PLAUSIBLE IMPACT ON CAPITAL DUE TO CLIMATE CHANGE

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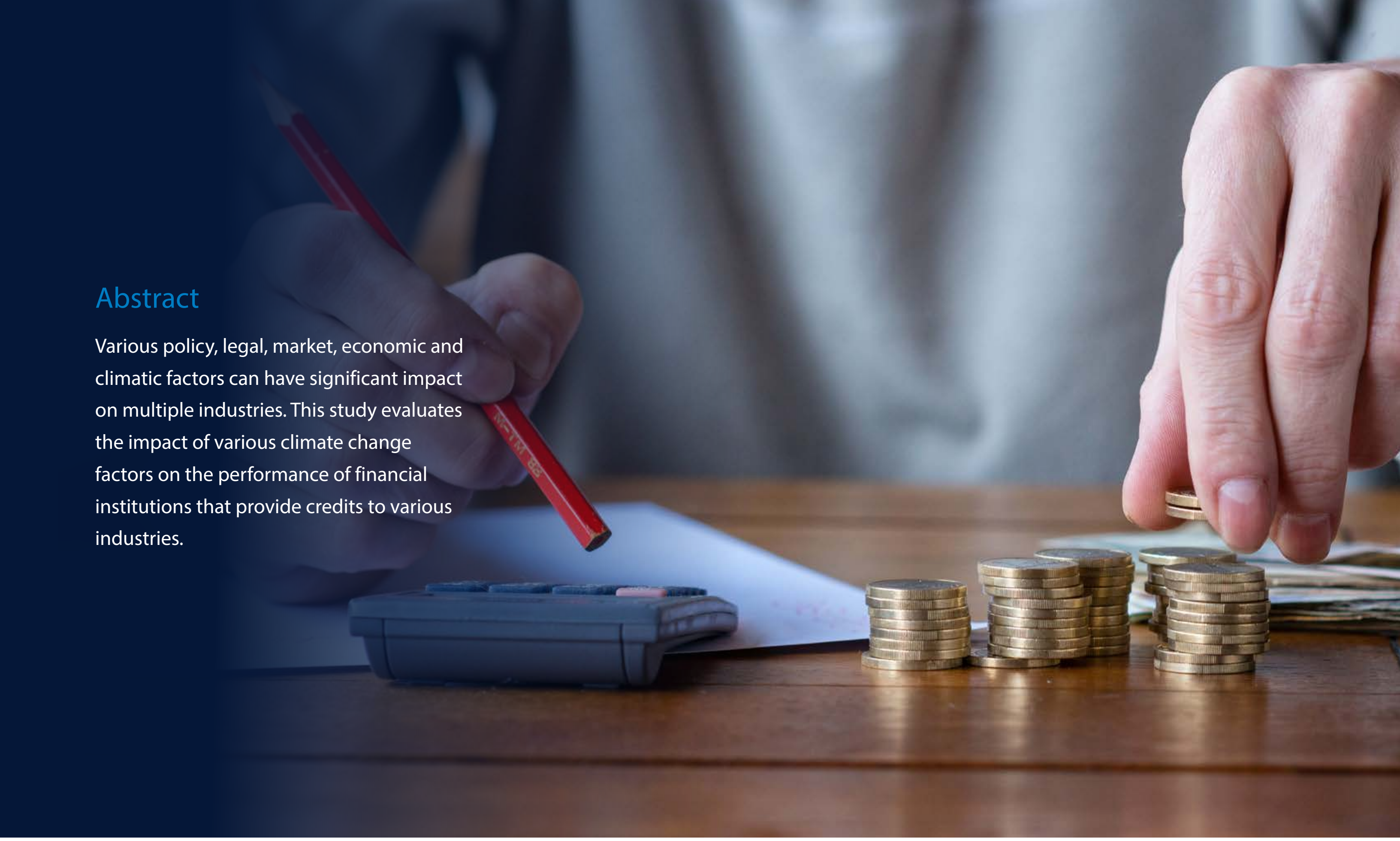

Abstract

Various policy, legal, market, economic and climatic factors can have significant impact on multiple industries. This study evaluates the impact of various climate change factors on the performance of financial institutions that provide credits to various industries.

The Purpose of Analysis

A climate scenario is a reasonable portrayal of future climate that has been constructed for overt use in looking into the significant impacts of anthropogenic (environmental pollution and pollutants originating due to human activity) climate change. Climate scenarios generally make use of climate predictions (details of the systematic response of the climate system to scenarios of greenhouse gas, CO_2 emission, temperature, rainfall and gas). Renowned economists infer climate change as one of most well-known market catastrophe in the known past with potentially turbulent consequences on the financial stability, economic well-being, and social inclusion of the present as well as future generations. Traditional approximation shows constant climate disruptions will lead to decrease in global GDP between 5 to 20% every year, now and in future as well.

Consequentially, both public and private administrator and investor around the world face the dual essence of:

- Remarkably and swiftly reducing greenhouse gas (GHG) discharge globally, by de-carbonizing the global economy, consequentially averting the mean worldwide temperature spike from attaining threatening levels.
- Attuning global production and consumption norms, social living, and the fundamental supply-network, to the meteorological, hydrological effects of changing climate that is clearly unstoppable.

The exploratory research has been done to establish relationship between climate change and derivatives like fossil fuel consumption, carbon emission, average rainfall, average temperature, European emission allowances, issuance of green bonds, Norway oil output etc. to some of the balance sheet factors like net interest income, net income, non-performing loans. This is primarily a statistical research that has been done post focused group discussions, data discovery and data profiling from public domain. This paper is first step research showcasing data collection, profiling, establishing relationship on aforementioned parameters.

We acknowledge that climate-change could have significant supposition on the financial institutions. The very first suggests a demand to alter time horizons on the long run along with contemplating measures today observing how the risks from climate change may evolve in the future. The second suggests the urge to maintain the equilibrium. It is anticipated that financial risks are going to be realized in some structure, the question is decreasing their aftermath while firms and society maximize the chances.

Climate Change Presents Financial Risks

Climate change causes financial risks those surfaces from two significant mediums or risk factors: Physical and Transition. Climate and weather related events such as storms, heatwaves, floods, sea level rise and droughts can lead to physical risks. They can consequentially cause substantial monetary losses, diminishing asset worth and the credibility of borrowers. Transition risks can rise in the procedure of acquiring a de-carbonized economy. Upgrading policy, technology and belief can trigger a re-assessment of the worth of the holdings and generate credit exposures for financial institutions.

These above said climate related risk factors manifest intensified market, credit and operational risk for banks and financial institutions.

Credit Risks

The financial obligations might fall onto other market partakers If the vandalism from physical risks are not insured which in turn would increase the credit exposures for financial institutions and banks. Homeowners will end up getting severely impacted due to hostile weather events, minimizing their scope to meet their debt obligations and damage the value of their assets. Consequentially, it would impact adversely on the credit risk of the loan books as both probability and loss give default increases.

Banks and financial institutions might have some credit exposures with firms having business models that seemingly are not in trend with the switchover to an economy with low carbon usage, and as an impact anticipate a greater chance of minimized corporate income along with business disruptions. Based on our research we have selected firms in the agriculture, property, and transport and energy sectors to be prone to the risk involved, specifically in the case if this transition is triggered late and not systematically.

Market Risks

Commodity prices, energy sector, equities, corporate bonds and certain derivate contract would largely be impacted in this transition on carbon rich sectors. In the coming future if the portfolios are not in line with expected climate protocols the financial risk from sudden transition to a de-carbonized economy may increase. Fundamental factors like inflation, employment and economic growth can be weakened through endured damage to national infrastructure. As a result we can conclude here that macroeconomic conditions would be eventually impacted by increasing frequency of extreme weather events.

Operational Risks

Business continuity like processes, infrastructure, offices, branch networks and staff would be tremendously impacted due to severe weather events. The cost-tariffs of inputs like insurance, water and energy might rise. Due to a strategic shift in sentiments among customers and rising scrutiny and alertness among stakeholders on the banking sectors response to climate change reputational risk may arise as well. As a result monitoring the financial risks from climate change needs a well-planned and strategic methodology, one that is progressive and well balanced in the long term financial interests of the firm.

Traction on Climate

Here, the main focus would be on what the regulatory and banking bodies have to say on the climate ordeal.

PRA: Prudential Regulation Authority -A UK financial services regulatory body formed as a successor to FSA firmly believes that economy is going to take a toll in the areas such as smooth functioning of the financial market, productivity of the work place or impacting total economic activity due to the climate change. Their study also showcases that the global economy too can be impacted by the environmental change. PRA has considered the physical risk that arises from events like droughts, storms and floods. For example, we consider the 2011 Thailand flood which resulted in over $45 billion of economic losses. Moreover, on a different side, the mangrove forests in Mexico bestow protection from storms and provide fisheries support and eco-tourism. These benefits have been estimated at $70 billion in financial terms.

PRA also mentions the transition risk that arises due to change in the policies for e.g., under Paris agreement the economies need to limit their carbon emission and fossil consumption down the line. These are the key concerns that has been taken into account while preparing the outcomes to stabilize the financial system around.

EBA: European Banking Authority has emphasized the aftermath of the climate change and its consequences through the materialization of 3 main risks- Physical Risk (covers direct damage to property or trade disruption, Transition Risk (covers the financial risk that arises from the transformation to a low-carbon economy) and liability risk (stating the responsibilities for the impact that will occur down the line and understanding the impact).

The report also mentions that the transition and physical climate shocks are going to affect credit, market and operational risk in different ways directly or indirectly. Soon EBA will come up with methodology to be implemented by FIs in their jurisdiction. Strong references have been found in EBA websites.

FSB: Financial Stability Board (formed by G20) observes and makes recommendations around the financial system of the globe. In 2015 G20 approached FSB to contemplate climate risk and in 2015 December, FSB initiated the industry-led Task Force on Climate-related Financial Disclosures (TCFD) to developed suggestions on climate-change related financial disclosures. The Task Force published its complete advisory in June 2017.

Declaration of climate-related financial information is now a precondition for financial firms to not only run and price climate risks suitably but also, if they are willing to take lending, investment or insurance underwriting decisions based on their view of transition scenarios.

FSB is currently working on recommendations that will ease habitual, comparable, dependable, clear and systematic climate-related declarations by companies. It is quite clear that FSB is considering climate change as a serious issue.

United Nations Financial Initiatives: UN report stresses on climate change related risks on financial institutions and borrowers. UN has also addressed the current climate change policies in Canada, Europe and the US in order to provide a framework for policy implementation in the future. This study also addressing the impact of future environmental liabilities on specific debt products and review strategies for calibrating the associated risk.

Paris Climate Agreement: As of May 2019, European Union and 194 states have signed the Agreement. EU and 185 states, demonstrating more than 88% of global greenhouse gas emissions, have been ratified or consented to the Agreement, India and China, the countries in top 3 list of largest greenhouse gas emissions of the UNFCC members total (about 42% together). All 197 members of UNFCCC have either signed or consented to the Paris Agreement. The agreement focus on the below points:

- Need to design a framework for sovereign/country actions on climate change in all of the major economies.
- A robust and transparent process to monitor the implementations.
- A timeline for the nations to review their actions.
- International mechanisms to promote climate friendly finance, carbon trading, technological upgrade and adjustment to climate change impacts.

Kyoto Protocol: The Kyoto Protocol is an international pact that puts out the 1992 United Nations Framework Convention on Climate Change (UNFCCC) that pledges state parties to decrease emissions from greenhouse gas, as established on the scientific consensus that firstly global warming is occurring and secondly it is very likely that CO2 emissions have primarily caused it. The Kyoto Protocol was adopted in Kyoto, Japan, on 11 December 1997 and came in action on 16 February 2005. There are currently 192 parties linked to the protocol.

By Kyoto protocol it is clear that the authorities understood the increasing GHG and carbon content in the atmosphere and planned to limit it by differentiating responsibilities based on the specific capabilities of the individual countries.

Objective of the Analysis

The study is based on considering specific geography (Europe) to evaluate the impact of various climate change factors on performance of financial institutions (banking). First section of the study is based adopting a framework on change in policies, technological changes, market factors, based on key performance metrics like non-performing loans, net interest income and net income. Report then explain the approach adopted to build a regression analysis based on R and perform stress analysis.

Framework for Climate Change Stress Testing & Risk Management

To assess the risks associated with climate change, we have built a Framework to understand and study the climate risk factors and their impact on banks portfolios. The Framework designed by us is as follows:

We have basically divided our Framework in 2 stages:

1) Assessing the Risk Exposure

2) Evaluating the R

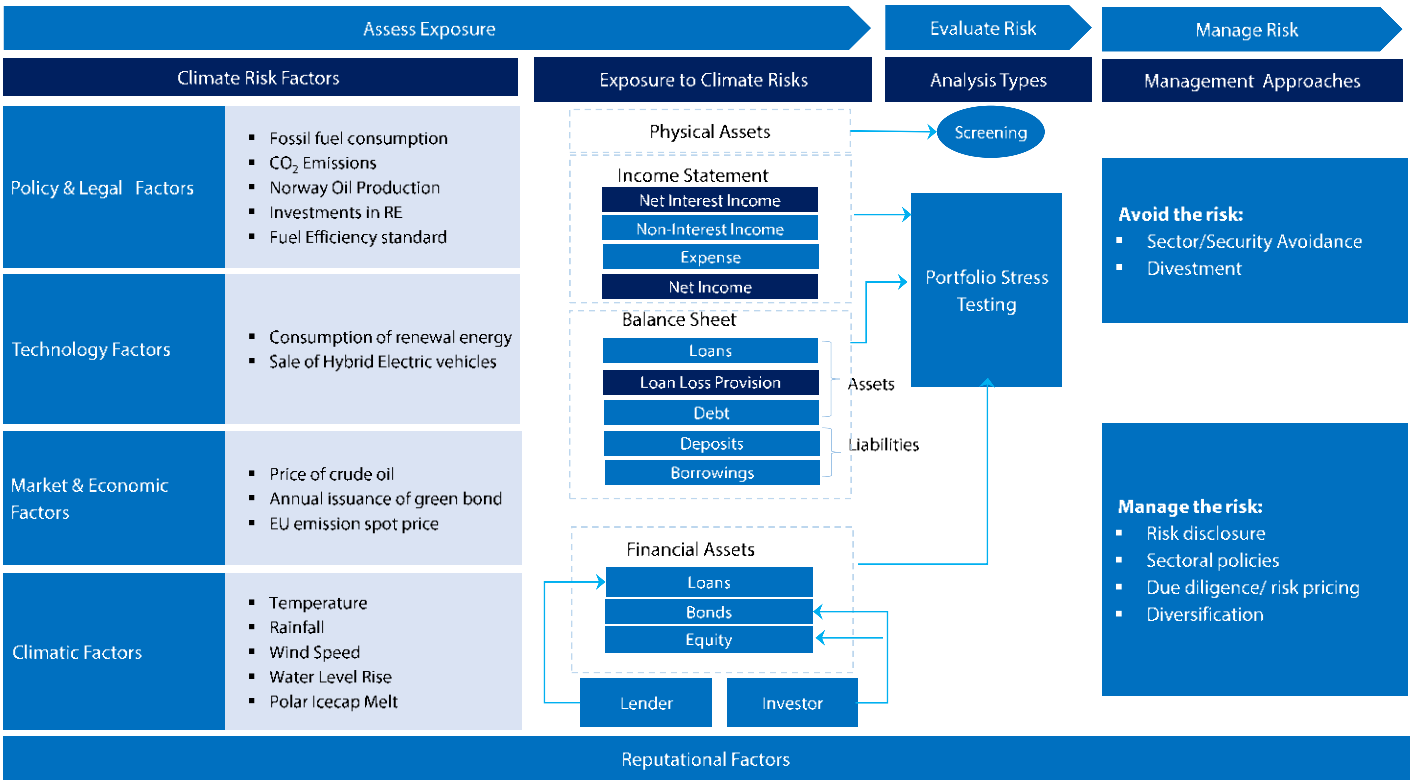

Fig. 1: Framework for Climate Change Stress Testing & Risk Management

Policy & Legal Factors

Policy and legal factors consist of changes in local government, national and international regulations and policies that might impact the financial and operational viability of carbon assets. Regulations and policies could enforce restrictions on emissions from GHG on certain kinds of physical assets, or those that negatively affect such assets. Regulatory and policy risks start from action taken by government; it may be at local, state or country level. As an outcome, the nature of these risk types might differ subject to geographical region of assets in question or company.

Technology Factors

These risk factors would affect the carbon assets & companies in various ways. Technological factors consist of new and innovative technological developments either in design, cost or both — and that lead to quick change of outdated technologies. Existing technologies largely face threat of replacement by latest technical alternatives that have greater function, reliability, efficiency, or lesser cost profile, and, with relation to carbon, lesser GHG emissions. Technological changes that lead to enhanced energy productivity can decrease the overall energy demand, therefore reducing the necessity for production from current technology assets.

Market & Economic Factors

These factors involve risks that derive from changes in the economic and market parameters that might be related to the operational feasibility or financial value of the physically used asset or institution. Such economic and markets changes can be due to changes in consumer's behavior. One contemporary example of how changes in market can negatively influence assets related to energy and other related companies is the current drastic slump in the oil prices. Lower demand for oil is correlated to lower growth rates in economy in many parts of the world and the ever-increasing efficiency, and moreover solid oil supply in some markets. It has been difficult for energy companies, for example, in the USA, where supplies have been tremendously increased by the exploration of new reserves made possible to access by the technology of hydraulic fracturing and horizontal drilling and other disruptive technologies which were developed recently in the field of oil explorations. There is a scenario where companies dealing in oil and gas business would go for higher cost development projects when there is low price environment and demand for disruptive tech advancements, energy, and even sovereign policies or political events.

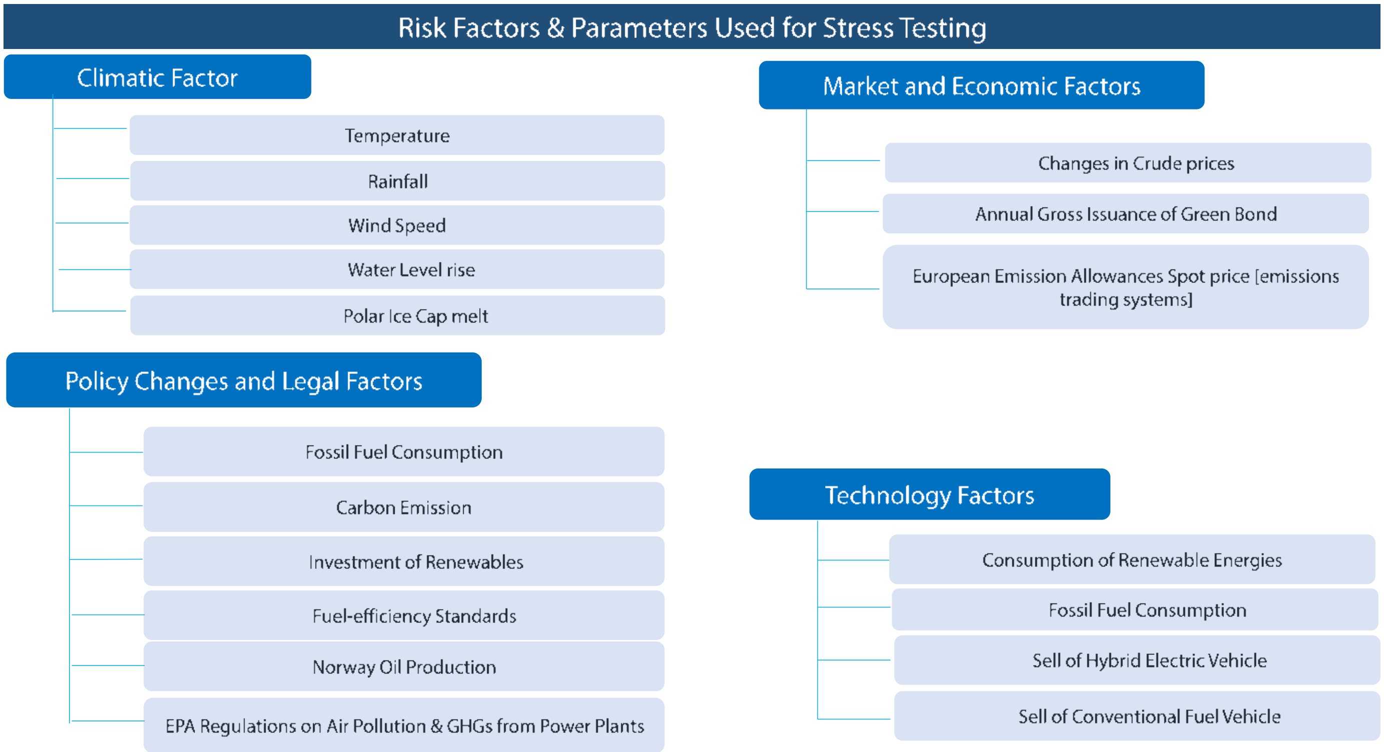

Fig.2: Risk Factors

Physical climate change risks, refer to the risks pertaining to the physical impacts that may affect the operating companies and their assets. These risks can affect and may contain physical impairment and along with that, capital expenses too in response to changes in weather scenarios (such as floods, severe drought and storms) and "slow onset" impacts such as sudden increase in the level of sea.

Transitional change risks, are the risks pertaining to the non-physical (i.e. intangible) climate change-related parameters being subjected on the assets of the companies. This includes technology, policy and legal, economic and market related risks — depending upon their type and magnitude of impact to the financial institutions. Based on the above factors, we have tried to identify the other variable, which would drive major changes in future.

Policy and Legal Factors: We have identified following changes which might be implemented by different countries to reduce temperature.

a) Policies to reduce fossil fuel consumption
b) Policies to reduce carbon emission
c) Increased focus on fuel efficiency standard
d) Increased investment on renewable energy
e) Other local government regulations
f) Norway oil production

Market and Economic Factors

- Changes in fuel/crude prices
- Changes in consumer preferences
- European emission allowances spot prices

Technology Factors

a) Increased demand of alternative energies
   - Increased consumption of renewable energy
   - Reduced consumption of fossil fuel
b) Advancement renewable energy technologies
   - Increased and demand in electric vehicle
   - Reduced demand of conventional Fuel vehicles

Climatic Factors

a) Temperature
b) Rainfall
c) Wind speed
d) Water level rise
e) Polar ice cap melt

Methodology

Selecting Dependent Variable

In order to select the key performance indicators for the predictive modelling, it was imperative to decide the geography from which the bank or financial institute is selected. Here in the study, the selected geography is Norway. Below is reason why Norway is considered for the study.

1. Norway has a history of environmental concern, much before other cities jumped on the eco bandwagon. The government outgrows on the populace by promoting sustainability. The Norwegian city Oslo replaced heating oil in city buildings with renewable energy sources, which is bold considering the amount of energy the metropolis uses. The government also provides incentives for new buildings to promote energy efficiency. All buses running on fossil fuels are converted to biofuels. The Oslo city has less CO_2 emission as compared to all European metropolises. Most of school children walk, cycle to school or use public transportation (the rail system is run on hydroelectric power). Ninety-four percent of household waste is recycled.

   Above mentioned facts are factored as part of Paris Agreement which has been addressed by Norwegian Government to save environment. This has led to policy implementation around the transition risk.

2. Further, The BEVs and PHEV's will capture 100% of the automobile market by 2025. Govt. of Norway plans to get rid of fossil based vehicles completely post 2025. Plan to impose heavy carbon tax is being contemplated to curb the CO_2 emission industry wise. Below is the plan to curb fossil fuel vehicle usage:
   - 100% by 2025
   - 50% by Dec'20
   - 44% as of March'19
   - 32% in Dec'17

3. Govt. of Norway plans to limit the fossil fuel consumption completely by 2030 and shift to renewables.

   From the above Framework we have extracted the Independent and dependent variables for climate change scenarios. Once variables are identified, then historical data for a specific timeframe were collected and a multiple variable linear regression analysis was performed to assess the relation between dependent and independent variables. Secondly, a transitive hypothetical stress testing study is performed on banks' variables to evaluate the effect of changes on variables which are Net Interest Income, Non-Performing Loans and Net Income of banks. Below is the pictographic depiction of the methodology followed.

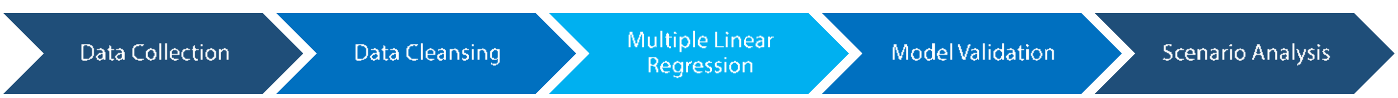

Fig.3

Data Collection

For the identified variables, which were identified based on their special mentions in the various green agreements like Kyoto Agreement and Paris Agreement etc., data were collected from 2009 to 2018 from different sources.

Data Cleansing

Data collected were of annual basis, therefore data were broken down to get the data of quarterly basis. Data for temperature and rainfall were seasonally adjusted and later transformed for better analysis. For regression all the data were used as rate of change by using natural log.

Multiple Linear Regression

Data were used to get a multiple linear regression equation in order to predict the key performance indicators like NII, NPL and Net Income etc.

Model Validation

Regression equation which was achieved in the analysis is validated by using test set of data to check the accuracy of the prediction.

Scenario Analysis

Scenario Analysis Hypothetical transitive stress testing is used to understand scenario analysis, to evaluate the effect of the dependent variable on net income of bank.

As per the most widely used industry standards, there are following ways to proceed for a stress-testing model.

- Portfolio P&L analysis
- Historical event analysis & replication
- Transitive analysis & forecast

Here we have measured transitive stress testing, which includes finest practices for generating forward-looking scenarios so as to identify parametric correlation. We have also added random methodology to forecast future values or projection and then the Stressed values. This is the enhanced or dynamic version of our stress test, where it uses models which allows the test to discreetly select the accurate upper and lower range of Independent Parameters. Based on the several hypotheses, Government/Policy guidelines given to control the independent parameters (i.e. CO_2 emission) which are dynamically adjusting to foresee future impact and monitoring the subsequent Asset classes or Incomes of Bank.

Steps Followed for Stress Testing

1. Historical data of last ten years has been collected quarter wise streamlined for the regression analysis.
2. Using linear regression, we have derived an equation for dependent variable (net income) with all the independent variable.
3. Each of the independent variable are grouped, within a risk factor/stress parameter.
4. By stimulating a set of independent variable, which falls under one particular risk factor (i.e. market factor) we can stress that particular factor.
5. We have used forecasting methodology for predicting the future values for coming ten years to derive the upper and lower range of variables within which the independent variables are going to move.
6. Several hypotheses are used and in some case government policies or regulatory, guidelines are used to decide the future path or transition of each of the independent variable.
7. We have used the upper and lower range along with the mean of last ten years' values of the parameter to derive the percentage value of "Upper Bound" and "Lower Bound" of change.
8. Using those bound values, we have randomized the parameter to derive the basic values of coming ten years of the future values of those independent parameters as per our hypothesis. These define the baseline scenario (1X)
9. Further, we have stimulated the upper and lower bound of each parameter to arrive at the stressed values of each independent variable. Summation of stressed position of all the variable under one risk factor gives a stress output (i.e. 2X Market Factor)
10. We have arrived to approximately 8 stress scenarios where on the combination of multiple Stressed risk factor derives the change on dependent variable (i.e. delta net income).
11. Regression equation is used where the coefficient is multiplied with the stressed changes of each independent variable (not all are stressed in each scenario) will return the stress output of dependent variable (i.e. bank's net income)

Logic for Designing the Stress Scenarios

As per the most widely used industry standards, there are following ways to proceed for a stress-testing model.

1. Portfolio P&L analysis
2. Historical event analysis & replication
3. Transitive analysis & forecast

- Here we have considered transitive (or predictive) stress testing, which includes best practices for creating forward-looking scenarios in order to identify parameters correlation.
- We have also added random methodology to forecast future values or projection and then the stressed values.

- There are two separate stress scenarios where we stress the rate of change of climatic factors which are categorized under physical stress scenarios.
- There are other stress scenarios where we stress the rate of change of other risk factors i.e. Market Factor, Policy Factor, Technology Factor and these are transitional stress scenario

SN	Scenario	Equation	Logic
1	Scenario 1A Climate Stress	Delta Net Income = 1x Policy Factor (Baseline of Fossil Fuel Consumption, CO_2 Emission, Norway Oil Output) + 1x Market Factor (Baseline of EU Emission Spot price, Green Bond Investments) +1x Technology Factor(Baseline of Renewable Consumption) + 2x Climate Factor(Temperature Upper Bound 2X, Rainfall Upper Bound 2X)	Physical stress scenario where, climatic factors are stressed keeping other constant. Temperature rises and so does the rainfall providing adverse climatic condition for few industries i.e. logistics, transport etc.
2	Scenario 1B Climate Stress	Delta Net Income = 1x Policy Factor (Baseline of Fossil Fuel Consumption, CO_2 Emission, Norway Oil Output) + 1x Market Factor (Baseline of EU Emission Spot price, Green Bond Investments) +1x Technology Factor(Baseline of Renewable Consumption) + 2x Climate Factor(Temperature Upper Bound 2X, Rainfall Lower Bound 2X)	Physical stress scenario where climatic factors are stressed keeping other constant. Temperature rises but the rainfall goes down, providing adverse climatic condition for few industries i.e. agriculture.
3	Scenario 2A Policy Stress	Delta Net Income = 2x Policy Factor (Fossil Fuel Consumption Lower Bound 2X, CO_2 Emission Lower Bound 2X, Norway Oil Output Lower Bound 2X) + 1x Market Factor (Baseline of EU Emission Spot price, Green Bond Investments) +1x Technology Factor(Baseline of Renewable Consumption) + 1x Climate Factor(Baseline of Temperature, Rainfall)	Transitional stress scenario with stress over policy factor keeping other constant. Policy enables all emissions and consumptions going down including oil production rate.
4	Scenario 2B Policy Stress	Delta Net Income = 2x Policy Factor (Fossil Fuel Consumption Lower Bound 2X, CO_2 Emission Lower Bound 2X, Norway Oil Output Upper Bound 2X & Lower Bound 0) + 1x Market Factor (Baseline of EU Emission Spot price, Green Bond Investments) +1x Technology Factor(Baseline of Renewable Consumption) + 1x Climate Factor(Baseline of Temperature, Rainfall)	Transitional stress scenario with stress over policy factor keeping other constant. Policy enables all emissions and consumptions going down but due to invention of oil across norway the oil production rate goes up.
5	Scenario 2C Policy Stress	Delta Net Income = 2x Policy Factor (Fossil Fuel Consumption Upper Bound 2X, CO_2 Emission Lower Bound 2X, Norway Oil Output Upper Bound 2X & Lower Bound 0) + 1x Market Factor (Baseline of EU Emission Spot price, Green Bond Investments) +1x Technology Factor(Baseline of Renewable Consumption) + 1x Climate Factor(Baseline of Temperature, Rainfall)	Transitional stress scenario with stress over policy factor keeping other constant. Policy enables all emissions s going down but due to invention of oil across norway the oil production rate goes up as well as the domestic fossil fuel consumption goes up.
6	Scenario 3 Market Stress	Delta Net Income = 1x Policy Factor (Baseline of Fossil Fuel Consumption, CO_2 Emission, Norway Oil Output) + 2x Market Factor (EU Emission Spot price upper Bound 2X, Green Bond Investments Upper Bound 2X) +1x Technology Factor(Baseline of Renewable 7Consumption) + 1x Climate Factor(Baseline of T8emperature, Rainfall)	Transitional stress scenario with stress over market factor keeping other constant. Market prices enables issuance and investment of green bond and the price for eu emission allowance spot going up.
7	Scenario 4 Technology Stress	Delta Net Income = 1x Policy Factor (Baseline of Fossil Fuel Consumption, CO2 Emission, Norway Oil Output) + 1x Market Factor (Baseline of EU Emission Spot price, Green Bond Investments) + 2x Technology Factor(Renewable Consumption Upper Bound 2X) + 1x Climate Factor(Baseline of Temperature, Rainfall)	Transitional stress scenario with stress over technology factor keeping other constant. Technology enables renewable energy consumption and hybrid vehicle sales going up.
8	Scenario 5 Combined Stress	Delta Net Income = 2x Policy Factor (Fossil Fuel Consumption Lower Bound 2X, CO_2 Emission Lower Bound 2X, Norway Oil Output Lower Bound 2X) + 2x Market Factor (EU Emission Spot price upper Bound 2X, Green Bond Investments Upper Bound 2X) +2x Technology Factor(Renewable Consumption Upper Bound 2X) +1x Climate Factor(Baseline of Temperature, Rainfall)	Transitional stress scenario with stress across all transitional scenarios apart from climate. It decreases consumption, emission, and oil production under policy, increases green bond investment and EU emission spot price under market and increases investment and consumption of renewables under technology impact.

Fig 4 : Stress Scenarios Logic

KPIs Targeted to Analyze the Climatic Related Risks

Types of Capital in the Capital Stack

Category	Types of Capital	Physical Asset or Company Level	Type of Investment	Types of Intermediaries and Investors	Service Providers
Equity	Equity markets (stocks, bonds); Private equity (institutional/ corporate or project)	Company-level (private equity, stock); Asset-level (public and private equity)	Ownership through the holdings of shares directly, or via others funds	Institutional investors; Retail investors	Banks (underwriting); Asset managers
Debt (Bonds	Debt capital markets; Private placements; Project specific bonds	Company-level (corporate related bonds); Asset-level (project funding bonds)	Leverage funding (lending), through direct holdings or through bonds or funds	Institutional investors; Retail investors	Banks (underwriting); Asset managers
Debt (Loans)	Corporate loans; Loans related to project financing	Company-level (corporate related loans); Asset-level (project funding bonds)	Leverage funding (lending), through holdings or through bonds or funds (syndicate i.e. multiple lenders)	Banks; Institutional investors	Banks (lenders)

Fig 5: Capital Stack

Defining Types of Climate Change Risks and Risk Factors

While defining risks associated with climate change, it is important to distinguish between:

Physical climate change risks, are the risks related to tangible impacts that could negatively affect the operating companies and carbon assets. These risks effect may comprise physical impairment and/or capital expenses that might be required to deal with the variations in weather patterns (i.e. extreme storms, certain floods, and long-lasting drought) and "slow onset" consequences like rising sea level, situation leading to desertification etc.

Transitional change risks, are the risks such as non-physical (i.e. intangible) climate change-related parameters subjected on the assets of companies. This includes technology, policy and legal, economic and market related risks — depending upon their type and magnitude of impact to the financial institutions.

Climate Change Risk Factors

In addition to reputation related risk, these frameworks emphasize on three risk factors that occur in current scenario, and also numerous other factors that may become significant in the future. These risk factors are:

1. Policy and Legal Factors
2. Technology Factors
3. Economic and Market Factors

Primary categories of Climate Change-related Risk Factors

Category of Risk	Definition	Nature of Impact	Examples
Policy and Legal	Policies or rules and regulations which would impact the financial and operational viability of carbon related assets.	Affects physical carbon assets and firms which deal in such assets.	Fuel-efficiency standards for private vehicles; emissions trading systems; EPA regulations (USA) on air pollution & GHGs from power plants.
Technology	Developments in the commercial accessibility and reduced cost of substitute and low carbon technologies.	Impact on the choice and deployment of technology, and the costs and demand profiles.	Energy storage technologies; changes in technologies related to renewable energy, carbon consumption and storage; alternative fuels.
Market and Economic	Changes in economic or market condition which would adversely affect carbon assets.	Impact on physical carbon assets and companies which deal in such assets.	Changes in fossil fuel prices; changes in the preferences of consumer.

Fig 6: Climate Risk Factors

Policy and Legal Factors

Factors related to policy and legal aspects include changes that are regulated by national, and local government and even by international policies or regulations, and which could negatively influence the operational and financial feasibility of carbon related assets. These may be rules or regulations that exert limitation on greenhouse gas emissions from particular types of assets, or which indirectly affect such assets. Risks related to policy and regulatory aspects come from tentative or actual government action, and can be at local, state, or national level. Due to this, nature wise, these risks may vary depending on the context related to geography of an asset or company.

Technology Factors

Technology risks can negatively disrupt carbon asset and related companies in many different ways. These include disruptive technological developments — can be in price (i.e. cost-effective methods), leaner design or both — that may lead to replacement of current technologies. More common, however, are the incremental improvements in current technologies that are created over a longer duration. In all these cases, current technologies basically face low to high level of risk of disruption by the newer substitutes, that has a low-cost profile or great value of functional, efficiency, robustness, user friendly features, and relative to carbon, less greenhouse emissions. Technology changes that lead to more energy efficient systems also have the tendency to lower the exiting demand for energy, and in doing so, need for production or generation is reduced from existing technology assets.

Market and Economic Factors

Risks related to market and economy include those risks which arise from changes in the market and economic conditions, and which may affect the operational feasibility or financial structure of an asset or related company. Such economic and market changes could be a driving function of changes in consumer behavior. One current example of impact of changes related to market on energy assets and related companies is the current drastic fall in the price of oil, a most commonly traded commodity globally. Oil demand is directly related to growth of economy for many countries. As the economic growth is lower, so is the demand of oil — for example, in the USA, where supplies have been tremendously increased by the exploration of new reserves made possible to access by the technology of hydraulic fracturing and horizontal drilling and other disruptive technologies (that were developed recently in the field of oil explorations). Fourteen gas and oil companies in USA found it more difficult to go for higher cost projects in a demand that is in lower-price environment for energy; and amidst tech advancements, and even policies or political events that are administered by government.

Based on the above factors we have tried to identify the other variable which would drive major changes in future.

Policy and Legal Changes:

We have identified following changes, which might be implemented by different countries to reduce temperature.

- Policies to reduce fossil fuel consumption
- Policies to reduce carbon emission
- Increased focus on fuel efficiency standard
- Increased investment on renewable energy
- Other local government regulations

Market and Economic Factors:

- Changes in fuel/crude prices
- Changes in consumer preferences
- European emission allowances spot prices

Technology Changes:

- Increased demand for alternative fuel
- Reduced demand for fossil fuel
- Advancement and demand in renewable energy technologies
- Reduced demand of conventional fuel vehicles

Apart from the above variables, we are trying to assess the impact of these changes on macroeconomic variables such as countries GDP and unemployment rate etc.

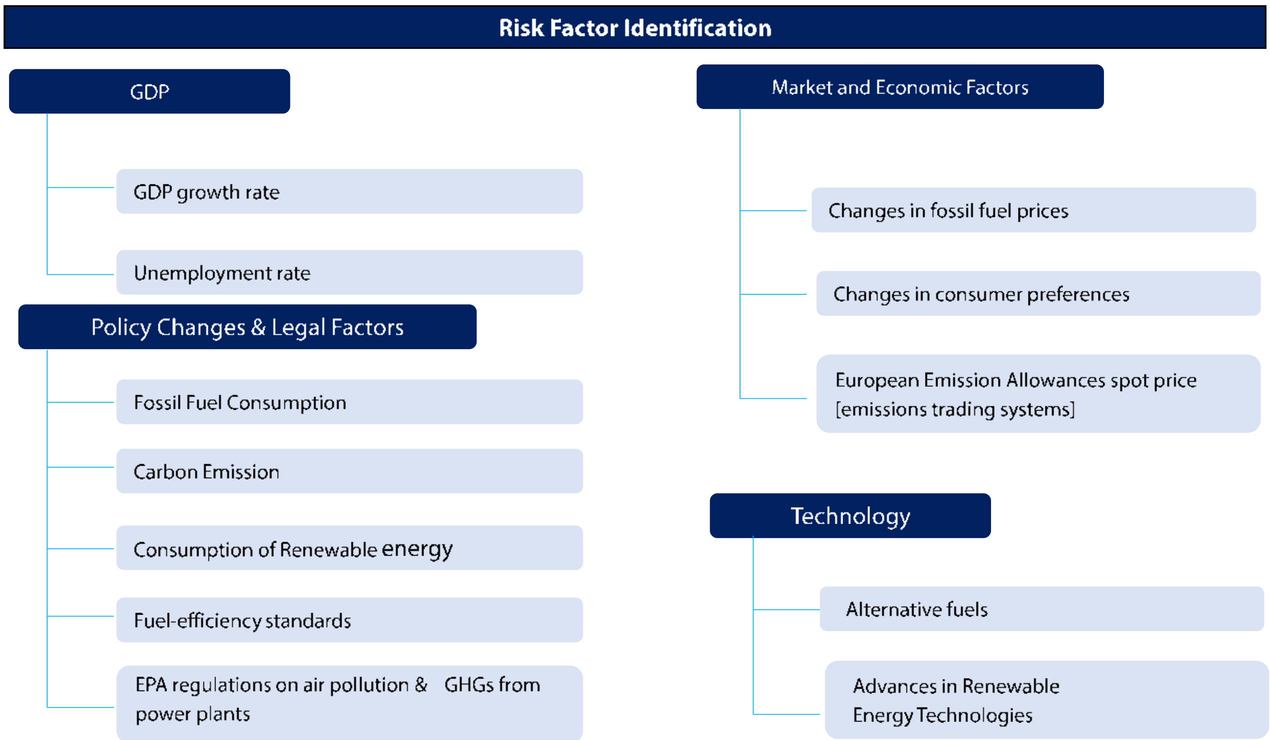

Fig 7 : Climate Change Risk Factors

Description of Para & Variables

Case 1: Non-performing loans dependent variable: Non-performing loans of a bank (based out of Norway). Data is gathered from its annual reports from 2008 to 2018. Data were annual and these are broken down to quarterly interval depending upon the rate of change annual and assuming equal change in quarterly interval.

Assumptions

1. NPL for 2008 = 3192.6
2. Annual Rate = -2.43%
3. Quarterly rate = -0.61%
4. Annual data of NPL are reported on or after Q4

**Detailed calculations are mentioned in the embedded spreadsheet (Accessible on google drive)*

S.No.	Year	NPL(NOK,MM)	Annual Rate	Quarterly Rate
1	2009	3115		
2	2010	4724	51.65%	10.97%
3	2011	2313	-51.04%	-16.35%
4	2012	3422	47.95%	10.29%
5	2013	2228	-34.89%	-10.17%
6	2014	3179	42.68%	9.29%
7	2015	3318	4.37%	1.08%
8	2016	2463	-25.77%	-7.18%
9	2017	4322	75.48%	15.09%
10	2018	2842	-34.24%	-9.95%

Fig.8: Annual Non-Performing Loans

Logic for calculation of Annual & Quarterly Rate

Rate of change for annual interval: Ra = (p2/p1)-1, where p2 is final value and p1 is initial value

Rate of change for quarterly interval: Rq = (1+Ra)(.25)-1, where Ra is annual rate of change

Above calculation has been used for breaking the annual data (both dependent and independent) into quarterly interval and for projecting the data wherever required. After projecting the data, random data is also generated between the actual historical data which were taken from the sources in annual terms. Then average of the projected data and random data is taken for each variables for the analysis. Below is the screenshot of data as discussed above from 2009-11 only for reference.

In the table, the last column i.e. Rate_of_change is calculated as continuous rate of change, by using the formula LN(p2/p1), here p2 is final data value and p1 is initial data value.

This same calculation is used for all variables in order to prepare data for analysis.

S.No	Year	Quarter	Projected Value	Random Value	NPL Value	Rate of Change
1		Q1	3173	3173	3173	
2		Q2	3154	3168	3161	-0.39%
3		Q3	3134	3154	3144	-0.53%
4	2009	Q4	3115	3115	3115	-0.93%
5		Q1	3457	3457	3457	10.41%
6		Q2	3836	3842	3839	10.49%
7		Q3	4257	4257	4257	10.33%
8	2010	Q4	4724	4724	4724	10.41%
9		Q1	3952	3952	3952	-17.85%
10		Q2	3306	3604	3455	-13.44%
11		Q3	2765	2674	2720	-23.93%
12	2011	Q4	2313	2313	2313	-16.19%

Fig.9: Quarterly Non Performing Loans

Case 2: Net interest income

Dependent variable: - Net interest income of a bank (based out of Norway). Data is gathered from its annual reports from 2008 to 2018. Data were annual and these are broken down to quarterly interval depending upon the rate of change annual and assuming equal change in quarterly intervals. Below is the screenshot of data as discussed above from 2009-11 only for reference.

Same calculation method is used as discussed in case 1.

Year	Quarter	Projected	Random	NII_NOK,MM	Rate of change
2009	Q1	22089	22089	22089	
	Q2	22269	22184	22226	0.62%
	Q3	22450	22327	22389	0.73%
	Q4	22633	22633	22633	1.09%
2010	Q1	22831	23089	22960	1.43%
	Q2	23031	22915	22973	0.06%
	Q3	23233	23434	23333	1.56%
	Q4	23436	23436	23436	0.44%
2011	Q1	23877	23792	23835	1.69%

Fig.10: Quarterly Net Interest Income

Case 3: Net income

Dependent variable: - Net income of a bank (based out of Norway). Data is gathered from its annual reports from 2008 to 2018. Data were annual and these are broken down to quarterly interval depending upon the rate of change annual and assuming equal change in quarterly intervals.

Below is the screenshot of data as discussed above from 2009-11 only for reference. Same calculation method is used as discussed in case 1.

Year	Quarter	Projected	Random	NII_NOK,MM	Rate of change
2009	Q1	8918	8918	8918	
	Q2	8402	7969	8185	-8.57%
	Q3	7916	7607	7761	-5.32%
	Q4	7026	7026	7026	-9.95%
2010	Q1	8357	12450	10403	39.25%
	Q2	9940	8800	9370	-10.46%
	Q3	11823	9758	10790	14.11%
	Q4	14062	14062	14062	26.48%
2011	Q1	13783	13907	13845	-1.55%

Fig.11: Quarterly Net Income

Independent Variables

1. Temperature: Average temperature is considered as factor as abrupt variation in temperature can indirectly signal for potential physical risk due to natural calamities.

Geography: Oslo, Norway

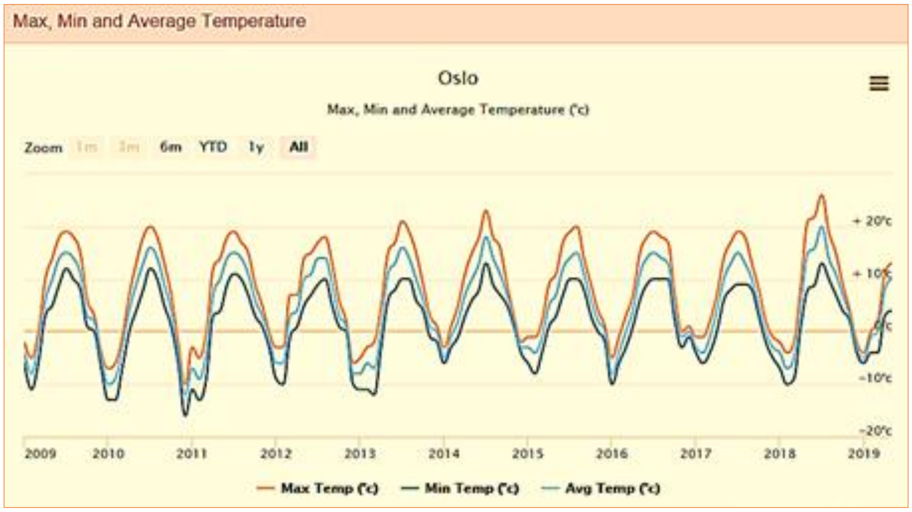

Fig.12: Average Temperature

Source: World Weather Online

Seasonal Adjustment of Temperature Data: As we collected data on quarterly basis, so it calls for adjusting the seasonality in the data. Below mentioned graph explain the smoothening which is achieved after seasonality adjustment. SA series (seasonal adjusted series) is used post squared transformation of the analysis. SA series is squared because few data of temp were negative and to calculate continuous rate of change by natural log we need positive data.

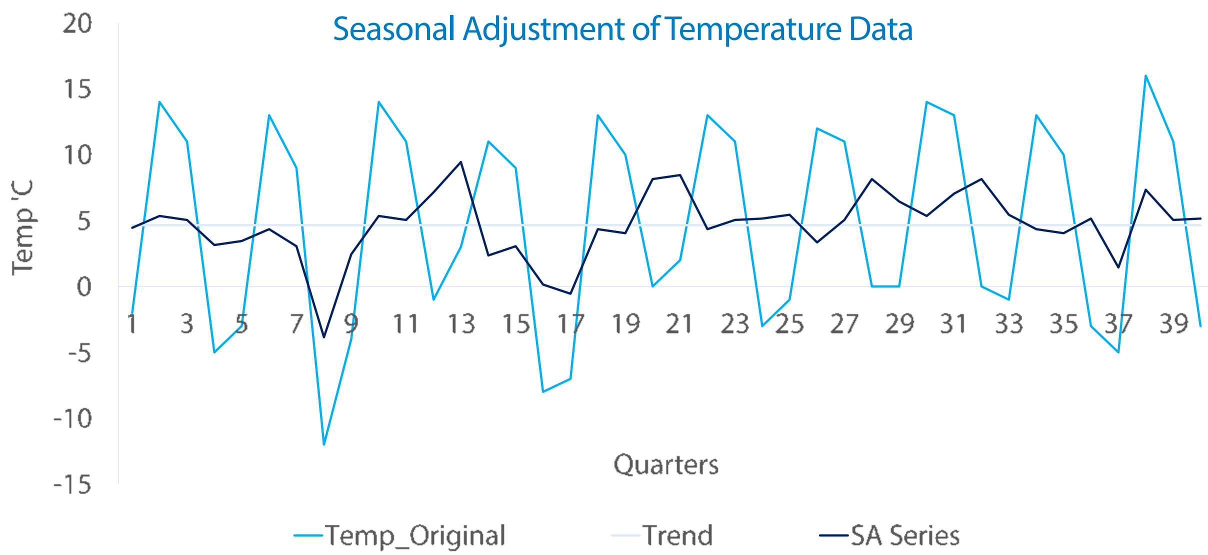

Fig.13: Seasonally Adjusted Temperature Series.

2. **Rainfall:** Average rainfall is one of the factor in the analysis as it is also one of the barometer to check how climatic condition of a geography is changing.

Geography: Oslo, Norway

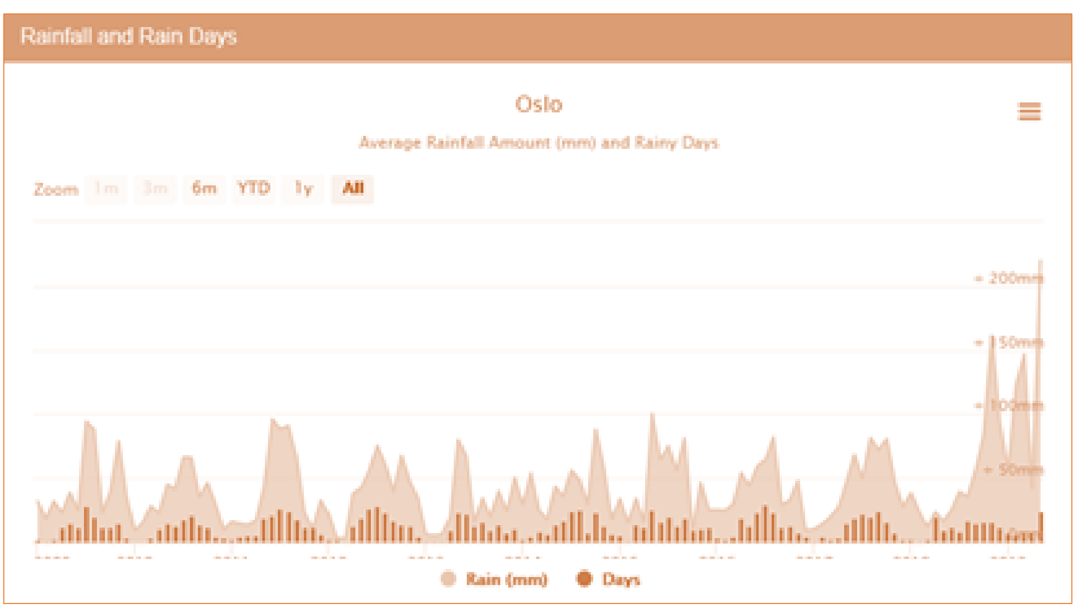

Fig14: Average Rainfall

Source: World Weather Online

Seasonal Adjustment of Rainfall Data: As we collected data on quarterly basis, so it calls for adjusting the seasonality in the data. Below mentioned graph explain the smoothening which is achieved after seasonality adjustment.

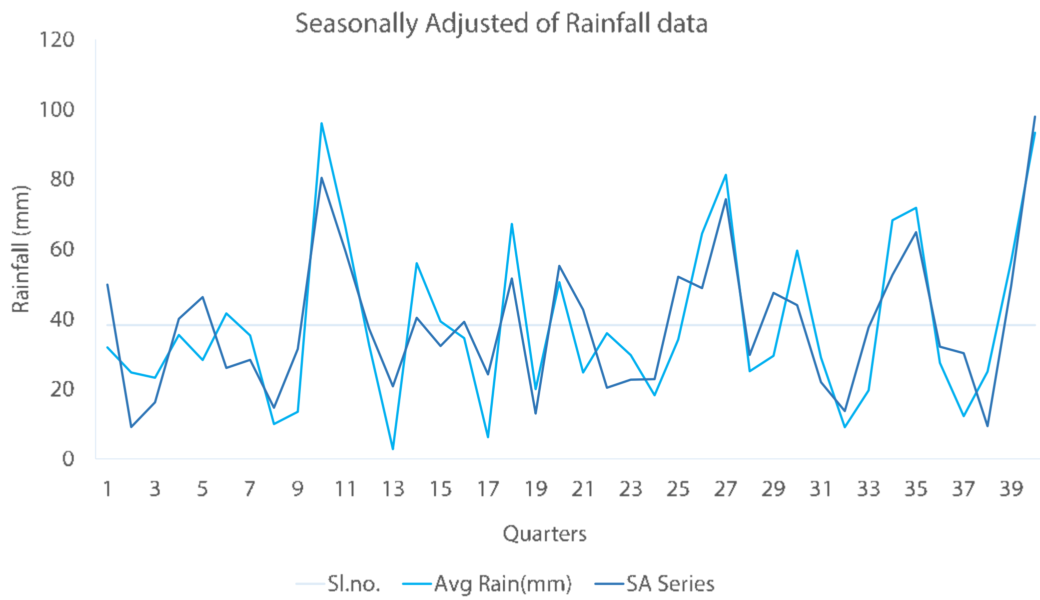

Fig.15: SA Rainfall Series

SA series (Seasonal Adjusted series) is used for the analysis.

Global Fossil Fuel Consumption: As agreement related to going green taking center stage, it become imperative to study how is the trend of fossil fuel consumption globally changing and kind of relation it has with the overall banking performance.

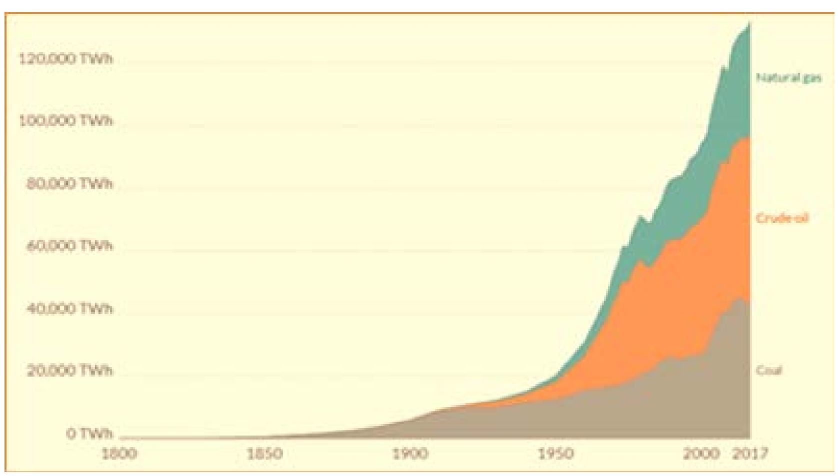

Fig.16: Global Fossil Fuel Consumption

Source: ourworldindata.org/fossil-fuels

Data collected from 2008-18 and projected for quarterly interval as discussed in case 1. Rate of change of fossil fuel consumption on quarterly basis is used for analysis.

3. **Global CO_2 Emission**: As agreement related to going green is taking center stage, it becomes imperative to study how is the trend of global CO_2 emission changing and what kind of relation it bears with the performance of the banks. Data for the period 2008-18 has been extracted from the graph of the trends published by the author Kelly Levin (December 05, 2018) on World Resource Institute. Data in analysis is used as rate of change on quarter to quarter. Please find the screenshot of the graph.

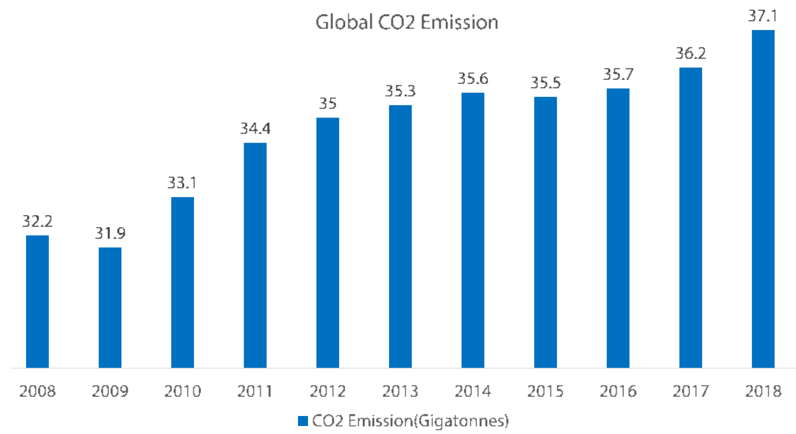

Fig.17: Global CO2 Emission

Source: Global Carbon Project

4. **CO_2 European Emission Allowances (EUA) Trading**: Objective was to capture any relevant behavior and sentiment of the traders who trade EUA, and also to capture the interplay between supply and demand for EUA units in the exchange which would influence the spot price of the EUA and later on to study if it bears any relation with the performance. Alongside is the graph showing the spot price of the EUA.

Fig.18: EUA Spot Price

Source: Markets Insider

5. **Global Consumption of Renewal Energy**: As due to green policies in place, the demand of renewal energy should increase drastically, it also gives a new venture for banks to invest in or transition their investment from fossil fuel to renewal energy. So, this factor becomes important to study its impact on banks' performance. Alongside is the graphical representation of the global renewal energy consumption.

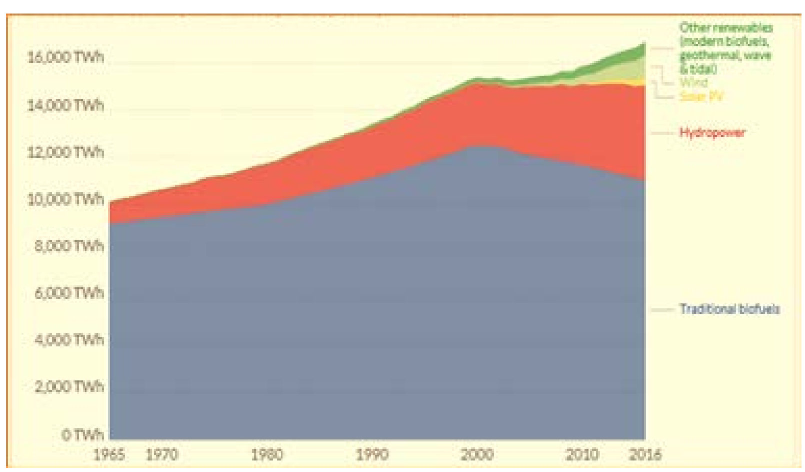

Fig.19: Global Renewable energy consumption

Source: Global Energy Production by Source- Vaclav Smil (2017) & BP Statistics Review Global Energy

+Rate of change in renewable consumption is used for regression analysis.

6. **Value of Issuance of Green Bond ($,Bn)**:

As green bond issuance is increasing exponentially year on year, it indicates how investment portfolio of different financial investor shifting toward financing green energy. It becomes important to study the impact of green bond issuance on banks' performance. Data for green bond was not directly available, so it has been extracted from the graph, which is as shown alongside.

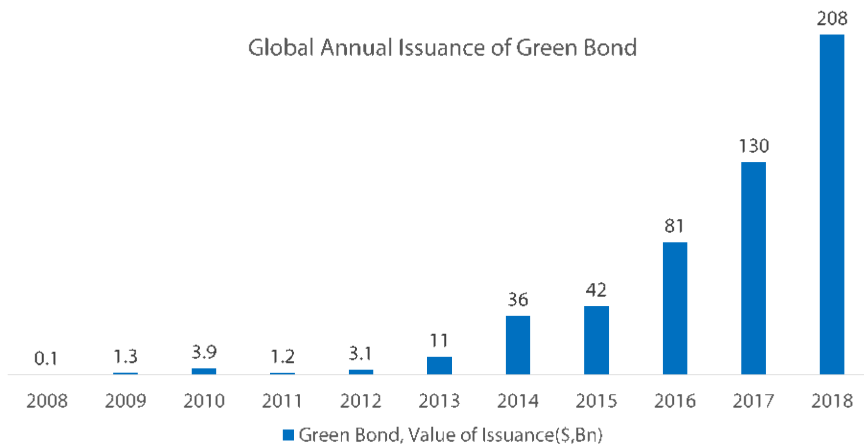

Fig.20: Global Annual Issuance of Green Bond

Source: Climate Bond Initiative. Data as of Sep. 29, 2017 [Data for 2018 is projected]

7. **Norway Oil Output**: As subject bank is based out of Norway, it become imperative to see how is the trend of Norway oil production output and study its impact on banks' performance. It was also noted that crude oil production in Norway decreased to 1.420 BBL/D in February from 1.488 BBL/D in January of 2019. Crude oil production in Norway averaged 1.674 BBL/D from 1973 until 2019, reaching an all-time high of 3.417 BBL/D in July of 2000 and a record low of 0.002 BBL/D in January of 1974. Data were extracted from the graph below and rate of change in Norway's oil production was calculated on quarterly interval. Below is the screen shot of the graph showing oil output for Norway.

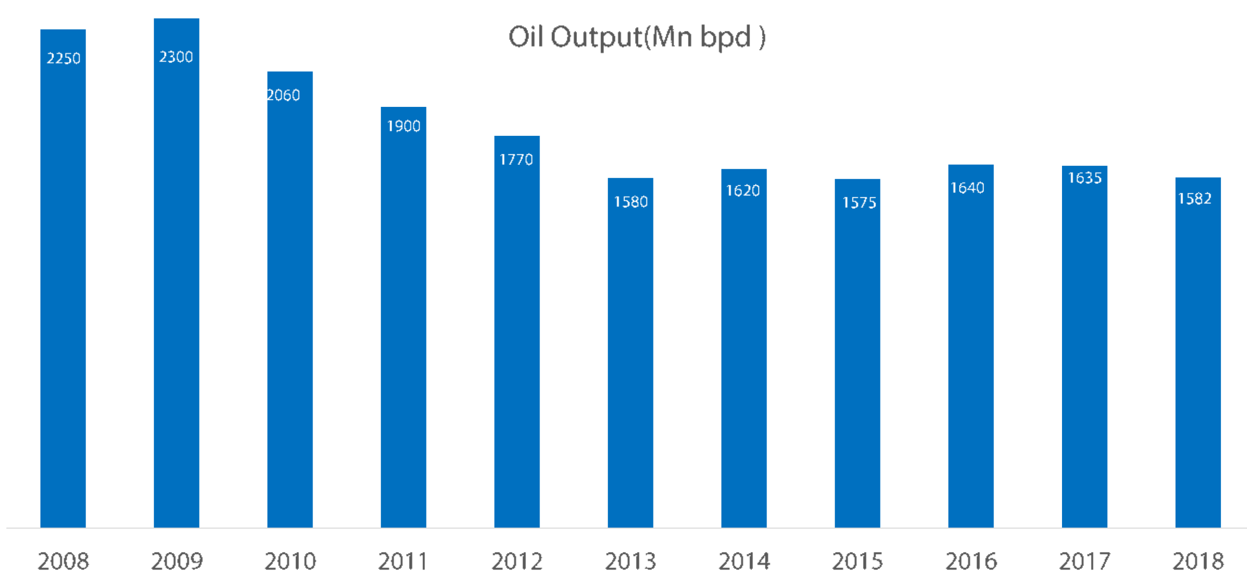

Fig.21: Norway Oil Output

Source: Tradingeconomics.com

Regression Procedure: Multiple Variable Linear Regression

Case 1: Dependent variable is Non-Performing Loans

Objective: To analyze the impact of climate related factors i.e. temperature, rainfall, CO_2 emission on non-performing loans (NPL) of the bank of a particular geography (Norway).

Methods: Multiple variable linear regression

Tool: MS Excel and R Studio

Time Period: 2009-2018, data used is of quarterly interval.

S.No.	Variable	Masked_name_Variable (Rate of change of variable)
1.	NPL data of DNB Bank(Dependent Row)	Npl
2.	Average Temp. for Oslo(Norway)	Temp
3.	Average Rain for Oslo(Norway)	Rain
4.	Global_Total_Consumption(terawatt-hours)	FF_consumption
5.	CO_2 Emission in gigatonnes	CO_2
6.	EUA_Spot Price	EUA
7.	Consumption_of_Renewale_ Energy(terawatt-hours)	RE_Consumption
8.	Green Bond Issuance	GB_Value
9.	Norway_oil_output_Oil output(million bpd)	Nor_oil

Fig 22. NPL Vs. Independent Variable

Data is collected considering their climatic significance and also considering their special mention in different "Green Agreements" like Kyoto Protocol (1997), Paris Agreement (2016), etc. Below is the detail of the dataset used.

Descriptive Analysis of the Variable

R code:

> summary(Climate_Data2)

```
> summary(Climate_Data2)
      Npl                  Temp                 Rain             FF_consumption
 Min.   :-0.239292   Min.   :-6.024523   Min.   :-1.702671   Min.   :-0.0074098
 1st Qu.:-0.088991   1st Qu.:-0.588972   1st Qu.:-0.530033   1st Qu.: 0.0009284
 Median :-0.006678   Median : 0.072297   Median : 0.006994   Median : 0.0025815
 Mean   :-0.002825   Mean   : 0.007492   Mean   : 0.017318   Mean   : 0.0033303
 3rd Qu.: 0.103719   3rd Qu.: 0.536657   3rd Qu.: 0.621157   3rd Qu.: 0.0054996
 Max.   : 0.208790   Max.   : 4.136026   Max.   : 1.666469   Max.   : 0.0273879
      CO2                   EUA             RE_Consumption          GB_Value
 Min.   :-0.0106934   Min.   :-0.63587   Min.   :-0.076393   Min.   :-0.65302
 1st Qu.: 0.0006983   1st Qu.:-0.09600   1st Qu.:-0.001115   1st Qu.: 0.05744
 Median : 0.0021544   Median : 0.04288   Median : 0.001756   Median : 0.18573
 Mean   : 0.0037047   Mean   : 0.01406   Mean   :-0.001508   Mean   : 0.17946
 3rd Qu.: 0.0056274   3rd Qu.: 0.14301   3rd Qu.: 0.003905   3rd Qu.: 0.29169
 Max.   : 0.0214713   Max.   : 0.54618   Max.   : 0.024933   Max.   : 1.27609
    Nor_oil
 Min.   :-0.065193
 1st Qu.:-0.022239
 Median :-0.002992
 Mean   :-0.009173
 3rd Qu.: 0.005728
 Max.   : 0.026206
```

Creating Correlation Matrix

Using Rstudio

```
> cor(Climate_Data2[,-1])
                        Temp        Rain FF_consumption         CO2          EUA
Temp            1.0000000000 -0.15681238    -0.08110622 -0.03246516 0.0009296639
Rain           -0.1568123833  1.00000000    -0.04932425  0.03381770 -0.1263193753
FF_consumption -0.0811062233 -0.04932425     1.00000000  0.38572886 -0.0567115034
CO2            -0.0324651646  0.03381770     0.38572886  1.00000000  0.3298374218
EUA             0.0009296639 -0.12631938    -0.05671150  0.32983742  1.0000000000
RE_Consumption  0.0007691865  0.05218856    -0.01873926  0.01657745 -0.0832451744
GB_Value        0.0579407967 -0.30877193    -0.09453961 -0.10674277  0.1720856755
Nor_oil        -0.0357918304 -0.03250986    -0.59808554 -0.27853345 -0.0445110319
               RE_Consumption    GB_Value     Nor_oil
Temp             0.0007691865  0.05794080 -0.03579183
Rain             0.0521885638 -0.30877193 -0.03250986
FF_consumption  -0.0187392636 -0.09453961 -0.59808554
CO2              0.0165774452 -0.10674277 -0.27853345
EUA             -0.0832451744  0.17208568 -0.04451103
RE_Consumption   1.0000000000  0.10686434 -0.11085177
GB_Value         0.1068643429  1.00000000  0.01857013
Nor_oil         -0.1108517747  0.01857013  1.00000000
```

Data preparation for regression

Dividing the dataset into test and train

R Code:

> train<-Climate_Data2[1:35,]

> test<-Climate_Data2[36:39,]

Running linear regression in Rstudio for test dataset

R Code:

>model<lm(Npl~Temp+Rain+FF_consumption+CO2+EUA+RE_Consumption+GB_Value+Nor_oil,data=train

Results: Output of the linear regression

```
Call:
lm(formula = Npl ~ Temp + Rain + FF_consumption + CO2 + EUA +
    RE_Consumption + GB_Value + Nor_oil, data = train)

Residuals:
      Min        1Q    Median        3Q       Max
-0.215960 -0.075303  0.003584  0.076279  0.195599

Coefficients:
               Estimate Std. Error t value Pr(>|t|)
(Intercept)    -0.02888    0.02827  -1.022   0.3163
Temp           -0.01758    0.01292  -1.361   0.1852
Rain            0.03413    0.03029   1.127   0.2700
FF_consumption  3.54692    4.69672   0.755   0.4569
CO2             0.61308    3.38347   0.181   0.8576
EUA             0.10702    0.09893   1.082   0.2893
RE_Consumption -1.99548    1.18206  -1.688   0.1033
GB_Value        0.15873    0.07024   2.260   0.0324 *
Nor_oil         0.73800    0.99641   0.741   0.4655
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.1137 on 26 degrees of freedom
Multiple R-squared:  0.3326,	Adjusted R-squared:  0.1272
F-statistic: 1.619 on 8 and 26 DF,  p-value: 0.1676
```

Interpretations of the Above Result

1. Looking at P-value i.e. last column of the table above chart, it can be said that not a single coefficient of the considered variable is significant except the GB_ Value. All the P-Values are greater than 5% (if level of confidence is considered 5%) except for GB_Value.

2. Due to the value of P-Value in the above table, null hypothesis is fail to reject for all but GB_value. Ha (Alternate Hypothesis): Coefficient of variable(β)≠0 H0 (Null Hypothesis): Coefficient of variable(β)=0 As from above table H0 is not rejected for the most of the variable, this means that coefficient of these variables are not statistically indifferent from zero. Therefore, these variable are not major in the analysis.

3. Coming to value of R-squared, which is very low i.e. 33.26%, it means that model is able to clarify a very sample portion of variability of the response data around its mean. Given the variables which are considered.

4. Coming to overall p-value of the model which is 0.1676(>0.05), again this value is very high, which is an indication of the inability of the model with the given set of the variable to be robust.

Predicted Vs. Actual values

R code:

```
> fitted.results <- predict(model,newdata = subset(test,select = c(2,3,4,5,6,7,8,9)),type='response')
> print(fitted.results)
> predicted_and_Actual<-cbind(test,fitted.results)
> View(predicted_and_Actual)
> predicted_vs._Actual<-predicted_and_Actual[,-(2:9)]
> View(predicted_vs._Actual)
```

	Npl	fitted.results
36	-0.10480256	0.0903497
37	-0.06779382	-0.0800829
38	-0.03964311	0.1016509
39	-0.20697074	0.0426976

As we can observe, in the above predicted value which are just four in number confines the analysis to conclude anything, as few predicted values are close to actual value.

Result

As per the above analysis, the impact of the climatic factors is not significantly felt on the rate of change in NPL. One of the important reasons is that most of the risk factors are not climatic but are the results of disruptive policies. These policies are becoming more important and disruptive in recent times like after Paris Agreement of 2016 and data which is used under analysis is from 2009-18. This is the period when the banking business was "Business as Usual" irrespective of green policies or climatic factors. So it is difficult to conclude that the above considered climatic factor play any significant role in explaining the NPL level of the bank. Most probably, the impact would be felt once policies disruptions become a reality in near future.

As we could not find any significant relation between the climatic variables and NPL, we decided to change our dependent variable to net interest income and study further to understand if these variables are having its impact on other dependent variable of banks' balance sheet.

Case 2: Dependent Variable is Net Interest Income

Case 1: Dependent variable is Non-Performing Loans

Objective: To analyze the impact of climatic factor on net interest income.

Methods: Multiple variable linear regression

Tool: MS Excel and R Studio

Time Period: 2009-2018, data used is of quarterly interval.

Data is collected considering their climatic significance and also considering their special mention in different "Green Agreements" like Kyoto Protocol (1997), Paris Agreement (2016), etc. Below is the detail of the dataset used.

Sl.No.	Variable	Masked_name_Variable (Rate of change of variable)
1.	NII data of DNB Bank(Dependent Row)	NII
2.	Average Temp. for Oslo(Norway)	Temp
3.	Average Rain for Oslo(Norway)	Rain
4.	Global_Total_Consumption(terawatt-hours)	FF_consumption
5.	CO_2 Emission in gigatonnes	CO_2
6.	EUA_Spot Price	EUA
7.	Consumption_of_Renewale_ Energy(terawatt-hours)	RE_Consumption
8.	Green Bond Issuance	GB_Value
9.	Norway_oil_output_Oil output(million bpd)	Nor_oil

Fig 23. NII vs. Independent Variable

Descriptive Analysis of the Variable

R Code:

> summary(model_data)

```
      Nii                  Temp                 Rain              FF_consumption             CO2
 Min.   :-0.01289   Min.   :-6.024523   Min.   :-1.702671   Min.   :-0.0074098   Min.   :-0.0106934
 1st Qu.: 0.00446   1st Qu.:-0.588972   1st Qu.:-0.530033   1st Qu.: 0.0009284   1st Qu.: 0.0006983
 Median : 0.01282   Median : 0.072297   Median : 0.006994   Median : 0.0025815   Median : 0.0021544
 Mean   : 0.01310   Mean   : 0.007492   Mean   : 0.017318   Mean   : 0.0033303   Mean   : 0.0037047
 3rd Qu.: 0.01773   3rd Qu.: 0.536657   3rd Qu.: 0.621157   3rd Qu.: 0.0054996   3rd Qu.: 0.0056274
 Max.   : 0.05864   Max.   : 4.136026   Max.   : 1.666469   Max.   : 0.0273879   Max.   : 0.0214713
      EUA            RE_Consumption          GB_Value             Nor_oil
 Min.   :-0.63587   Min.   :-0.076393   Min.   :-0.65302   Min.   :-0.065193
 1st Qu.:-0.09600   1st Qu.:-0.001115   1st Qu.: 0.05744   1st Qu.:-0.022239
 Median : 0.04288   Median : 0.001756   Median : 0.18573   Median :-0.002992
 Mean   : 0.01406   Mean   :-0.001508   Mean   : 0.17946   Mean   :-0.009173
 3rd Qu.: 0.14301   3rd Qu.: 0.003905   3rd Qu.: 0.29169   3rd Qu.: 0.005728
 Max.   : 0.54618   Max.   : 0.024933   Max.   : 1.27609   Max.   : 0.026206
```

Creating Correlation Matrix

> cor(model_data)

```
                      Nii          Temp        Rain FF_consumption         CO2           EUA
Nii             1.00000000  0.0317778748  0.33989533     0.13756546 -0.07009918 -0.2009808851
Temp            0.03177787  1.0000000000 -0.15681238    -0.08110622 -0.03246516  0.0009296639
Rain            0.33989533 -0.1568123833  1.00000000    -0.04932425  0.03381770 -0.1263193753
FF_consumption  0.13756546 -0.0811062233 -0.04932425     1.00000000  0.38572886 -0.0567115034
CO2            -0.07009918 -0.0324651646  0.03381770     0.38572886  1.00000000  0.3298374218
EUA            -0.20098089  0.0009296639 -0.12631938    -0.05671150  0.32983742  1.0000000000
RE_Consumption  0.10483651  0.0007692409  0.05218857    -0.01873920  0.01657748 -0.0832451501
GB_Value       -0.12115427  0.0579407967 -0.30877193    -0.09453961 -0.10674277  0.1720856755
Nor_oil        -0.40209204 -0.0357918207 -0.03250987    -0.59808555 -0.27853344 -0.0445110199
               RE_Consumption    GB_Value     Nor_oil
Nii              0.1048365132 -0.12115427 -0.40209204
Temp             0.0007692409  0.05794080 -0.03579182
Rain             0.0521885731 -0.30877193 -0.03250987
FF_consumption  -0.0187392025 -0.09453961 -0.59808555
CO2              0.0165774809 -0.10674277 -0.27853344
EUA             -0.0832451501  0.17208568 -0.04451102
RE_Consumption   1.0000000000  0.10686434 -0.11085168
GB_Value         0.1068643408  1.00000000  0.01857016
Nor_oil         -0.1108516844  0.01857016  1.00000000
```

Running Regression on the Dataset

R Code:

> model4<-lm(Nii~Temp+Rain+FF_consumption+CO2+EUA+RE_Consumption + GB_Value+Nor_oil,data=model_data)

> summary(model4)

```
Call:
lm(formula = Nii ~ Temp + Rain + FF_consumption + CO2 + EUA +
    RE_Consumption + GB_Value + Nor_oil, data = model_data)

Residuals:
      Min        1Q    Median        3Q       Max
-0.019395 -0.009638 -0.001493  0.006420  0.028002

Coefficients:
                 Estimate Std. Error t value Pr(>|t|)
(Intercept)     0.0125127  0.0033064   3.784 0.000688 ***
Temp            0.0004966  0.0014550   0.341 0.735267
Rain            0.0062361  0.0032922   1.894 0.067878 .
FF_consumption -0.2541690  0.5806563  -0.438 0.664720
CO2            -0.3104355  0.4052466  -0.766 0.449638
EUA            -0.0091928  0.0112593  -0.816 0.420673
RE_Consumption  0.0253376  0.1464944   0.173 0.863845
GB_Value       -0.0011502  0.0082587  -0.139 0.890167
Nor_oil        -0.3106484  0.1230855  -2.524 0.017137 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.01419 on 30 degrees of freedom
Multiple R-squared:  0.3313,    Adjusted R-squared:  0.153
F-statistic: 1.858 on 8 and 30 DF,  p-value: 0.1049
```

Result

AR-squared of the regression analysis is 33.13%, which is very low and p-value of the regression model is 0.1049 which is more than excepted level of significance of 0.05 (i.e. confidence interval of 95%). It can be concluded that climatic factors considered in the analysis don't bear any significant influence on the net interest income of the bank.

As we could not find any significant relation between the climatic variables and net interest Income also, we lastly tried to change our dependent variable to net income.

Case 3: Multiple Variable Regression: Climatic Risk Analysis on Bank's net income

Objective: To study the impact of climatic factor on net income.

Dependent Variable: Net Income of the institute

Independent Variables:

Sl.No.	Variable	Masked_name_Variable (Rate of change of variable)
1.	Net income data of DNB Bank (dependent variable)	Net_income
2.	Average temp. for Oslo (Norway)	Temp
3.	Average rain for Oslo (Norway)	Rain
4.	Global_Total_Consumption (terawatt-hours)	FF_consumption
5.	CO_2 emission in gigatonnes	CO_2
6.	EUA_Spot Price	EUA
7.	Consumption_of_Renewale_Energy (terawatt-hours)	RE_Consumption
8.	Green bond issuance	GB_Value
9.	Norway_oil_output_Oil output(million bpd)	Nor_oil

Fig 24. Net Income Vs. Independent Variable

Descriptive Analysis of the data

```
> summary(net_income_Data)
       X1          Net_Income             Temp                 Rain
 Min.   : 2.0   Min.   :-0.116886   Min.   :-6.024523   Min.   :-1.702671
 1st Qu.:11.5   1st Qu.:-0.026716   1st Qu.:-0.588972   1st Qu.:-0.530033
 Median :21.0   Median : 0.006499   Median : 0.072297   Median : 0.006994
 Mean   :21.0   Mean   : 0.025684   Mean   : 0.007492   Mean   : 0.017318
 3rd Qu.:30.5   3rd Qu.: 0.052265   3rd Qu.: 0.536657   3rd Qu.: 0.621157
 Max.   :40.0   Max.   : 0.392518   Max.   : 4.136026   Max.   : 1.666469
 FF_consumption            CO2                  EUA             RE_Consumption
 Min.   :-0.0074098   Min.   :-0.0106934   Min.   :-0.63587   Min.   :-0.076393
 1st Qu.: 0.0009284   1st Qu.: 0.0006983   1st Qu.:-0.09600   1st Qu.:-0.001115
 Median : 0.0025815   Median : 0.0021544   Median : 0.04288   Median : 0.001756
 Mean   : 0.0033303   Mean   : 0.0037047   Mean   : 0.01406   Mean   :-0.001508
 3rd Qu.: 0.0054996   3rd Qu.: 0.0056274   3rd Qu.: 0.14301   3rd Qu.: 0.003905
 Max.   : 0.0273879   Max.   : 0.0214713   Max.   : 0.54618   Max.   : 0.024933
    GB_Value            Nor_oil
 Min.   :-0.65302   Min.   :-0.065193
 1st Qu.: 0.05744   1st Qu.:-0.022239
 Median : 0.18573   Median :-0.002992
 Mean   : 0.17946   Mean   :-0.009173
 3rd Qu.: 0.29169   3rd Qu.: 0.005728
 Max.   : 1.27609   Max.   : 0.026206
```

Correlation Matrix

```
> cor(Model_data)
                 Net_Income          Temp        Rain FF_consumption         CO2
Net_Income      1.000000000  0.0031738485 -0.03037497     0.68855465  0.10010361
Temp            0.003173849  1.0000000000 -0.15681238    -0.08110622 -0.03246516
Rain           -0.030374969 -0.1568123833  1.00000000    -0.04932425  0.03381770
FF_consumption  0.688554651 -0.0811062233 -0.04932425     1.00000000  0.38572886
CO2             0.100103610 -0.0324651646  0.03381770     0.38572886  1.00000000
EUA             0.083004847  0.0009296639 -0.12631938    -0.05671150  0.32983742
RE_Consumption  0.041279206  0.0007692409  0.05218857    -0.01873920  0.01657748
GB_Value        0.158966354  0.0579407967 -0.30877193    -0.09453961 -0.10674277
Nor_oil        -0.669574169 -0.0357918207 -0.03250987    -0.59808555 -0.27853344
                        EUA RE_Consumption    GB_Value     Nor_oil
Net_Income      0.0830048471   0.0412792061  0.15896635 -0.66957417
Temp            0.0009296639   0.0007692409  0.05794080 -0.03579182
Rain           -0.1263193753   0.0521885731 -0.30877193 -0.03250987
FF_consumption -0.0567115034  -0.0187392025 -0.09453961 -0.59808555
CO2             0.3298374218   0.0165774809 -0.10674277 -0.27853344
EUA             1.0000000000  -0.0832451501  0.17208568 -0.04451102
RE_Consumption -0.0832451501   1.0000000000  0.10686434 -0.11085168
GB_Value        0.1720856755   0.1068643408  1.00000000  0.01857016
Nor_oil        -0.0445110199  -0.1108516844  0.01857016  1.00000000
```

Dividing Dataset into Test and Train

R Code:

```
> #dividing dataset into test, train and scenario_1x
>
> reg_train<-data_scenario_model[1:35,]
> reg_test<-data_scenario_model[36:39,]
```

Regression Analysis

R Code:

```
> # Running regression on reg_train
>
> model_reg<-lm(Net_Income~Temp+Rain+FF_consumption+CO2+EUA+RE_Consumption+GB_Value+Nor_oil,data=reg_train)
> summary(model_reg)
```

Output of the Regression Analysis

```
Call:
lm(formula = Net_Income ~ Temp + Rain + FF_consumption + CO2 +
    EUA + RE_Consumption + GB_Value + Nor_oil, data = reg_train)

Residuals:
      Min        1Q    Median        3Q       Max
-0.110453 -0.038598 -0.006564  0.031390  0.111353

Coefficients:
                Estimate Std. Error t value Pr(>|t|)
(Intercept)    -0.021484   0.015979  -1.345 0.190388
Temp            0.003109   0.007302   0.426 0.673784
Rain            0.015165   0.017119   0.886 0.383800
FF_consumption 11.013859   2.654680   4.149 0.000317 ***
CO2            -4.404259   1.912405  -2.303 0.029534 *
EUA             0.074810   0.055919   1.338 0.192540
RE_Consumption  0.040652   0.668125   0.061 0.951948
GB_Value        0.061843   0.039702   1.558 0.131394
Nor_oil        -1.498499   0.563190  -2.661 0.013183 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.06429 on 26 degrees of freedom
Multiple R-squared:  0.6937,	Adjusted R-squared:  0.5994
F-statistic: 7.359 on 8 and 26 DF,  p-value: 4.303e-05
```

Running Regression with only Significant Variables

R Code:

> model3<-lm(Net_Income~FF_consumption+CO2+Nor_oil,data=Model_data)

Output of regression

> summary (model3)

```
Call:
lm(formula = Net_Income ~ FF_consumption + CO2 + Nor_oil, data = Model_data)

Residuals:
      Min        1Q    Median        3Q       Max
-0.146056 -0.031939  0.000084  0.045980  0.136331

Coefficients:
                Estimate Std. Error t value Pr(>|t|)
(Intercept)    -0.009028   0.012184  -0.741 0.463640
FF_consumption  9.259166   2.408685   3.844 0.000489 ***
CO2            -3.097015   1.613353  -1.920 0.063088 .
Nor_oil        -1.673390   0.523676  -3.195 0.002954 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.06213 on 35 degrees of freedom
Multiple R-squared:  0.6178,	Adjusted R-squared:  0.585
F-statistic: 18.86 on 3 and 35 DF,  p-value: 1.888e-07
```

Interpretation of Above Regression: Here we can see that all the three variable has once again have become significant but one important observation is that adjusted R-squared value has dropped from 0.599 to 0.585. This indicate the previous regression result is better than considering only three variables.

Result

Three variables i.e. fossil fuel consumption, CO_2 emission and Norway oil consumption are significantly contributing in explaining the net income of the DNB bank.

R-Square = 69.37%, P-value = 9.774e-06 (which is very less than 0.05), this explains the significance of the model. Model is robust as far as statistical analysis is concerned. This can be used for scenario analysis and stress testing. Equation for predictive rate of change of net income is as below:

Rate of change of net income = -0.021484 + 0.003109(Temp)+ 0.015165(Rainfall)+ 11.0138(Global Fossil Fuel consumption)- 4.40426(Global CO_2 Emission) + 0.074810(EUA)+ 0.040562(Global Renewal Energy Consumption) + 0.061843(Green bond issuance value) -1.498499(Norway oil output).

Scenario Analysis for Climatic Factors on Net Income of the Bank

Objective: To stress test various independent factors to analyze its impact on the net income of the bank by creating various scenario.

Tool: MS excel and R studio

Pre-requisite: Multiple variable linear regression equation

Rate of change of Net Income:
0.02148394+ 0.00310907*(Temp)+ 0.0151651*(Rainfall)+ 11.013859*(Global Fossil Fuel consumption) -4.404259*(Global CO_2 Emission) + 0.07481*(EUA)+ 0.040652*(Global Renewal Energy Consumption) + 0.061843*(Green bond issuance value) -1.49849946693371*(Norway oil output)

Case 1: Baseline Scenario

In baseline scenario, it is considered that all the independent variables would change w.r.t rate which is calculated from the historical data from 2009-18. As shown in below equation.

Delta Net Income = 1x Policy Factor (Baseline of Fossil Fuel Consumption, CO_2 Emission, Norway Oil Output) + 1x Market Factor (Baseline of EU Emission Spot price, Green Bond Investments) +1x Technology Factor (Baseline of Renewable Consumption) + 1XClimate Factor (Temperature Upper Bound, Rainfall Upper Bound).

R Code used:

```
# predicting for the given scenario

scenario_1x.results<- predict(model_reg,newdata=scenario_1x)
print(scenario_1x.results)
scenario_1x_pred<-cbind(scenario_1x,scenario_1x.results)
```

Predicted Output for Net Income from 2019-25 on Quarterly Basis

```
> Scenario_1A_Climate_Stress<- predict(model_reg,newdata=scenario_1xA)
> print(Scenario_1A_Climate_Stress)
          1           2           3           4           5           6           7           8
-0.33096229 -0.19008559 -0.18571028 -0.05031585 -0.10202864 -0.26179004 -0.39054325 -0.05282861
          9          10          11          12          13          14          15          16
-0.30936908 -0.30919026 -0.26227286 -0.04216728 -0.16444162 -0.39753485 -0.16653070 -0.25372168
         17          18          19          20          21          22          23          24
-0.28665503 -0.40233816 -0.33740559 -0.31723083 -0.37518415 -0.21386147 -0.17573406 -0.38658259
         25          26          27          28
-0.19040706 -0.12716226 -0.22112063 -0.35168358
```

Graphical Representation of the Predicted Net Income

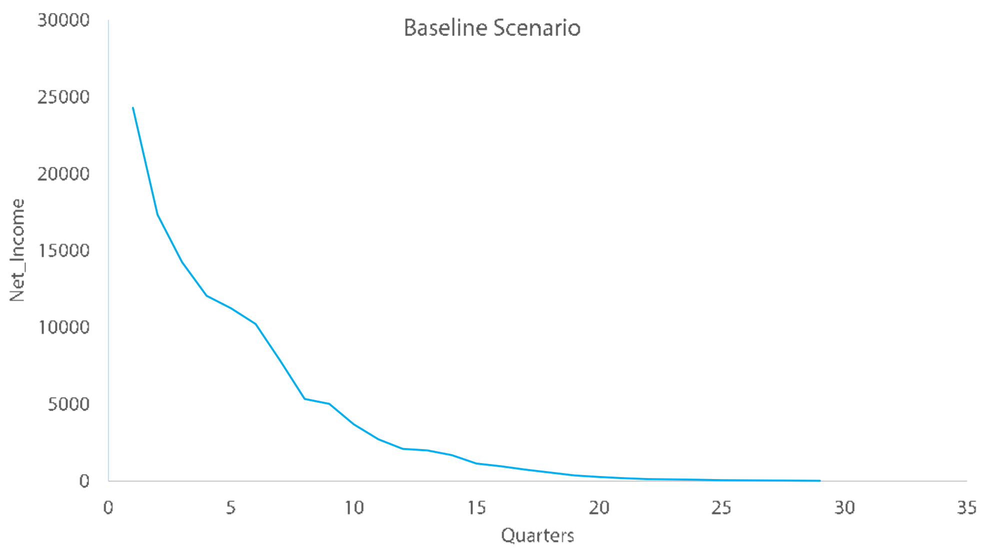

Fig 25: Baseline Scenario

Result: As it is evident from the above graph that even if business remains as usual and no precaution is taken by bank, net income of the bank would take a massive downward hit on its bottom line.

Case 2: Scenario 1A Climate Stress

Delta Net Income = 1x Policy Factor (Baseline of Fossil Fuel Consumption, CO_2 Emission, Norway Oil Output) + 1x Market Factor (Baseline of EU Emission Spot price, Green Bond Investments) +1x Technology Factor (Baseline of Renewable Consumption) + 2 X Climate Factor (Temperature Upper Bound, Rainfall Upper Bound)

In this scenario, climatic factors i.e. temperature and rainfall are stress as shown in aforementioned equation and all other factors remain as baseline.

R Code:

```
# predicting for the given scenario_1XA

Scenario_1A_Climate_Stress<- predict(model_reg,newdata=scenario_1xA)
print(Scenario_1A_Climate_Stress)
scenario_1xA_pred<-cbind(scenario_1xA,Scenario_1A_Climate_Stress)
```

Predicted Output for Net Income:

```
> Scenario_1A_Climate_Stress<- predict(model_reg,newdata=scenario_1xA)
> print(Scenario_1A_Climate_Stress)
          1           2           3           4           5           6           7           8
-0.33096229 -0.19008559 -0.18571028 -0.05031585 -0.10202864 -0.26179004 -0.39054325 -0.05282861
          9          10          11          12          13          14          15          16
-0.30936908 -0.30919026 -0.26227286 -0.04216728 -0.16444162 -0.39753485 -0.16653070 -0.25372168
         17          18          19          20          21          22          23          24
-0.28665503 -0.40233816 -0.33740559 -0.31723083 -0.37518415 -0.21386147 -0.17573406 -0.38658259
         25          26          27          28
-0.19040706 -0.12716226 -0.22112063 -0.35168358
```

Graphical Representation of Predicted Net Income

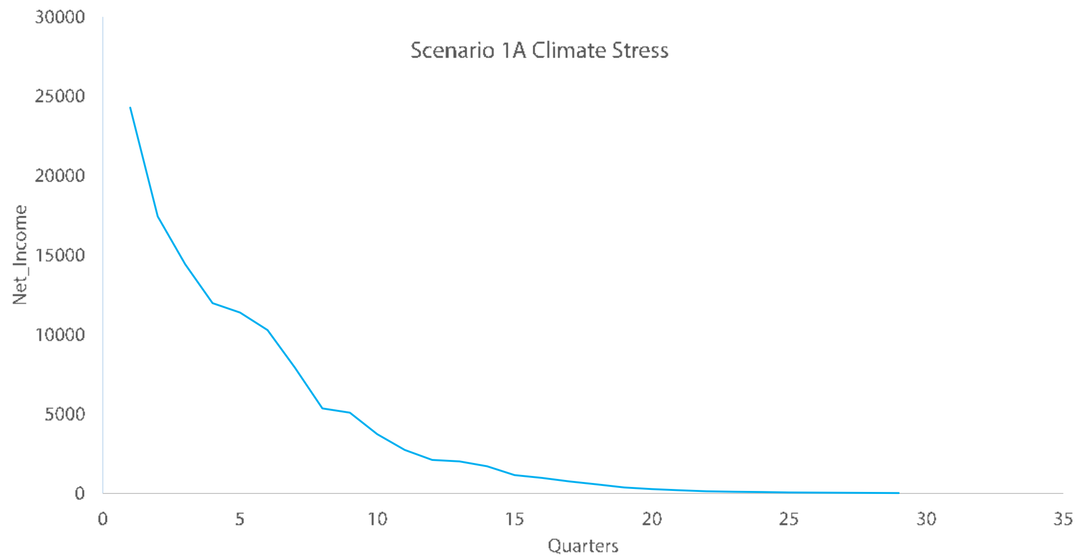

Fig 26: Scenario 1A Climate Stress

Result: As it is evident from the above graph that, even if business remains as usual and no precaution is taken by the bank, net income of the bank would take a massive downward hit on its bottom line.

Case 3: Scenario 1B Climate Stress

Delta Net Income = 1x Policy Factor (Baseline of Fossil Fuel Consumption, CO_2 Emission, Norway Oil Output) + 1x Market Factor (Baseline of EU Emission Spot price, Green Bond Investments) +1x Technology Factor (Baseline of Renewable Consumption) + 2x Climate Factor (Temperature Upper Bound 2X, Rainfall Lower Bound 2X).

In this scenario, climatic factors i.e. temperature and rainfall are stress as shown in above equation and all other factors remains as baseline.

R Code:

```
# predicting for the given scenario_1XB
Scenario_1B_Climate_Stress<- predict(model_reg,newdata=scenario_1xB)
print(Scenario_1B_Climate_Stress)
scenario_1xB_pred<-cbind(scenario_1xB,Scenario_1B_Climate_Stress)
```

Predicted Output for Net Income:

```
> Scenario_1B_Climate_Stress<- predict(model_reg,newdata=scenario_1xB)
> print(Scenario_1B_Climate_Stress)
          1           2           3           4           5           6           7           8 
-0.34191442 -0.18465770 -0.17493081 -0.06177839 -0.10755333 -0.25768605 -0.38610463 -0.05332820 
          9          10          11          12          13          14          15          16 
-0.31879238 -0.30705564 -0.25749186 -0.04404936 -0.17402085 -0.39651455 -0.16338789 -0.25252416 
         17          18          19          20          21          22          23          24 
-0.29071214 -0.40727104 -0.33422053 -0.31913624 -0.37422330 -0.21786674 -0.17710972 -0.39589015 
         25          26          27          28 
-0.17651281 -0.13643953 -0.23530056 -0.34498264 
```

Graphical Representation of Predicted Net Income

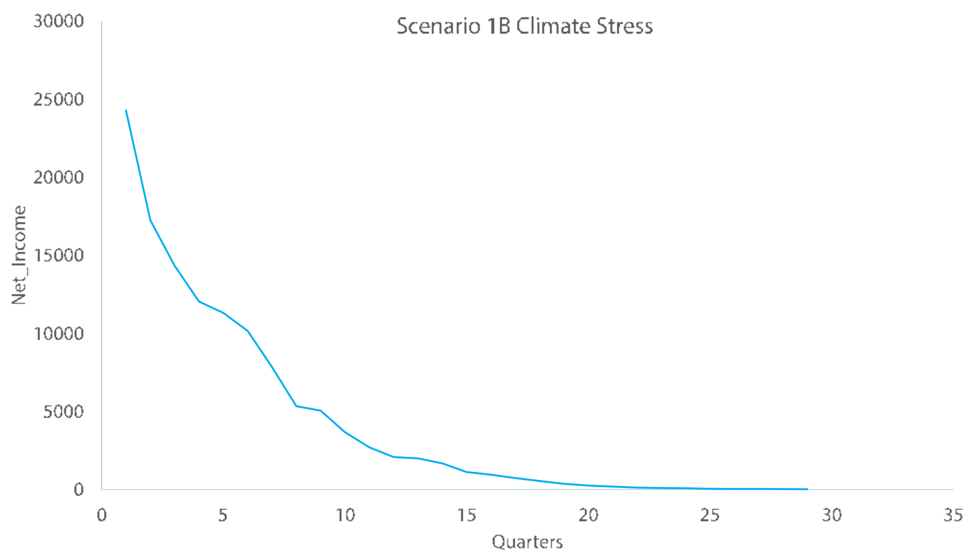

Fig 27: Scenario 1B Climate Stress

Result: In case 3, where we have stressed only climatic factors (2x Climate Factor (Temperature Upper Bound 2X, Rainfall Lower Bound 2X) and the remaining independent factors remain as baseline, this also gives us almost the same trend of net income as going downwards. Same can be seen in the above graph.

Case 4: Scenario 2A Policy Stress

Delta Net Income = 2x Policy Factor (Fossil Fuel Consumption Lower Bound 2X, CO_2 Emission Lower Bound 2X, Norway Oil Output Lower Bound 2X) + 1x Market Factor (Baseline of EU Emission Spot price, Green Bond Investments) +1x Technology Factor (Baseline of Renewable Consumption) + 1x Climate Factor (Baseline of Temperature, Rainfall).

in this scenario, policy factors i.e. Fossil Fuel Consumption, CO_2 Emission and Norway oil output were stressed taking into consideration that growth trend for this variable would follow a negative one. All other factors remain as baseline.

R Code:

```
# predicting for the given scenario_2A

Scenario_2A_Climate_Stress<- predict(model_reg,newdata=scenario_2A)
print(Scenario_2A_Climate_Stress)
scenario_2A_pred<-cbind(scenario_2A,Scenario_2A_Climate_Stress)
```

Predicted Output for Net Income:

```
> print(Scenario_2A_Climate_Stress)
          1           2           3           4           5           6           7           8
-0.16921105 -0.30671857 -0.09281606 -0.26406241 -0.32011096 -0.16926602 -0.01076658 -0.40461378
          9          10          11          12          13          14          15          16
-0.19580364 -0.10035515 -0.34523128 -0.05379974 -0.11903041 -0.17284789 -0.11424297  0.02370816
         17          18          19          20          21          22          23          24
-0.16299770 -0.07161661 -0.05994953 -0.17682986  0.03682239 -0.14528128 -0.32818458 -0.22836219
         25          26          27          28
-0.25047413 -0.39046900 -0.28608574 -0.26240182
```

Graphical Representation of Predicted Net Income

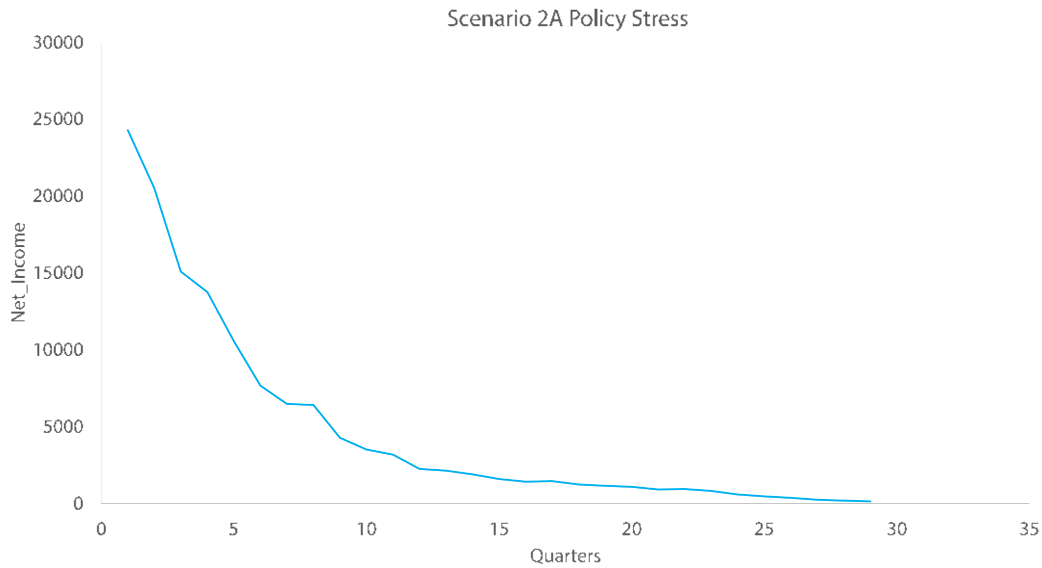

Fig 28 : Scenario 2A Policy Stress

Result: In case 4, where we have stressed only policy factors 2x Policy Factor (Fossil Fuel Consumption Lower Bound 2X, CO_2 Emission Lower Bound 2X, Norway Oil Output Lower Bound 2X) and the remaining independent factors remain as baseline, this also gives us almost the same trend of net income as going downwards. Same can be seen in the graph above.

Case 5: Scenario 2B Policy Stress

Delta Net Income = 2x Policy Factor (Fossil Fuel Consumption Lower Bound 2X, CO_2 Emission Lower Bound 2X, Norway Oil Output Upper Bound 2X & Lower Bound 0) + 1x Market Factor (Baseline of EU Emission Spot price, Green Bond Investments) +1x Technology Factor (Baseline of Renewable Consumption) + 1x Climate Factor (Baseline of Temperature, Rainfall)

in this scenario, policy factors i.e. Fossil Fuel Consumption, CO_2 Emission and Norway oil output were stressed taking into consideration that growth trend for these variables i.e. fossil fuel and CO_2 emission would follow a negative one and whereas Norway oil output would follow a positive trend. All other factors remain as baseline.

R Code:

```
# predicting for the given scenario_2B
Scenario_2B_Climate_Stress<- predict(model_reg,newdata=scenario_2B)
print(Scenario_2B_Climate_Stress)
scenario_2B_pred<-cbind(scenario_2B,Scenario_2B_Climate_Stress)
```

Predicted Output for Net Income:

```
> print(Scenario_2B_Climate_Stress)
          1           2           3           4           5           6           7           8 
-0.75716985 -0.56800029 -0.22863056 -0.09983565 -0.59220700 -0.25100629 -0.71572285 -0.27181198 
          9          10          11          12          13          14          15          16 
-0.65478086 -0.24941596 -0.38529817 -0.69257030 -0.16421472 -0.69114982 -0.56594715 -0.17026537 
         17          18          19          20          21          22          23          24 
-0.67497953 -0.13217028 -0.26372857 -0.35662321 -0.62432821 -0.34211749 -0.15850145 -0.56309324 
         25          26          27          28 
-0.35080476 -0.40177248 -0.75997353 -0.50199836 
```

Graphical Representation of Predicted Net Income

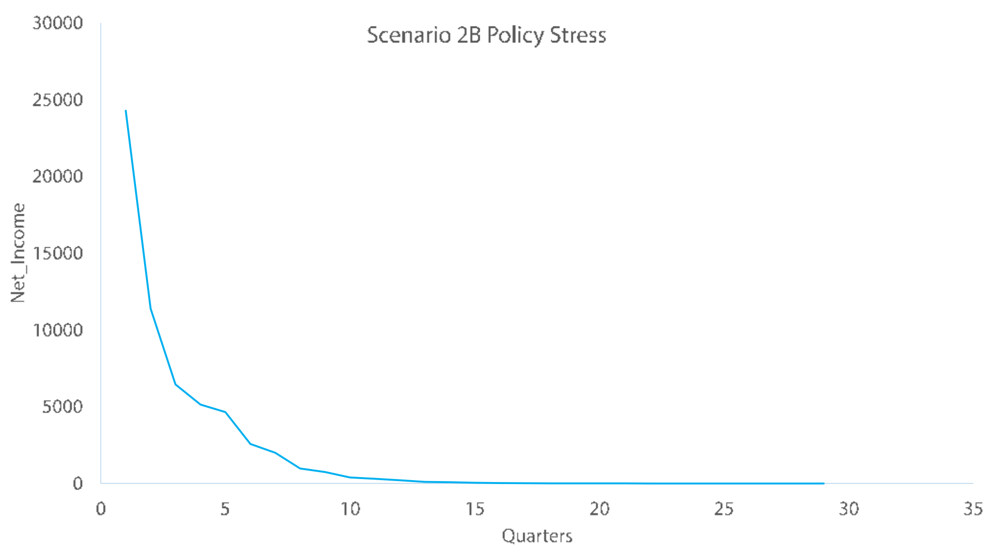

Fig 29: Scenario 2B Policy Stress

Result: In case 5, where we have stressed only policy factors 2x Policy Factor (Fossil Fuel Consumption Lower Bound 2X, CO_2 Emission Lower Bound 2X, Norway Oil Output Upper Bound 2X & Lower Bound 0) and the remaining independent factors remain as baseline, this also gives us almost the same trend of net income as going downwards. Same can be seen in the above graph.

Case 6: Scenario 2C Policy Stress

Delta Net Income = 2x Policy Factor (Fossil Fuel Consumption Upper Bound 2X, CO_2 Emission Lower Bound 2X, Norway Oil Output Upper Bound 2X & Lower Bound 0) + 1x Market Factor (Baseline of EU Emission Spot price, Green Bond Investments) +1x Technology Factor (Baseline of Renewable Consumption) + 1x Climate Factor (Baseline of Temperature, Rainfall). in this scenario, policy factors i.e. Fossil Fuel Consumption, CO_2 Emission and Norway oil output were stressed taking into consideration that growth trend for these variables would be positive one. All other factors remain as baseline.

R Code:

```
# predicting for the given scenario_2C

Scenario_2C_Climate_Stress<- predict(model_reg,newdata=scenario_2C)
print(Scenario_2C_Climate_Stress)
scenario_2C_pred<-cbind(scenario_2C,Scenario_2C_Climate_Stress)
```

Predicted Output for Net Income:

```
> print(Scenario_2C_Climate_Stress)
          1           2           3           4           5           6           7           8
-0.39624571 -0.06857185  0.02642362 -0.33890938 -0.48287172  0.10793641 -0.43824078 -0.01675780
          9          10          11          12          13          14          15          16
-0.14201484 -0.28829419 -0.37861952 -0.01862776 -0.08907145 -0.32190871 -0.21185560 -0.06610766
         17          18          19          20          21          22          23          24
-0.28408441 -0.48122514  0.08937869 -0.47451444 -0.33657841 -0.41500223 -0.13430214 -0.32304731
         25          26          27          28
-0.32563641 -0.34142700 -0.24211205 -0.34660206
```

Graphical Representation of Predicted Net Income

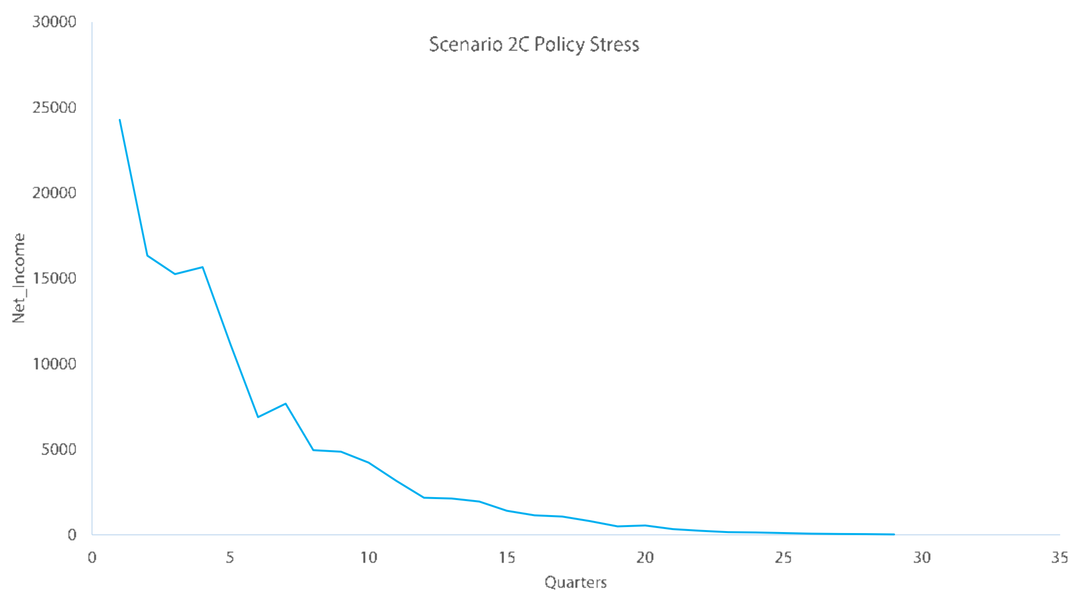

Fig 30 : Scenario 2C Policy Stress

Result: In case 6, where we have stressed only policy factors 2x Policy (Fossil Fuel Consumption Upper Bound 2X, CO_2 Emission Lower Bound 2X, Norway Oil Output Upper Bound 2X & Lower Bound 0) and the remaining independent factors remain as baseline, this also gives us almost the same trend of net income as going downwards. Same can be seen in the above graph.

Case 7: Scenario 3 Market Stress

Delta Net Income = 1x Policy Factor (Baseline of Fossil Fuel Consumption, CO_2 Emission, Norway Oil Output) + 2x Market Factor (EU Emission Spot price upper Bound 2X, Green Bond Investments Upper Bound 2X) +1x Technology Factor (Baseline of Renewable Consumption) + 1x Climate Factor (Baseline of Temperature, Rainfall).

in this scenario, market factors i.e. EUA spot price and Green bond investment are stress as shown in above equation and all other factors remains as baseline.

R Code:

```
# predicting for the given scenario_3
Scenario_3_Climate_Stress<- predict(model_reg,newdata=scenario_3)
print(Scenario_3_Climate_Stress)
scenario_3_pred<-cbind(scenario_3,Scenario_3_Climate_Stress)
```

Predicted Output for Net Income:

```
> print(Scenario_3_Climate_Stress)
          1           2           3           4           5           6           7           8
-0.34217078 -0.16095144 -0.17517205 -0.06924529 -0.10063096 -0.27749574 -0.35825759 -0.04432921
          9          10          11          12          13          14          15          16
-0.30368140 -0.30446689 -0.26775704 -0.05163248 -0.15726924 -0.40360840 -0.16441708 -0.24063114
         17          18          19          20          21          22          23          24
-0.27228450 -0.39662150 -0.33903524 -0.29042868 -0.38508093 -0.23237117 -0.16807951 -0.37653335
         25          26          27          28
-0.19175846 -0.11744655 -0.21742786 -0.34082623
```

Graphical Representation of Predicted Net Income

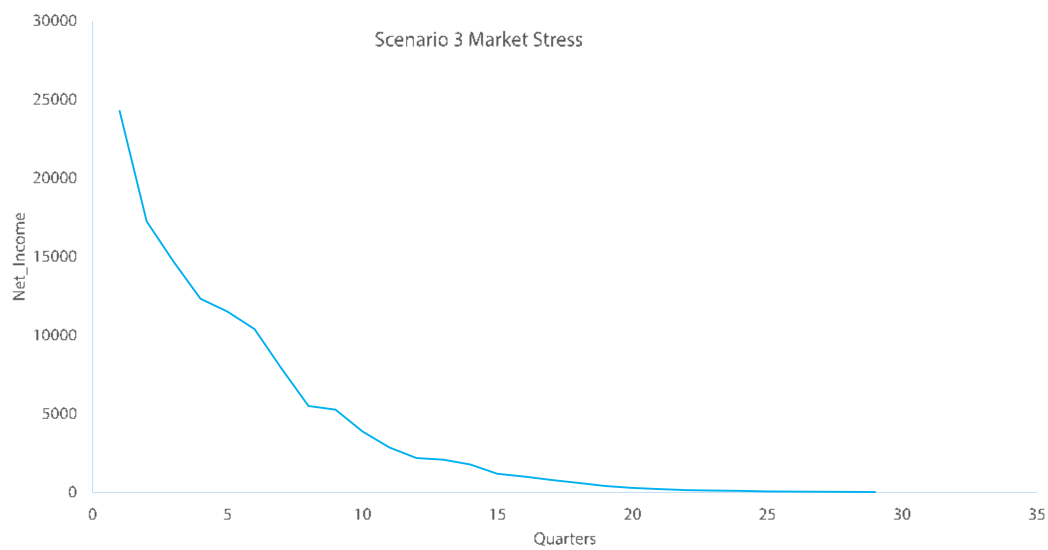

Fig 31 : Scenario 3 Market Stress

Result: In case 7, where we have stressed only market factors 2x Market Factor (EU Emission Spot price upper Bound 2X, Green Bond Investments Upper Bound 2X) and the remaining independent factors remain as baseline, this also gives us almost the same trend of net income as going downwards. Same can be seen in the above graph.

Case 8: Scenario 4 Technology Stress

Delta Net Income = 1x Policy Factor (Baseline of Fossil Fuel Consumption, CO_2 Emission, Norway Oil Output) + 1x Market Factor (Baseline of EU Emission Spot price, Green Bond Investments) + 2x Technology Factor (Renewable Consumption Upper Bound 2X) + 1x Climate Factor (Baseline of Temperature, Rainfall).

in this scenario, technology factor i.e. renewable energy consumption is stressed as shown in above equation and all other factors remains as baseline.

R Code:

```
# predicting for the given scenario_4

Scenario_4_Climate_Stress<- predict(model_reg,newdata=scenario_4)
print(Scenario_4_Climate_Stress)
scenario_4_pred<-cbind(scenario_4,Scenario_4_Climate_Stress)
```

Predicted output for net income:

```
> print(Scenario_4_Climate_Stress)
          1           2           3           4           5           6           7           8 
-0.33578253 -0.19520534 -0.16333128 -0.06907527 -0.09296177 -0.26249037 -0.38437520 -0.06068209 
          9          10          11          12          13          14          15          16 
-0.30836677 -0.30122132 -0.25904761 -0.04763488 -0.16828251 -0.38936061 -0.16954487 -0.25140789 
         17          18          19          20          21          22          23          24 
-0.28757373 -0.40819744 -0.33803873 -0.31116902 -0.37995155 -0.21802040 -0.17126070 -0.37572833 
         25          26          27          28 
-0.19790042 -0.13533074 -0.21159538 -0.34581267 
```

Graphical Representation of Predicted Net Income

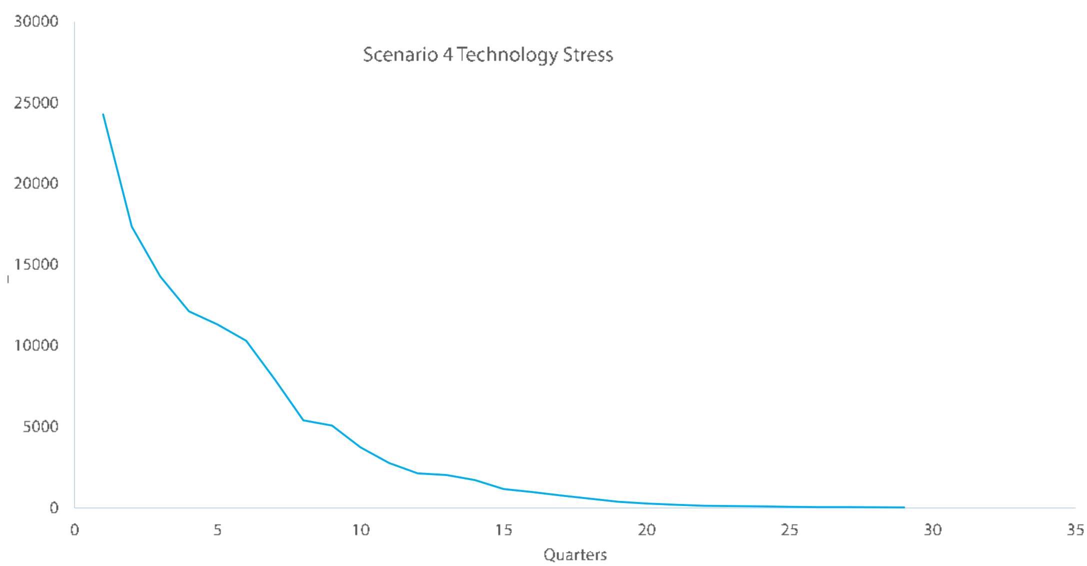

Fig 32 : Scenario 4 Technology Stress

Result: In case 8, where we have stressed only technology factors i.e. 2x Technology Factor (Renewable Consumption Upper Bound 2X) and the remaining independent factors remain as baseline, this also gives us almost the same trend of net income as going downwards. Same can be seen in the above graph.

Case 9: Scenario 5 Combined Stress

Delta Net Income = 2x Policy Factor (Fossil Fuel Consumption Lower Bound 2X, CO_2 Emission Lower Bound 2X, Norway Oil Output Lower Bound 2X) + 2x Market Factor (EU Emission Spot price upper Bound 2X, Green Bond Investments Upper Bound 2X) +2x Technology Factor (Renewable Consumption Upper Bound 2X) +1x Climate Factor (Baseline of Temperature, Rainfall)

In this scenario, combined factors are stressed as shown in above equation and all other factors remains as baseline.

R Code:

```
# predicting for the given scenario_5

Scenario_5_Climate_Stress<- predict(model_reg,newdata=scenario_5)
print(Scenario_5_Climate_Stress)
scenario_5_pred<-cbind(scenario_5,Scenario_5_Climate_Stress)
```

Predicted output for net income:

```
> print(Scenario_5_Climate_Stress)
           1            2            3            4            5            6            7            8 
-0.153746333 -0.121080474 -0.147359348 -0.514072657 -0.495297721 -0.405734359 -0.469402483 -0.466208947 
           9           10           11           12           13           14           15           16 
-0.266044847 -0.250599196 -0.503449699 -0.310159126 -0.599321564 -0.215741785 -0.300669750 -0.543861954 
          17           18           19           20           21           22           23           24 
 0.008925687  0.079808598 -0.677237348 -0.608336112 -0.596136834 -0.207997071 -0.250586532 -0.505507671 
          25           26           27           28 
-0.060749684 -0.178070147 -0.555666986  0.018358618 
```

Graphical Representation of Predicted Net Income

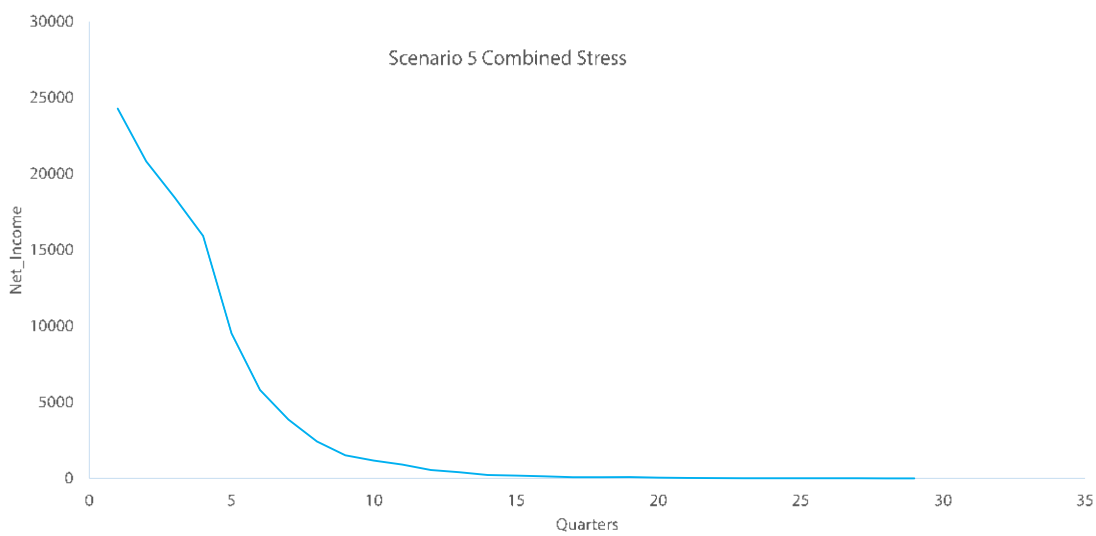

Fig 33 : Scenario 5 Combined Stress

Result: In case 9, where we have stressed combined factors and the remaining independent factors remain as baseline, this also gives us almost the same trend of net income as going downwards. Same can be seen in the above graph.

Conclusion Drawn from Scenario Analysis

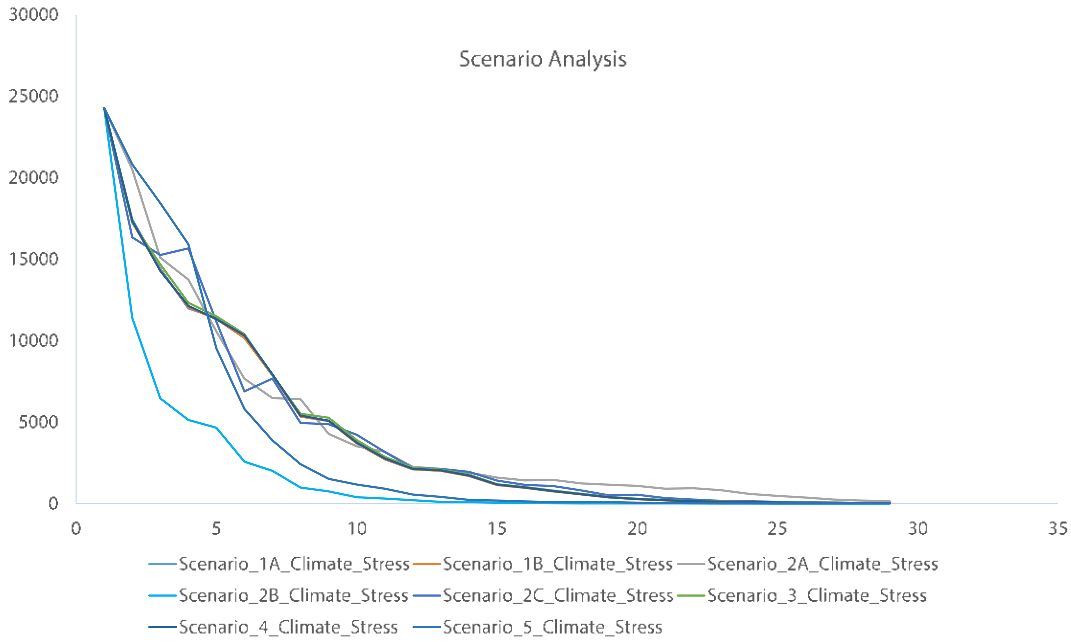

Fig 34 : Scenario Analysis

It is evident from the above graph, that when the different scenarios are taken under consideration, there is adverse impact on the net income of bank depending upon the policies that comes into play and the climatic factors becoming unpredictable.

Multiple Variable Regression: Climatic Risk Analysis on Bank's Non-Performing Loans (NPL)

Based on the collected data for each of the variables, we have performed a Regression Analysis to understand the effect of these independent variable on the dependent variable NPL.

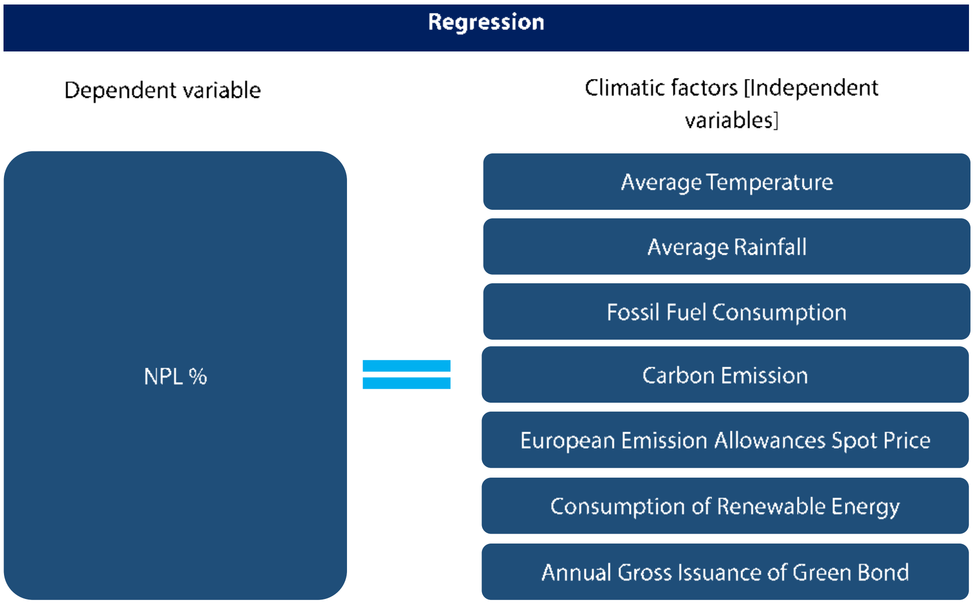

Fig 35 : Regression Model

In the initial study conducted by us we have performed a regression analysis on independent variable such as average temperature, average rainfall, carbon emission to ascertain its impact non-performing loans.

Based on the all the 3 regression analysis performed by us we could identify some correlation between variables like fossil fuel consumption, CO_2 emission and Norway oil consumption has significant correlation with banks' net income. However, we have also observed that there is no correlation between other variables and banks portfolio in the time frame from 2009-2018.

So based on the historical trend we can also conclude that that there is going to be significant impact on banks net income due to the changing patterns in the fossil fuel consumption and CO_2 emissions.

However, we would also like to bring it to notice that the historical data may not represent the correct picture of future changes. As in history we have not seen any major events or changes related to climate. So there are high chances that the banks will be highly exposed to the policies and technological change which would be driven by their local and global bodies to reduce the temperature. If the countries come up with aggressive policies and legal frameworks it might have significant impact on banks. As they need to adopt to those policies and act fast to perform a quick transition from consumption of non-renewable to renewable source of energy.

Conclusion

In the analysis performed by us, it has been observed that most of the key performance indicators like NPL, NII etc. do not bear any statistical significant relationship with climatic factors considered in the study, though one of the KPI i.e. Net Income of the bank does have significant relation with three climatic factors, especially with rate of change of global Fossil Fuel Consumption, rate of Change of Global CO2 emission and Rate of Change of Oil Output of Norway. On the basis of the regression analysis between Net Income of the bank with climatic factors, a valid predictive regression equation is created, and same equation is used in scenario analysis. In scenario analysis, it was evident from the stress test results that Net Income of the bank would have negative impact and capital need to be allocated against the probable loss.

This study is based on few KPI factors and limited climatic related data, results can be more prominent if sectoral data is available for analysis.

Appendix

Data set used for studying the impact of climate variables on NPL	https://drive.google.com/open?id=1rz2EQXwXnbnv7a0Y40tzKMdKEKx9I6kd
Data set used for studying the impact of climate variables on net interest income	https://drive.google.com/open?id=1jEUf5t375BJZAiYxkDIdW8lxcm6hLXqE
Data set used for studying the impact of climate variables on net income	https://drive.google.com/open?id=1583jayeCB5MdWSPf-w7_Cj-KErVJxcXR
Net Income	https://drive.google.com/open?id=1Fy5rvX8X0kJaEIQ-UPezRIXW0n4P_mqf
Net interest income	https://drive.google.com/open?id=1SCLVHKk2aGghdPPX5_uaQpP3p_W3j6n9
NPL data	https://drive.google.com/open?id=1bmpYmCdO7Y2cWq3UDqj9Y8y--EVwtis2

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Literature study on climate change impacts on Credit risk, Market risk and Operational Risk factors are studied from

https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=3&cad=rja&uact=8&ved=2ahUKEwiTkdir_oTjAhUv4HMBHWn0AJsQFjACegQIBhAC&url=https%3A%2F%2Fwww.sustainablefinance.hsbc.com%2F-%2Fmedia%2Fgbm%2Fsustainable%2Fattachments%2Ftransition-in-thinking-the-impact-of-climate-change-on-the-ukbanking-sector.pdf&usg=AOvVaw1q9v0RHhCTVroYrtPoNWgu

Various other regulatory documents are studied for literature review to understand the climate change initiatives includes: https://www.bankofengland.co.uk/knowledgebank/climate-change-why-it-matters-to-the-bank-of-england

https://www.bankofengland.co.uk/prudential-regulation/publication/2019/enhancing-banks-and-insurers-approaches-to-managing-the-financial-risks-from-climate-change-ss

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To understand the literature on carbon asset risk and adopt a generic risk framework for our study

https://www.unepfi.org/publications/climate-change-publications/portfolio-carbon-initiative-publications/carbon-asset-risk-framework/

Traction on Climate-

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https://www.worldweatheronline.com/oslo-weather-history/oslo/no.aspx

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