Carbon Neutrality:

The Role of Banks in Optimal Environmental Management Strategies

Abstract

This study explores the ecological ambitions of banks by studying the coincidence of economic realities with environmental management strategies. We address this question by studying the environmental performance of US banks and its impact on their tail risk as US is not committed to carbon neutrality in COP 21. We proxy economic reality with tail risk of banks and employ a novel extreme value theory to measure this. We use Asset4 ESG data for environmental performance score and test our hypothesis with a sample of 256 US banks. The results indicate that the US banks are ecologically ambitious and their environmental strategies are likely to reduce their tail risk. This provides evidence that better environmental strategies do coincide with the economic realities. We test the consistency of our results by using alternate proxies for tail risk and find our results robust. Our results are also not driven by endogeneity concerns. Finally, our additional results show that the nature of relationship differs with corporate governance levels, CSR committee existence, institutional ownership presence and crisis period.

JEL codes: Q50, G21, G32, C49

Keywords: Environmental performance, multivariate extreme value theory, tail risk, banks, ESG

1. Introduction

Climate change and carbon neutrality are very important challenges that we face today. Although 196 countries have signed Paris Agreement in 2015 to reduce carbon emissions yet this commitment lies in the honouring of this promise. The environmental concerns now reflect a serious global issue with complex challenges and its effects. This global issue has influence on societies, companies, groups and individuals. For example, UN Intergovernmental Panel on Climate change (IPCC, 2007) state that the climate change is an extreme single threat to humanity. Therefore, these environmental changes cannot be resolved without appropriate handling of social, financial and economic systems, which creates sustainable developed society. One of the countries that has not been committed to carbon neutrality is the USA. Therefore, a natural questions arises how the US firms are doing in terms of optimal management strategies if they decide to commit to the Paris Agreement. Based on the environmental management strategies, our main research aims are as follows: Do economic realities coincide with environmental management strategies of banks? We answer this question by studying environmental performance of US banks and its impact on their tail risk. Broadly speaking, we test the ecological ambitions of US banks and whether they are aware of environmental issues and whether they adopt optimal environmental strategies. We measure ecological ambition of banks by calculating their tail risk and explore if their environmental friendly policies have any impact on their risk.

The concept of carbon neutrality has gained attention in recent years and many businesses has adopted different provisions for carbon neutrality. Moreover, carbon neutrality can be attained through different approaches and many industries are using different ways. For example, companies may measure the level of its carbon footprints; there are many available web-based calculators' to measure this estimation. Second, they can adopt emission reduction techniques to decrease carbon emission as much as possible before calculating the carbon emission. Third, they can recognise the provider and purchasers to offset the remainder quantity of carbon emission. In connection with carbon neutrality, India is comprising of 17% of the world population, however, it is only accountable for 2.4% of total carbon emissions (CO_2) since 1750 (Banerjee and Rao, 2007). While India and China are accountable for CO_2 emission of 1293.17 and 6017.69 million metric tons respectively, the United States is accountable for 5902.75 million metric tons of CO_2.

This reflects per capita emissions of India, China and United States are 1.16, 4.58 and 19.78 respectively (Union of Concerned Scientists, 2009). In comparison, the average American is accountable for 20 tons of CO2 and other gases per annum, while average human being is accountable for 2.5 tons (Revkin, 2007). Therefore, it is important to understand that carbon neutrality through environmental justice, determine the responsibility for the burden of cost and distribution benefits (Taylor, 2000).

The banking system plays an important role in society in general and in economic development in particular. Therefore, banks are often criticised for contributing to global warming because of their failure to understand the carbon consequences of their lending process (Ackerman 2014; Richardson 2009). On the other hand, some studies show evidence towards use of societal resources of banks, their depositors' anticipate that climate consideration of borrowers is factored into lending decisions, and carbon-intensive borrowers take banks into major reputational and business risks (e.g. Cogan et al. 2008; Goss and Roberts 2011; Jung et al. 2016; Saunders and Potter 2015; Thompson and Cowton 2004). In developed countries, energy shifts to carbon neutrality concern the relationship between technology, policies, business and society. It is a complex procedure with hidden lock-ins based on the current framework of financial, institutional and infrastructure systems (Geels, 2011). Such systems are potential to change the different socio-technical systems, for instance technology, consumer practices, cultural importance and scientific information (Geels, 2011). Recently Bigerna et al. (2021) demonstrated that carbon neutrality could be better achieved, instead, increased investment in RES provides the optimal option to reduce the fossil fuel power stations' dominance and increase the role of domestic resources spurring for the resolution of infrastructure problems.

In this paper we use novel approach of extreme value theory to measure tail risk of US banks. Furthermore, we use Asset4 ESG data for environmental performance score. This score reflects the impact of bank policies on land, water and air. A higher score reflects better impact and a lower score reflects worse impact. Our results indicate that the banks' better environmental strategies are likely to reduce their tail risk providing evidence that better environmental strategies do coincide with the economic realities. To the best of our knowledge, this is the first paper that studies environmental performance of banks and its impact on their tail risk.

We contribute to the literature in the following several ways. First, this is the first paper providing evidence that environmental performance of banks reduce their tail risk. Second, we use novel extreme value theory to calculate tail risk of banks. We use tail quantile as a measure of tail risk. The tail quantiles are calculated for probability values ranging from 0.1% to 0.2%, and the corresponding tail quantile (tail-VaRs) are expected to be violated every 500 days and every 1000 days, respectively. Lastly, we also investigate the expected shortfall estimates conditioned on tail quantile. Third, we provide additional evidence that environmental performance of banks reduce their tail risk only for banks with higher corporate governance score, for banks with institutional ownership, for banks without CSR committee and during normal times. Fourth, we test the consistency of our results by using alternate proxies for tail risk and our results are not driven by endogeneity concerns. Finally, we also contribute to the literature through informing bankers about the significance of eco-friendly policies as eco-friendly banks are rewarded with a reduced tail risk. The study provides evidence to the banks who refrain from eco-friendly policies as it shows it not only beneficial for themselves but it also advantageous for the general public in the form of cleaner world.

The remainder of the paper is organized as follows. Section 2 reviews the related literature. Section 3 provides details on the data, the empirical models and the econometric methodology. Section 4 reports the empirical findings and a discussion on those findings. Section 5 provides robustness test and additional results and section 6 concludes the paper and provides policy implications.

2. Related Literature

2.1 Challenges to Environmental Activities

Existing studies illustrates an unlimited variety of environmental activities. For example, a few studies show corporate social responsibility into environmental activities, a few other add on compliance with environmental regulation, customer and employees' satisfaction, efficient cast savings measures, acquiring unique competitive advantage against competitors, better brand image, diversifying business into new markets, link with native groups, enhance insurance policy settings, facilities to loans, agreement with international bodies and ethical motives. Nevertheless, corporate firms influence some of these environmental activities and it is possible that same environmental activities have the same significance in different contexts. On the other hand, ethical reasons and satisfying international agreements are barely stated by the corporate firms (Alexopoulos et al., 2018; Cornett et al., 2016; Fatemi et al., 2018; Ferrero-Ferrero et al., 2016; Finger et al., 2018; Horváthová, 2010; Manrique and Martí-Ballester, 2017; Nizam et al., 2019; Shen et al., 2019).

According to Garcia et al. (2017), key environmental activities can be grouped into four categories, i.e., financial, legislative, social and international activities. In financial activities, financial institutions, for instance the Inter-American Development Bank (IADB) and World Bank (WB) incorporate environmental strategies into loan plans, considering that corporate firms and countries with deprived environmental activities lead to excessive financial. Similarly, shareholders are assuming the environmental expenditures and possible environmental obligations link with firms, it affects share performance (Halbritter and Dorfleitner, 2015; Junkus and Berry, 2015), and hedgers are hedging environmental conditions into their insurance plans (Schmidheiny et al. 1992).

In the context of *legislative* activities, environmental protocols are imposing corporate firms to enhance environmental performance. The risk of non-compliance environmental legislation is very low in countries where fines are high and implementation is efficient. This is possible in the developed countries because institutional structure for enforcing environmental legislation is robust as compared to the developing countries (Epstein 1995). Besides legislation, Garcia et al. (1999) explain that government has also specific policies and objectives towards economic growth and health elevation by cutting down environmental pollution, increasing age expectancy and fulfilling world-wide treaties, among others. The differences between the European Union and the United States on climate, carbon and energy legislation have been apparent from last two decades. Skjærseth et al. (2013) propose three major differences in the policy outcomes of the EU and the US. First, the agenda-setting arrangements from policy makers in the EU and the US are very much diverse in terms of policies and link issues. Second, link issues support to overcome the obstacles in EU countries, however, it drives more sophisticated and greater policy challenges in the US. Finally, legislative rules, procedures and standards have complexity in the coalition-building efforts of lawmakers in the two systems in different ways, affecting negotiation processes and outcomes. Such differences in agenda-setting in the EU and the US have left them wide apart in international climate negotiations.

The social activities raise community attention on environmental problems throughout last few decades in the EU and the US because of its adverse effects associated with resource based events. Dunlap et al. (1993) illustrate that public are concerned for air quality, soil contamination, contaminated water, catastrophe of species and rainforest, carbon emission and global rising temperature, deteriorating ozone layer. Similarly, in the recent times non-government organisations (NGOs) putting force on government agencies and firms to stimulate environmental activities.

The *international activities*, such as free trade zone of America, the Kyoto protocol and earth summit held in Rio - 1992 consider international trade agreements (Garcia et al. 1999). According to Barkin (1999) free trade agreement is reflection towards Mexican policymakers to demand for superior environmental concern as member of the international integration. In order to improve the international market place with the assumption of carbon neutral world, encouraging firms to establish a system toward carbon neutrality is important. Therefore, EU has set the targets to reduce greenhouse gas emission to 80% lower than the 1990 levels. All segments of the markets need to participate in order to achieve the milestone of low carbon levels and it is feasible and affordable (Mazzucato, 2018). In order to achieve this optimally, organised set of international regulations required to be in place for stable carbon neutral market to develop.

2.2 Bank Performance and Environmental Strategies

Banks, do not form dangerous substances or pollution into the air, water or land. However, banks are engaged in lending practices that associate with commercial activities that deteriorate the environment (Gray and Bebbington, 2001; Sarokin and Schulkin, 1991; Smith, 1994). Hence, banks can be part of business activities that cause environmental pollution.

Understanding of the environmental strategies for banks comes into existence when enormous banks in the world engaged with United Nations Environment programme called 'Statement by Banks on the Environment and Sustainable Development' (UNEP, 1992). The UNEP declaration recognises sustainable development that meets the highest standards. Further, declaration promises participants to follow common values of environmental safety by adopting highest standards of environmental management in their internal processing and associate environmental risks into their risk assessment and management checklist. Hill et al. (1997) and Cowton and Thompson (2000) highlight that UNEP declaration to recognise publically as a possible relationship between bank advancing and the environment.

The increase in environmental issues provides prospects in the form of lending to corporate firms deals in environmental responsive technologies and pollution resistor measure (Fatemi et al. 2018; Finger et al. 2018; Nizam et al. 2019; Shen et al. 2019; Thompson, 1999a; UNEP, 1995). In order to consider this, banks require correct data and carefully include environmental factors into their credit decisions. Further, it also provides banks an awareness to establish an environmental posture to their brand centrally. For instance, a co-operative bank in the UK has dismissed some present banking relationships because of environmental issues (Kitson, 1996). However, ethical and environmental attitude develops successful market segment and productivity (Cowton and Thompson, 1999; Cowton et al., 2000; Davis and Worthington, 1993; Harvey, 1995; Kitson, 1996; Thompson, 1999b). In addition, focussed banks like Triodos in the UK is growing significantly, although it caters niche market where environmental challenges appear in large scale (Cowton and Thompson, 1999, Cowton and Thompson, 2001).

2.3 Extreme Value Theory and Tail Risk

Extreme value theory (EVT) has been extensively useful across various fields by researchers. For instance, Danielsson and de Vries (2000), Gilli and Kellezi (2006), McNeil and Frey (2000), Neftci

(2000), Onour (2010), and Straetmans et al. (2008) have been measured tails of financial data. According to Zhao (2020) illustrates that extreme value theory is significant methodology for measuring tail performance of financial markets. Moreover, Gkillas and Katsiampa (2018) covered the tail risk of five main cryptocurrencies i.e. Bitcoin, Ethereum, Ripple, Bitcoin Crash and Litecoin by adopting EVT to closing prices of each cryptocurrency. Osterrieder and Lorenz (2017) and Osterrieder et al. (2016) also use extreme value theory into cryptocurrency.

Existing literature illustrate that extreme value theory (EVT) has been used widely to measure tail risk, systemic risk and spillover risk in financial markets. However, the effect of environmental management strategy on banking tail risk have not received much attention. We find some literature on Environment Social and Governance (ESG), for example; Goldreyer et al. (1999), social activists identify that organisations with better societal history will be more appreciated because of less litigation cases. Chan and Walter (2014) identify that environmental standard in the long run benefit to shareholders because it avoids possible expenditures of litigation, reputation damages and environmental catastrophes. Henke (2016) suggest that socially responsible bonds exceed in recession period and underperform, similarly Nofsinger and Varma (2014) find social mutual funds perform better than conventional funds in market crisis and underperform in the non-crisis times.

In summary, the carbon neutrality is certainly an interesting, and one could debate on its benefits based on intrinsic as well as instrumental grounds. Carbon neutrality is not considered as an end of carbon free world, but it is a direction of living, precisely, following the appropriate system that contributes to the environment (Barry, 1999). Therefore, we cannot evaluate a firm to be of high standards on the basis of lone act towards carbon neutrality, instead the firm must consistently and continually support the benefits of carbon neutrality.

3. Sample and Method

3.1 Data collection and sample

Our analysis use secondary data from three different databases. First, we fetch data from Compustat database. Prior studies consider this database to collect firm financial information. Second, we access stock return data from Chicago's Center for Research in Security Prices (CRSP). Mainly, CRSP contains the market related data for all listed companies. Finally, we use Asset4 ESG data that is managed by Thomson Reuters. Asset4 ESG contains the firm level qualitative information.

We started our sample construction with listed US banks. Following the prior literature, our sample consists of all US banks with a SIC code 6000 to 6799 (Lee et al., 2019; Liu and Skerratt, 2018; among others). The data extracted from Compustat consists of 1,925 bank-year observations. Then, we match this data with CRSP and Asset4 ESG databases. We delete all those observations with missing data. Following Asset4 ESG starting period, we start data extraction from 2002. After applying all these matching exclusions steps, our final sample of 536 bank-year observations from US for the period of 2002-2017.

For computation of *tail quantile*, our primary risk factor, we access daily stock price data from CRSP for all the banks in our sample from 2nd January 1998 to 31st December 2017. We use five-year rolling window to compute *tail quantile*. For example, we use daily data from 2nd January 1998 to 31st December 2002 to calculate *tail quantile* for the year 2000, 2nd January 1999 to 31st December 1993 to calculate *tail quantile* for the year 2003 and so on. This is how we get our yearly values for tail risk from 2002 to 2017 matching with our data from Compustat and from Asset4 ESG. Our start date is 2nd January 1998 because we required minimum of 1000 observation to compute *tail quantile* as extreme value theory requires at least 1000 observations to produce reliable measure.

As an additional robustness check, we substitute the *tail quantile* with the *tail expected shortfall*. The definition of each variable and their data sources are provided in the Appendix A.

3.2 Tail Risk Measure:

We measure the tail risk in the stock prices of banks by a sharp fall in their prices. We follow univariate extreme value theory to identify stock tail risk. The univariate extreme value theory composes of Generalised Extreme Value (GEV) distribution and consider as limit law for maxima of stationary method. We select Peaks-Over-Threshold (POT) method to measure the parameters of GEV distribution. We use semi-parametric method and match the distributional excess losses over a high threshold that leads to Generalised Pareto Distribution (GPD) See for example, Straetmans and Chaudhry (2015) and Chaudhry et al. (2020).

Since we know empirically that stock returns of banks show fat tails, $X = -\ln\left(\frac{S_t}{S_{t-1}}\right)$ is defined as the loss distribution where S_t is denoted as the stock price of a bank which is adjusted for dividend. Because of fat tail implications, we can approximate the marginal tail probability for X as a function of the tail quantile that is varying regularly (or by a power law):

$$P\{X > x\} = L(X)^{-\alpha}, x \text{ large}, \quad (1)$$

And with $\lim_{x\to\infty} L(tx)/L(x)$=1 and t>0, i.e., “slowly varying”.

α is the tail index here that determines how fast is the decay in the tail probability. If the value of α is small, the decay to zero will be slower and tail probability of x will be larger. Similarly, if the value of α is large, the decay to zero will be quicker and tail probability of x will be smaller. As per regulation variation property, the moments of the distribution greater than α ($E[X^r], r > \alpha$), are not bounded but we know that the Student-t distribution show heavy tails. In our paper, we call the probability that values exceed a certain threshold for given values of x, which is commonly called as value at risk (VaR) level x or tail-VaR x could be the given value of the tail probability p.

Because of its simplicity, risk managers and other stakeholders categorise VaR an important risk measure. The biggest drawback of VaR is that it is not coherent. In order to address this drawback, we also use expected shortfall (ES), which shows the expected loss given the loss exceeds a certain threshold if there a big fall in the stock price ($X > x_p$). Contrary to VaR, expected shortfall tells us how much will be the loss once loss exceeds the threshold of VaR. We show this as follows:

$$E(X - x_p | X > x_p) = \frac{x_p}{\alpha - 1}, \quad (2)$$

We can see from this equation that the ES is a linear transformation of x_p according to the extreme value theory.

We apply De Haan et al. (1994) method of semi parametric estimator to examine the quantile *x* for very small values of $p = P\{X. x\}$ as follows:

$$\hat{x}_p = X_{n-m,n} \left(\frac{m}{np}\right)^{1/\alpha} \tag{3}$$

As $X_{n-m,n}$ is indication tail cut-off point of *(n-m)*th ascending order statistics from a sample size n such that $q > X_{n-m,n}$.

We apply Hill (1975) to estimate α in the mentioned in equation (1), as follows:

$$\hat{\alpha} = \left(\frac{1}{m}\sum_{j=0}^{m-1} ln\left(\frac{X_{n-j,n}}{X_{n-m,n}}\right)\right)^{-1} \tag{4}$$

Where parameter m indicates how many extreme returns are evaluated in estimation.For our baseline regressions we use nuisance parameter m = 175. We perform sensitivity analysis by changing m = 225. We use sensitivity analysis by adjusting $m = 175$ for pre-crisis and m = 137 for crisis and m = 67 for another crisis. We examine m values by adopting Hill (1975) estimator. We find expected shortfall estimator by substituting the Hill (1975) equation (2) and tail quantile estimator in equation (1) as follows:

$$\hat{E}\left(X - \widehat{x_p} | X > \widehat{x_p}\right) = \frac{\widehat{x_p}}{\widehat{\alpha - 1}} \tag{5}$$

3.3 Environmental performance measure

For bank environmental performance, we employ data from Thomson Reuters Asset4 ESG. Asset4 founded in 2002 and in 2009 acquired by Thomson Reuters. Asset4 is managing firm level ESG for 4000 global companies and very popular among corporate finance researchers (Baboukardos, 2017; El Ghoul, Guedhami, and Kim, 2017; Kölbel, Busch, and Jancso, 2017; Liang and Renneboog, 2017). Asset4 ESG data is mainly consisted of three main dimensions: Environmental, Social and Governance. These dimensions are an accumulation of 250 different objective indicators.

More specifically, we only deploy environmental rating for this study. The environmental pillar shows the firm effective strategies and management practices to generate sustainable shareholders value. Environmental performance (*ENV_P*) is based on the attributes such as the effect of firm practices on land, water and air including both living and non-living creatures along with ecosystem (i.e. resources reduction, emission reduction, and product innovation benefiting the environment). The measure by Asset4, *ENV_P* is scaled from 0% (eco-hostile) to 100% (eco-friendly). For instance, if a company is using natural resources effectively and environmentally friendly then it considers as a good performance. And, if a company is emitting more carbon and also polluting the water and other natural resources then it would be a bad performance. In this research, we use environmental pillar of Asset4 ESG as our main independent variable (*ENV_P*).

3.4 Econometric methodology

This study examines the association between bank's environmental performance and tail risk. To evaluate this relationship, we employ three different techniques those are commonly used in corporate finance literature (Boubaker et al., 2020; Cappa et al., 2020; among others). First, we test our result with pooled OLS regression and this OLS version also controls the temporal along with correctional variations. Next, we use cluster effect that adjusts the standard errors in regression for heteroscedasticity, cross-sectional and serial correlations using one-dimensional clustering at firm level (Petersen, 2009). Lastly, we employ random-effect model and this technique is considered very appropriate for panel data. Random effect controls the firm specific unobserved heterogeneity over time that is not addressed by simple OLS (Legesse and Guo, 2020).

To test our hypothesis, we use the following econometric model.

$$T\_RISK_{b,t} = \beta_0 + \beta_1 ENV\_P_{b,t} + \beta_2 B\_SIZE_{b,t} + \beta_3 B\_LEV_{b,t} + \beta_4 C\_FLOW_{b,t} + \beta_5 M\_CAP_{b,t} + \beta_6 Fixed\_Effects_{b,t} + \varepsilon_{b,t} \quad (6)$$

where *T_RISK* is the tail quantile for bank 'b' and time 't'. *ENV_P* is the environmental performance of a bank in the current year. Following the prior literature on tail risk (Adhikari and Agrawal, 2016; Diemont et al. 2016; among others), we also control the other bank characteristics that may affect the banks' tail risk. These bank level controls are bank size (*B_SIZE*), bank leverage (*B_LEV*), cash flow (*C_FLOW*) and market capitalization (*M_CAP*). We also control the year fixed effect in this model. For detailed definitions and data sources see Appendix 'A'.

4. Results and Discussion

4.1 Descriptive statistics and correlation

Table 1 explains the descriptive statistics of main dependent and explanatory variables. We find a big variation in the values of *tail quantile*, our main dependent variable, whose values range from 5.700 to 89.600 with a mean of 16.943 and median of 12.000. Similarly, we find a big variation in the values of *ENV_P*, which is our main explanatory variable. It ranges from 8.440 to 95.440 with a mean of 33.097 and median of 13.580. Our explanatory variable shows more disparities as it has a standard deviation of 31.560. Our other variables include natural logarithm of total assets (*B_SIZE*), return on total assets (*B_ROA*), leverage (*B_LEV*), cash flow (*C_FLOW*) and market capitalisation (*M_CAP*). We find the highest value of mean for *M_CAP*, followed by *B_SIZE*, *B_ROA*, *B_LEV* and *C_FLOW* with means of 1.601 billion, 14.543, 1.201, 0.074 and 0.013 respectively.

We find that the standard deviation the highest for our main explanatory variable (*B_ENV*), followed by our main dependent variable (*tail quantile*), which have double digit standard deviation. The other control variable such as *B_SIZE*, *RB_ROA*, *M_CAP*, *B_LEV* and *C_FLOW* have a single digit or below 1 standard deviation. The *B_LEV* and *B_FLOW* have the lowest standard deviation of 0.062 and 0.035 respectively.

[Insert Table 1 about here]

4.2 Baseline regressions

In unreported results, we check pairwise correlation coefficient among the explanatory variables. Most of the explanatory variables have very low or moderate correlation between each other eliminating any concerns of multicollinearity. The highest correlation is between *ENV_P* and *B_SIZE*, which is positive and significant. All but *C_FLOW* have statistically significant correlation with each other. The *C_FLOW* does not have any statistically significant correlation with any other variable. The *M_CAP* variable is found to be negatively correlated with the *tail quantile*, *ENV_P*, *B_SIZE* and *B_LEV* while it positive correlation with *B_ROA* and *B_FLOW*. Among these last two variables *M_CAP*'s correlation coefficient is only statistically significant with *B_ROA*. We also calculate variance inflation factor (VIF) to test for multicollinearity and find that most of the values are below 3 indicating ideal conditions with only one value higher than 3 which is also acceptable (Diemont et al., 2016). Table 2 provides main findings of our econometric model given in equation (6). In Table 2 our dependent variable is *tail quantile* as given in equation (3) in section 3.2 and we call it *T_RISK*. In column 1, we report results from the OLS regression with fixed effects to capture year heterogeneity. We find that our core explanatory variable (*ENV_P*) is negative and statistically significant at the 1% level of significance, indicating that the banks that score high in their environmental performance exhibit lower tail risk. This is an important result showing that the banks that are environment friendly are rewarded in the form of lower risk. This is contrast to Diemont et al. (2016) who do not find statistically significant results for US and Asian non-financial firms but find statistically positive results for European non-financial firms. However, our findings are in consistent with Shafer and Szado (2019) who find positive relationship between environmental performance and tail risk (measured via volatility smirk) of US non-financial firms. In column 2, we report results by clustering at the bank level and with year fixed effects. We find that the results are stronger economically but statistically significant at the 5% level of significance. Next we also use random effects to check the robustness of our results and we find that environmental performance (*ENV_P*) is negative and statistically significant at the 1% level of significance. With random effects, the results are the strongest of all the three core models shown in columns 1-3 of Table 2.

Moving to the control variables, we find that the signs of the coefficients of most of the control variables are intuitive and in line with the literature (Diemont et al., 2016; Shafer and Szado, 2019). We find that bigger banks are likely to have higher tail risk. This is in line with the argument of too-big-to-fail as regulators are not able to let big banks fail because of the fear of financial instability, these banks keep on building huge amount of risk (Farhi and Tirole, 2012; Dam and Koetter, 2012). Similarly, highly levered banks are likely to exhibit higher tail risk as well, which is intuitive as banks with excessive amount of debt will have higher risk. However, less profitable banks and banks with low market capitalisation carry higher tail risk. We only find in our random effects model that banks with higher net operating cash flow tend to increase the tail risk. This effect is not statistically different from zero in our baseline models. Our baseline model in column 1 also shows very high adjusted R^2 of 0.736 with very high F-stat of 72.16*** indicating good fit of the model. Overall, we can conclude that there is a strong negative effect of environment performance of banks on their tail risk.

[Insert Table 2 about here]

4.3 Alternative proxies

In Table 3, we use alternative proxies for the dependent and explanatory variable. Instead of using nuisance parameter m = 175 in Table 2, in Table 4 we use nuisance parameter m = 225 and we call our dependent variable as *T_RISK_A*. We provide results of our alternative proxy in column 1. We find that environmental performance (*ENV_P*) variable still holds its negative sign at 10% level of significance. All other control variables keep their sign, economic and statistical significance. In column 2, we use tail expected shortfall as given in equation 3 in section 3.2. As explained above tail quantile is not a coherent risk measure and is superior to VaR in terms of mathematical properties of continuity and sub-additivity (Artzner et al., 1999). Therefore, we use tail expected shortfall (T_ES) as an alternative proxy for the dependent variable. In order to be consistent with column 1, we use nuisance parameter m = 225 in this model as well. Similar to our results in column 1, our prime variable of interest (*ENV_P*) remains negative and statistically significant.

However, we do find some weakness in some of the control variables. In column 3 of Table 3, we use a more general proxy as an explanatory variable. We use environmental, social and governance (ESG) score of banks to check if it has similar impact on tail risk of banks. We keep all other control variables in this model as well and we find that all of the control variables retain their sign and they are economically and statistically significant.

[Insert Table 3 about here]

5. Robustness test and additional results

5.1 Instrumental variable analysis

Although we put all the necessary controls yet there might be some selection issue that a certain group of banks from within an industry who are less risky are involved in environmentally friendly policies because of peer pressure and hence do high in their environmental score (*ENV_P*). Therefore, to rule out any kind of selection issue we use instrumental variable analysis (IV) and we report results in Table 4. We use two instruments, which are average of bank environmental score over the year (*ENV_I*) and average of bank environmental score over the year that are headquartered in the same city (*ENV_H*). We hypothesize that banks from the same area and having headquarter in the same city are more likely to involve in environmentally friendly policies because of peer pressure, therefore they are likely to have positive impact on their environmental performance (*ENV_P*).

We report IV regressions in Table 4. We run IV regressions for our complete model in column 1 of Table 3. We use an OLS model to regress environmental performance (*ENV_P*) on the average of bank environmental score over the year (*ENV_I*) and average of bank environmental score over the year that are headquartered in the same city (*ENV_H*) and all other controls in the first stage and then we use the fitted values as an instrument in the second stage. First stage results are reported in column 1 of Table 4. Our selected instruments are positively related to the environmental performance (*ENV_P*) of banks as hypothesized above: that banks from the same area and having headquarter in the same city are more likely to involve in environmentally friendly policies because of peer pressure. The first stage Wald test also indicates that the instrument is valid. The 2^{nd} stage results in column 2 of Table 4 are larger in absolute value terms than our baseline estimates. Overall, our baseline results in Table 2 are robust that environmental performance of banks reduce tail risk of banks.

[Insert Table 4 about here]

5.2 Additional results

We produce four additional results to check if there are any differences in the impact of environmental performance (*ENV_P*) on tail quantile (*T_RISK*) of banks if we split the sample into higher and lower corporate governance score, greater than 5% and lower than 5% institutional ownership, existence and non-existence of CSR (Corporate Social Responsibility) committee and during and not during the financial crisis. We use our main dependent variable, tail quantile (*T_RISK*), in all the regressions. We define corporate governance dummy equal to 1 (*CG_D*=1) if bank Asset4 ESG corporate governance score is greater than mean in the current year, otherwise 0 (*CG_D*=0). We split the sample into two, i.e., when *CG_D*=1 and when *CG_D*=0 and we report these results in columns 1 and 2 of Table 5. We can see from column 1 that if banks score high in the corporate governance, they are likely to reduce tail risk of banks compared to the ones if they score lower in the corporate governance whose results are report in column 2. This shows that the banks that adopt environmentally friendly policies and they adhere better to the corporate governance guidelines as well. This is in contrast to Diemont et al. (2016) who find that governance performance and tail risk are unrelated for non-financial firms in the US but positives for these firms in Europe. Next, we study if institutional ownership of banks has any different impact of environmental performance (*ENV_P*) on tail risk of banks. We define *IO_D* =1 if institutional owners possess more than five percent of total market shares and 0 otherwise (*IO_D*=0). The results are given in column 3 if *IO_D* =1 and in column 4 if *IO_D* =0. We can see in column 3 that institutional ownership is more credible in terms of impact of environmental performance (*ENV_P*) on tail risk of banks as we only find negative and statistically significant results for banks for whom institutional owners possess more than five percent of total market shares. This is in contrast to Laeven and Levine (2009) who find that powerful owners of banks encourage banks to take more risk. We do not find any impact of *ENV_P* if institutional owners possess less than five percent of total market shares of a bank. This might be due to the reason that non-financial firms with environmental concerns get lower institutional ownership as shown by Chava (2014). Next, we also split the sample into two: first if there is existence of a CSR committee (*CSR_D*=1) in the banks and second if there is no existence of a CSR committee (*CSR_D*=0). The results are provided in columns 4 and 5 respectively. We find that the environmental performance (*ENV_P*) does not manifest itself in the form of reduction in tail risk of banks if there is a CSR committee in a bank. However, if there is no CSR committee, banks need to have higher environmental performance score (*ENV_P*) to be able to reduce their tail risk. Finally, we want to check if environmental performance (*ENV_P*) during the financial crisis has any bearing on the tail risk of banks. We devise a dummy equal to 1 (*FC_D*=1) for the year 2007 and 2008 and 0 otherwise (*FC_D*=0). We find that during the financial crisis environmental performance (*ENV_P*) has no impact on tail risk of banks. It may be due to the fact that risk of banks is very high during the crisis and they focus more about their commercial activities than environmental issues. However, we do find negative impact of environmental performance *ENV_P*) on the tail risk of banks during normal times. The results are reported in columns 7 and 8 of Table 5.

[Insert Table 5 about here]

6. Conclusion and policy implications

In this paper, we study whether the environmental performance (*ENV_P*) of banks have helped reduce the tail risk of banks, which has not been studied earlier. To address this question, we use multivariate extreme value theory and calculate tail quantile (*T_RISK*) as a measure of bank tail risk. Tail quantile is analogous to value at risk (VaR) but the tail version of VaR. We also calculate tail expected shortfall (*T_ES*) as a measure of tail risk. Environmental performance (*ENV_P*) is based on the attributes such as the effect of bank practices on land, water and air that benefit the environment. We find that environmental performance (*ENV_P*) of banks reduce tail risk of banks indicating that banks that have eco-friendly policies are rewarded with reduced tail risk. We find our results are robust by alternative proxies of changing the value of nuisance parameter *m* for calculation of tail quantile and by using tail expected shortfall (*T_ES*). Furthermore, our results are robust to broader measure of sustainable policies like ESG (Environment, Social and Governance) score. Finally, our findings are robust to endogeneity concerns. Our additional analyses show differing impact of environmental performance (*ENV_P*) on tail risk of banks whether banks do better in corporate governance score, whether banks have institutional ownership, whether there exists a CSR (Corporate Social Responsibility) committee and during the financial crisis.

Our paper has policy implications because it provides quantitative evidence to bankers about the importance of eco-friendly policies as eco-friendly banks are rewarded with a reduced tail risk. Furthermore, it also provides evidence to bank regulators and policy makers to formulate policies geared toward developing environmentally friendly banks. The results of our paper may encourage banks who refrain from eco-friendly policies to adopt such policies as it not only benefits them but it also benefit the general public in the form of cleaner world. Our paper also contributes toward providing knowledge to investors who can recognise the benefits of eco-friendly banks in the form of lower tail risk. The limitations of this study is that we focus on only one industry and we look at the tail risk of banking industry. The future research could focus on other industries like transport, electricity, oil and gas that are responsible for more carbon emissions and are considered to be not environmentally friendly. Furthermore, the future research can look at whether high environmental performance of banks can help them reduce their systemic risk.

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Table 1: Descriptive statistics

Variable	**Obs**	**Mean**	**Std**	**Min**	**Median**	**Max**
T_RISK	536	16.943	12.112	5.700	12.000	89.600
ENV_P	536	33.097	31.560	8.440	13.580	95.440
B_SIZE	536	14.543	1.932	11.150	14.224	18.572
B_ROA	536	1.201	0.825	-5.670	1.130	5.470
B_LEV	536	0.074	0.062	0.000	0.059	0.320
C_FLOW	536	0.013	0.035	-0.486	0.014	0.137
M_CAP	536	1.601	0.610	0.312	1.538	4.653

Table 2: Main findings

Variable	T_RISK	T_RISK	T_RISK
	OLS	**Cluster Effect**	**Random Effect**
	(1)	**(2)**	**(3)**
ENV_P	-0.042***	-0.058**	-0.059***
	(-2.91)	(-2.10)	(-3.00)
B_SIZE	1.250***	2.751***	2.751***
	(4.22)	(4.59)	(7.90)
B_ROA	-2.896***	-5.388***	-5.388***
	(-7.03)	(-4.22)	(-9.17)
B_LEV	3.999	18.502*	18.502**
	(0.74)	(1.68)	(2.34)
C_FLOW	4.081	32.722	32.722***
	(0.52)	(1.39)	(2.80)
M_CAP	-1.767***	-5.032***	-5.032***
	(-2.77)	(-5.31)	(-6.54)
Constant	4.531	-8.425	-8.425*
	(0.87)	(-1.21)	(-1.79)
Obs	536	536	536
Fixed Effects	Yes	Yes	Yes
Adj R2	0.736	0.383	
F-stat	72.16***	17.20***	
Number of Nid			126
Overall R^2			0.390
Chi^2			337.5***

The parameter estimates are standardized coefficients with t-stat in parentheses.
*, **, & *** indicate the significance at 10%, 5%, and 1 % level, respectively.

Table 3: Alternate proxies

Variable	**T_RISK_A** **(1)**	**T_ES** **(2)**	**T_RISK** **(3)**
ENV_P	-0.030*	-0.001**	
	(-1.66)	(-1.99)	
ESG			-0.028*
			(-1.68)
B_SIZE	1.209***	0.007	1.006***
	(3.30)	(1.20)	(3.24)
B_ROA	-1.859***	0.002	-2.824***
	(-3.35)	(0.20)	(-6.83)
B_LEV	1.512	-0.080	2.395
	(0.23)	(-0.75)	(0.44)
C_FLOW	-2.528	-0.312**	4.884
	(-0.27)	(-2.05)	(0.62)
M_CAP	-2.452***	-0.029**	-1.918***
	(-3.13)	(-2.28)	(-2.96)
Constant	8.726	0.159	9.248*
	(1.36)	(1.53)	(1.82)
Obs	531	485	536
Fixed Effects	Yes	Yes	Yes
Adj R^2	0.709	0.666	0.733
F-stat	62.58***	46.88***	71.11***

The parameter estimates are standardized coefficients with t-stat in parentheses.
*, **, & *** indicate the significance at 10%, 5%, and 1 % level, respectively.

Table 4: Two-stages least square

Variable	**1st stage (1)**	**2nd stage (2)**
ENV_P		-0.062***
		(-2.91)
B_SIZE	2.468***	2.799***
	(6.26)	(7.71)
B_ROA	-1.283**	-5.395***
	(-2.29)	(-9.23)
B_LEV	1.051	18.518**
	(0.15)	(2.36)
C_FLOW	2.274	32.670***
	(0.21)	(2.82)
M_CAP	2.599***	-5.029***
	(2.93)	(-6.58)
ENV_I	1.497**	
	(2.40)	
ENV_H	0.903***	
	(44.76)	
Constant	-68.021***	-8.988*
	(-3.99)	(-1.85)
Obs	536	536
Fixed Effects	Yes	Yes
Adj R2	0.918	
Centered R2		0.383
F-stat	303.01***	56.14***

The parameter estimates are standardized coefficients with t-stat in parentheses.
*, **, & *** indicate the significance at 10%, 5%, and 1 % level, respectively.

Table 5: Additional results

Variable	CG_D=1 (1)	CG_D=0 (2)	IT_D=1 (3)	IT_D=0 (4)	CSR_D=1 (5)	CSR_D=0 (6)	FC_D=1 (7)	FC_D=0 (8)
ENV_P	-0.045*	-0.010	-0.072***	0.016	0.005	-0.046***	0.013	-0.039***
	(-1.91)	(-0.66)	(-3.88)	(0.64)	(0.08)	(-2.92)	(0.15)	(-2.66)
B_SIZE	2.493***	0.423	1.877***	0.224	0.627	1.528***	1.376	1.211***
	(4.00)	(1.38)	(5.08)	(0.43)	(0.66)	(4.28)	(0.71)	(4.16)
B_ROA	-4.863***	-0.397	-3.656***	-0.945	-3.837***	-3.035***	-4.312***	-2.700***
	(-7.09)	(-0.74)	(-7.62)	(-1.10)	(-2.67)	(-6.72)	(-3.32)	(-5.91)
B_LEV	2.408	1.199	6.313	-6.996	16.019	0.781	33.470	0.133
	(0.25)	(0.20)	(0.89)	(-0.77)	(1.06)	(0.13)	(1.45)	(0.02)
C_FLOW	20.387	-5.280	-0.726	59.283**	11.540	3.260	79.492*	-1.112
	(0.67)	(-0.78)	(-0.09)	(2.41)	(0.32)	(0.40)	(1.73)	(-0.14)
M_CAP	-1.054	-2.381***	-1.838**	-2.264*	-1.540	-1.451**	-3.596	-1.397**
	(-0.90)	(-3.41)	(-2.31)	(-1.92)	(-0.85)	(-1.99)	(-1.27)	(-2.12)
Constant	-15.105	15.449***	-4.881	18.629**	11.050	0.715	-3.962	4.355
	(-1.42)	(2.85)	(-0.71)	(2.15)	(0.67)	(0.11)	(-0.13)	(0.86)
Obs	244	292	371	165	99	434	42	494
Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj R2	0.737	0.766	0.739	0.724	0.793	0.726	0.661	0.744
F-stat	33.39***	46.47***	50.81***	21.49***	18.84***	55.66***	12.42***	76.30***

The parameter estimates are standardized coefficients with t-stat in parentheses.
*, **, & *** indicate the significance at 10%, 5%, and 1 % level, respectively.

Appendix A: Variable definitions

Variable	Symbol	Definition	Source
Dependent			
Tail Risk	*T_RISK*	See section 3.3 Tail Risk Measure	CRSP
Core			
Environmental Performance	*ENV_P*	Bank environmental score from Asset4 ESG environmental dimension.	Asset4 ESG
Control			
Bank Size	*B_SIZE*	Natural logarithm of banks total assets.	Compustat
Bank Profitability	*B_ROA*	Net profit scaled by total assets.	Compustat
Bank Leverage	*B_LEV*	Total debt divided by total assets.	Compustat
Cash Flow	*C_FLOW*	Net operating cash flow to total assets.	Compustat
Market Capitalization	*M_CAP*	Market value scaled by divided by book value of bank.	CRSP, Compustat
Other			
Environmental, Social and Governance	*ESG*	Bank CSR score from Asset4 ESG.	Asset4 ESG
Industry environmental mean	*ENV_I*	Average of bank environmental score over the year.	Asset4 ESG
Headquarter environmental mean	*ENV_H*	Average of bank environmental score over the year headquarter in same city.	Asset4 ESG
Corporate Governance dummy	*CG_D*	Dummy is 1, if bank Asset4 ESG corporate governance score is greater than mean in current year.	Asset4 ESG
Institutional ownership dummy	*IO_D*	Dummy is 1, if institutional owners possess more than five percent of total market shares.	Compustat
CSR committee dummy	*CSR_D*	Dummy is 1, if bank holds the CSR committee.	Asset4 ESG
Financial crisis dummy	*FC_D*	Dummy is 1, if current year is 2007 and 2008.	Compustat