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Article

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Climate factor and banks' resilience: Evidence from US banks

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Abstract

This study explores how the climate factor impacts the resilience of the US banking system. Using an extended sample of banks, spanning the period 2000-2020, the findings document a negative effect of this climate factor on banks' resilience. They also highlight the role of climate risk over the post-global financial crisis period. The results could have a substantial value as climate conditions can serve as an early warning system for policymakers and regulators in detecting signs of weakness, calling for immediate actions to mitigate potential vulnerabilities of banks.

Keywords: Climate change; Banks' resilience; US banks
JEL Classification Codes: Q54, G21, C33

1. Introduction

Our work contributes to exploring the link between climate change and banks' resilience for the case of an extended sample of US banks, spanning the period 2000-2020. The link seems to be highly meaningful for the financial sector, especially in the aftermath of the COVID-19 pandemic. Climate change involves the realisation of tail-related events considered as global externalities that pose systemic financial risks, involve market failures, and call for supportive public intervention and international coordination. Asset managers can facilitate the management of climate risk and promote green financing through hedging and engagement with mitigation by disciplining market participants to stimulate mitigation efforts by the real sector. Moreover, investments in climate mitigation, e.g., incentives for firms to adopt decarbonization technologies and reach net-zero targets, could have positive effects on stock valuations. The realization of the explored link will allow us to properly respond to questions such as: what are the risks associated with climate change and which risk-management tools are appropriate to address them? What is the role of central banks and asset managers in the transition to a green economy? How does the systemic nature of climate shocks affect

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diversification and hedging strategies of financial intermediaries? Overall, financial institutions are expected to integrate environment-related risks explicitly into their risk appetite frameworks and improve their reporting of climate-related exposures. They are expected to determine a forward-looking business strategy in which climate risk factors are monitored on a continuous basis and incorporated into credit risk management. Banks and other financial intermediaries must be part of the solution to the climate change threat.

This work contributes to certain literature strands. First, it touches the literature on climate finance. Studies have examined the impact of climate change on banks' loan pricing. Chava (2014) provides evidence that banks charge higher interest rates on the loans provided to firms with environmental issues, while Ginglinger and Quentin (2019) show that higher climate risks lead to lower leverage, since lenders increase the spreads when lending to firms exposed to greater climate risks. Finally, Krueger et al. (2020) find that institutional investors tend to believe that climate risks have substantial financial implications for their portfolio firms, while these risks have already begun to materialize. The theoretical background of the role of climate risk in relevance to the financial sector asserts that there exist two primary mechanisms: disruptions of economic activity associated with the physical impacts of climate change (through weather shocks), and changes in policies as economies transition to a less carbon-intensive environment (through the presence of exposure to firms whose business models do not conform to a low-carbon economy). Therefore, climate change tends to pose a considerable risk to the financial sector.

Moreover, our study touches the literature on stress testing. Just to name a few of those references from this extensive literature, Banque de France (2013) provides certain indicators that assess the resilience of the banking institutions, with Holló and Kremer (2012) also recommending a resilience index of systemic stress in the banking system. Gai (2013) also asserts that banks behave as complex adaptive systems and document that network disciplines, such as ecology, epidemiology and statistical mechanics, improve our understanding of the role of systemic risks. The Duisenberg School of Finance (2015) provide evidence on the role of non-traditional sources of global risks that can disrupt banks, while it distinguishes two groups of banking resilience: structural and behavioral. Finally, Hernandez et al. (2022) investigate the main drivers of the change in the credit risk provisions at a portfolio level for the banks that have been subject of the 2018 EBA stress tests. Their findings document the substantial role played by bank-level variables, banking sector features in each country, and the specific characteristics of the portfolio in explaining part of the provisions. Their results also indicate the presence of complementary/substitution effects of both bank- and portfolio-level variables with the characteristics of the banking sector when explaining credit risk provisions.

2. Data

According to the definition of risks from climate change, physical risk can be deemed to have the most direct impact on changes in banks' financial resilience. Physical risk may cause direct damage to assets, as well as the indirect impact of supply chain disruption. Moreover, this type of risk, i.e., extreme temperature changes, can affect firms' structure, operations, supply chain, transportation needs, and employee safety, therefore, directly affecting the asset quality in the banking system. As a result, this type of risk depends on losses covered by insurance, which create substantial risks for banking institutions. The decrease in value of the collateral and the worsening household and corporate balance sheets may, in turn, push up loss given default (LGD) and probability of default (PD), while the increase in the Non-Performing-Loans ratio increases the risk exposure of banks, hence, adversely impacting the banking system. Overall, physical risk affects the systemic risk in banks mainly through three channels: collateral value, liquidity, and capital. In contrast, transition risk affects the stability of the financial system through uncertainties in social governance or industrial structural transition, resulting from the pressure of climate change. Such impact is deemed an indirect impact of climate change on changes in financial risks. Transition risk can be defined as the risk of economic imbalance and financial loss related to the transition to a low-carbon economy. The transition risk affects the systemic risk in banks primarily through climate policies and policies for industrial transition.

To the end of the paper's goal, to measure the climate risk factor (related to the transition risk definition), the analysis uses the methodology described by Jung et al. (2021). They employ Litterman's 'stranded asset' portfolio return as a measure of transition risks. This portfolio has three main pillars of investments, i.e., a long position of 30% in Energy Select Sector SPDR ETF (*XLE*) and 70% in VanEck Vectors Coal ETF (*KOL*), and a short position in SPDR S&P 500 ETF Trust (*SPY*):

$$CF = 0.3\, XLE + 0.7\, KOL - SPY \quad (1)$$

The short position describes a bet on the underperformance of coal and other fossil fuel firms, with a lower value implying the underperformance of these firms and higher levels of transition risks. However, given that the VanEck Vectors Coal ETF started in 2008 was liquidated in 2020, Equation (1) turns into:

$$CF = XLE - SPY \quad (2)$$

over the period outside of 2008-2020. A short position in the stranded asset portfolio highlights a bet on the underperformance of coal and other fossil fuel firms; hence, lower values of the CF index are associated with higher transition risks.

Next, to measure the resilience of the US banking system, we employ the methodology of the Composite Index (CI) proposed by Ruza et al. (2019) for each US bank. The sample includes annual data for 7,809 U.S. banks based on data availability. The dataset contains commercial banks, savings associations, and national banks. Data are sourced from the Orbis database. The CI contains certain determinants of resilience coming from different parts in relevance to macroprudential regulatory concerns, such as leverage, inter financial linkages, asset size and composition, liability composition, international exposure, market concentration, ownership diversity, securitization, and monetary policy actions. The benefit of their index is that they refine the variables' definition, as for instance international exposure, inter-financial linkages, asset composition and liability composition. They have also included a more complete set of variables, such as, z-scores, non-performing loans' variability within a banking system, credit expansion, bank efficiency, house price index and indicators of regulatory quality. Their methodology permits the selection of the more relevant variables for constructing the index and clusters the countries according to the different positions. Finally, their index expands the time period covered and includes some new countries. The index has been used in similar studies in the literature ever since, i.e., Gospodarchuk and Amosova (2020), Dien and Duen (2021), Mikita (2022), among others.

In addition, annual data on certain bank characteristics are obtained from the same database, such as: total assets (proxying the bank size), primary liquidity over total assets (proxying banks' liquidity), retails deposits over total debts, assets over book equity (proxying leverage); additional control variables are market value of equity over book value of equity, the Herfindhal index of bank asset concentration, real GDP growth, and the inflation rate. Data on the control variables were obtained from Datastream. Data spans the period 2000-2020.

3. Empirical analysis

We model bank i's resilience as:

$$CI_{it} = \alpha_i + b_j + \beta_t + a\, CF_t + v_{it} \quad (3)$$

where CI_{it} is the resilience composite index of bank i, and CF is the climate factor. α_i, b_j and β_t capture bank, state, and time fixed effects, respectively, while ε_{it} is the error term. The analysis estimates the panel data model using the general method of moments (GMM) estimation recommended by Arellano and Bover (1995) and Blundell and Bond (1998). In that sense, Equation (3) is expressed as:

$$\Delta CI_{it} = \alpha_i + \beta_t + a\,\Delta CI_{i(t-1)} + \sum_{s=0}^{p} \gamma_s\,\Delta CF_{t-s} + \sum_{s=0}^{q} \delta_i X'_{i(t-s)} + v_{it} \quad (4)$$

where X' is a vector that includes both bank characteristics variables and control variables (as in Vallascas and Keasey, 2012). Next, the analysis involves the Pesaran (2007) panel unit root test to investigate the presence of a unit root for all variables included in the modelling approach. The results are reported in Table 1 and support the presence of a unit root across all variables under consideration. Moreover, Table 1 reports the General Least Squared Dickey-Fuller test recommended by Elliott et al. (1996) for the time series variables. The results again illustrate the presence of a unit root in the levels of all variables under study.

The empirical results are reported in Table 2, with the standard errors being clustered on banks and time through the approach recommended by Petersen (2009). The findings show two specifications. In the first column, the findings are based on the bivariate model between CI and CF, while in the second column, the findings are based on the model that includes both the banks' characteristics and the control variables. The estimates clearly highlight that the climate factor exerts a negative impact on bank's resilience index, implying that increases in CF lead to higher climate systemic risk, thus, having a detrimental effect on banks' resilience. The findings imply that climate risk seems to impose substantial systemic risk to banking institutions, probably either through certain disruptions of economic activity resulting from the physical impacts of climate change, or through changes in environmental and regulatory policies as the economy transitions to a less carbon-intensive environment. Moreover, relevant diagnostics report the validity of the instruments used. These instruments were generated from two lags for levels and differences in the control variables.

Table 1. Unit root tests.

Panel variables		
	CIPS	
Pesaran's CIPS test	***Levels***	***1st Differences***
CI	-1.148	-6.274***
Total assets	-1.067	-6.742***
Liquid assets	-1.238	-6.562***
Deposits over debt	-1.177	-6.709***
Leverage	-1.348	-6.652***
Time series variable		
GLS test		
CF	-1.042	-6.429***
Market value of equity/book value of equity	-1.195	-6.859***
Herfindhal index	-1.246	-6.704***
GDP	-1.066	-7.018***
Consumer price index	-1.322	-6.981***

Notes: The results are reported at lag = 3 for the CI variable, and at lag = 2 for the CF variable. ***: p≤0.01.

Table 2. Dynamic panel estimates (the resilience composite index).

Variables	***(1)***	***(2)***
Δresilience index(-1)	0.649***	0.586***
	[0.00]	[0.00]
ΔClimate factor	0.037***	.034***
	[0.01]	[0.01]
ΔClimate factor(-1)	0.009**	0.005*
	[0.05]	[0.07]
ΔTotal assets		0.073***
		[0.01]
ΔLiquid assets		0.147*
		[0.08]
ΔDeposits over debt		-0.035*
		[0.10]
ΔLeverage		0.010**
		[0.02]
Δ Market value of equity/book value of equity		0.022**
		[0.05]
Δ Herfindhal index		-0.238*
		[0.10]
ΔGDP		0.759***
		[0.00]
ΔConsumer price index		2.074***
		[0.00]
Diagnostics		
R^2-adjusted	0.39	0.61
AR(2)	[0.42]	[0.47]
Hansen test	[0.45]	[0.52]
Instruments	6	26
Bank x time fixed effects	YES	YES
State x time fixed effects	YES	YES

Notes: Figures in brackets denote p-values. AR(2) is the test for autocorrelation of order 2. Hansen is the test for the overidentification check for the validity of instruments. The number of lags was determined through the Akaike criterion. Standard errors have been clustered on both banks and time. *: p<0.10; **: p<0.05; ***: p<0.01.

4. The role of the global financial crisis

The global financial crisis led to the deferment and postponement of environmental projects and investments that could impair the future profitability and resilience of the banking sector (Del Río and Labandeira, 2009), while others support the opposite conclusion (Greenpeace, 2008). Therefore, this part of the empirical analysis estimates Equation (5) across two different regimes, i.e., the pre-2008 crisis regime (2000-2007) and the post-crisis regime (2008-2020). The new findings (based on the multivariate specification and focusing on the primary variable of interest) are indicated in Table 3. They clearly show that although the CF exerts a negative impact on banks' resilience in both regimes, it turns stronger over the latter regime, indicating that the link between climate change and the resilience of the banking system surged over the years following the 2008 financial crisis (Carney, 2015).

Table 3. Dynamic panel estimates (pre- and post-crisis regimes).

Variables	***pre-crisis regime***	***post-crisis regime***
ΔResilience index	0.548***	0.603***
	[0.00]	[0.00]
ΔClimate factor	0.0088*	0.0504***
	[0.09]	[0.00]
ΔClimate factor(1)	0.0023	0.0177**
	[0.26]	[0.02]
Diagnostics		
R^2-adjusted	0.32	0.46
AR(1)	[0.00]	[0.00]
AR(2)	[0.35]	[0.47]
Hansen test	[0.36]	[0.49]
Difference Hansen test	[0.42]	[0.57]
Bank and time fixed effects	YES	YES
State and time fixed effects	YES	YES

Notes: Similar to those in Table 2. *: p<0.10; **: p<0.05; ***: p<0.01.

Anderson et al. (2019) argue that due to the property stressful conditions, such markets fail to incorporate climate change risks, which induced excessive investments to cope with high risks of weather-related disasters, thus, reducing systemic risks in banking. Furthermore, the financial environment faced tighter financial conditions in the post-crisis regime with further repercussions for banks, thus, rendering a vicious cycle between banks and climate conditions (Levine et al., 2019).

5. Conclusion

This work attempted to assess the health of the US banking institutions in line with climate change concerns. Through an extended sample of US banks, spanning the period 2000-2020 the results identified that climate factors had a detrimental effect on banks' resilience and, hence, can be used as an early warning system for future banking (and other) crises which can exacerbate banks' vulnerabilities. The findings are expected to have relevant implications for the literature on the role of climate risks in the process of the optimal bank size. The importance of banking institutions' exposure to systemic shocks related to climate change, seem to favor the adoption of specific prudential rules that will mitigate the impact of climate risks on the banks' resilience. Overall, the paper considered the question on whether the realisation of a transition risk decreases banks' resilience, and the answer was yes. The key question for policymakers is: how much potential there is for any future realization of the transition risk and how much will be that impact on bank resilience.

The next level of research should study whether banks with different loan exposures to geographic regions characterized by severe extreme climate events could have high physical-risk-related climate factors.

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