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THE INTRICACIES OF CLIMATE-RELATED RISKS ON EUROPEAN BANKS' ESTIMATION OF EXPECTED CREDIT LOSSES: LINKING PROPER ACCOUNTING OF CLIMATE RISKS TO SHAREHOLDER REQUIRED RETURNS

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Abstract

Global banks face a predicament amidst the dictates of IFRS9 accounting policies. Commencing in 2018, incurred losses plus expected losses are to be reported. Loss allowances on loans and advances should be set aside earlier and should therefore be higher than they would be pursuant to the impairment provisions of IAS39. This paper focused on a sample of the top 40 European banks by assets and assessed the transition from IAS39 to IFRS9 through panel data distinguishing credit risk allowances over distinct IAS39 and IFRS9 periods. Economic climate damage data was obtained from the European environmental agency website, and incurred losses as well as expected credit losses data was fetched from annual financial reports. A null hypothesis indicating that banks had lesser or equal IAS39 incurred losses than IFRS9 expected credit losses was tested and rejected. The relationship between economic damages and estimates of credit losses was investigated using a two-sample t-test and Pearson product-moment correlation. Results revealed that banks have been conservative in estimating credit losses since adopting IFRS9. Consequently, the paper contributes in revealing to banks the need to proactively account for climate damages in the wake of IFRS9. It prompts shareholders to incorporate economic climate-induced damages in risk/return decisions.

Keywords: Incurred Losses, Expected Credit Losses, Climate Economic Damages, IAS39, IFRS9

JEL Classifications: G01, G17, G21, G23, G28, G32, D81

1. Introduction

Investigating the accounting treatment of climatic risks by banks in relation to shareholders' interests makes sense for several reasons. Boros (2020) and Capasso *et al*. (2020) argued that the effects of climate risk shall be felt in the short term and that the implications could be drastic for financial markets since various assets could be repriced speedily. Elaborating on the aspect of time horizons, Rudebusch (2019) pointed out that climate impacts will have serious consequences even in the short term and this could be particularly true for financial markets, as the assets involved can be repriced quickly. There is compelling evidence that climate-related events such as hurricanes and droughts, that is, physical risks, already have a negative impact on both equity and debt instruments through lower payoffs and higher non-performing loans (Campiglio *et al*. 2019).

In addition, climate change poses a substantial aggregate risk to the economy and the financial system (Litterman, 2020). Referring to rising sea levels and the potential damages they may cause, Giglio *et a*l. (2021) posited that even though a significant number of damages might take place in the distant future, present-day real estate prices might already be significantly affected by climate risk. Using questions that are driving the reassessment of risk and asset values, Fink (2020) disclosed challenges facing banks and their shareholders. In summary, Fink (2020) questioned the ability of cities to afford their infrastructure in the potential impact to the 30-year mortgage in the event that lenders could not project the impact of climate risk in the long term. What would become of inflation and in turn interest rates in the event of a high rise in cost of food as a consequence of floods and droughts, probed Fink (2020). The attempt by some sectors to align to the 2-degree trajectories stipulated in the Paris agreement could bring about abrupt adjustments that may in turn engender the manifestation of larger financial losses to be borne by these sectors (Roncoroni *et al.* 2021).

In tandem with the risk of loss from climate-related events, the discourse on stranded assets is also taking prominence. Stranded assets are defined as assets that have suffered from unanticipated or premature write-downs, devaluations, or conversion to liabilities (Caldecott *et al.* 2013). In yet another argument, Caldecott *et al.* (2016) noted that natural capital, stranded assets culminating from climate-related risks, are prone to impact the cashflows of companies and the markets' perception of their financial soundness, which in turn impact the investment and lending portfolios of financial institutions. Hence, researchers such as Caldecott *et al.* (2016) went on to assert that climate-related risks are not adequately addressed or incorporated into financial accounting and analysis with reasons ranging from lack of training to difficulties in quantification. Others, such as Boros (2020) hinted that the task of accurately capturing climatic shocks and the identification of their macroeconomic channels is daunting for financial institutions.

This paper aims to investigate the extent to which banks incorporate climatic risks in their financial accounting and analysis. In particular, the extent to which expected credit losses (ECL) are arrived at considering the impact of climate risk on credit risk is investigated. It is argued that the inputs (direct or indirect) culminating in the determination of expected credit losses should be fully disclosed by banks to furnish existing and potential shareholders with adequate information leading to the determination of perceived risks. Even though shareholders and other stakeholders do not all perceive risks in the same way, nor do they have the same desired relationship between perceived risk and required return, the fundamental principle that investors will demand a return commensurate with the risk characteristics that they perceive in their investment (Bender and Ward, 2014) comes to the fore. Furthermore, underestimation of expected credit losses may lead to lower required returns by investors. Although Jacobs Jr. (2019) did not link climate-related risks to current expected losses, the suggestion to investors was to analyze the inputs leading to the expected losses quantification in order to make prudent investment decisions. However, we are of the view that Jacobs Jr.'s (2019) exhortation to investors can only be feasible if banks fully disclose the extent to which climate-related risks impact other risks such as credit risk. As a reflection, the subsequent impact of climate risks on macroeconomic factors such as inflation, unemployment, and gross domestic product (GDP), which are channels used to estimate probabilities of default, should not be opaque.

The layout of the paper is as follows: in Section 2, the literature review is presented, Section 3 provides data sources and methodology, Section 4 presents results, and Section 5 provides conclusions and recommendations.

2. Literature review

In the following subsections, climate risk as a source of credit risk, the nexus between climate risk and shareholders, the primacy of IFRS9 as a tool for aiding climate risks disclosures, and climate risks and the commensurate impact on macroeconomic variables are dealt with.

2.1. Climate risk as a source of credit risk

Researchers (Monnin, 2019; Capasso *et al*. 2020; Nehrebecka, 2021; Semieniuk *et al.* 2021) have shown that exposure to climate risks impacts the risk profiles of loans and bonds issued by companies negatively. Put differently, climate risks are a source of credit risk. It stands to reason that banks should precisely assess credit risk as underestimation may lead to substantial losses. Such losses may become systemic and engender financial instability (Monnin, 2019). Climate-related financial risks may show up as credit, market, or operational risks and may render the balance sheets of banks to be precarious with losses and volatility likely to damage funding liquidity and lending conditions (Oguntuase, 2020). However, whichever risk one considers (physical or transitional), there is a relationship with credit risk. To these challenges, Oguntuase (2020) concluded that the impact on companies' capital levels, profitability as well as liquidity could spawn increases in default rates of corporate loans that could induce instability in the banking system. Literature is already replete with the types of risks categorized as climate related. It is worth noting though that the resultant economic uncertainty and volatility in default risk have different impacts on Islamic banks, which are immune to changes in uncertainty, compared to conventional banks, which are prone to increases in default risk (Bilgin *et al*. 2021). Put differently, the leverage risk of conventional banks is more impacted while Islamic banks remain unaffected, indicating the insignificance in default risk in Islamic banks when faced with economic uncertainties. Restrictions on Islamic banks can limit risk-taking and that is part of the reasons that led Dibooglu *et al.* (2022) to establish higher default risk measures for Islamic banks than conventional banks in general. Resultantly, this study focuses on conventional banks which are affected significantly by uncertainties brought about by such phenomena as climate-related damages.

Grippa *et al*. (2019) explained the potential of physical risk through rising sea levels and higher incidents of extreme weather events to homeowners by emphasizing that mortgage defaulters and diminished property values are unavoidable. According to Monnin (2019), physical costs can manifest through channels such as reduced revenue from decreased production caused by either acute or chronic hazards. Furthermore, according to Monnin (2019), climate-related hazards are considered acute when they arise from extreme climate events such as droughts, floods, and storms; they are chronic when they arise from progressive shifts in climate patterns such as increasing temperatures.

Another identifiable risk pertains to transition risk, which can spawn transition costs that can be defined as the costs of economic dislocation and financial losses associated with the process of adjusting toward a low-carbon economy (Campiglio *et al*. 2019). To Carbone *et al.* (2022) account, companies that fail to address transition risks now and into the future may face tougher government policies that are designed to drive them toward low carbon emissions. In part, government policies can trigger increases in financing costs in the wake of changing market sentiments, all of which exacerbate companies' credit risk.

Much influenced by the need to identify non-financial enterprises to transition climate risks as well as to conduct stress tests related to climate change, Nehrebecka (2021) identified credit risk related to lower profitability of high-carbon entities and higher household expenditures as one of the channels by which effects in scenario assessing the impact of transition risks could be transferred to the banking sector.

Worth noting is the fact that transition risks such as climate change mitigation policy (policy seeking to internalize the carbon externality is a key driver of risks), technological change (it can contribute substantially to price changes even without any new policy changes), and change in consumer preferences (buyers' preferences can drive demand and prices) increase the likelihood of default on debt (Semieniuk *et al.* 2021). It would seem therefore that a common contention in the nexus between climate and credit risks is the impact on bank profitability.

2.2. The nexus between climate risk and shareholders

It would appear likely that defaults and diminished asset values weaken the bank's balance sheet, reduce profitability, and ultimately compromise the returns that are due to shareholders. Banks create value for shareholders through the way they configure their assets and liabilities as well as the manner in which they handle the associated risks, including credit risk (Calomiris and Nissim, 2014). Essentially, the exposure of bank assets to credit and other risks implies the potential for large, possibly abrupt losses (Bogdanova *et al.* 2018).

Resultantly, accounting for expected credit losses in a forward-looking manner is critical in the banking sector today to avoid the reactive improper treatment of credit losses which was partly to blame for the great recession. Bogdanova *et al*. (2018) also posited that investors seem to value attempts by banks to address asset quality in a proactive fashion. However, if it is as Campiglio *et al*. (2019); Giglio *et al.* (2021); Boros (2020); and Capasso *et al*. (2020) suggested that climatic risks are already with us, attempts to fully disclose the potential impact of climate risks through expected credit losses should be non-negotiable. Realizing the pertinence of full disclosure, Bushman and Williams (2015) contended that reductions in transparency could induce greater investor uncertainty about banks' intrinsic value, weaken market discipline over risk-taking behavior, and mask banks' efforts to suppress negative information that will be revealed in future periods.

A fundamental consequence of not adequately incorporating climate risks in expected credit losses is that shareholders stand to suffer substantial losses. The opaque nature of the fusion between climate risks and expected credit losses may imply the non-factoring of such risks in determining the required rate of returns (RoRs). Campiglio *et al*. (2019) noted that several empirical studies point to investors' lack of awareness about future climate costs, which supports the concerns that financial markets currently do not adequately price in climate financial risks. In illustration of this basic premise, Figure 1 is used.

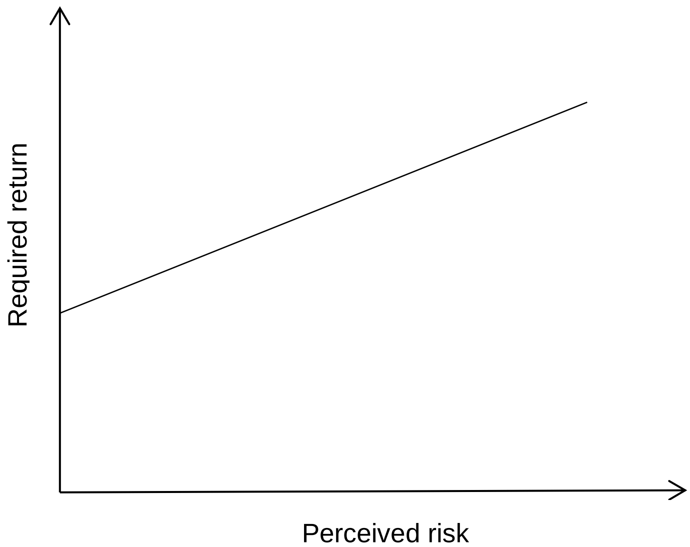

Figure 1. Value creation as a function of required return and perceived risk

It can be seen from Figure 1 that as shareholders perceive increasing risk, they demand higher returns. Hence if the expected credit risk that comes about as a result of climate-induced events is not incorporated or disclosed fully, shareholders are compromised. Hence, bank transparency, defined by Bushman and Williams (2015) as the availability of bank-specific information to those outside of the bank, which includes depositors, investors, borrowers, counterparties, regulators, policymakers, and competitors, is non-negotiable.

When taken to its logical conclusion, the financial crisis of 2007-2009 was exacerbated by accounting failures which manifested through the untimely information about banks' credit losses (Sánchez Serrano, 2018; Gornjak, 2020; Dong and Oberson, 2021). Therefore, it is apparent that to achieve financial stability and shareholder value creation and protection, banks need to properly account for expected credit losses. In this context, proper accounting does not only point to incorporating climate-related risks, both physical and transitional, but it also embraces the high ethical code of disclosure. In tandem with the discourse on proper accounting, disclosure, in turn, means informing shareholders and other stakeholders of the extent to which climate risks impact credit risks directly or indirectly through other channels such as unemployment, gross domestic product, and interest rates. Seemingly, in the period of COVID-19, banks have been able to estimate the potential impact of the pandemic on credit risk via macroeconomic factors such as those just mentioned. It is in the same breath that the issue of climate-related risks should be treated.

2.3. The primacy of IFRS9 as a tool for aiding climate risks disclosures

In response to the drawback caused by financial accounting failures leading to the financial crisis, the International Accounting Standards Board (IASB) published International Financial Reporting Standard (IFRS9) in 2014, which includes an expected credit loss (ECL) model for the impairment of financial assets (Covas and Nelson, 2018; Gornjak, 2020; Schutte *et al.* 2020; Dong and Oberson, 2021). Effective from the first fiscal quarter of 2018, IFRS9 ECL replaced the International Accounting Standard (IAS) 39 incurred loss (IL) model with the objective of recognizing credit losses earlier (Monnin, 2019).

The challenge with the incurred loss model was that it precluded banks from provisioning appropriately for credit losses likely to arise from emerging risks culminating in recognition of credit losses that were widely regarded as too little, too late (Edwards, 2014). The ultimate delay in recognizing credit losses is toxic in that it is associated with significantly higher co-dependence between the downside risk of individual banks and the downside risk of the banking sector (Bushman and Williams, 2015). Fortunately, IFRS9 introduced the new, more principle-based classification and measurement of financial instruments, the forward-looking expected loss impairment model of financial assets better aligned to risk management activities (Groff and Mörec, 2021). The expected loss provides a measure of the value of the credit losses that a bank may reasonably expect to incur on its portfolio.

In an Advanced Internal Rating Based (AIRB) Approach, in its basic form, the *expected loss* (EL) can be represented as in Equation (1).

$$EL = PD * EAD * LGD, \tag{1}$$

where PD is the *probability of default* that can be counterparty's probability of default that measures a counterparty's creditworthiness in terms of likelihood to go into default, while EAD is the *exposure at default* which is the counterparty's exposure at default. It is intended to estimate the outstanding amount or obligation at the moment of default in the future. LGD is the *loss given default*, which is intended to estimate the amount a bank will lose when liquidating collateral pledged in association with a given loan or financial obligation.

As for the stages in allocating expected credit losses under IFRS 9, Sánchez Serrano (2018) provided clarity on guidelines to be adopted by banks as depicted in three stages in Table 1. In stage 1, if credit risk has not increased significantly since origination, an entity shall recognize a loss allowance at an amount equal to 12-month expected credit losses. This amount should reflect the estimated lifetime losses derived from events that are possible to occur in the 12 months following the reporting date. Interest revenues are accrued over the gross carrying amount of the exposure. In stage 2, if credit risk has significantly increased and the exposure is still not defaulted, an entity shall recognize a loss allowance at an amount equal to lifetime expected credit losses. This amount should consider losses from default events which are possible over the life of the exposure until its maturity. Interest revenues are accrued over the gross carrying amount of the exposure. In stage 3, if an exposure is identified as credit-impaired since a default event has already occurred, an entity shall recognize a loss allowance for an amount equal to full lifetime expected credit losses. This stage is equivalent, in broad terms, to the impaired assets under the incurred loss model in IAS 39. Interest revenues are accrued over the (net) carrying amount, which is the difference between the gross carrying amount and the loss allowance) of the exposure. Table 1 depicts the three (3) stages.

Table 1. Three-stage approach in the expected credit loss approach of IFRS 9

Stage 1	Stage 2	Stage 3
Unchanged credit risk	Significant increase in credit risk	Credit impaired (incurred losses)
12-month expected credit losses	Lifetime expected credit losses	Lifetime expected losses
Interest accrued on gross carrying amount	Interest accrued on gross carrying amount	Interest accrued on net carrying amount

Source: Sánchez Serrano (2018)

As can be deduced from stages 1 to 3, estimated losses are derived from events that are either possible to occur or have occurred. Based on the literature reviewed, it is clear that climate events should be part of events that are either possible to occur or have occurred and, therefore, should be a key component in influencing macroeconomic conditions. It is important, first, to note the various time horizons catered for by IFRS9 in the estimation of credit losses. Stage 1 effectively deals with the short-term horizon by calling for estimations based on one month period even if no significant increase in credit risk has occurred. Stages 2 and 3 are long-term based as they relate to lifetime expected credit losses. While stage 2 purports to incorporate events leading to significant increases in credit risk even without registered defaults, stage 3 implies embracing lifetime expected losses where default events have been recorded.

For the estimation of expected credit losses, IFRS9 requires banks to use a broad range of relevant information, including forward-looking macroeconomic variables. To implement these requirements, banks typically consider several macroeconomic scenarios weighted in terms of their probabilities (Sánchez Serrano, 2018). When calculating expected credit losses, IFRS9 calls for the use of reasonable and supportable information that is available and relevant at the reporting date, including information about past events, current conditions, and forecast of future economic conditions (Vaněk and Hampel, 2017; Sánchez Serrano, 2018; Gornjak, 2020).

2.4. Climate risks and the commensurate impact on macroeconomic variables

The forward-looking element of the ECL model does therefore require considerable modeling efforts and management judgment as to how macroeconomic conditions affect provision (Frykström and Li, 2018). The aforementioned statement by Frykström and Li (2018) illustrates the obligation placed on bank management to ensure proper judgment is made with regard to the impact of climate risks on macroeconomic variables. Referring to the aspect of climate change modeling, Kompas *et al*. (2018) argued that the known future effect of global warming should be included in forward-looking forecasts for prices and profitability.

Worth noting is the observation by Batten (2018) that climatic factors can directly affect economic outcomes such as output, investment, and productivity, and understanding the economic consequences of climate change is becoming a necessity not just for climate economists but also for a wider range of economic professionals involved in modeling and forecasting of macroeconomic variables. Kahn *et al.* (2019) examined the impact of climate change on macroeconomic variables and provided evidence using data from a sample of 48 U.S. states between 1963 and 2016 and showed that climate change has a long-lasting adverse impact on real output in various states and economic sectors, including labor productivity and employment. More significantly, the analysis suggested that a persistent increase in average global temperature by 0.04°C per year, in the absence of mitigation policies, reduces world real GDP per capita by 7.22% by 2100 (Kahn *et al.* 2019).

It is argued in this paper that in reporting quantifiable estimates of expected credit losses, banks should reveal how they foresee climate risks to impact macroeconomic variables, which they use to assess expected credit losses in stages 1, 2, or 3 as provided by IFRS9. The following paragraph by Batten *et al.* (2020, p.13) runs parallel to the idea of the suggested manner in which banks should capture their reporting in order to remove opaqueness in credit losses estimates where climate risks are contributors: "climate change can affect the macroeconomy both through gradual warming and the associated climate changes (for example total seasonal rainfall and sea level increased) and through increased frequency, severity and correlation of extreme weather events (physical risks)".

Inflationary pressures might arise from a decline in the national and international supply of commodities or from productivity shocks caused by weather-related events such as droughts, floods, storms, and sea level rises. These events can potentially result in large financial losses, lower wealth, and lower GDP. As a final reflection, there is no excuse for not including climate-based risks in expected credit loss estimations nor adequately disclosing the potential impacts on macroeconomic variables that are then used for the estimations. However, accounting maneuvers dictate that the more expected credit losses are estimated, the more the negative impact on bank profitability. Moreover, banks should hold a reserve (as part of their capital base) to cover the expected losses in their credit portfolios. Although capital reserve requirements are an important safeguard, they also directly undermine a bank's efforts to maximize income (Willi III, 2020).

Due to scenarios mentioned above we were prompted to hypothesize that for given comparative periods, the average credit losses under the incurred loss model based on IAS39 could be greater than the average expected credit losses under IFRS9. Resultantly this paper seeks to establish the level and extent to which banks have been going about divulging the impact of climate change on expected credit losses directly or indirectly through macroeconomic variables. The following section describes the data sources and methodology used.

3. Data and methodology

3.1. Data sources

Panel data from Europe's top 40 banks by assets in the form of expected credit losses (2018-2020) and incurred losses covering the period 2015-2017 were collected. Hence a non-probability approach was undertaken. Data was collected from the banks' annual reports found on their websites. Specifically, expected credit losses and incurred losses were drawn from credit risk management reports and notes on consolidated financial positions.

In order to verify the extent to which climatic disasters have been incorporated in determining incurred losses and expected credit losses, data from the European environmental agency website was utilized. The provided data relates to annual economic damage in monetary terms caused by weather and climate-related extreme events in the EU member states. Specifically, data relating to the period 2015-2020 was collected.

3.2. Methodology

3.2.1. The two-sample t-test

Using Microsoft Excel (version 16.16.27, 201012, volume license 2016), spreadsheets, the aggregate of the incurred losses and expected losses were computed. The means of the two (2) data sets were then computed. The two-sample t-test which is used to compare the means of two samples to see if the difference is unusual and allow for the inference that the samples are not drawn from the same population was employed. Ideally, according to Jankowski *et al*. (2018): (1)

the data used to calculate the t-test must be on at least an interval scale, (2) the measurement should provide data that range across at least 11 values, and (3) the data must be free from extreme values, also known as outliers. Comparisons in terms of the sizes in value were undertaken. To minimize the risk of wrongly rejecting H_0, that is the probability of committing a Type 1 error, α, we denoted α as the significance level and used it as an indication of the maximum risk that is willing to be taken in rejecting a true null hypothesis. An α of 0.05 was taken as the significance level. The null hypothesis tested by the two-sample t-test is that the population mean of incurred losses under IAS39 is lesser or equal to that under IAFRS9.

The null hypothesis is $H_0\ \mu IAS39 \leq\ \mu IFRS9$, whereas the alternative hypothesis is $H_{1:}\ \mu IAS39 > \mu IFRS9$, where $\mu IAS39$ refers to the mean of incurred losses under the IAS39 accounting regime and $\mu IFRS9$ refers to the mean of expected credit losses under the IFRS9 framework. This followed an assumption that the sample data was drawn from a normally distributed population. The critical value that separated the rejection and acceptance regions was computed. The test statistic and the probability of obtaining the test statistic (the p-value) were then computed to assess the strength of the evidence against the null hypothesis.

3.2.2. Pearson product-moment correlation

In order to determine the impact of climate damages on incurred and expected losses, the process used was anchored on the ideas of Kompas *et al.* (2018), who argued that the known future effect of global warming should be included in forward-looking forecasts for prices and profitability. Hence data was used to establish the nature of relationships between climate disasters and incurred/expected credit losses. Pearson product-moment correlation was employed. It ranges from -1 (a perfect positive linear relationship through 0 (no linear relationship) to +1 (a perfect positive linear relationship). Due to its imprecise description, the proportion of variance was further established.

The reaction by banks in instituting incurred losses and expected losses were observed based on the quantum of economic damage caused by weather and climate-related extreme events. The means of reactionary periods 2015-2017 for incurred losses and 2018-2020 were used to indicate bank reactions in their calculations of incurred losses as well as expected credit losses.

3.3. Homoscedasticity

Finally, in order to test the principle of homoscedasticity, that is to analyze if the standard error of estimate s_{esty} will accurately estimate the error in prediction, a scatter plot of average economic damages and of incurred/expected credit losses was plotted. The linearity assumption can best be tested with scatter plots. The scatter plot is a good way to check whether the data are homoscedastic, meaning the residuals are equal across the regression line (Sureiman and Mangera, 2020).

4. Results

4.1. The two-sample t-test

In order to determine whether the means of losses in the two groups (IAS39 losses and IFRS9 losses) are significantly different, the two-sample t-test was employed. Due to the provision of estimates of the same variance reflected in sample size standard deviation, we utilized pooled variance estimates based on the t-value, number of degrees of freedom, and two-tailed probability. Table 2 reports the results.

Table 2. IAS39 losses against IFRS9 expected credit losses: two-sample t-test

Independent samples Group 1: IAS39 t-test for losses		Group 2: IFRS9				
	Number of cases	**Mean**	**Standard deviation**	**Standard error**	**p-value**	**r**
Group 1	120	6076	5836	533	0.0255	0.8578
Group 2	120	5524	5679	518		
		Pooled Variance Estimate				
F Value	**2-tail p-value**	**t-value**	**Df**	**2-tail p value**	**Std dev**	
0,76780	0.924	0.74403	238	0,05	5758	

The two-sample t-test assumes that the variances of the two (2) groups in the population are the same. In this case neither sample standard deviation is more than twice the other. Hence we looked at t-value, number of degrees of freedom and two-tailed probability under the pooled variance estimate.

The F-test for equality of variances involves forming the ratio of two sample variances and is based on the F-distribution. The F-value of 0.76 is close to unity which implies that the sample variances are almost similar. The larger the F-value, the more dissimilar are the sample variances. However, the F-value is not significant at 0.924, hence the pooled variance estimates results are applicable. Considering that our hypothesis is directional our p-value is significant at 0.025, hence the null hypothesis that the mean obtained from incurred losses is lesser or equal to the mean of expected losses under IFRS9, can be rejected in support of the alternative hypothesis.

4.2. Climate-induced economic damages compared to incurred and expected credit losses

For the analysis of the impact of climate-related economic damages to losses, a distinction was made between IAS39 economic losses and IFRS9 expected losses. The computation of the results is provided in Table 3.

Table 3. Climate-induced economic damages and incurred/expected credit losses

Year	Quantum of economic damage (Euro, billions)	Incurred losses IAS39 (Euro, billions)	IAS39 Incurred losses as a % of quantum economic damage	Expected losses IFRS9 (Euro, billions)	IFRS9 ECL as a % of Quantum Economic Damage
2014	11,690				
2015	9,973	6,562	56%		
2016	9,606	6,183	62%		
2017	27,872	5,483	57%		
2018	22,068			5,322	19%
2019	18,852			5,206	24%
2020				6,041	32%

The first piece of information to note from the outputs in Table 3 is that between 2015-2017 that is the period characterized by the IAS39 policy framework of using incurred losses for credit risk allowances, the quantum of economic damages caused by extreme climate conditions was much lower than those witnessed between 2018-2020. However, it is equally important to note that during the deployment of IAS39 accounting policies, the incurred losses as percentages were much higher than the expected credit loss percentages despite more climate economic damages witnessed in the period 2018-2020. Assuming that all measures of expected credit losses are based on the model ($PD * EAD * LGD$), whereby macroeconomic variables such as GDP, inflation, and unemployment are considered, it, therefore, seems that the onset of IFRS9 has brought about a conservative approach in the manner in which banks predict these variables. Clearly, with the quantum of economic damages caused by extreme climate conditions, more impact on variables GDP and unemployment, which are inputs to the model ($PD * EAD * LGD$), should be observed in the resultant expected credit losses. Instead, it appears as if more economic damages lead to more conservatism in the calculation of expected credit losses.

4.3. Correlation results

We utilized correlation results to help us to uncover and to assess relationships between economic damages and expected losses. These results are appropriate in distinguishing between the existence, direction and strength of a relationship. The importance of the accompanying measure of association is indicated with a significant test. A clearer picture of the relationship between economic damages and bank incurred/expected losses is illustrated in Table 4.

Table 4. Correlation analysis between economic damages and bank incurred/expected losses

r	-0.60
df	4
T	-1.50215
p-value	0.05
R-squared	0.36

A Pearson correlation of -0.60 suggests a negative but moderate association between the quantum of economic damage and the incurred and expected losses. In order to transcend this somewhat imprecise description, the calculated proportion of variance r-squared in incurred and expected losses that is explained by the quantum of weather and climate damages is 0.36. Therefore, only 36% of the variance in losses is explained by the variation in the quantum of economic damage caused by extreme climate conditions. The results are significant at 5%.

4.4. Applying the principle of homoscedasticity

Homoscedasticity assumes that the variability of expected loss values around the regression line is the same for different values of economic damages. Figure 2 is a depiction of the scatter plot of these two variables.

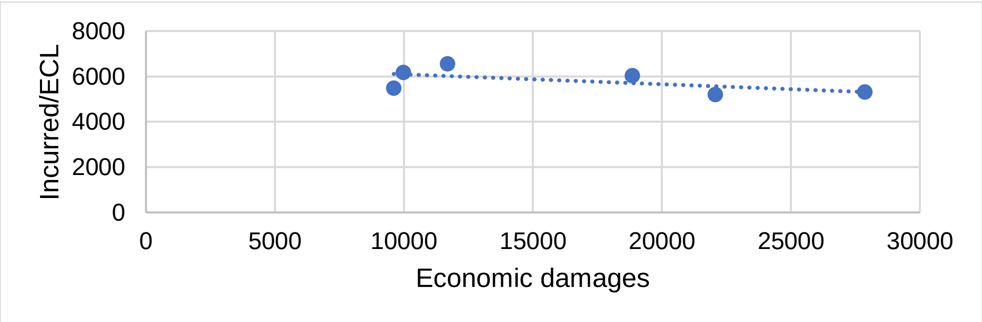

Figure 2. The variability in expected losses for values of economic damages

Since the standard error of estimate assumes that the variability of Y values around the regression line is the same for different X values, the principle of homoscedasticity is met and therefore the standard error of estimate, $s_{esty,}$ will accurately estimate the error in prediction.

These aforementioned results bring to the fore the issue of using reasonable and supportable information that is available to banks at the time of reporting their financial results (Vaněk and Hampel, 2017; Sánchez Serrano, 2018; Gornjak, 2020). If expected credit losses incorporate economic damages caused by climatic changes and include incurred losses, then more losses should be experienced under IFRS9, all else being equal. Information incorporating past events such as climate-induced economic damages, current conditions, and subsequent forecasts of future economic conditions linked to the immediate past should be considered reasonable and supportable. It would seem, therefore, from the results that there is still a gap in ensuring proper judgment is made with regard to the impact of climate risks on macroeconomic variables. The call by Frykström and Li (2018) for a forward-looking element of the ECL model to consider modeling efforts and management judgment as to how macroeconomic conditions affect provisioning needs to be fully heeded. Considering how climate risks have a long-lasting adverse impact on real output, labor productivity, and unemployment (Kahn *et al.* 2019), provisions incorporating incurred losses, expected losses, and climate-induced risks should reflect this long-lasting adverse impact through increased sizes of ECL. However, the results also highlight the observation by Willi III (2020) that although capital reserve requirements associated with ECL are an important safeguard, they also directly undermine a bank's efforts to maximize income. Therefore the trade-offs between ECL and profitability may be central to the seemingly conservative approach under IFRS9.

5. Conclusion

Even though the rejection of the null hypothesis that the mean obtained from incurred losses is less or equal to the mean of expected losses under IFRS9 in support of the alternative hypothesis, $\mu IAS39 > \mu IFRS9$, is statistically significant, it points to conservatism in estimating expected credit losses considering that IFRS9 encompasses both the incurred and expected losses.

It would seem that expertise in assessing the impact of climate-related damages on macroeconomic variables used by banks to predict expected credit losses needs to be enhanced from the current levels. This conclusion emanates from the fact that the relationship between climate-induced economic damages and expected credit losses is significantly negative, even though the strength is moderate. However, accounting for expected credit losses in a forward-looking manner is critical in the banking sector today to avoid the reactive improper treatment of credit losses, which was partly to blame for the great recession. Even the proactive treatment of credit losses still needs to be properly executed to avoid similar losses of magnitudes such as those witnessed during the great recession. Hence, Bogdanova *et al.* (2018) posited that investors seem to value attempts by banks to address asset quality in a proactive fashion. It appears that banks are aware of the fact that the higher the estimated expected credit loss allowances, the lower the profitability, as earnings are negatively impacted. Furthermore, banks should hold a reserve (as part of their capital base) to cover the expected losses in their credit portfolios - hence, a conservative approach in the estimation. The substantive significance lies in this conservative approach's challenge: it becomes difficult for investors, particularly shareholders, to perceive the degree of risk associated with their investments. This anomaly may trigger scenarios in which shareholders may underestimate the overall risks actually faced by banks in the wake of climate-related damages to the economy and may require returns that are not commensurate with the actual risks.

It, therefore, behooves bank executives to avail more resources to improve the levels of competence in incorporating the forward-looking element of the ECL model. The model requires considerable modeling efforts and management judgment, especially in the midst of economic damages caused by extreme climate conditions. Despite the subsequent transparency in financial statements, the perception of risk by shareholders can improve, leading to shareholder value sustainability.

References

Batten, S., 2018. *Climate change and the macro-economy: a critical review*. Working Paper No. 706, London: Bank of England. https://doi.org/10.2139/ssrn.3104554

Batten, S., Sowerbutts, R., and Tanaka, M., 2020. Climate change: macroeconomic impact and Implications for monetary policy. In: T. Walker, D. Gramlich, M. Bitar, and P. Fardnia, eds. 2020. *Ecological, societal, and technological risks and the financial sector*. Cham: Springer International Publishing, pp.13-38. https://doi.org/10.1007/978-3-030-38858-4_2

Bender, R. and Ward, K., 2014. *Corporate financial strategy*. 2nd ed. Oxford: Butterworth-Heinemann.

Bilgin, M.H., Danisman, G. O., Demir, E., and Tarazi, A., 2021. Economic uncertainty and bank stability: conventional vs. Islamic banking. *Journal of Financial Stability*, 56, p. 100911. https://doi.org/10.1016/j.jfs.2021.100911

Bogdanova, B., Fender, I., and Takáts, E., 2018. The ABCs of bank PBRs: what drives bank price-to-book ratios? *BIS Quarterly Review*.

Boros, E., 2020. Risks of climate change and credit institution stress tests. *Financial and Economic Review*, 19(4), pp. 107-131. https://doi.org/10.33893/FER.19.4.107131

Bushman, R. M. and Williams, C. D., 2015. Delayed expected loss recognition and the risk profile of banks. *Journal of Accounting Research*, 53(3), pp. 511-553. https://doi.org/10.1111/1475-679X.12079

Caldecott, B., Elizabeth, H., Cojoianu, T., Kok, I., and Pfeiffer, A., 2016. *Stranded assets: a climate risk challenge*. Washington, D.C.: Inter-American Development Bank. https://doi.org/10.18235/0000517

Caldecott, B., Howarth, N., and McSharry, P., 2013. *Stranded assets in agriculture: protecting value from environment-related risks*. Oxford: Smith School of Enterprise and the Environment. University of Oxford.

Calomiris, C. W. and Nissim, D., 2014. Crisis-related shifts in the market valuation of banking activities. *Journal of Financial Intermediation*, 23(3), pp. 400-435. https://doi.org/10.1016/j.jfi.2014.05.002

Campiglio, E., Monnin, P., and von Jagow, A., 2019. *Climate risks in financial assets*. CEP Discussion Note No. 2019/2. Zurich: Council on Economic Policies.

Capasso, G., Gianfrate, G., and Spinelli, M., 2020. Climate change and credit risk. *Journal of Cleaner Production*, 266, p.121634. https://doi.org/10.1016/j.jclepro.2020.121634

Carbone, M., Guizio, S., Kapadia, J. S., Kramer, K. N., and Vozian, K., 2022. *The low-carbon transition, climate commitments and firm credit risk*. Working Paper No. 2631, Frankfurt am Main: European Central Bank. https://doi.org/10.2139/ssrn.3991358

Covas, F. and Nelson, W., 2018. *Current expected credit loss: lessons from 2007-2009*. Staff Working Paper No. 2018-1. Washington, D.C.: Bank Policy Institute. https://doi.org/10.2139/ssrn.3215559

Dibooglu, S., Cevik, E. I., and Al Tamimi, H. A. H., 2022. Credit default risk in Islamic and conventional banks: evidence from a GARCH option pricing model. *Economic Analysis and Policy*, 75, pp.396-411. https://doi.org/10.1016/j.eap.2022.06.006

Dong, M. and Oberson, R., 2021. Moving toward the expected credit loss model under IFRS 9: capital transitional arrangement and bank systematic risk. *Accounting and Business Research*, 52(6), pp. 1-39. https://doi.org/10.1080/00014788.2021.1952060

Edwards, G. A., 2014. Upcoming new era of expected loss provisioning. *SEACEN Financial Stability Journal*, 2, pp. 13-24.

Fink, L., 2020. *A fundamental reshaping of finance*. Larry Fink's 2022 letter to CEOs. [online] Available at: <https://www.blackrock.com/corporate/investor-relations/2020-larry-fink-ceo-letter> [Accessed on 28 October 2022].

Frykström, N. and Li, J., 2018. IFRS 9 - the new accounting standard for credit loss recognition. *Econometric Commentaries*, 3, pp. 1-3.

Giglio, S., Kelly, B., and Stroebel, J., 2021. Climate finance. *Annual Review of Financial Economics*, 13(1), pp. 15-36. https://doi.org/10.1146/annurev-financial-102620-103311
Gornjak, M., 2020. Literature review of IFRS 9 and its key parameters. *Management*, 20, p. 22.
Grippa, P., Schmittmann, J., and Suntheim, F., 2019. Climate change, central banks and financial risk. *Finance & Development,* pp. 26-29.
Groff, M. Z. and Mörec, B., 2021. IFRS 9 transition effect on equity in a post bank recovery environment: the case of Slovenia. *Economic Research-Ekonomska Istraživanja*, 34(1), pp. 670-686. https://doi.org/10.1080/1331677X.2020.1804425
Jacobs Jr., M., 2019. An analysis of the impact of modeling assumptions in the Current Expected Credit Loss (CECL) framework on the provisioning for credit loss. *The Journal of Risk and Control*, 6(1), pp. 65-114.
Jankowski, K. R., Flannelly, K. J. and Flannelly, L. T., 2018. The t-test: An influential inferential tool in chaplaincy and other healthcare research. *Journal of Health Care Chaplaincy*, 24(1), pp. 30-39. https://doi.org/10.1080/08854726.2017.1335050
Kahn, M. E., Mohaddes, K., Ng, R. N. C., Pesaran, M. H., Raissi, M., and Yang, J.-C., 2019. *Long-term macroeconomic effects of climate change: a cross-country analysis*. Working Paper No. 19/215, Washington, D.C.: International Monetary Fund. https://doi.org/10.5089/9781513514598.001
Kompas, T., Pham, V. H. and Che, T. N., 2018. The effects of climate change on GDP by country and the global economic gains from complying with the Paris climate accord. *Earth's Future,* 6(8), pp. 1153-1173. https://doi.org/10.1029/2018EF000922
Litterman, B., 2020. Managing climate risk in the U.S. financial system. *Commodity Futures Trading Commission*. [online] Available at: < https://www.cftc.gov/sites/default/files/2020-09/9-9-20%20Report%20of%20the%20Subcommittee%20on%20Climate-Related%20Market%20Risk%20-%20Managing%20Climate%20Risk%20in%20the%20U.S.%20Financial%20System%20for%20posting.pdf> [Accessed on 22 October 2022].
Monnin, P., 2019. *Integrating climate risks into credit risk assessment - current methodologies and the case of central banks corporate bond purchases*. Discussion Note 2018/4, Zurich: Council on Economic Policies. https://doi.org/10.2139/ssrn.3350918
Nehrebecka, N., 2021. Climate risk with particular emphasis on the relationship with credit-risk assessment: what we learn from Poland. *Energies*, 14(23), p. 8070. https://doi.org/10.3390/en14238070
Oguntuase, O. J., 2020. Climate change, credit risk and financial stability. In: R. Haron, Md. H., Maizaitulaidawati, and M., Murg, eds. 2020. *Banking and finance*. Rijeka: IntechOpen, pp. 75-91.
Roncoroni, A., Battiston, S., Escobar-Farfán, L. O., and Martinez-Jaramillo, S., 2021. Climate risk and financial stability in the network of banks and investment funds. *Journal of Financial Stability*, 54, p.100870. https://doi.org/10.1016/j.jfs.2021.100870
Rudebusch, G. D., 2019. Climate change and the Federal Reserve. *FRBSF Economic Letter*, 9.
Sánchez Serrano, A., 2018. Financial stability consequences of the expected credit loss model in IFRS 9. *Financial Stability Review*, 34, pp. 77-95.
Schutte, W. D., Verster, T., Doody, D., Raubenheimer, H., and Coetzee, P. J., 2020. A proposed benchmark model using a modularised approach to calculate IFRS 9 expected credit loss. *Cogent Economics & Finance*, 8(1), p. 1735681. https://doi.org/10.1080/23322039.2020.1735681
Semieniuk, G., Campiglio, E., Mercure, J. F., Volz, U. and Edwards, N. R., 2021. Low-carbon transition risks for finance. *Wiley Interdisciplinary Reviews: Climate Change*, 12(1), p. e678. https://doi.org/10.1002/wcc.678
Sureiman, O. and Mangera, C. M., 2020. F-test of overall significance in regression analysis simplified. *Journal of the Practice of Cardiovascular Sciences*, 6(2), p. 116. https://doi.org/10.4103/jpcs.jpcs_18_20
Vaněk, T. and Hampel, D., 2017. The probability of default under IFRS 9: multi-period estimation and macroeconomic forecast. *Acta Universitatis Agriculturae et Silviculturae*

Mendelianae Brunensis, 65(2), pp. 759-776. https://doi.org/10.11118/actaun201765020759

Willi III, R. E., 2020. CEC: the new expected credit loss standard a big loss for small banks. *NC Banking Inst.,* 24, pp. 193.