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Climate Related Financial Risk for Automobile Industry and Impact to Financial Institutions

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***Abstract*—**As per the recent changes happening in the global policies, climate related changes and the impact it causes across every sector are viewed as green swan events – in essence, climate related changes can happen often and lead to risk and lot of uncertainty, but need to be mitigated instead of considering them as black swan events. This brings about a question on how this risk can be computed, so that the financial institutions can plan to mitigate it. Climate related changes impact all risk types – credit risk, market risk, operational risk, liquidity risk, reputational risk and others. And the models required to compute this have to consider the different industrial needs of the counterparty, as well as the factors that are contributing to this – be it in the form of different risk drivers, or the different transmission channels or the different approaches and the granular form of data availability. This brings out to the suggestion that the climate related changes, though it affects Pillar I risks, will be a Pillar II risk. This has to be modeled specifically based on the financial institution's actual exposure to different industries, instead of generalizing the risk charge. And this will have to be considered as the additional capital to be met by the financial institution in addition to their Pillar I risks, as well as the existing Pillar II risks. In this paper, we present a risk assessment framework to model and assess climate change risks - for both credit and market risks. This framework helps in assessing the different scenarios, and how the different transition risks affect the risk associated with the different parties. This research paper delves on the topic of increase in concentration of greenhouse gases, that in turn causing global warming. It then considers the various scenarios of having the different risk drivers impacting credit and market risk of an institution, by understanding the transmission channels, and also considering the transition risk. The paper then focuses on the industry that's fast seeing a disruption: automobile industry. The paper uses the framework to show how the climate changes and the change to the relevant policies have impacted the entire financial institution. Appropriate statistical models for forecasting, anomaly detection and scenario modeling are built to demonstrate how the framework can be used by the relevant agencies to understand their financial risks. The paper also focuses on the climate risk calculation for the Pillar II capital calculations, and how it will make sense for the bank to maintain this in addition to their regular Pillar I and Pillar II capital.

***Keywords*—**Capital calculation, climate risk, credit risk, pillar II risk, scenario modeling.

I. Introduction

CLIMATE related changes have been happening in the environment since time immemorial, but during the recent past, the number of occurrences have increased. We can see that there are multiple occasions when the global warming has affected and caused the increase in the temperature, which is again caused due to multiple reasons like deforestation, carbon emissions etc. The increase in the temperature has caused an impact across the globe – be it in the case of the Great Barrier Reef in Australia, where the sea and air temperatures are increasing, and the entire shallow water coral reefs have been eroded by almost 50% in the recent years, as per [1], or the melting of the ice and snow in the Arctic region, as per [2]. There have also been other climate related changes like more occurrence of tsunamis and earthquakes and other natural disasters. This led to the signing of the international treaty of Paris Agreement 2016, that mandatorily made all countries to pledge for reducing the average global warming temperature by at least 2 °C, compared to pre-industrial levels. To achieve this goal, all the countries aim to reduce the greenhouse gas emissions as soon as possible.

All the above-mentioned climate related changes and its effects are seen as one-off events by the different financial institutions. The different financial institutions in focus are the banks, insurance firms, securities firms and other financial institutions. They consider any of these climatic changes and the impact they bring to the financial institutions as black swan events, and do not consider any of it in their risk management practices. For example, any housing loan issued to a person and the property being caused damage due to tsunami is not completely considered for computing the risk of the bank. Though slowly there are insurance coverage and other kind of mitigants to handle these risks, this is still not wide-spread. This brings out a need for the framework to handle the financial risks caused by these climate changes, and the financial institutions have to consider these as green swan events, and not as black swan events. In essence, this means that the financial institutions have to be prepared for the climate related change and the associated risks, and have to mitigate it, and wherever not possible, hold additional capital to take care of the loss. As mentioned, nowadays, banks are considering mortgages to be associated mandatorily with insurance, as they are slowly moving towards mitigation of climate related risks.

II. Automobile Industry: Focus of the Research

Automobile Industry is one of the most impacted industries, due to the climate related policy initiatives. And this industry is the backbone for all, and impacts every one – the layman to the business man, to the economy in either direct or indirect manner. There are lots of financial assistance provided by government to help the automobile firms in coming up with latest technological changes that would reduce the carbon

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emissions. Reference [1] have detailed on how the carbon emission of each vehicle is computed, and it has been proved that the emissions of vehicles running on Gasoline or Petrol, LPG and Diesel are all high and the major breakthrough was on the usage of the electric vehicles, wherein electricity has to be generated using renewal energy. This is the same strategy now being followed by all the countries, wherein they are moving away from the fossil fuels to something based on renewable energy. This can either be in the form of electric vehicles or hydrogen vehicles or other forms of vehicles.

Fig. 1 details the greenhouse gas emissions by different countries, and the share of them covered by the carbon tax and its related instruments. Many countries have started levying carbon tax, and expect that all industries will mandatorily pay the appropriate carbon tax, that is determined on the basis of their greenhouse gas emissions.

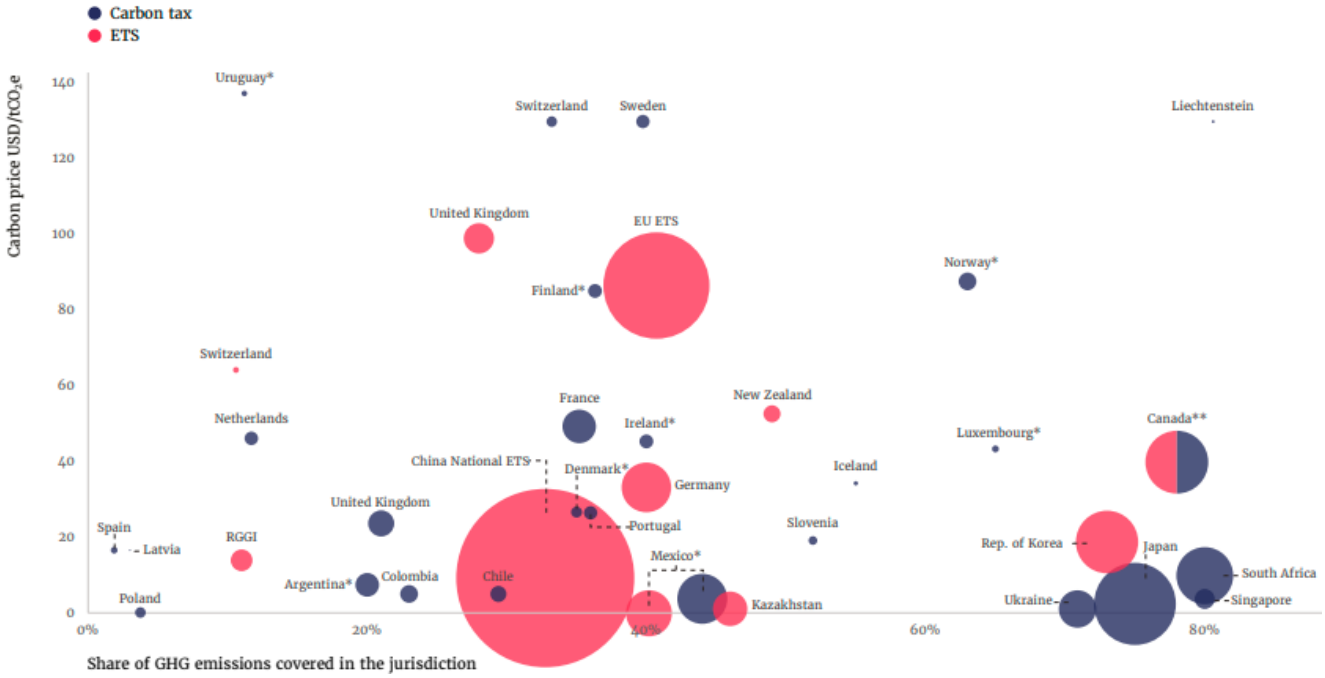

Fig. 1 Absolute emissions coverage, share of emissions covered, and prices for CPIs [8]

III. Effect of Climate Risk on Banks

The climate risk will have different effect for each party type. The lending done by banks for housing in locations prone to natural disasters will have to be priced accordingly. Or the insurance premium collected by insurers will have to take note of the probability of natural disasters in the region before coming up with the premium value.

The different financial institutions have an effect according to their nature of business. For example, a bank will be pricing their loan given to an automobile industry player, working on non-fossil fuels different from the same automobile industry player working on a fossil fuel related project. This emphasizes the need for arriving at a strategy to price the products differently for a green business versus a business that is dependent on fossil fuel. References [4]-[6] talk about the importance of capturing climate risk, and how investors and other different parties view this.

Reference [7] talks about the requirement for a strategy to price the different products in detail, and provides the basis for pricing the syndicate loans. The same strategy can also be used by the banks to price the products.

We attempt at identifying the effect of climate risk on banks. Reference [7] also provided the different fossil fuel reserves used as variables for modeling the impact on the automobile industry. Table I gives the details of the same.

TABLE I
Fossil Fuel Firm's Reserves Data [7]

Variable	Description	Source
Fossil Fuel Reserves	Fossil fuel firms' relative amount of oil, gas and coal reserves by countries.	Annual reports and own calculations
Proved Reserves (USD)	Standardized measure of discounted future net cash flows related to proved oil and gas reserves (in million USD).	Annual reports and own calculations
Climate Policy Exposure	The climate policy exposure of fossil fuel firms determined by weighting the countries' climate policy index by the relative amount of a firm's fossil fuel reserves of each firm in each year in that country (see equation 1). As climate policy indices we use the C3I and CCPI.	Annual reports and climate policy indices
Climate Policy Exposure by Headquarter	The climate policy exposure of the fossil fuel firms' headquarter determined by climate policy index of the country of the firms' headquarter. As climate policy indices we use the C3I and CCPI.	Annual reports and climate policy indices
Political Instability Exposure	The political instability exposure of fossil fuel firms determined by weighting the countries' political instability index by the relative amount of a firm's fossil fuel reserves of each firm in each year in that country	Annual reports and political instability indices

IV. Framework for Calculating the Risk

The climate risk assessment has a high-level framework that involves risk identification, and ensuring that the different types of risk are categorized. The risks need to be categorized into physical risk, wherein the risk gets assigned based on the economic costs and the financial losses that result from the physical changes in the environment, and as well as transition risk, wherein they are related to business and have an indirect impact. In the case of automobile industry, the microeconomic and macroeconomic factors also play an important role, and they get classified and treated as transmission channels, as this is the driving change.

The exposures of the bank need to be then mapped and measured based on the kind of data that are available. This can be assessed in the form of more granular data (which is the bottom-up approach) or doing the computations based on high level data (which is the top-down approach), and also multiple scenarios of data can be considered. The analysis of the data has to be done to ensure that they are classified into different risk types – credit risk, market risk, liquidity risk etc. In this framework, the suggestion is to use based on the kind of data that is available, and accordingly model it out.

The risk quantification happens based on the modeling of economic impact, which is by the usage of scenario analysis and sensitivity analysis. The scenario analysis is the preferred mechanism for the calculation of the climate related financial risks, as there can be different factors affecting the different automobile customers, on the basis of their microeconomic factors, and internal policies and data availability.

The risk management is based on the continuous assessment and calculation according to the different risk types. There are mandatory disclosures required for the same. This also gets handled as part of internal risk management policies to ensure that the risks are being managed efficiently and also by following any mandatory regulatory compliance provided by the regulators. Fig. 2 gives a snapshot view of this framework.

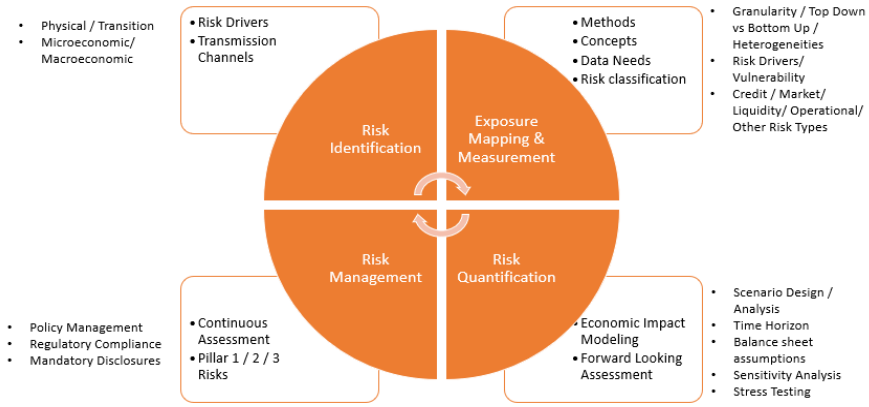

Fig. 2 Climate Risk Assessment Framework

V. Reason for the Selected Approach

The Scenario Analysis and Causal modeling mechanism has been considered as part of this paper to compute the Climate related financial risk. This mechanism helps in identifying the causes behind the processes that take place in the system. This demonstrates the importance of random allocation of units and the industry knowledge can help in improving the weights that are being given to the different factors. And this mechanism also provides the benefits of replication of the model, if there is a need for it.

The causal inference is a combination of logical and statistical methods. And this helps in identifying the relationship between cause and effect. This also helps in identifying how any cause can change different effects and hence the capital can be different for the same. And the regression models are not preferred, as this can have any combination of dependent and independent variables.

VI. Model Proposed

The climate related financial risk has to be split and derived for each risk type differently. This cannot be clubbed together with all the other risk types, as each risk will have its own risk drivers, and risk drivers also play a vital role in the calculation. And for each risk driver (which can be any physical risk driver or a transition risk driver), the impact of any micro economic factor or a macroeconomic factor on the risk drivers is different. And also, this changes on the basis of how the particular financial institution has maintained the data. If we are looking at the data availability, the factor that is being assigned to individual exposures' data (Bottom-up approach of data availability) will be different from the factor that gets assigned to the total exposures' data (top-down approach of data availability), as the other relevant attributes required for the capital charge will not be available in the case of the top-down approach of data.

The factors or in statistical terms, the weights that are assigned to each of the input used for the calculation will be different, and this cannot be generalized as this will be specific to the various attributes like data availability, and the micro economic factors and the risk driver can change for each automobile industry participant.

The model formulae for calculating the capital charge related to any risk is as below:

$$\begin{aligned} &Capital\ Charge\ for\ Each\ Risk\ Type \\ &= \sum(Individual\ Risk\ Drivers \\ &* the\ Weight\ Assigned\ for\ the\ Individual\ Risk\ Driver) \\ &* \begin{pmatrix} Different\ Transmission\ Channels * the\ weight\ assigned\ for \\ the\ different\ transmission\ channels \end{pmatrix} \\ &* (Data\ Granularity \\ &* \ the\ weight\ assigned\ for\ the\ data\ granularity) \end{aligned} \tag{1}$$

And this capital charge gets aggregated across risk types to arrive at the total risk charge to be maintained by the financial institution. Based on the Capital charge formulae specified with respect to each risk type as seen in (1), and Fig. 3, which details the logic of the scenario analysis model, (2) will be the climate related financial risk for a single risk type, having a single risk driver and a single macroeconomic factor, but with different data granularity.

$$\begin{aligned} &Climate\ Related\ Financial\ Risk\ for\ a\ Single\ Risk\ Type \\ &= ((Physical\ Risk\ Driver\ 1 * w21) \\ &* (Macro\ economic\ Factor\ 1 * w31) * \\ &* (Top\ Down\ Approach\ Data * w41)) \\ &+ ((Physical\ Risk\ Driver\ 1 * w21) \\ &* (Macro\ economic\ Factor\ 1 * w31) * \\ &* (Bottom\ up\ Approach\ Data * w42)) \end{aligned} \tag{2}$$

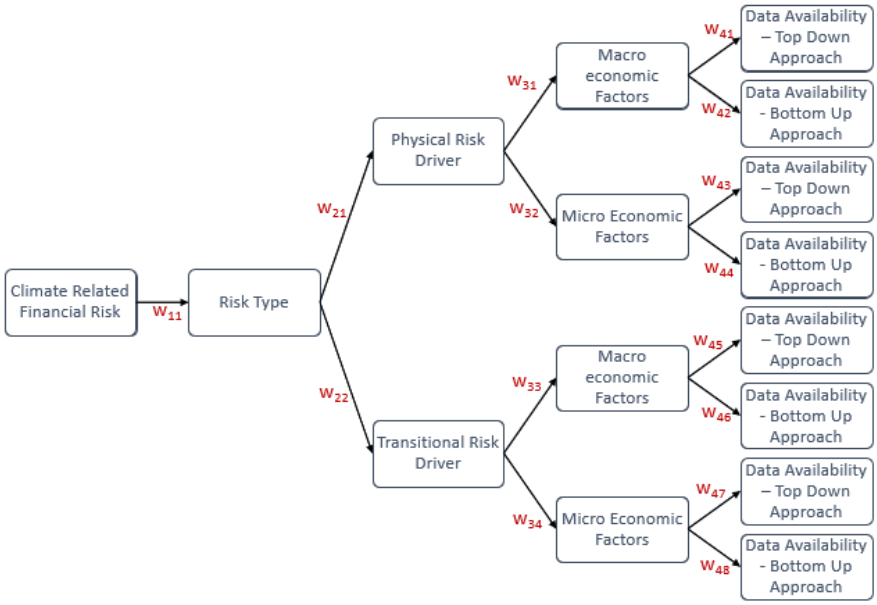

Fig. 3 Model for Climate Related Financial Risk

Applying the Model to Automobile Industry

The suggested model, as can be seen in Fig. 3 and (2), can be assigned to the automobile industry on the basis of the mapping of the appropriate risk drivers, economic factors and the data granularity. Fig. 4 provides this mapping of the model to a specific scenario of the automobile industry. The credit risk associated with the companies that are involved in the electric vehicle production have to be assessed differently from the regular corporates involved in the fossil fuel related vehicles production. There are multiple transitional risk drivers in this scenario like the technological changes that are being followed by the particular customer. It has been seen that corporates that have embraced the climate related changes have a higher brand value, as compared to corporates that are yet to embrace any of the technological changes.

There are also macro economic factors that affect the credit risk, like the government initiatives wherein the regulators and the central government are actually funding the cost, and also cover up as a guarantor for some of the corporates. And depending on the data, the calculation logic as mentioned changes.

Equation (3) will be the formulae for the calculation of the credit risk, as per the example in Fig. 4, for one of the risk driver pertaining to technological enhancements.

$$\begin{aligned} &Credit\ Risk \\ &= \begin{pmatrix} Changes\ caused\ due\ to\ Technological \\ enhancements * w11 \end{pmatrix} \\ &* \begin{pmatrix} Changes\ caused\ due\ to\ Government\ Allocation \\ for\ Zero\ Emission\ Vehicles * w21 \end{pmatrix} \\ &* (Total\ Exposure\ Amount\ as\ per\ Bottom\ up\ Approach * w31) \end{aligned} \tag{3}$$

VIII. Reasons for Considering Climate Related Financial Risk as Pillar 2 Capital

As can be seen in the suggested model from Fig. 3 and the example mentioned in Fig. 4, the factors that are contributing to the total capital charge are determined by few corporate specific calculations like the microeconomic factors, data availability etc. This cannot be completely handled by making this a Pillar 1 calculation wherein the capital charge is computed based on the ratings of the counterparty and other solvency related parameters. But, this includes even reputational parameters like brand value, which helps in determining how the customers will buy the vehicles, and hence the capital charge to be maintained

by the bank for each corporate can be different. And the Pillar 1 calculation already considers the credit enhancement which also considers a portion of the environment risk into it. So, all this points to the need of this climate related financial risk being a specific Pillar II Risk and not a Pillar I risk. This has to be maintained by the bank or the financial institution in addition to their existing Pillar I and Pillar II risk requirements.

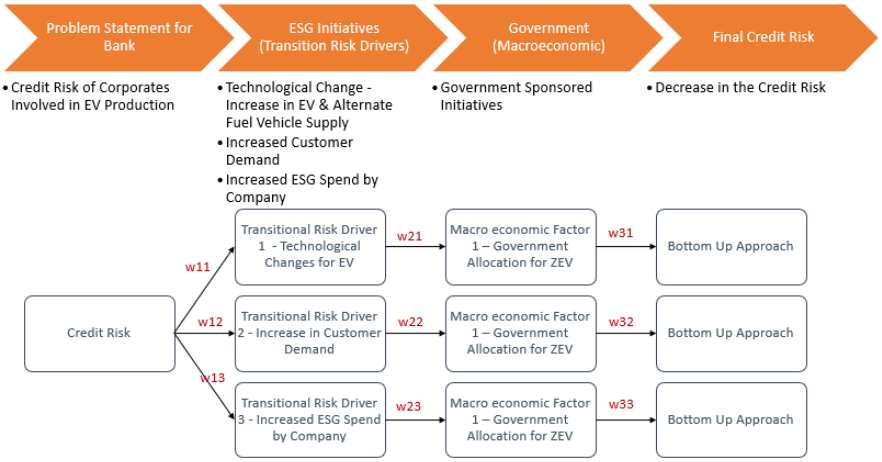

Fig. 4 Example of assigning the proposed model to a Corporate involved in Electric Vehicle Production

VIII. Conclusion

On the basis of the framework suggested for the modeling of climate related financial risk and the example pertaining to the automobile industry, it can be concluded that the climate related financial risk is a Pillar II risk. The capital charge pertaining to the climate related financial risk can be computed using scenario modeling and the framework suggested in this research paper, as seen in Fig. 3. There is additional scope of improvement in the model, by using deep learning to improvise the framework, and also by having additional industries analyzed using the same model, and adding the risk drivers that are going to be specific for each of them.

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