Cash Flow',
           'Financing Cash Flow', 'End Cash Position', 'Capital Expenditure',
           'Free Cash Flow']

company_dataframes = {}

for company in companies:

    company_data = data_to_forecast[data_to_forecast.index.str.
    ↪contains(company)]
    company_dataframes[company] = company_data[columns]

airbus_df = company_dataframes['Airbus']
boeing_df = company_dataframes['Boeing']
embraer_df = company_dataframes['Embraer']
bombardier_df = company_dataframes['Bombardier']
```

```
[23]: forecasts = {}
for company, df in company_dataframes.items():
    mean_forecast = df.mean()
    forecasts[f"{company} 2024 Forecast"] = mean_forecast
```

Gaussian noise is added to the 2025 forecasts to introduce a level of realistic variability, reflecting potential uncertainties and fluctuations that could affect future values, which are not captured by simple averaging methods (because it is equal to the previous one) (we use `np.random.normal` to generate gaussian noise that will compute the uncertainty for 2025 values. (simple but efficient for our problem since we want to avoid excessive precision.

Also, the scale parameter in `np.random.normal(0, scale)` is set to a percentage of the forecast values, here we set it at 20 % , to simulate reasonable deviations based on expected volatility. and to avoid sign error, we multiply it by the absolute value.

Also, to simplify the calculus, we convert float into integers to have a better views on figures.

```
[24]: for company, df in company_dataframes.items():

    forecast_index = f'{company} 2024'
    df.loc[forecast_index] = forecasts[f'{company} 2024 Forecast']

    df.sort_index(ascending=True, inplace=True)

    mean_forecast_2025 = df.mean()
    noise = np.random.normal(0, scale=0.2 * np.abs(mean_forecast_2025))
    df.loc[f'{company} 2025'] = mean_forecast_2025 + noise

for company, df in company_dataframes.items():

    company_dataframes[company] = df.round().astype(int)
    #print(f"DataFrame Forecasted for {company}:")
    #print(company_dataframes[company])
    #print("\n")
company_dataframes
```

```
[24]: {'Airbus':
```

		Net Income	Total Revenue	Gross Profit	Operating
Income \					
Index					
Airbus 2020	-1133000000	4991200000	5662000000		664000000
Airbus 2021	4213000000	5214900000	9631000000		4833000000
Airbus 2022	4247000000	5876300000	10571000000		5252000000
Airbus 2023	3789000000	6544600000	10044000000		4266000000
Airbus 2024	2779000000	56567500000	8977000000		3753750000
Airbus 2025	2252673251	56934811162	9314841081		3113602898

	Current Assets	Current Liabilities	Total Assets \
Index			
Airbus 2020	58400000000	49471000000	110095000000
Airbus 2021	55694000000	47807000000	107047000000
Airbus 2022	63002000000	52595000000	115944000000
Airbus 2023	64001000000	53750000000	118871000000
Airbus 2024	60274250000	50905750000	112989250000
Airbus 2025	75988931817	45260258714	82087938305

	Total Liabilities	Net Minority Interest	Stockholders Equity \
Index			
Airbus 2020		103639000000	6445000000
Airbus 2021		97561000000	9466000000

Airbus 2022	102962000000	12950000000
Airbus 2023	101141000000	17695000000
Airbus 2024	101325750000	11639000000
Airbus 2025	84282231315	10583167623

	Total Debt	Operating Cash Flow	Investing Cash Flow \
Index			
Airbus 2020	15622000000	-5420000000	4126000000
Airbus 2021	13461000000	4639000000	-2719000000
Airbus 2022	10983000000	6288000000	-3113000000
Airbus 2023	11322000000	6255000000	-4128000000
Airbus 2024	12847000000	2940500000	-1458500000
Airbus 2025	12728718923	2400357617	-1535727126

	Financing Cash Flow	End Cash Position	Capital Expenditure \
Index			
Airbus 2020	6833000000	14439000000	-1759000000
Airbus 2021	-2179000000	14572000000	-1928000000
Airbus 2022	-2115000000	15823000000	-2464000000
Airbus 2023	-1276000000	16473000000	-3051000000
Airbus 2024	315750000	15326750000	-2300500000
Airbus 2025	332518481	15414995869	-2493080125

	Free Cash Flow
Index	
Airbus 2020	-7179000000
Airbus 2021	2711000000
Airbus 2022	3824000000
Airbus 2023	3204000000
Airbus 2024	640000000
Airbus 2025	728317536 ,

'Boeing': Net Income Total Revenue Gross Profit Operating  
Income \

Index				
Boeing 2020	-11941000000	58158000000	-5685000000	-12978000000
Boeing 2021	-4202000000	62286000000	3049000000	-3357000000
Boeing 2022	-4935000000	66608000000	3530000000	-3509000000
Boeing 2023	-2222000000	77794000000	7724000000	-821000000
Boeing 2024	-5825000000	66211500000	2154500000	-5166250000
Boeing 2025	-4007230920	63632647627	2168710583	-5235620957

	Current Assets	Current Liabilities	Total Assets \
Index			
Boeing 2020	121642000000	87280000000	152136000000
Boeing 2021	108666000000	81992000000	138552000000
Boeing 2022	109523000000	90052000000	137100000000
Boeing 2023	109275000000	95827000000	137012000000

Boeing 2024	112276500000	88787750000	141200000000
Boeing 2025	153930697404	121686347296	146558088708

	Total Liabilities	Net Minority Interest	Stockholders Equity \
Index			
Boeing 2020		170211000000	-18316000000
Boeing 2021		153398000000	-14999000000
Boeing 2022		152948000000	-15883000000
Boeing 2023		154240000000	-17233000000
Boeing 2024		157699250000	-16607750000
Boeing 2025		188006256559	-14541868550

	Total Debt	Operating Cash Flow	Investing Cash Flow \
Index			
Boeing 2020	63851000000	-18410000000	-18366000000
Boeing 2021	58370000000	-3416000000	9324000000
Boeing 2022	57277000000	3512000000	4370000000
Boeing 2023	52603000000	5960000000	-2437000000
Boeing 2024	58025250000	-3088500000	-1777250000
Boeing 2025	54649302332	-3572956826	-2319574972

	Financing Cash Flow	End Cash Position	Capital Expenditure \
Index			
Boeing 2020	34955000000	7752000000	-1303000000
Boeing 2021	-5600000000	8052000000	-980000000
Boeing 2022	-1266000000	14614000000	-1222000000
Boeing 2023	-5487000000	12691000000	-1527000000
Boeing 2024	5650500000	10777250000	-1258000000
Boeing 2025	4622770820	7259849838	-1270566319

#### Free Cash Flow

Index	
Boeing 2020	-19713000000
Boeing 2021	-4396000000
Boeing 2022	2290000000
Boeing 2023	4433000000
Boeing 2024	-4346500000
Boeing 2025	-5293532003 ,

'Embraer':	Net Income	Total Revenue	Gross Profit	Operating
Income \				

Index				
Embraer 2020	-731900000	3771100000	477600000	-147700000
Embraer 2021	-44700000	4197200000	659600000	185200000
Embraer 2022	-185400000	4540400000	912200000	220100000
Embraer 2023	164000000	5268500000	909600000	244800000
Embraer 2024	-199500000	4444300000	739750000	125600000
Embraer 2025	-278542613	5688647730	597746302	132931028

	Current Assets	Current Liabilities	Total Assets \
Index			
Embraer 2020	6115700000	2428700000	10516000000
Embraer 2021	5875800000	2828800000	10155000000
Embraer 2022	5756600000	3217300000	10142100000
Embraer 2023	6055400000	3665600000	10782500000
Embraer 2024	5950875000	3035100000	10398900000
Embraer 2025	5841633570	3476269998	5762192385

	Total Liabilities	Net Minority Interest	Stockholders Equity \
Index			
Embraer 2020		7608500000	2794900000
Embraer 2021		7380000000	2667900000
Embraer 2022		7317800000	2567500000
Embraer 2023		7743200000	2786500000
Embraer 2024		7512375000	2704200000
Embraer 2025		7272497070	3135729722

	Total Debt	Operating Cash Flow	Investing Cash Flow \
Index			
Embraer 2020	4512700000	-1290200000	-105300000
Embraer 2021	4090700000	515300000	-131600000
Embraer 2022	3274200000	751300000	-109500000
Embraer 2023	2982400000	617000000	-447600000
Embraer 2024	3715000000	148350000	-198500000
Embraer 2025	3939679709	92582773	-220091334

	Financing Cash Flow	End Cash Position	Capital Expenditure \
Index			
Embraer 2020	1008700000	1883100000	-223700000
Embraer 2021	-430600000	1838600000	-268200000
Embraer 2022	-669200000	1815600000	-256000000
Embraer 2023	-348700000	1626300000	-430800000
Embraer 2024	-109950000	1790900000	-294675000
Embraer 2025	-107511549	1870825816	-331705547

	Free Cash Flow
Index	
Embraer 2020	-1513900000
Embraer 2021	247100000
Embraer 2022	495300000
Embraer 2023	186200000
Embraer 2024	-146325000
Embraer 2025	-144399948

'Bombardier': Net Income Total Revenue Gross Profit  
Operating Income \



Index				
Bombardier 2020	-868000000	6487000000	516000000	-269000000
Bombardier 2021	5041000000	6085000000	924000000	232000000
Bombardier 2022	-148000000	6913000000	1257000000	471000000
Bombardier 2023	445000000	8046000000	1631000000	786000000
Bombardier 2024	1117500000	6882750000	1082000000	305000000
Bombardier 2025	867528893	5017073757	679114201	359737841

	Current Assets	Current Liabilities	Total Assets \
Index			
Bombardier 2020	16646000000	16827000000	23090000000
Bombardier 2021	5481000000	4768000000	12764000000
Bombardier 2022	5585000000	5437000000	12324000000
Bombardier 2023	5934000000	5938000000	12458000000
Bombardier 2024	8411500000	8242500000	15159000000
Bombardier 2025	8815162556	8790466142	17450208667

	Total Liabilities	Net Minority Interest	Stockholders Equity
\			
Index			
Bombardier 2020		29747000000	-9325000000
Bombardier 2021		15853000000	-3089000000
Bombardier 2022		15086000000	-2762000000
Bombardier 2023		14862000000	-2404000000
Bombardier 2024		18887000000	-4395000000
Bombardier 2025		25880496809	-3527567362

	Total Debt	Operating Cash Flow	Investing Cash Flow \
Index			
Bombardier 2020	10075000000	-1672000000	1104000000
Bombardier 2021	7047000000	332000000	-89000000
Bombardier 2022	5980000000	1072000000	-304000000
Bombardier 2023	5607000000	623000000	156000000
Bombardier 2024	7177250000	88750000	216750000
Bombardier 2025	9533649025	97504013	133352682

	Financing Cash Flow	End Cash Position	Capital Expenditure \
Index			
Bombardier 2020	630000000	2450000000	-364000000
Bombardier 2021	-3205000000	1675000000	-237000000
Bombardier 2022	-1132000000	1291000000	-355000000
Bombardier 2023	-438000000	1594000000	-366000000
Bombardier 2024	-1036250000	1752500000	-330500000
Bombardier 2025	-1019650873	1867053099	-374948499

	Free Cash Flow
Index	

```

Bombardier 2020      -2036000000
Bombardier 2021       950000000
Bombardier 2022       717000000
Bombardier 2023       257000000
Bombardier 2024      -241750000
Bombardier 2025      -211382455  }

```

### 5.3 C. Plot of the forecasted ratios

Now that we have all our forecasted financial infos, we can compute our new ratios.

#### 1. Forecasted Profitability Ratio :

```

[25]: profitability_ratios = {}

for company, df in company_dataframes.items():
    profitability_ratios[company] = pd.DataFrame({
        'ROA': df['Net Income'] / df['Total Assets'],
        'ROE': df['Net Income'] / df['Stockholders Equity'],
        'Gross Margin Ratio': df['Gross Profit'] / df['Total Revenue'],
        'Operating Margin Ratio': df['Operating Income'] / df['Total Revenue'],
        'Net Profit Margin': df['Net Income'] / df['Total Revenue']
    })

    #print(f"Forecasted Profitability Ratios for {company}:")
    #print(profitability_ratios[company])
    #print("\n")

for company, df in profitability_ratios.items():

    df['Year'] = df.index.str.split().str[-1]
    df['Company'] = company

    df.reset_index(drop=True, inplace=True)

all_profitability_ratios = pd.concat(profitability_ratios.values())
all_profitability_ratios

```

```

[25]:
      ROA      ROE  Gross Margin Ratio  Operating Margin Ratio  \
0 -0.010291 -0.175795      0.113440      0.013303
1  0.039357  0.445067      0.184682      0.092677
2  0.036630  0.327954      0.179892      0.089376
3  0.031875  0.214128      0.153470      0.065184
4  0.024595  0.238766      0.158695      0.066359
5  0.027442  0.212854      0.163605      0.054687
0 -0.078489  0.651944     -0.097751     -0.223151
1 -0.030328  0.280152      0.048952     -0.053897
2 -0.035996  0.310710      0.052997     -0.052681
3 -0.016218  0.128939      0.099288     -0.010554

```

4	-0.041254	0.350740	0.032540	-0.078026
5	-0.027342	0.275565	0.034082	-0.082279
0	-0.069599	-0.261870	0.126647	-0.039166
1	-0.004402	-0.016755	0.157152	0.044125
2	-0.018280	-0.072210	0.200907	0.048476
3	0.015210	0.058855	0.172649	0.046465
4	-0.019185	-0.073774	0.166449	0.028261
5	-0.048340	-0.088829	0.105077	0.023368
0	-0.037592	0.093083	0.079544	-0.041468
1	0.394939	-1.631920	0.151849	0.038127
2	-0.012009	0.053584	0.181831	0.068133
3	0.035720	-0.185108	0.202709	0.097688
4	0.073719	-0.254266	0.157205	0.044314
5	0.049715	-0.245928	0.135361	0.071703

	Net Profit Margin	Year	Company
0	-0.022700	2020	Airbus
1	0.080788	2021	Airbus
2	0.072273	2022	Airbus
3	0.057895	2023	Airbus
4	0.049127	2024	Airbus
5	0.039566	2025	Airbus
0	-0.205320	2020	Boeing
1	-0.067463	2021	Boeing
2	-0.074090	2022	Boeing
3	-0.028563	2023	Boeing
4	-0.087976	2024	Boeing
5	-0.062974	2025	Boeing
0	-0.194081	2020	Embraer
1	-0.010650	2021	Embraer
2	-0.040833	2022	Embraer
3	0.031128	2023	Embraer
4	-0.044889	2024	Embraer
5	-0.048965	2025	Embraer
0	-0.133806	2020	Bombardier
1	0.828431	2021	Bombardier
2	-0.021409	2022	Bombardier
3	0.055307	2023	Bombardier
4	0.162362	2024	Bombardier
5	0.172915	2025	Bombardier

On the same model than the previous plot in the first ratio analysis, we create new plots that contains the forecasted values. we just add the `plt.tight` command that ensure that there is no unuseful graph. Also here and on the next plot, we keep the `seaborn darkgrid` theme for a better coherence. We also used the `flatten` command to have one big plot figure, ( here the subplots tuples contains the dimensions of our plot figure (as we have 5 ratio to compare, we create a 2 x3 plot matrix( in order to have a more compact plot table.we also let the same size as before but we can change the `figsize` values

Here we also include a if condition on the curve plot method, if the portion of the curve has an x : 2023 x 2025 (ie x>2024), we plot a dashed line curve portion for this x. In this term, we have a different representation for the forecasted values.

REMINDER: The for loop is used to iterate over each company present in the dataframe, the corresponding ratio, and create within a general for loop, a graph for each ratio as before.

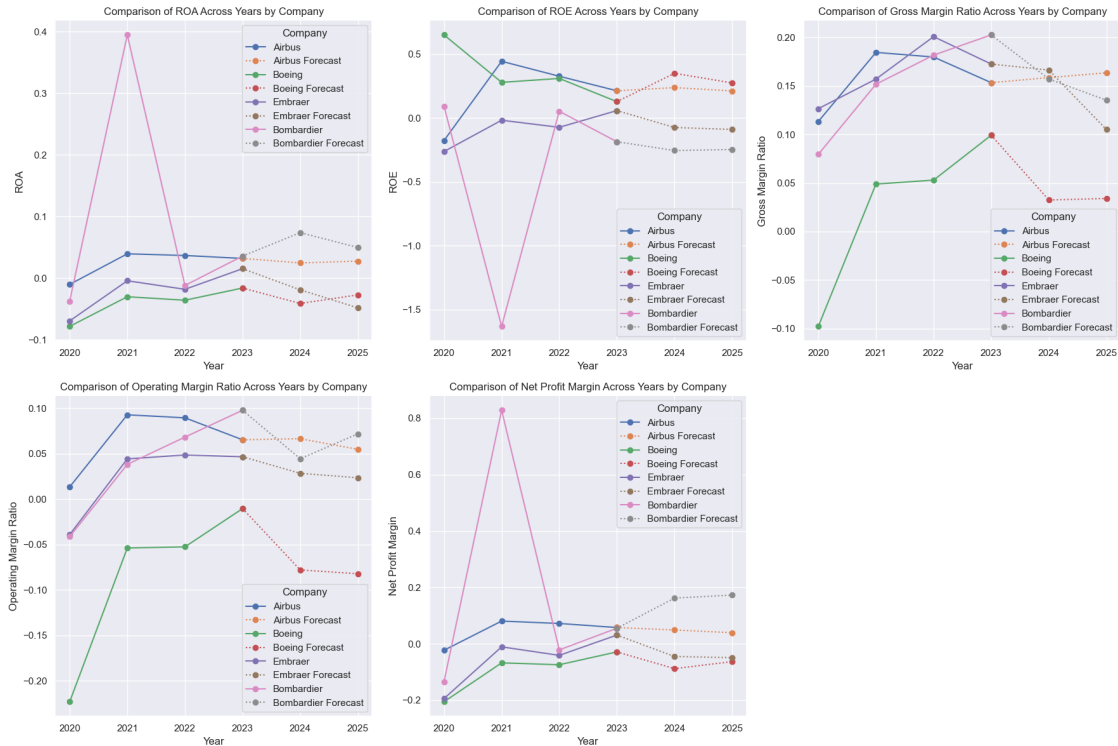
```
[26]: sns.set_theme(style='darkgrid')

plot_profitability_ratios = ['ROA', 'ROE', 'Gross Margin Ratio', 'Operating_
↳Margin Ratio', 'Net Profit Margin']

fig, axes = plt.subplots(2, 3, figsize=(18, 12))
axes = axes.flatten()
for i, ratio in enumerate(plot_profitability_ratios):
    for company in all_profitability_ratios['Company'].drop_duplicates():
        subset = all_profitability_ratios[all_profitability_ratios['Company']_
↳== company]
        normal_years = subset[subset['Year'].astype(int) <= 2023]
        forecast_years = subset[subset['Year'].astype(int) >= 2023]
        axes[i].plot(normal_years['Year'], normal_years[ratio], marker='o',_
↳linestyle='-', label=f"{company}")
        if not forecast_years.empty:
            axes[i].plot(forecast_years['Year'], forecast_years[ratio],_
↳marker='o', linestyle=':', label=f"{company} Forecast")

        axes[i].set_title(f'Comparison of {ratio} Across Years by Company')
        axes[i].set_xlabel('Year')
        axes[i].set_ylabel(ratio)
        axes[i].legend(title='Company')
        axes[i].grid(True)

plt.tight_layout()
if len(plot_profitability_ratios) < len(axes):
    axes[-1].axis('off')
plt.show()
```



## 2. Forecasted Liquidity Ratios

```
[27]: liquidity_ratios = {}
for company, df in company_dataframes.items():
    inventory = df.get('Inventory', pd.Series([0]*df.shape[0], index=df.index))
    liquidity_ratios[company] = pd.DataFrame({
        'Current Ratio': df['Current Assets'] / df['Current Liabilities'],
        'Quick Ratio': (df['Current Assets'] - inventory) / df['Current Liabilities']
    })
    liquidity_ratios[company]['Year'] = df.index.str.split().str[-1]
    liquidity_ratios[company]['Company'] = company
    liquidity_ratios[company].reset_index(drop=True, inplace=True)

all_liquidity_ratios = pd.concat(liquidity_ratios.values())
```

```
[28]: sns.set_theme(style='darkgrid')

plot_liquidity_ratios = ['Current Ratio', 'Quick Ratio']

fig, axes = plt.subplots(1, 2, figsize=(18, 6))
axes = axes.flatten()
```

```

for i, ratio in enumerate(plot_liquidity_ratios):
    for company in all_liquidity_ratios['Company'].drop_duplicates():
        subset = all_liquidity_ratios[all_liquidity_ratios['Company'] ==
        ↪company]
        normal_years = subset[subset['Year'].astype(int) <= 2023]
        forecast_years = subset[subset['Year'].astype(int) >= 2023]
        axes[i].plot(normal_years['Year'], normal_years[ratio], marker='o',
        ↪linestyle='-', label=f"{company}")
        if not forecast_years.empty:
            axes[i].plot(forecast_years['Year'], forecast_years[ratio],
            ↪marker='o', linestyle=':', label=f"{company} Forecast")

        axes[i].set_title(f'Comparison of {ratio} Across Years by Company')
        axes[i].set_xlabel('Year')
        axes[i].set_ylabel(ratio)
        axes[i].legend(title='Company')
        axes[i].grid(True)

plt.tight_layout()
if len(plot_liquidity_ratios) < len(axes):
    axes[-1].axis('off')
plt.show()

```



### 3. Forecasted Solvency ratios

```

[29]: solvency_ratios = {}
for company, df in company_dataframes.items():
    solvency_ratios[company] = pd.DataFrame({
        'Debt to Equity Ratio': df['Total Debt'] / df['Stockholders Equity'],
        'Debt to Assets Ratio': df['Total Debt'] / df['Total Assets']
    })
    solvency_ratios[company]['Year'] = df.index.str.split().str[-1]
    solvency_ratios[company]['Company'] = company

```

```

solvency_ratios[company].reset_index(drop=True, inplace=True)

all_solvency_ratios = pd.concat(solvency_ratios.values())

```

```

[30]: sns.set_theme(style='darkgrid')

plot_solvency_ratios = ['Debt to Equity Ratio', 'Debt to Assets Ratio']
fig, axes = plt.subplots(1, 2, figsize=(18, 6))
axes = axes.flatten()

for i, ratio in enumerate(plot_solvency_ratios):
    for company in all_solvency_ratios['Company'].drop_duplicates():
        subset = all_solvency_ratios[all_solvency_ratios['Company'] == company]
        normal_years = subset[subset['Year'].astype(int) <= 2023]
        forecast_years = subset[subset['Year'].astype(int) >= 2023]
        axes[i].plot(normal_years['Year'], normal_years[ratio], marker='o',
↳linestyle='-', label=f"{company}")
        if not forecast_years.empty:
            axes[i].plot(forecast_years['Year'], forecast_years[ratio],
↳marker='o', linestyle=':', label=f"{company} Forecast")

    axes[i].set_title(f'Comparison of {ratio} Across Years by Company')
    axes[i].set_xlabel('Year')
    axes[i].set_ylabel(ratio)
    axes[i].legend(title='Company')
    axes[i].grid(True)

plt.tight_layout()
if len(plot_solvency_ratios) < len(axes):
    axes[-1].axis('off')
plt.show()

```



In conclusion, for the 2024 forecasts, we utilized the simplest method by taking the average of past ratios, which provided a straightforward prediction. For the 2025 forecasts, we added Gaussian

noise to the average to introduce a degree of uncertainty into our projections, reflecting the inherent unpredictability in future trends.

## 6 IV. ESG Performance Analysis

To perform the ESG Analysis, an Excel Sheet has been create to store the different scores:

- <https://www.sustainalytics.com/esg-rating/embraer-sa/1008561965>
- <https://fr.finance.yahoo.com/quote/AIR.PA/sustainability>
- <https://www.sustainalytics.com/esg-rating/bombardier-inc/1008573450>
- <https://fr.finance.yahoo.com/quote/BA/sustainability>

### 6.1 A. ESG Rating Analysis

```
[31]: ESG_file= "https://raw.githubusercontent.com/adclair/ESG-Analysis/main/
↳ESG_Sheet.xlsx"
#ESG_file=pd.read_excel(r'/ESG Sheet.xlsx')

[32]: ESG_Ratings = pd.read_excel(ESG_file)

companies = ESG_Ratings['Company'].tolist()
risk_ratings = ESG_Ratings.drop('Company', axis=1)

bar_positions = np.arange(len(risk_ratings.columns))

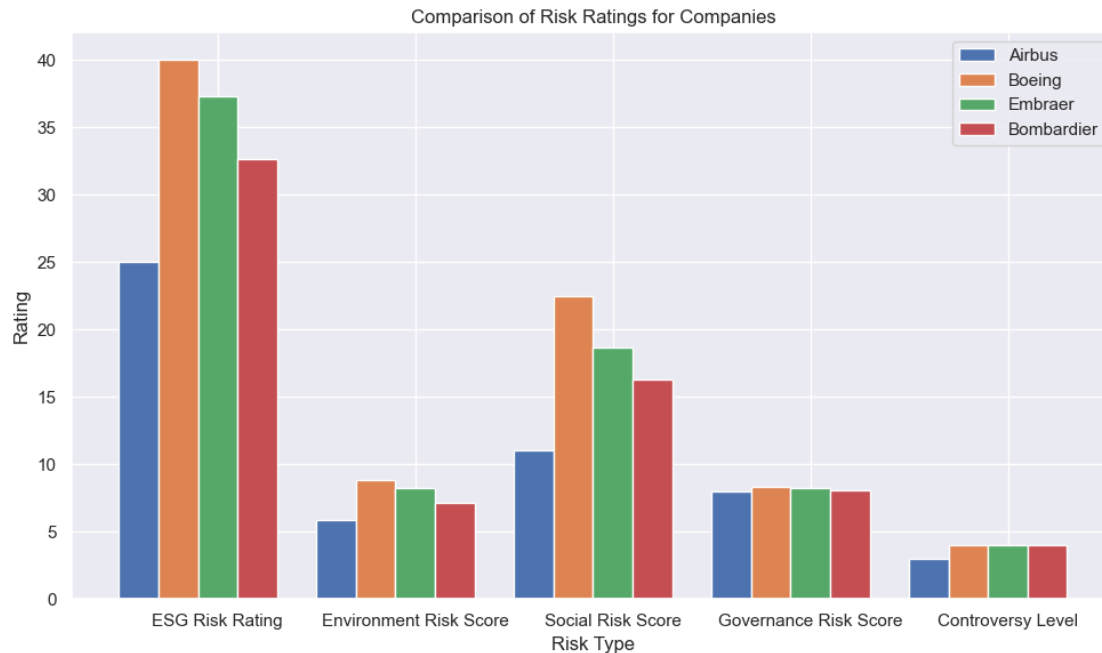
bar_width = 0.2

fig, ax = plt.subplots(figsize=(10, 6))
for i, company in enumerate(companies):
    ax.bar(bar_positions + i * bar_width, risk_ratings.
↳loc[ESG_Ratings['Company'] == company].values.flatten(), width=bar_width,
↳label=company)

plt.xlabel('Risk Type')
plt.ylabel('Rating')
plt.title('Comparison of Risk Ratings for Companies')
plt.xticks(bar_positions + bar_width * len(companies) / 2, risk_ratings.columns)
plt.legend()

plt.tight_layout()
plt.show()
```





## 6.2 B. Relationship Between ESG and Financial health

```
[33]: financial_health_df=pd.concat([Liquidity_ratios[['Company','Current_
    ↳Ratio','Quick Ratio']],
                                Profitability_ratios[['ROE','ROA','Gross_
    ↳Margin Ratio','Operating Margin Ratio','Net Profit Margin']],
                                Solvency_ratios[['Debt to Equity Ratio','Debt_
    ↳to Assets Ratio']]])

financial_health_df=financial_health_df.groupby(level=0).first()

average_ratios_by_company=financial_health_df.groupby('Company').mean()#this_
    ↳calculate the average
average_ratios_by_company=average_ratios_by_company.reindex(["Airbus",
    ↳"Boeing", "Embraer", "Bombardier"])
```

To concatenate the 2 tables, we reindex the ESG rating table, by computing the same index(company) than the financial health dataframe.

```
[34]: ESG_Ratings.set_index('Company', inplace=True)
ESG_Ratings.index = ESG_Ratings.index.map(lambda x: x.strip())
print(ESG_Ratings)
```

	ESG Risk Rating	Environment Risk Score	Social Risk Score	\
Company				
Airbus	25.0	5.900	11.00	

Boeing	40.0	8.800	22.50
Embraer	37.3	8.206	18.65
Bombardier	32.6	7.172	16.30

Company	Governance Risk Score	Controversy Level
Airbus	8.000	3
Boeing	8.300	4
Embraer	8.206	4
Bombardier	8.100	4

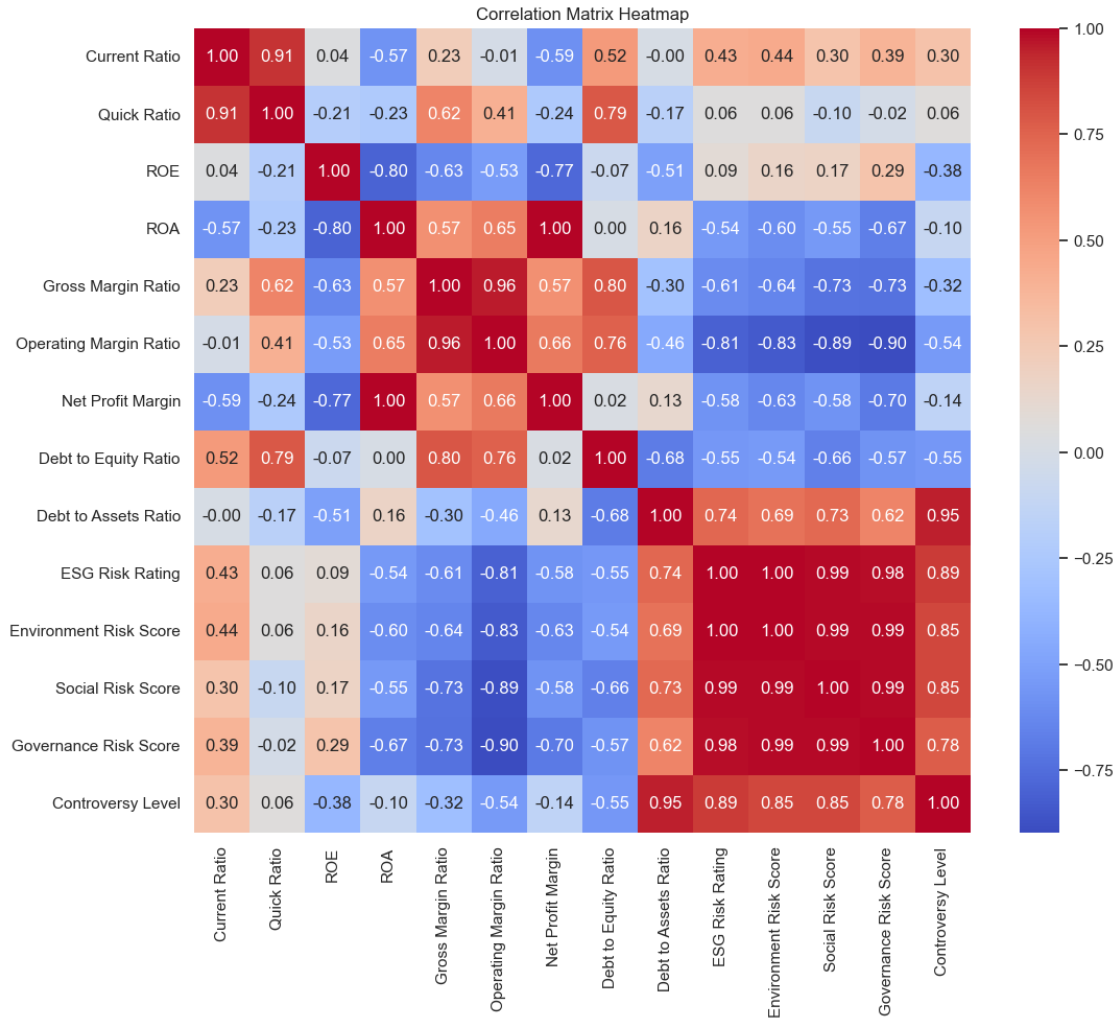
### 6.2.1 Correlation Matrix :

```
[35]: correlation_data=pd.concat([average_ratios_by_company,ESG_Ratings])
      correlation_data = correlation_data.groupby(level=0).first()
```

We use Seaborn to plot the heatmap correlation matrix for a better visibility

```
[36]: correlation_matrix = correlation_data.corr()

plt.figure(figsize=(12, 10))
sns.heatmap(correlation_matrix, annot=True, fmt=".2f", cmap='coolwarm',
            cbar=True)
plt.title('Correlation Matrix Heatmap')
plt.show()
```



Except, the ESG Square that is red (normal because  $ESG = E + S + G$ ), we can observe a negative correlation between ESG Risk Rating and Profitability Ratio. This is because profit is positively correlated with bad ESG rates (the more profit a company makes, especially in the aerospace industry, due to increasing flights, etc.), the worse the ESG risk rating becomes.