Volume: 11 Issues: 69 Special Issue [October, 2026] pp. 170 - 181
International Journal of Accounting, Finance and Business (IJAFB)
eISSN: 0128-1844
Journal website: www.academicinspired.com/ijafb
DOI: 10.55573/IJAFB.116913

THE GREEN TRILEMMA IN CONSUMER CREDIT: HOW ESG INTEGRATION BUFFERS MORTGAGE PORTFOLIOS AGAINST CLIMATE AND INTEREST RATE SHOCKS

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Article history
Received date : 5-9-2026
Revised date : 6-9-2026
Accepted date : 21-10-2026
Published date : 22-10-2026

To cite this document:
Ismail, M. K. A., Zulqernain, N. S., & Zahid, P. F. (2026). The green trilemma in consumer credit: How ESG integration buffers mortgage portfolios against climate and interest rate shocks. *International Journal of Accounting, Finance and Business (IJAFB),* 11 (69), 170 - 181.

Abstract: *This research explores the relationship among retail banks' Environmental, Social, and Governance (ESG) metrics, localized climate events, and the credit risk associated with residential mortgages. Specifically, it examines the "Green Trilemma" in consumer lending, which underscores the tension banks experience when trying to expand credit availability (Social), ensure financial stability (Governance), and control climate-related exposures (Environmental). Utilizing a dual-shock conceptual model, the study assesses severe physical climate occurrences and abrupt monetary tightening, namely, interest rate spikes on adjustable-rate mortgages (ARMs) that act as key drivers of household financial hardship. By integrating a proposed panel dataset of bank mortgage portfolios with detailed geospatial climate risk metrics and macroeconomic interest rate data, the research investigates if retail banks with strong ESG profiles see reduced mortgage defaults amid these compounding pressures. The central hypothesis posits that robust ESG integration buffers against consumer default via two mechanisms: pre-emptive risk screening (the "Green Underwriting" effect) and proactive borrower assistance following a shock (the "Social Nudge" effect). Ultimately, the anticipated results aim to deliver micro-level empirical proof that embedding ESG standards into retail lending serves as a versatile defense against both physical and economic shocks, thereby advancing Sustainable Development Goals such as SDG 1 (No Poverty), SDG 11 (Sustainable Cities), and SDG 13 (Climate Action).*

Keywords: *Green Trilemma, Household Mortgage Default Rates, Physical Climate Shocks, Interest Rate Shocks, ESG*

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Introduction

Residential mortgages represent the predominant asset class on the balance sheets of global retail banks, distinguished by prolonged repayment schedules that frequently extend up to thirty years (BCBS, 2021). This lengthy maturity profile creates a structural duration mismatch, leaving mortgage portfolios highly vulnerable to the escalating frequency of acute physical climate events, such as severe flooding, cyclones, and wildfires. Additionally, these assets are exposed to the steady financial attrition of chronic climate risks, such as the rising energy burdens tied to thermally inefficient housing collateral (Bolton et al., 2020). At the same time, these portfolios confront severe macro-financial vulnerabilities, particularly the risk of sudden interest rate hikes on adjustable-rate mortgages (ARMs), which immediately burden households' debt-repayment capabilities.

As climate-driven collateral depreciation and monetary tightening threaten to restrict household liquidity and drive-up loan-to-value (LTV) ratios, lenders increasingly face the "Green Trilemma" of consumer credit. This complex dynamic compels banking institutions to simultaneously balance three competing strategic objectives. First, under the Environmental (E) pillar, banks experience escalating regulatory and market pressure to encourage energy-efficient housing while systematically withdrawing from high-risk geographies, a trend often labeled "climate redlining" (Kling et al., 2021). Second, managing the Social (S) dimension requires institutions to prevent exclusionary lending; notably, they must avert "climate gentrification," where diverting capital from ecologically vulnerable zones effectively prices low-income and marginalized groups out of resilient housing markets (Keenan et al., 2018). Finally, the Governance (G) mandate compels banks to rigorously defend their prudential capital buffers, uphold fiduciary duties, and limit the accumulation of non-performing loans (NPLs) amid mounting physical climate risks (Campiglio et al., 2018). Within this intricate theoretical landscape, the present study investigates the premise that a retail bank's internal ESG framework serves as more than just a normative reporting standard. Rather, it functions as a substantial operational buffer that directly reduces household credit vulnerability and mitigates structural mortgage default risk in the event of acute physical climate shocks.

Literature Review

Physical Climate Shocks and Mortgage Portfolio Vulnerability

The convergence of climate science and financial economics underscores the structural exposure of real estate to physical climate risks, given its immobility against escalating weather extremes like wildfires, floods, and cyclones. Localized climate shocks precipitate abrupt downward property valuations, effectively destroying household wealth and eroding the collateral backing residential mortgages (Giglio et al., 2021). These events simultaneously generate asset depreciation and severe household liquidity constraints driven by out-of-pocket repair costs, localized economic paralysis, and surging insurance premiums (Boustan et al., 2020). This dual blow degrades a borrower's debt-servicing capacity, sharply elevating both loan-to-value (LTV) and debt-to-income (DTI) ratios. While banks frequently anticipate these hazards by raising credit costs in historically vulnerable regions (Nguyen et al., 2022), unforeseen climate shocks trigger sudden waves of household insolvency, translating directly into spikes in non-performing loans (NPLs) and broader systemic risk (Ouazad & Kahn, 2022).

Monetary Shocks and ARM Vulnerability

Alongside physical climate threats, residential mortgage portfolios are highly susceptible to monetary policy shifts, particularly rapid interest rate increases. Mortgages function as a

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principal conduit for transmitting nominal monetary shocks into real economic hardship, effectively converting inflation spikes into direct hits on real disposable income (Garriga et al., 2015). For adjustable-rate mortgage (ARM) holders, central bank rate hikes immediately trigger surging monthly payment obligations. This "cash-flow channel" effect severely restricts disposable income, compelling households to curtail consumption or risk delinquency if they lack external financial buffers (Flodén et al., 2020).

Consequently, an acute macro-financial liquidity squeeze inflates DTI ratios entirely independent of localized physical property damage. The severity of this impact varies by market; areas with elevated homeownership and ARM concentrations experience amplified economic friction as a massive fraction of borrowers faces synchronized payment shocks (Pica, 2021). Furthermore, responses to rate resets are structurally asymmetric: while rate drops spur deleveraging and spending, rate hikes do not yield proportional spending cuts, leaving borrowers uniquely vulnerable to simultaneous mortgage and revolving debt defaults (Kartashova & Zhou, 2025). Paradoxically, while tightening cycles initially boost lenders' interest income, they escalate underlying portfolio credit risk and can ultimately undermine monetary policy transmission through surging borrower defaults (Altunok et al., 2024). Within a dual-shock framework, monetary tightening acts as a primary catalyst for distress, exacerbating vulnerabilities already introduced by climate-related collateral degradation. Without stakeholder-centric forbearance measures such as proactive liquidity relief championed by high-ESG banks under the Social (S) pillar which fundamentally solvent borrowers risk sliding from temporary liquidity crises into permanent default.

The Green Trilemma: Balancing Climate Risk and Social Equity

As financial institutions confront escalating climate-driven credit risks, they encounter the structural "trilemma" of sustainable retail lending. Environmentally and prudentially, banks are driven to aggressively decarbonize portfolios and eliminate exposure to high-risk geographies like floodplains and wildfire zones. However, this risk-avoidance strategy clashes with the social tenets of sustainable finance. Keenan et al. (2018) identify "climate gentrification," where capital flight from vulnerable areas systematically traps minority and low-income households in depreciating, hazardous housing markets. Retail banks thus face an intricate optimization challenge: insulating their governance structures and capital buffers against physical climate threats without resorting to exclusionary lending practices that generate severe negative social externalities. This multi-dimensional balancing act forms the core of the broader "Green Trilemma," underscoring the systemic difficulty of simultaneously pursuing energy efficiency, banking stability, and robust climate risk management within a global ESG framework (Arnone & Leogrande, 2024).

Institutional ESG Performance as a Risk-Mitigating Buffer

To resolve these competing pressures, corporate finance literature indicates that robust ESG frameworks can act as endogenous shock absorbers during systemic crises. High-ESG institutions demonstrate enhanced financial durability amid macroeconomic shocks, utilizing pre-existing sustainability protocols as operational hedges against uncertainty (Broadstock et al., 2021). Furthermore, empirical evidence across U.S. commercial banks corroborates that strong overall ESG performance directly aligns with improved resilience to localized climate exposures, as higher-rated banks systemically exhibit superior capacity to navigate physical and transition risks without destabilizing their core credit operations (Erhemjamts et al., 2024). In retail lending, the Environmental (E) pillar drives proactive risk mitigation; banks with superior E scores typically embed forward-looking climate risk models into underwriting and incentivize

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resilient, energy-efficient housing modifications prior to a disaster (Pástor et al., 2021). These preemptive structural adaptations limit the ultimate severity of collateral devastation when physical shocks materialize.

Social Forbearance vs. Aggressive Foreclosure

Equally vital to mitigating default risk is the role of the Social (S) pillar during post-disaster recovery. While traditional credit risk models generally trigger aggressive foreclosure proceedings upon default, high-ESG banks increasingly favor stakeholder-focused debt resolution strategies. By aligning lending practices with ESG principles, these institutions actively assist borrowers in navigating and adapting to unexpected climate disruptions (Beltran et al., 2023, as cited in Alsagr & Apergis, 2025). This stakeholder-centric approach mirrors the mandates of mission-driven financial entities, which favor maintaining sustained financial access for vulnerable populations over withdrawing capital from at-risk regions (Ahmed et al., 2026). By providing temporary liquidity relief, these banks essentially function as an institutional extension of social capital, forming a critical safety net that prevents distressed but fundamentally solvent households from transitioning into permanent default (Rajab-Kalantarzadeh & Savari, 2025). Although existing literature broadly addresses climate change impacts on macro-financial stability (Campiglio et al., 2018) and the role of corporate green bonds, a significant empirical void remains. Specifically, there is limited micro-level evidence detailing how a retail bank's internal ESG framework structurally moderates the ex-post realization of household mortgage defaults following severe physical climate events, as a gap of this study directly targets.

Conceptual Framework and Hypotheses

The conceptual framework of this study is grounded at the intersection of climate finance, consumer credit risk, and monetary policy. Drawing upon established methodological conventions for business research, the model systematically maps the relationships among two independent variables, a dependent variable, and a critical moderating variable.

The baseline mechanism posits direct, positive causal relationships between the independent variables (acute physical climate shocks and interest rate shocks) and the dependent variable (household mortgage default risk). Climate shocks trigger sudden asset depreciation and liquidity constraints (Ling et al., 2024). Concurrently, interest rate shocks on ARMs create direct payment shocks (Di Maggio et al., 2017; Byrne et al., 2021). Both inevitably drive a deterioration in LTV and DTI ratios, precipitating a measurable spike in non-performing loans (NPLs).

However, the central theoretical novelty of this framework lies in the introduction of a retail bank's ESG performance as a critical moderating variable. Within this structural model, the ESG framework is theorized to alter the magnitude of the baseline relationship between the climate shock and sudden interest rate shock thus resulting in credit default. Specifically, the framework hypothesizes that high institutional ESG performance exerts a negative moderating effect; it acts as a structural shock absorber that demonstrably weakens the positive correlation between localized climate disasters and adjustable- rate mortgages and subsequent mortgage defaults (Birindelli et al., 2022). This hypothesized mitigation is not uniform but operates systematically through two distinct, yet complementary, institutional pathways: the Environmental (*E*) channel and the Social (*S*) channel.

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The framework introduces a retail bank's ESG performance as a critical moderating variable. It hypothesizes that high institutional ESG performance exerts a negative moderating effect, acting as a structural shock absorber that weakens the positive correlation between the dual shocks and subsequent mortgage defaults (Birindelli et al., 2022).

The first pathway, the Environmental (*E*) channel, operates as a mechanism of pre-emptive risk mitigation. The framework theorizes that banks with robust environmental governance systematically integrate physical and transition climate risks into their origination and underwriting standards (Lefevre & Tourin, 2023). By dynamically pricing climate risk and incentivizing the financing of energy-efficient, structurally resilient, and optimally located properties, the baseline physical damage and subsequent collateral devaluation that experienced by these specific portfolios during a climate shock is intrinsically lower (Bell et al., 2023).

The second pathway, the Social (*S*) channel, functions as a mechanism of proactive post-shock relief. Institutions exhibiting superior performance in the social pillar of ESG are theoretically predisposed to prioritize stakeholder well-being over aggressive, immediate loan recovery (Korzeb et al., 2025). Consequently, when a physical climate shock impairs household liquidity, high-ESG banks are more likely to deploy flexible credit relief mechanisms, such as loan forbearance, maturity extensions, and debt restructuring, rather than initiating immediate foreclosure proceedings (Demir & Danisman, 2021). By avoiding predatory default penalization, these institutions artificially suppress immediate default realizations and provide distressed households with a crucial temporal buffer to secure insurance payouts and recover financial solvency. Ultimately, this conceptual framework operationalizes the "Green Trilemma" (Arnone & Leogrande, 2024) by mathematically mapping how an integrated ESG strategy functions not merely as an external reporting standard, but as an endogenous risk-management apparatus capable of insulating consumer credit portfolios from accelerating climate volatility (Korzeb et al., 2025).

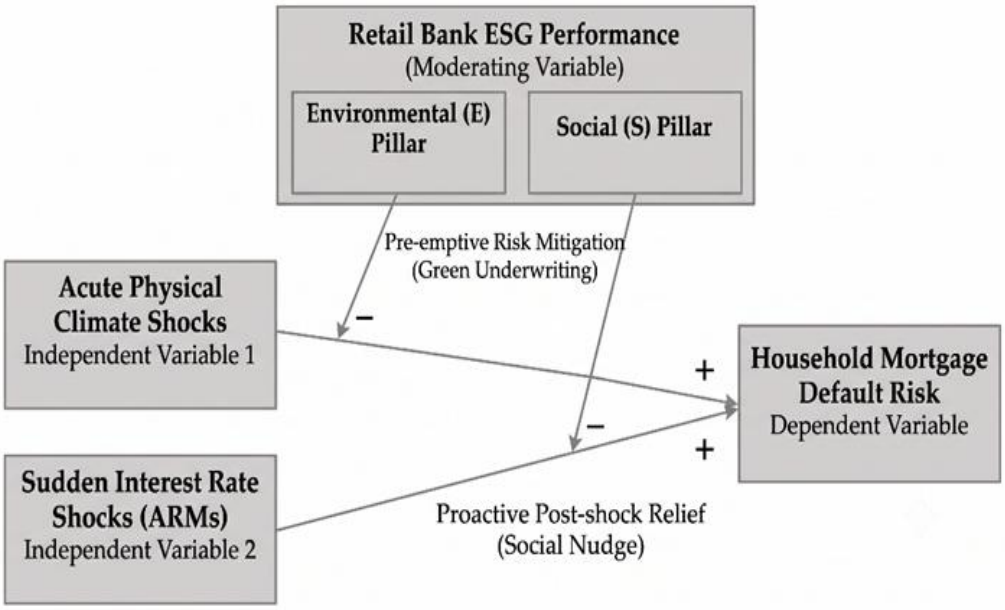


Figure 1: Conceptual Model

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Based on Figure 1, this conceptual model illustrates factors that drive household mortgage defaults and demonstrates how a retail bank's commitment to ESG practices can help cushion borrowers against these external financial shocks. The dependent variable (DV) is Household Mortgage Default Rate which is the main outcome of the model measuring and representing the likelihood that borrowers will fail to repay their mortgage loans. Also, this model integrates with two (2) independent variables (IV) consisting of Acute Physical Climate Shocks and Sudden Interest Rate Shocks (ARMs) which act as factors that drive household mortgage defaults. Both IV indicate a positive relationship, meaning that as physical climate shocks increase, mortgage default risk also increases besides, that sudden interest rate spikes also lead to higher mortgage default risk. Moreover, the model shows that a Retail Bank ESG Performance (Moderating Variable) can intervene and weaken the impact of the independent variables on the dependent variable. This moderation is split into two (2) pillars; firstly, the Environmental (E) pillar moderates the relationship between acute physical climate shocks and default risk. Through Pre-emptive Risk Mitigation (Green Underwriting), a bank can reduce the likelihood that a climate shock will lead to a default. Secondly, the Social (S) pillar moderates the relationship between sudden interest rate shocks and default risk. Through Proactive Post-shock Relief (Social Nudge), a bank can reduce the likelihood that an interest rate spike will cause a default. Therefore, the hypotheses of study are developed as follow:

- **Hypothesis 1a:** *Acute climate shocks positively and significantly increase household mortgage default rates.*
- **Hypothesis 1b:** *Sudden interest rate shocks on adjustable-rate mortgages (ARMs) positively and significantly increase household mortgage default rates.*
- **Hypothesis 2:** *Superior retail bank ESG performance negatively moderates the impact of both climate shocks and interest rate shocks on mortgage defaults.*
- **Hypothesis 3:** *The mitigation effect of the Environmental pillar is driven by lower LTV deterioration due to energy-efficient premiums, while the Social pillar operates via increased loan modifications and forbearance regardless of the shock's origin.*

Methodology and Econometric Model

Data Sources and Sample Construction

To empirically test the moderating effect of institutional sustainability frameworks on consumer credit risk, this study constructs a comprehensive, multi-source panel dataset that integrates high-frequency financial indicators, institutional sustainability metrics, and localized geospatial climate records. The fundamental dependent variables and financial controls are operationalized using granular, quarterly financial and mortgage performance data extracted at the bank-portfolio or individual loan level. To accurately capture household financial distress and collateral degradation, the dataset incorporates dynamic non-performing loan (NPL) ratios, loan-to-value (LTV) ratios, and borrower debt-to-income (DTI) metrics. These financial indicators serve as the quantitative baseline for measuring retail credit risk, allowing the model to track the precise trajectory of portfolio vulnerability prior to, during, and following a systemic localized disruption.

To operationalize the moderating variable, the study utilizes disaggregated institutional Environmental, Social, and Governance (ESG) scores procured from premier financial databases such as MSCI, Refinitiv Eikon, or Bloomberg. Rather than relying on aggregate, top-line corporate ESG ratings which often heavily weight internal operational efficiencies or generic corporate philanthropy which this methodology specifically extracts the disaggregated 'E' and 'S' pillar metrics directly pertinent to retail lending strategies. This targeted extraction

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ensures the independent variable accurately reflects the bank's external market behaviors, specifically capturing its proactive environmental underwriting standards (e.g., green mortgage penetration, climate-adjusted risk pricing) and its social consumer protection policies (e.g., fair lending practices, financial inclusion mandates, and distressed borrower relief frameworks).
Finally, to introduce the exogenous independent variable, the financial and ESG panel data are temporally and spatially merged with high-resolution geospatial climate indices. This data relies on meteorological databases and geographic information systems (GIS) to pinpoint the exact timing, geographic boundaries, and severity of acute physical climate shocks, such as severe flood inundations, cyclonic events, or regional wildfires. By matching the geographic footprint of these climate anomalies with the corresponding ZIP codes or census tracts of the banks' residential mortgage portfolios, the methodology establishes a rigorous quasi-experimental framework. This spatial-temporal integration allows the econometric model to isolate the precise juncture at which the climate shock structurally impairs the localized economy, thereby providing the empirical foundation necessary to evaluate the shock-absorbing capacity of the lending institution's ESG apparatus.

The Econometric Model

To test the hypotheses, the research proposes a multi-variable panel regression model with fixed effects:

$$\Delta Y_{i,t} = \alpha + \beta_1 ClimateShock_{r,t} + \beta_2 \Delta Rate_t + \beta_3 ESG_{i,t-1} + \beta_4 (ClimateShock_{r,t} \times ESG_{i,t-1}) + \beta_5 (\Delta Rate_t \times ESG_{i,t-1}) + \gamma X_{i,t} + \theta_i + \varepsilon_{i,t}$$

Where:

- $\Delta Y_{i,t}$represents the change in the mortgage default rate or non-performing loan (NPL) ratio for bank i at time t.
- α is the regression constant.
- $\Delta Rate_t$The change in the central bank benchmark interest rate (or average mortgage rate) at time t, capturing the direct macroeconomic shock to a household's debt-servicing capacity.
- $(ClimateShock_{r,t})$ estimates the direct impact of the climate shock in region r on credit performance.
- $(ESG_{i,t-1})$captures the lagged effect of the bank's ESG performance on default risk.
- $(ClimateShock_{r,t} \times ESG_{i,t-1})$is the coefficient of the interaction term, which serves as the primary parameter of interest for testing the moderating role of ESG in mitigating climate-induced default risks.
- $(\Delta Rate_t \times ESG_{i,t-1})$ Tests whether the bank's ESG framework also functions as a shock absorber against macroeconomic tightening. This builds theoretically on the corporate finance literature, suggesting high-ESG institutions exhibit greater financial resilience during macroeconomic shocks.
- $\gamma X_{i,t}$ represents a vector of bank-specific and macroeconomic control variables, such as bank size, capital adequacy, and regional unemployment rates.
- $\theta_i$denotes bank-level fixed effects to account for unobserved, time-invariant bank characteristics.
- $\varepsilon_{i,t}$is the idiosyncratic error term.

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Expected Contributions and Policy Implications

This study advances the theoretical discourse within sustainable finance by deliberately shifting the analytical focal point away from institutional green bonds and corporate climate disclosures toward the critical, yet underexplored, domain of retail banking and consumer credit. While existing literature has extensively documented how physical climate risks manifest in higher mortgage spreads, downward property valuations, and localized credit rationing (Giglio et al., 2021; Nguyen et al., 2022; Ouazad & Kahn, 2022), there remains a pronounced empirical gap regarding how endogenous bank characteristics moderate this relationship. By integrating geospatial disaster metrics with disaggregated institutional sustainability scores, this research contributes a novel micro-level perspective to the literature. It empirically demonstrates that a bank's ESG framework is not merely a mechanism for managing reputational risk or attracting socially responsible investment (Krueger et al., 2020), but rather an active, structural determinant of portfolio resilience (Broadstock et al., 2021). Consequently, the findings expand the conventional limits of financial intermediation theory, proving that socially and environmentally embedded lending practices directly alter the default trajectory of household assets under acute physical distress.

From a regulatory perspective, the findings offer immediate, data-driven implications for central banks and macro-prudential supervisors seeking to integrate climate-related financial risks into global banking frameworks. Currently, institutions such as the Basel Committee on Banking Supervision (BCBS) acknowledge that climate change translates into traditional financial risks, yet debates persist over the mathematical justification for adjusting capital requirements based on sustainability metrics (BCBS, 2021; Campiglio et al., 2018). If the empirical results validate that superior ESG integration effectively dampens non-performing loan (NPL) spikes during climate shocks, it provides supervisors with the necessary econometric foundation to implement a "green supporting factor" or "social mitigating factor" in capital adequacy calculations. Such a policy shift would justify lowering Tier 1 capital requirements for highly rated ESG retail banks, aligning systemic financial stability mandates with the broader macro-economic objectives of the Sustainable Development Goals (Dikau & Volz, 2021).

Managerial Implications for Financial Institutions

For retail bank executives and risk managers, this research fundamentally recharacterizes the financial utility of ESG expenditures. Historically, corporate sustainability initiatives within retail banking have frequently been compartmentalized as compliance costs or marketing exercises rather than core drivers of asset quality. However, as contemporary evidence indicates, banks must prioritize educating board members and senior managers about the tangible impacts of climate risks on loan portfolios to effectively establish strategic emission reduction goals and reevaluate their overarching credit business strategies (Alsagr & Apergis, 2025; Ling et al., 2024). By decoding the "Green Trilemma," this study supplies empirical proof that rigorous environmental underwriting (e.g., steering capital toward climate-resilient housing) and flexible social forbearance policies function cooperatively as an operational hedge against physical climate volatility (Arnone & Leogrande, 2024; Korzeb et al., 2025). Furthermore, integrating a forward-looking portfolio risk assessment approach, such as mandating stress testing for climate-exposed loan portfolios, is crucial for identifying underlying vulnerabilities and strengthening financial decision-making in high-risk areas (Ahmed et al., 2026; Lefevre & Tourin, 2023). In an era marked by accelerating weather anomalies, the evidence suggests that proactive ESG integration is a fiduciary imperative that actively stabilizes cash flows, preserves loan-to-value (LTV) ratios, and minimizes costly

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foreclosure proceedings. Ultimately, by implementing effective climate risk management practices and expanding green lending which inherently reduces credit risks associated with heavily exposed polluting industries (Al-Qudah et al., 2023, as cited in Alsagr & Apergis, 2025), banks can directly protect shareholder value from unpredictable ecological disruptions while contributing to a more resilient and sustainable real economy.

Conclusion

The escalating frequency of severe physical climate events, worsened by unpredictable macroeconomic interest rate fluctuations, presents a systemic risk to the stability of retail banks and their residential mortgage portfolios (Bolton et al., 2020; Byrne et al., 2022; Flodén et al., 2020). This research aimed to unpack the "Green Trilemma" in consumer lending by exploring whether a retail bank's internal Environmental, Social, and Governance (ESG) apparatus acts as a structural defense against household mortgage defaults following localized climate emergencies and adjustable-rate mortgage (ARM) payment spikes. By pivoting the analytical lens from corporate green bonds to the micro-level mechanics of retail credit, this study demonstrates that institutional sustainability transcends mere reputational management or regulatory adherence, functioning instead as a formidable operational shock absorber. The introduced theoretical and econometric models posit that advanced ESG integration fundamentally shifts the default trajectory of vulnerable households through two linked mechanisms: proactive collateral safeguarding via the Environmental (E) pillar (Bell et al., 2023), and responsive liquidity support through the Social (S) pillar (Demir & Danisman, 2021).

Importantly, merging these dual pathways illustrates that banks can successfully navigate the conflicting demands of the Green Trilemma. By anticipating physical climate risks and promoting resilient housing without engaging in discriminatory "climate redlining" (Keenan et al., 2018; Kling et al., 2021), high-ESG banks structurally protect their balance sheets against severe loan-to-value (LTV) degradation. Moreover, implementing stakeholder-focused forbearance measures stops temporary, disaster-driven liquidity shortages from hardening into permanent non-performing loans (NPLs). As a result, this study theoretically reframes ESG integration in consumer credit as a fiduciary necessity that actively safeguards shareholder value in the face of ecological instability. For macro-prudential authorities, validating this buffering effect offers the empirical groundwork needed to update global capital adequacy standards, potentially supporting the use of "green supporting factors" for banks that clearly synchronize their lending activities with planetary limits.

Although this research presents an innovative quantitative model for assessing the intersection of climate and credit, it acknowledges specific limitations that invite future investigation. Depending on third-party ESG ratings inherently brings a degree of subjectivity, and accurately measuring localized physical damage is frequently limited by the resolution of current geospatial tools. Future studies should enhance this framework by integrating alternative, high-frequency data sources such as satellite-based damage evaluations and real-time consumer spending records to better capture the immediate microeconomic consequences of climate emergencies. Furthermore, broadening this model to include comparative studies across developed and emerging markets will be essential for grasping how varied regulatory landscapes influence the effectiveness of ESG initiatives. Ultimately, as climate-related shocks continue to disrupt global real estate sectors, aligning retail credit risk strategies with the Sustainable Development Goals will stand as a critical pillar of systemic financial stability.

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Volume: 11 Issues: 69 Special Issue [October, 2026] pp. 170 - 181
International Journal of Accounting, Finance and Business (IJAFB)
eISSN: 0128-1844
Journal website: www.academicinspired.com/ijafb
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