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Bank Responses to Physical and Transition Risks in Lending: A Diagnostic Framework From a Systematic Literature Review

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ABSTRACT

Banks face mounting pressure to integrate climate risks into lending, yet responses remain incoherent. This systematic literature review of 9034 studies synthesizes 68 peer-reviewed articles and develops a behavioral typology of five bank responses: recovery, containment, repricing, reallocation, and relational transformation. Responses vary by risk type, visibility, and salience. Acute, unexpected physical risks (nine studies) trigger recovery lending, while expected (five) or chronic risks (12) lead to containment or repricing. Transition risks (42) are more consistently priced when indicators are quantifiable and policy-aligned; softer ESG signals elicit conditional responses. Asymmetries arise: recovery and containment occur only for physical risks, while strategic reallocation remains rare. Carbon-intensive firms are penalized, while green firms benefit only when performance is credible and verifiable. We propose a diagnostic framework to evaluate climate risk management in lending, providing a novel tool to assess climate risk integration in bank lending and inform regulatory design and sustainability-oriented strategy.

1 | Introduction

In the United States, climate risk is no longer abstract—it is "coming through your mail slot" (Flavelle 2024). As wildfires, floods, and hurricanes intensify, insurers are withdrawing from high-risk areas, canceling policies, or raising premiums to unaffordable levels (Consumer Federation of America 2025). This insurance retreat, now described as a national "crisis" (Flavelle 2024), reflects a deeper market failure: the inability to price escalating physical risks (Gelles 2025). It also destabilizes broader financial chains. Without insurance, mortgages become unobtainable; without mortgages, homeownership declines. The result is falling property values, credit contraction, eroding tax bases, and systemic financial risk (Flavelle 2024). This raises critical questions for banks: How should lenders respond when risks become uninsurable? And why do some continue financing vulnerable assets?

This phenomenon reflects a broader pattern: while awareness of climate risk is rising, bank responses remain reactive and short-term. Lending tightens after disasters (Ouazad and Kahn 2022), ESG scores are repriced after controversies (Duan and Li 2024), and fossil-fuel firms are penalized following policy shifts (Nguyen et al. 2025). These responses are not rooted in

Abbreviations: AJG, Academic Journal Guide; COP, conference of the parties; GSE, government-sponsored enterprise; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; SBA, Small Business Administration (US); SLR, sea-level rise; WACC, weighted average cost of capital.

ignorance, but in the absence of consistent frameworks to evaluate and manage climate risks (Keenan and Bradt 2020).

The systemic consequences of this misalignment are significant. Underpricing or selectively pricing climate risks allows capital to flow into vulnerable regions and emissions-intensive sectors. This delays portfolio adjustment, increases the likelihood of abrupt repricing, and exposes banks to rising defaults and deteriorating collateral quality (Battiston et al. 2021; Dafermos et al. 2018). These risks aggregate at the system level, threatening financial stability and undermining confidence in climate-aligned finance (Carney 2015; NGFS 2019). Implications extend beyond banks to regulators and borrowers navigating a more volatile credit environment (BCBS 2021).

Empirical studies increasingly show that climate signals affect lending. Banks with fewer ESG controversies tend to take less risk (Galletta and Mazzù 2023), strong governance is associated with greater climate engagement (Adu and Roni 2024), and high-quality disclosures improve credit access (Rehman et al. 2023; Wellalage and Kumar 2021) and reduce financial distress (Alshahrani et al. 2023). However, the underlying mechanisms of climate risk integration in lending remain poorly understood.

Climate risks are typically classified as physical or transition. Physical risks arise from acute weather events (e.g., floods and hurricanes) or chronic hazards (e.g., sea-level rise and droughts) (Caldecott et al. 2021; Tankov and Tantet 2019). Transition risks arise from decarbonization policies, regulatory shifts, legal liability, or market revaluation (Curtin et al. 2019; Semieniuk et al. 2021). Both affect credit risk and balance sheets (BCBS 2021; Giglio et al. 2021), yet backward-looking credit models often fail to capture their forward-looking and nonlinear nature (Battiston et al. 2021; BCBS 2022).

Despite growing interest in climate finance, existing reviews offer limited insight into lending responses to climate risks. Many focus on ESG (Atz et al. 2023; Friede et al. 2015) or equity markets (Giglio et al. 2021; Venturini 2022). Existing reviews on banking are fragmented, covering specific areas like ESG lending (Carnevale and Drago 2024), supervision (Feridun and Güngör 2020), WACC (Meneses Cerón et al. 2024), sector-level risk (de Bandt et al. 2025), or green lending characteristics (Ongena 2024). Mihaylova and Blumer (2022) review risk estimation tools but do not address how banks adjust credit behavior. However, no existing review systematically integrates behavioral explanations for bank-level credit responses to physical and transition risks.

This review addresses that gap by asking: Which strategic responses do banks adopt to integrate physical and transition climate risks into lending decisions? Applying a systematic literature review methodology (Cooper 1982; Tranfield et al. 2003), we screened 9034 records and identified 68 peer-reviewed quantitative studies published between 2009 and 2025: 26 on physical risks and 42 on transition risks.

Our findings reveal a behavioral asymmetry. Acute, unexpected physical risks often trigger short-term recovery lending, while chronic or anticipated physical risks elicit reactive containment or pricing adjustments shaped by salience and heuristics. Transition risks are more consistently priced, particularly when signals are quantifiable, third-party verified, and policy-aligned, whereas softer ESG indicators often result in symbolic or relationship-based responses. Across studies, we find more consistent evidence for the penalization of carbon-intensive ("brown") firms than for preferential treatment of low-carbon ("green") firms.

To explain these patterns, we introduce a behavioral typology comprising five response types: *recovery lending, reactive containment, risk pricing adjustment, strategic reallocation*, and *relational transformation*. These categories correspond to risk type and visibility, offering a framework to understand why some risks provoke action while others do not. The typology functions as both a conceptual lens and diagnostic framework, identifying institutional blind spots and signaling where regulatory or strategic intervention may be needed.

Finally, we propose five future research priorities: improving carbon risk metrics, analyzing bank characteristics, understanding cognitive biases, assessing policy effectiveness, and unpacking bank–borrower dynamics. By identifying empirical patterns, response asymmetries, and structural gaps, this review advances our understanding of climate risk integration in bank lending. The review offers practical insights for financial institutions managing climate risk, regulators evaluating institutional readiness, and sustainability professionals shaping credit conditions in the low-carbon transition.

2 | Theoretical Foundations

2.1 | Understanding Climate Change Risks: Physical and Transition Risks

Climate risks are commonly categorized as either physical or transition risks (Carney 2015). Physical risks refer to acute events such as droughts, floods, and storms, and chronic changes like sea-level rise, temperature shifts, and altered precipitation patterns that disrupt assets, operations, or supply chains (BCBS 2021; Caldecott et al. 2021; Venturini 2022).

Transition risks arise from a shift toward a low-carbon economy, including policy tightening, technological change, and shifts in investor or consumer expectations. These factors may lead to asset devaluation or stranded assets—resources rendered nonviable under climate targets such as the Paris Agreement (Curtin et al. 2019; McGlade and Ekins 2015).

Firms' exposure to climate risks depends on their carbon intensity, geographic location, and operational vulnerabilities. High-profile cases such as the PG&E bankruptcy in California—triggered by wildfire-related liabilities—demonstrate that climate risks can have immediate, material financial consequences (Gold 2019; MacWilliams et al. 2019).

While institutional investors increasingly factor such risks into portfolio decisions (Krueger et al. 2020), it remains unclear to what extent banks have integrated these concerns into lending practices (Stroebel and Wurgler 2021).

2.2 | Why Banks (Should) Consider Climate Change Risks: The Risk Mitigation View

Credit risk is central to lending decisions. While traditionally grounded in backward-looking financial metrics, credit assessments now increasingly incorporate ESG criteria to reflect forward-looking exposures. The risk mitigation view holds that strong corporate social responsibility (CSR) correlates with a lower risk of borrower default (Goss and Roberts 2011; Stellner et al. 2015). High-CSR firms tend to exhibit greater resilience during downturns, resulting in more favorable credit terms (Houston and Shan 2022). Evidence from Nordic countries suggests that financial benefits accrue only when sustainability practices are deeply embedded, not superficial (Lueg and Pesheva 2021). Empirical research also shows that firms with stronger environmental performance experience smaller stock price declines after extreme weather events (Schuster et al. 2025). Conversely, high carbon intensity signals vulnerability to regulatory, legal, and reputational risks, which can disrupt cash flows and increase default probabilities (Chava 2014; Huang et al. 2021).

Beyond measurable credit risk, climate-aligned lending is increasingly shaped by reputational and legitimacy concerns. Lending to carbon-intensive borrowers can damage a bank's public image and undermine investor confidence (Chalabi-Jabado and Ziane 2024; Hauptmann 2017). As Rasche et al. (2023) argue, corporate sustainability is influenced not only by market pressures but also by evolving societal expectations and governance norms. Banks respond through both *exit strategies* (denying credit to high-emission borrowers) and *voice strategies* (engaging clients to support adaptation and decarbonization efforts) (Houston and Shan 2022). These approaches can enhance alignment with sustainability goals while promoting long-term portfolio resilience.

One technical yet critical factor in climate risk assessment is how emissions are measured. The Greenhouse Gas Protocol distinguishes between Scope 1 (direct), Scope 2 (indirect from purchased energy), and Scope 3 (indirect across the value chain) emissions (WRI and WBCSD 2004). Scope 3 emissions, while often the largest, are the most difficult to quantify. Their inclusion—or omission—can materially affect credit evaluations, particularly for firms with extensive supply chains.

2.3 | Why Banks (Do Not) Consider Climate Change Risks: The Behavioral Constraints Perspective

While awareness of climate-related risks is increasing, bank responses remain inconsistent, short-term, and largely reactive. Behavioral finance offers compelling explanations for this mismatch. The complexity, uncertainty, and long-term nature of climate risks do not align well with traditional credit risk frameworks, making them particularly susceptible to cognitive and organizational biases (Battiston et al. 2021).

A key mechanism is salience bias: dramatic, visible events such as floods or wildfires tend to dominate attention, while gradual, abstract threats like sea-level rise are often discounted (Bordalo et al. 2012; Tversky and Kahneman 1974). Media coverage can further distort perception, triggering localized overreactions while leaving equally significant but less visible risks ignored (Sunstein and Zeckhauser 2011).

Relatedly, the availability heuristic leads decision-makers to prioritize recent or memorable experiences over probabilistic risk assessments (Kahneman and Tversky 1982). This dynamic helps explain why climate risks may be underpriced in regions without recent disasters, even when model-based assessments signal growing exposure.

At the institutional level, myopic loss aversion (Benartzi and Thaler 1995) and short-termism (Dallas 2012) discourage proactive adaptation to long-horizon risks. Traditional credit risk management models prioritize backward-looking financial data and lack the capacity to reflect systemic or anticipatory climate dynamics (Battiston et al. 2021).

Structural barriers within organizations further inhibit climate integration. Bounded rationality (Simon 1990) and siloed structures constrain the flow of information between sustainability and credit teams. Many credit officers lack both access to climate data and the authority to act on it—especially where regulatory incentives are weak or absent (ECB 2021).

Together, these cognitive and institutional constraints contribute to the partial and uneven integration of climate risks in bank lending. These constraints help explain why reactive and short-term responses—such as recovery lending and repricing—dominate the literature, while strategic adaptation remains rare.

3 | Methodology

This study applies a systematic literature review (SLR) to synthesize empirical evidence on how financial institutions integrate climate-related risks into lending. The review follows the protocol outlined by Tranfield et al. (2003), widely used in management and finance research, and adheres to the PRISMA framework (Page et al. 2021) for transparent reporting of review processes. The procedure is summarized in Figure 1.

A total of 74 structured queries were executed across the Scopus and Web of Science databases. Search strings were applied to titles, abstracts, and keywords, yielding 9034 initial records. After removing duplicates ($n=4485$), 4549 unique articles remained for screening.

Screening proceeded in three stages. First, eligibility screening excluded non-English articles ($n=149$), nonempirical publications ($n=1191$), and papers published in journals ranked below Level 3 in the 2024 Academic Journal Guide (AJG) ($n=2742$). This quality threshold ensured methodological rigor and peer-reviewed relevance, filtering out gray literature and practitioner-oriented reports that lack replicable methods or robust data, yielding 467 articles.

Second, relevance screening based on titles and abstracts excluded 355 and 41 articles, respectively, not focused on

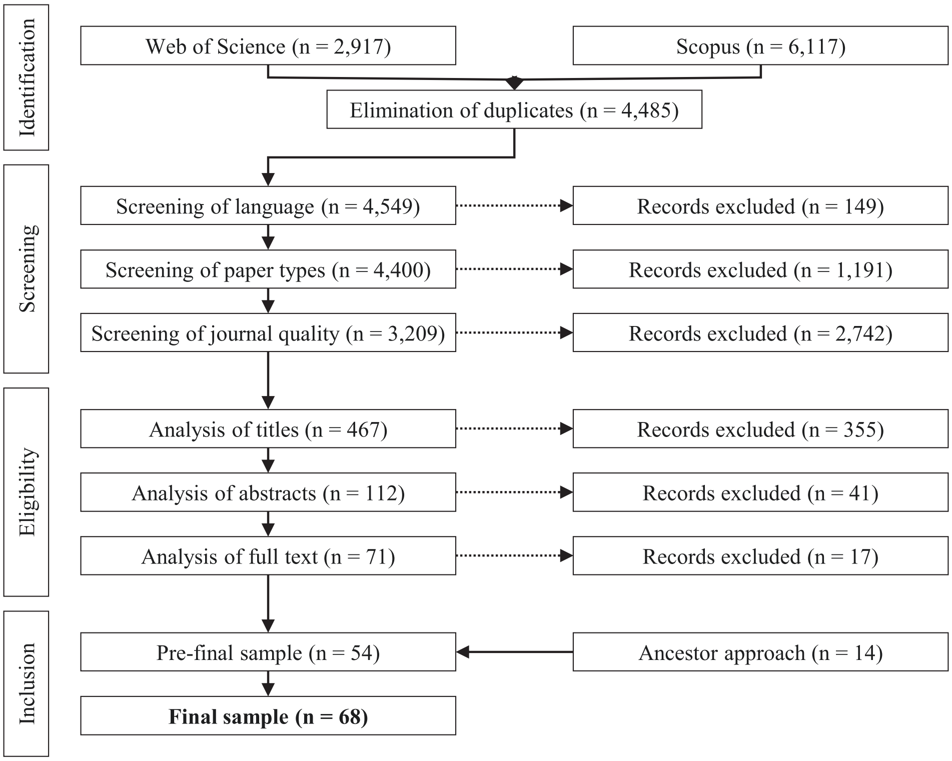

FIGURE 1 | Selection process following the PRISMA framework (Page et al. 2021) The systematic literature review adhered to the PRISMA guidelines (Page et al. 2021). Initially, relevant articles were identified from databases, and any duplicates were eliminated. During the screening phase, articles were excluded if they were not in English, did not meet the specified document type criteria, or were published in journals that did not meet the required quality standards. The eligibility phase involved a review of titles and abstracts to assess relevance. Subsequently, full-text analysis was conducted on the shortlisted articles. Finally, additional articles were included through the ancestor method to complete the review process.

climate-related financial risk in bank lending or those lacking archival, quantitative data, resulting in 71 articles. Full-text screening identified a core sample of 54 articles meeting all criteria.

To mitigate search limitations, Cooper's (1982) ancestry approach was applied through backward citation tracing. This added 14 frequently cited studies, including both high-impact early-stage work and studies using alternative terminology (e.g., "natural disasters"). Though some were published in lower ranked or unranked outlets, their inclusion was justified by analytical relevance and citation frequency in AJG-rated literature. The final sample comprises 68 peer-reviewed empirical studies, with the ancestry method contributing approximately 21% of the total and enriching thematic and regional diversity.

4 | Exploring the Landscape: A Bibliometric Analysis of the Literature

This section maps the 68 empirical studies included in the review, offering a bibliometric overview of publication trends, disciplinary orientation, journal quality, and geographic scope. These structural patterns provide important context for the synthesis that follows.

Figure 2 shows the annual and cumulative number of studies published between 2009 and 2025. Research output rose significantly after the 2015 Paris Agreement, with a marked increase from 2018 onwards. Transition risk studies have gained traction in recent years. Eleven studies explicitly incorporate the Paris Agreement into their empirical design, reflecting growing alignment between financial research and international climate policy. The apparent decline in 2025 publications is due to the review's cutoff in April 2025 and does not reflect a broader trend reversal.

Figure 3 presents the disciplinary and quality distribution of journals based on the 2024 AJG. While inclusion required a minimum rating of AJG 3, five additional studies—three from AJG 1-rated journals and two from nonrated outlets—were added via the ancestry method due to their influence and analytical relevance. Most studies appear in accounting and finance journals, followed by sustainability-focused and economics or management outlets. Physical risk studies are concentrated in high-ranked finance journals, while transition risk studies span a broader disciplinary range.

Figure 4 highlights the geographic concentration of the literature. Empirical evidence is dominated by high-income countries, particularly the United States, which alone accounts for one-third of the sample and over half of all physical risk studies. China and Australia appear only in transition risk studies. The limited coverage of low- and middle-income countries raises important concerns about the generalizability of findings—particularly for regions facing high climate vulnerability and low institutional capacity.

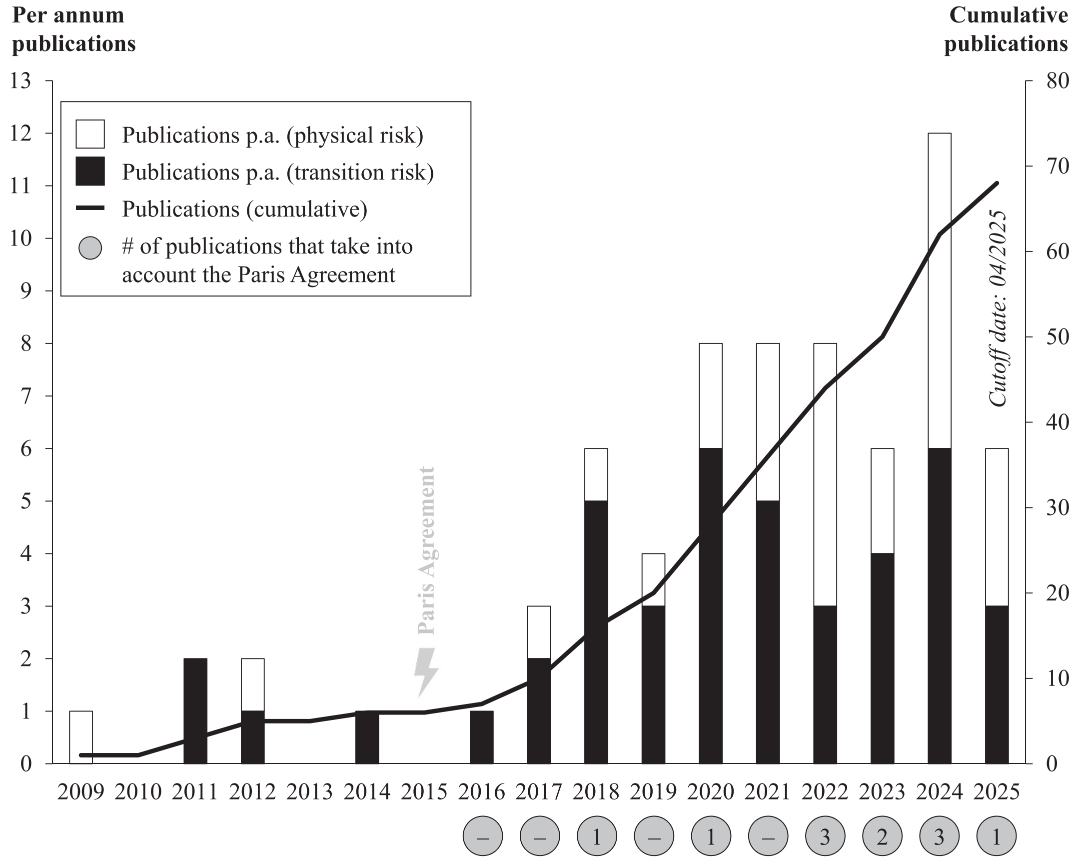

FIGURE 2 | Trends in empirical research on climate-related risks in banking 2009–2025 ($n=68$) This bar and line graph depicts the annual and cumulative number of published studies analyzing physical and transition risks in bank lending. It also highlights the number of studies considering the Paris Agreement over the same period. The data indicates an overall increase in research focus on transition risk, especially following the adoption of Paris Agreement, as shown by the marked points on the graph.

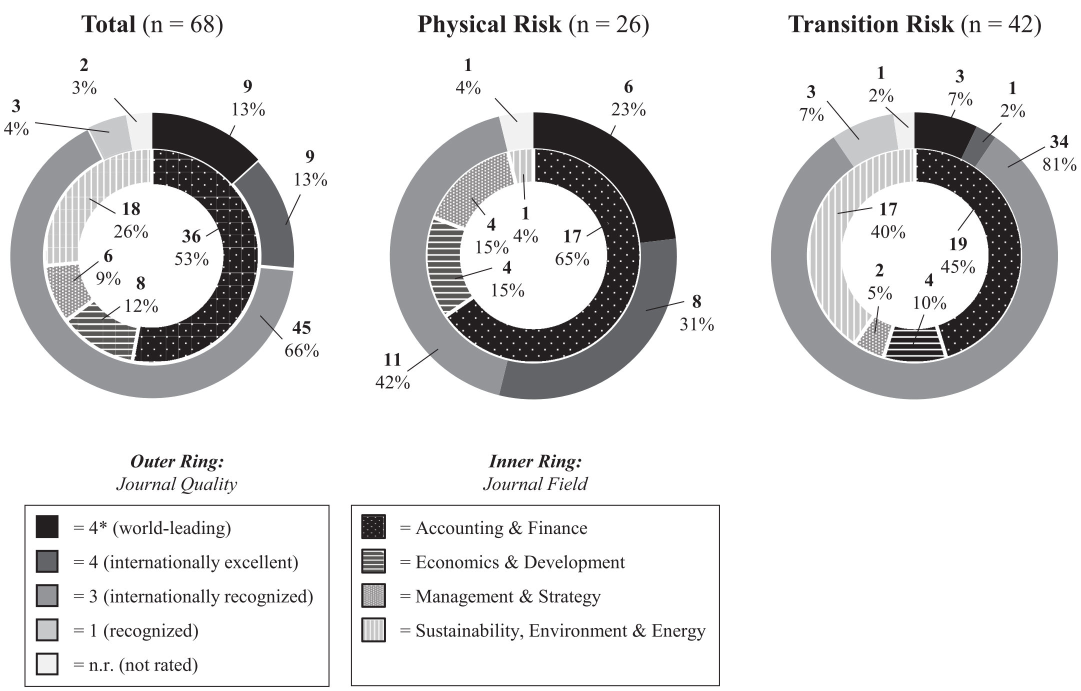

FIGURE 3 | Distribution of journal fields and journal quality (AJG 2024) This set of ring charts presents the combined distribution of journal disciplines and journal quality ratings for empirical studies on climate-related risks in bank lending. Each chart displays a double-ring structure: the inner circle categorizes studies by journal discipline, while the outer circle indicates the journal's quality based on the Academic Journal Guide (AJG) 2024. The left chart reflects the total sample ($n=68$), while the middle and right charts represent the subsamples of studies addressing physical risks ($n=26$) and transition risks ($n=42$), respectively.

United States	**23**	**34%**	**Germany**	**1**	**1%**
- Physical	14	54% (of physical studies)	*- Physical*	1	4% (of physical studies)
- Transition	9	21% (of transition studies)	*- Transition*	0	0% (of transition studies)
China	**8**	**12%**	**Iran**	**1**	**1%**
- Physical	0	0% (of physical studies)	*- Physical*	1	4% (of physical studies)
- Transition	8	19% (of transition studies)	*- Transition*	0	0% (of transition studies)
Australia	**3**	**4%**	**Turkey**	**1**	**1%**
- Physical	0	0% (of physical studies)	*- Physical*	1	4% (of physical studies)
- Transition	3	7% (of transition studies)	*- Transition*	0	0% (of transition studies)
Italy	**2**	**3%**			
- Physical	2	8% (of physical studies)			
- Transition	0	0% (of transition studies)	*Not depicted*		
United Kingdom	**2**	**3%**	**Worldwide**	**18**	**26%**
- Physical	1	4% (of physical studies)	*- Physical*	4	15% (of physical studies)
- Transition	1	2% (of transition studies)	*- Transition*	14	33% (of transition studies)
Ecuador	**1**	**1%**	**Europe**	**8**	**12%**
- Physical	1	4% (of physical studies)	*- Physical*	1	4% (of physical studies)
- Transition	0	0% (of transition studies)	*- Transition*	7	17% (of transition studies)

FIGURE 4 | Geographic distribution of empirical studies on climate-related risks in bank lending ($n = 68$) The map displays the country-level focus of the reviewed studies, with darker shading indicating higher study frequency. The table below summarizes the number and percentage of studies per country, distinguishing between physical and transition climate risk coverage. Multicountry studies categorized as "Europe" and "Worldwide" are not visualized on the map but are included in the total.

5 | Uncovering Patterns: Content Analysis of the Literature

5.1 | Physical Risks

Of the 68 studies reviewed, 26 examine physical climate risks in bank lending. Most adopt a single-country focus—14 in the United States—and only five use cross-national designs. Measures vary widely, reflecting differences in how institutions respond to climate shocks.

Fifteen studies apply an ex post lens, analyzing credit behavior after events like hurricanes or floods; nine adopt an ex ante perspective, examining responses to anticipated risks like sea-level rise or drought. Only two (Huang et al. 2022; Xu and Xu 2020) compare both, providing rare insights into the timing of risk assessment.

Although not caused by climate change, some earthquake studies are included to isolate credit responses to acute, low-probability events. These analogies help illuminate how banks manage uncertain but high-impact risks.

For synthesis, studies are grouped by risk type: chronic (12) and acute (14). All chronic risk studies report credit tightening via higher interest rates (e.g., Aslan et al. 2022; Ge et al. 2025; Ginglinger and Moreau 2023; Javadi and Masum 2021; Trinh et al. 2024), stricter covenants (Huang et al. 2022), or reduced access (e.g., Duan and Li 2024; Fu et al. 2025; Kling et al. 2021).

Findings for acute risks are heterogeneous. Only five of the 14 studies report tighter credit. A clearer pattern emerges when classifying by *risk expectation*: Anticipated acute risks (e.g., frequent flooding and seismic activity) lead to preemptive credit restrictions (Bassetti et al. 2025; Berg and Schrader 2012; Faiella and Natoli 2018; Garmaise and Moskowitz 2009; Xu and Xu 2023). Unexpected disasters often trigger post-event lending expansions (Abedifar et al. 2024; Garbarino and Guin 2021; Koetter et al. 2020), hurricanes (LaCour-Little et al. 2024; Schüwer et al. 2019), and other events (Cortés and Strahan 2017).

Most studies on acute, unexpected risks report recovery lending. Ouazad and Kahn (2022) find partial risk pricing, though LaCour-Little et al. (2024) attribute this to measurement error, with corrected results showing no significant tightening[1]. Benincasa et al. (2024) are the only study to find increased loan rejection after disasters. Since repricing credit during or immediately after a disaster is often neither feasible nor desirable, some banks instead adjust their provisioning behavior: Dal Maso et al. (2024) find that banks in high-risk areas increase loan loss provisions, enabling continued lending while managing future losses.

A recurring theme is temporality: nine studies show that responses to physical risk are short-lived and shaped by salience, media coverage, and heuristics (Choi et al. 2022; Nguyen et al. 2022). Only a few institutions integrate these risks systematically (Huang et al. 2022).

Sectoral focus matters. Ten studies focus on mortgages, often revealing risk transfer rather than repricing. Lenders shift risk to public entities like government-sponsored enterprises (GSEs) through securitization (Ouazad and Kahn 2022; Xu and Xu 2023), raising concerns about hidden systemic exposure.

Taken together, the findings highlight a key behavioral asymmetry: anticipated risks prompt tightening, while unanticipated disasters trigger short-term expansions. These divergent responses mirror salience effects and availability heuristics, where visible, emotionally charged events provoke stronger action than chronic or abstract risks (Sunstein and Zeckhauser 2011; Tversky and Kahneman 1974). They also underscore short-termism and myopic incentives in credit practices, which discourage proactive risk integration for slow-moving hazards (Benartzi and Thaler 1995; Dallas 2012). Banks' dual role as risk allocators and shock absorbers underscores tensions in climate risk management.

Finally, the dominance of US-based research limits geographic generalizability. More cross-country studies are needed to explore how institutional contexts shape responses to physical climate risks.

5.2 | Transition Risks

Of the 68 studies in this review, 42 examine how transition risks affect bank lending. Transition risks arise from the shift toward a low-carbon economy and include regulatory changes such as carbon pricing, reputational concerns, technological disruption, or market revaluation of emission-intensive assets (BCBS 2021). Unlike physical risks, they are typically forward-looking and often endogenous, linked to firms' emissions, sustainability practices, or disclosures.

A notable feature of this literature is its global orientation: 21 studies adopt multicountry designs, while others focus on the United States (nine) and China (eight). The literature has expanded significantly since the 2015 Paris Agreement, with 38 of the 42 studies published thereafter. Many use climate policy events as natural experiments to assess the salience of transition risk.

5.2.1 | From Risk to Rate: Uncovering the Influence of Transition Risks on Loan Pricing

Thirty-two studies assess how transition risks affect loan pricing, primarily through loan spreads or the cost of debt. Results vary based on the type of risk proxy, institutional setting, and borrower or lender characteristics. Fifteen studies report a green premium (higher borrowing costs for environmentally weak firms), 11 observe a green discount, three find U-shaped effects, while three show mixed or null results. To structure this heterogeneity, the studies can be grouped according to the transition risk measure used.

5.2.1.1 | The Influence of CSR or ESG Performance on Loan Pricing. Nine studies use CSR or ESG indicators to proxy transition risk. Of these, six report green discounts (lower spreads for firms with strong sustainability profiles). However, these effects are often context-dependent. For example, Cheung et al. (2018, 2020) find that pricing benefits are limited to countries with strong stakeholder norms. Desender et al. (2020) show that ESG benefits are most pronounced for firms near default, while Li et al. (2024) attribute lower spreads to China's Green Finance Policy. Francis et al. (2018) and Hoepner et al. (2016) emphasize the role of institutional CSR and national ESG norms, which may influence pricing more than firm-level ESG alone.

At the same time, several studies highlight limits to the effectiveness of ESG signals. Goss and Roberts (2011) suggest that greenwashing concerns may trigger higher spreads, while Hauptmann (2017) finds that only sustainability-minded banks respond positively to ESG ratings. Bae et al. (2018) document both effects, showing that CSR concerns increase spreads when credit ratings are unavailable, whereas CSR strengths consistently lower costs. Together, these studies suggest that the financial value of ESG signals depends on their credibility and institutional context.

5.2.1.2 | The Influence of Environmental Performance on Loan Pricing. A smaller set of studies relies on direct environmental performance indicators. Among these, Du et al. (2017) and Nandy and Lodh (2012) find that strong environmental records reduce borrowing costs. By contrast, Chava (2014) reports that environmental concerns raise spreads, and environmental strengths are not rewarded. Effects also vary depending on how environmental performance is measured. Several studies use related proxies—such as disclosure quality, regulatory exposure, or sustainability-linked donations—and generally report pricing effects when signals are aligned with policy frameworks or standardized taxonomies (Fard et al. 2020; Luo et al. 2019; Sautner et al. 2025).

Ye and Zhang (2011) find a U-shaped relationship between sustainability-related donations and loan pricing, where moderate donations reduce borrowing costs, but excessive donations are penalized. This suggests that lenders may interpret aggressive CSR behavior as inefficient capital allocation. Bell et al. (2023), focusing on energy efficiency, find no consistent pricing response, indicating that not all environmental signals are salient or actionable from a lending perspective.

The evidence indicates that the financial impact of environmental indicators depends strongly on how clearly they are defined and how easily they can be interpreted by lenders.

5.2.1.3 | The Influence of Carbon Risk on Loan Pricing. Fifteen studies assess carbon risk using emissions-based proxies, mainly Scope 1 or 2. Eleven report higher borrowing costs for high-emission firms, especially around policy events. For example, Nguyen et al. (2025) document pricing effects following Australia's Kyoto Protocol ratification, with similar findings in China (Huang et al. 2021) and California (Ivanov et al. 2021). Post-Paris Agreement studies confirm intensified penalties for carbon-intensive borrowers (Delis et al. 2024; Demetriades and Politsidis 2025; Ehlers et al. 2022; Owolabi et al. 2024).

Some evidence points to anticipatory effects: Palea and Drogo (2020) and Bruno and Lombini (2023) find spread increases for high emitters even before COP21. Verified emissions data improve signal clarity (Kleimeier and Viehs 2021), and banks price risk more steeply when borrowers appear unaware of their carbon exposure (Jung et al. 2018).

Other studies show more mixed effects. Al-Fakir Al Rabab'a et al. (2023) find a green discount in low-governance settings; Caragnano et al. (2020) show effects vary by firm performance. Dimitras et al. (2024) report no pricing effect for carbon intensity but identify lower spreads for firms with high environmental scores. Zhou et al. (2018) observe a U-shaped pattern linked to pollution violations.

Taken together, Sections 5.2.1.1 to 5.2.1.3 suggest that banks price transition risks most consistently when signals are standardized, policy-aligned, and third-party verified. Softer indicators like ESG scores yield less reliable responses. These patterns reflect salience bias, bounded rationality, and heuristic-based decisions (ECB 2021; Simon 1990; Tversky and Kahneman 1974). In weak regulatory environments or where data are ambiguous, banks may discount transition risks entirely—leaving risk pricing fragmented and context-dependent.

5.2.2 | From Risk to Credit: Exploring the Impact of Transition Risks on Credit Access

Five studies investigate how transition risk affects credit availability. Most conclude that environmentally aligned firms benefit from improved credit access and lower collateral requirements (Fernández-Cuesta et al. 2019; Huang et al. 2023; Zhang 2021). Reghezza et al. (2022) show that banks reduced exposure to high-emission borrowers after the Paris Agreement. However, Brutscher et al. (2020) find no significant effect for energy efficiency, suggesting that some sustainability signals carry less weight in credit allocation decisions.

These findings point to selective responsiveness in how banks link transition risks to credit decisions. Observable, policy-relevant sustainability traits tend to unlock better credit conditions, while subtler or less standardized signals are often ignored. This behavior reflects bounded rationality and salience-driven heuristics: credit officers prioritize risks that are easier to process or more visibly tied to regulatory expectations (Simon 1990; Tversky and Kahneman 1974). In the absence of strong institutional incentives, abstract indicators like energy efficiency may fail to trigger lending adjustments—even when they imply long-term risk mitigation.

5.2.3 | From Risk to Resilience: Revealing the Connection Across Multiple Factors

Several studies go beyond pricing and access to examine how transition risks affect banks' risk management, profitability, and borrower relationships. A link between climate exposure and credit risk is evident: Umar et al. (2021) find that green lending lowers default risk, while Zhang et al. (2024) show that both physical and transition risks raise nonperforming loan (NPL) ratios. These findings support a risk-based rationale for climate-aligned lending.

Other studies underscore alignment and profitability effects. Chalabi-Jabado and Ziane (2024) find that low-carbon lending enhances loan growth and bank returns. Houston and Shan (2022) demonstrate that ESG-oriented banks actively influence borrower behavior and align lending strategies with client profiles. Herbohn et al. (2019) show that equity markets respond positively to sustainability-linked loan revisions.

Together, these findings suggest that transition risk is not only a pricing concern or access constraint—it reshapes the financial sector's operational logic. Green lending emerges as a strategy that mitigates credit risk, enhances profitability, and strengthens client alignment, thereby reinforcing institutional resilience in the face of long-term systemic change. Yet, despite these advantages, not all banks adopt such strategies. This divergence may reflect organizational frictions and incentive misalignment that prevent banks from realizing the full value of proactive climate lending (Benartzi and Thaler 1995; ECB 2021). Where climate strategies do succeed, they are often embedded in broader governance structures that enable forward-looking, cross-functional decision-making.

5.3 | Cross-Risk Synthesis

While Chapters 5.1 and 5.2 examined physical and transition risks separately, this synthesis reveals that institutional, borrower, sectoral, and geographic factors critically shape whether and how climate risks are priced and translated into credit constraints.

5.3.1 | Why Bank Size, Structure, and Sustainability Profiles Shape Climate Risk Responses

Institutional characteristics significantly influence how banks perceive and act on climate risk. Bank size shapes responsiveness and resilience. Larger banks, with more capital access, often provide recovery lending postdisaster (Faiella and Natoli 2018), while smaller banks tend to reallocate capital or raise collateral demands (Cortés and Strahan 2017; Xu and Xu 2023). Some studies highlight the agility of rural banks (Abedifar et al. 2024), though others find smaller institutions more reactive under stress (Duan and Li 2024). Across all sizes, carbon-neutral lending reduces credit risk (Umar et al. 2021).

Business model and governance also matter. Relationship-based and jointly governed banks integrate climate risk more effectively (Huang et al. 2021; Nguyen et al. 2022), whereas diversified banks often default to collateral requirements (Ouazad and Kahn 2022; Xu and Xu 2023). Funding constraints can limit lending in less embedded banks following climate shocks (Garmaise and Moskowitz 2009; Koetter et al. 2020).

Environmental orientation further differentiates behavior. Some studies find that green banks more strongly penalize polluters (Delis et al. 2024; Hauptmann 2017; Sautner et al. 2025), though others report mixed effects (Dimitras et al. 2024; Ehlers et al. 2022). Symbolic sustainability commitments often fail to translate into strategic action (Lueg and Pesheva 2021). Greenwashing and greenhushing, as discussed by Rasche (2025a), may mask weak climate alignment. Reputational pressures affect depositor behavior (Choi et al. 2022), and only ESG-leading banks appear able to influence borrower conduct (Houston and Shan 2022).

In sum, structural features shape both how risks are perceived and how proactively they are managed. Organizational silos, narrow mandates, and short-term incentives often hinder integration, in line with bounded rationality and legitimacy-driven behavior identified in behavioral finance research.

5.3.2 | Why Small- and Medium-Sized Enterprises (SMEs) Remain Overlooked Despite High Vulnerability to Climate Risk

SMEs are especially vulnerable to climate risk but remain underrepresented in the literature. In physical risk contexts, SMEs face higher credit rationing, especially when insurance markets are weak or public recovery frameworks are limited (Berg and Schrader 2012; Faiella and Natoli 2018). Public guarantees (e.g., SBA loans) can mitigate this vulnerability (Schüwer et al. 2019).

In transition risk settings, few studies analyze SMEs explicitly. Most focus on listed firms or large borrowers, despite evidence that SMEs bear disproportionate regulatory costs. For example, Huang et al. (2021) show that environmental regulations in China significantly raised both loan spreads and default rates for SMEs. This limited visibility is problematic given that SMEs make up the majority of private-sector employment in many economies and are critical to supply chain resilience.

This exclusion is partly structural and partly behavioral. SMEs often lack standardized reporting and climate disclosures, reducing their visibility to lenders. At the same time, capacity constraints and established practices lead banks to prioritize larger, easier-to-assess clients. In the absence of tailored tools or simplified frameworks, banks may unintentionally treat SMEs as nonclimate-relevant, thereby reinforcing their marginalization in the sustainable finance transition.

5.3.3 | How Industry Exposure and Firm Emissions Interact to Shape Credit Outcomes

Industry affiliation affects how climate risks are perceived and priced, though mechanisms differ for physical and transition risks.

For physical risks, sector vulnerability is relatively direct: Real estate, agriculture, and infrastructure are highly exposed to acute and chronic hazards (Berg and Schrader 2012). In these cases, external factors, such as insurance availability or flood zone designations, serve as signals that influence credit terms (Faiella and Natoli 2018; Garmaise and Moskowitz 2009).

In transition risk context, sector effects are more nuanced. While carbon-intensive sectors such as manufacturing or energy are frequently studied, findings suggest that banks respond more strongly to firm-level emissions than sector labels. For example, Ehlers et al. (2022) find no evidence of stranded asset effects, implying that emission intensity matters more than sector affiliation.

Nonetheless, the structure and timing of sectoral transitions matter. Upstream fossil-fuel firms face higher spreads than downstream ones (Demetriades and Politsidis 2025), and low-polluting sectors were repriced more post-Paris, while high-polluting ones had already been penalized (Palea and Drogo 2020). Huang et al. (2021) show that regulatory timing significantly influenced how high emitters were priced in China.

These findings suggest that banks do not apply sectoral risk uniformly. Instead, transition risk is filtered through a mix of regulatory signals, institutional routines, and the visibility of firm-specific emissions data. Where signals are ambiguous, lenders may revert to heuristics. Where emissions data are specific and credible, banks adjust pricing more systematically—mirroring the behavioral logic of salience and cognitive simplification.

5.3.4 | How Policy Frameworks and Geography Amplify or Mute Climate Risk Pricing

Policy and geography strongly influence whether and how financial institutions recognize and price climate risks. Global agreements such as the Paris Agreement mark turning points: 10 studies document stronger pricing and lending responses post-2015 (Aslan et al. 2022; Delis et al. 2024; Demetriades and Politsidis 2025; Ehlers et al. 2022; Ginglinger and Moreau 2023; Owolabi et al. 2024; Trinh et al. 2024). European banks, for example, cut exposure to high-emission firms following the Agreement and the US withdrawal (Reghezza et al. 2022). Some effects appear anticipatory: High-polluting sectors were penalized even before 2015, while low-polluting sectors were repriced only afterward (Bruno and Lombini 2023; Palea and Drogo 2020).

National reforms reinforce these dynamics. The Kyoto Protocol in Australia (Nguyen et al. 2025), China's Clean Air Action (Huang et al. 2021), and the Green Finance Policy (Li et al. 2024; Zhang et al. 2024) tightened credit for polluters and improved lending outcomes for greener borrowers. Market-based policies like cap-and-trade (Ivanov et al. 2021) and the SEC's climate guidance (Ge et al. 2025) also affected lending terms.

Geographic context mediates policy transmission, yet the literature remains concentrated in high-income countries, mainly the United States, Europe, and China. Empirical gaps persist for the Global South, Least Developed Countries (LDCs), or Small Island Developing States (SIDS), despite their high exposure to climate risk and limited institutional capacity. Heat-related shocks confirm that geographic exposure to physical climate risk is financially relevant (Schuster et al. 2025), but underresearched regions risk being overlooked by both lenders and scholars.

This imbalance constrains generalizability and reflects a broader visibility bias. As Kunkel et al. (2025) show, ESG scores are more closely linked to national income than geography, with weaker predictive power in lower income contexts. Where policy frameworks are clear and institutional capacity strong, banks integrate climate risks more effectively. In low-capacity settings, however, mispricing, heuristic decision-making, and risk neglect persist—both in practice and in research.

5.4 | Toward a Typology of Climate Risk Integration in Bank Lending

The review reveals significant heterogeneity in how financial institutions respond to climate risks. Responses vary systematically by risk type, salience, and institutional capacity. To synthesize these findings, we developed a typology matrix (Figure 5) that maps climate risk indicators to five observed bank behaviors: recovery lending, reactive containment, risk pricing adjustment, strategic reallocation, and relational transformation.[1]

For physical risks, the matrix distinguishes between acute-unexpected, acute-expected, and chronic-expected events. Acute-unexpected risks (e.g., hurricanes) typically trigger recovery lending, reflecting short-term liquidity support rather than strategic portfolio change (Abedifar et al. 2024; Cortés and Strahan 2017; Koetter et al. 2020).

	Physical Risks			Transition Risks			
	Acute x Unexpected	Acute x Expected	Chronic x Expected	CSR / ESG Performance	Environmental Performance	Carbon Performance	Other
Recovery Lending	• Cortés & Strahan 2017 • Schüwer et al. 2019 • Koetter et al. 2020 • Garbarino & Guin 2021 • Ouazad & Kahn 2022 • Abedifar et al. 2024						
Reactive Containment	• Benincasa et al. 2024	• Garmaise & Moskowitz 2009 • Berg & Schrader 2012 • Faiella & Natoli 2018 • Xu & Xu 2020 • Xu & Xu 2023	• Xu & Xu 2020 • Kling et al. 2021 • Aslan et al. 2022 • Choi et al. 2022 • Huang et al. 2022 • Duan & Li 2024 • Fu et al. 2025				• Fard et al. 2020
Risk Pricing Adjustment	• Schüwer et al. 2019[1] • Dal Maso et al. 2024[2]	• Bassetti et al. 2025	• Javadi & Masum 2021 • Kling et al. 2021 • Huang et al. 2022 • Nguyen et al. 2022 • Ginglinger & Moreau 2023 • Trinh et al. 2024 • Ge et al. 2025	• Cheung et al. 2018[5] • Cheung et al. 2020[6] • Desender et al. 2020[7] • Li et al. 2024 • Francis et al. 2018 • Hoepner et al. 2016[8] • Goss & Roberts 2011 • Hauptmann 2017[9] • Bae et al. 2018[10]	• Du et al. 2017 • Nandy & Lodh 2012 • Chava 2014 • Dimitras et al. 2024	• Jung et al. 2018[14] • Zhou et al. 2018[15] • Caragnano et al. 2020 • Palea & Drogo 2020 • Huang et al. 2021 • Ivanov et al. 2021 • Kleimeier & Viehs 2021 • Ehlers et al. 2022 • Al-Fakir Al Rabab'a et al. 2023 • Bruno & Lombini 2023 • Delis et al. 2024 • Owolabi et al. 2024 • Demetriades & Politsidis 2025 • Nguyen et al. 2025	• Ye & Zhang 2011[20] • Luo et al. 2019[21] • Fard et al. 2020[22] • Sautner et al. 2025[23]
Strategic Reallocation				• Huang et al. 2023	• Zhang 2021	• Fernández-Cuesta et al. 2019 • Reghezza et al. 2022 • Bruno & Lombini 2023	
Relational Transformation				• Houston & Shan 2022			
Other Effect			• Zhang et al. 2024[3] • Chalabi-Jabado & Ziane 2024[4]			• Herbohn et al. 2019[16] • Huang et al. 2021[17] • Umar et al. 2021[18] • Zhang et al. 2024[3] • Chalabi-Jabado & Ziane 2024[19]	
No Effect	• LaCour-Little et al. 2024			• Goss & Roberts 2011[11] • Hoepner et al. 2016[8] • Cheung et al. 2018[12]	• Bell et al. 2023[13] • Brutscher et al. 2020[13]	• Dimitras et al. 2024	

FIGURE 5 | Typology of bank responses to physical and transition risks The matrix maps 68 studies on climate risk in bank lending across two dimensions: the type and manifestation of climate risk (columns) and the observed bank response (rows). Transition risks are categorized by the type of risk indicator (e.g., CSR/ESG scores and carbon performance), and physical risks are classified by their temporal profile and predictability. Superscripts indicate study-specific nuances or conditional effects.

In contrast, expected physical risks, whether acute or chronic, lead to reactive containment and risk pricing adjustment, including tighter terms, higher provisions, or increased collateral (e.g., Berg and Schrader 2012; Huang et al. 2022). However, these responses are often shaped by salience, media coverage, or heuristics rather than systematic risk integration (Nguyen et al. 2022; Xu and Xu 2020).

Transition risks are more frequently linked to risk pricing adjustments, especially when indicators are quantifiable, policy-aligned, and based on carbon performance (e.g., Ehlers et al. 2022; Nguyen et al. 2025; Owolabi et al. 2024). Related signals such as disclosure quality or environmental scores show weaker, context-dependent effects, and energy efficiency lacks robust pricing evidence (Bell et al. 2023; Brutscher et al. 2020).

ESG- and CSR-based pricing appears contingent on national stakeholder orientation (Cheung et al. 2018), borrower credit risk (Desender et al. 2020), or the sustainability profile of the lender (Hauptmann 2017). In these cases, influence is often channeled through relational transformation, suggesting that softer signals drive engagement rather than price-based discrimination (Houston and Shan 2022).

The typology reveals behavioral asymmetries: recovery lending and containment occur only in response to acute physical risks, while strategic reallocation and relational transformation are largely absent from physical risk studies. Across transition risks, the penalization of carbon-intensive firms is more consistent than any preferential treatment of green firms. Positive pricing occurs only when performance is clearly quantified, verified, and policy-anchored.

Overall, the typology underscores the dominance of short-term, visible responses to physical risks and more strategic engagement with well-defined transition risks. This behavioral divide highlights a persistent gap: physical risks are managed reactively, while long-term adaptation remains rare. As climate risks intensify, future research should explore whether financial institutions can shift from short-term coping to structural climate integration in lending practices.

6 | Synthesis: Discussion, Contributions, and Future Research Opportunities

This chapter synthesizes the review's key findings, highlights their theoretical and practical implications, and outlines a future research agenda. Central to this synthesis is the behavioral typology introduced in Chapter 5, which captures how banks respond to climate risks. This framework not only structures empirical evidence but also functions as a diagnostic tool for evaluating institutional practices and guiding regulatory and strategic interventions.

6.1 | Theoretical Contributions

A central theoretical contribution of this review is the development of a behavioral typology that links empirical findings to a structured response logic. Rather than simplifying bank responses into the presence or absence of climate risk consideration, the typology distinguishes five behavioral modes (recovery lending, reactive containment, risk pricing adjustment, strategic reallocation, and relational transformation) that capture the diversity of institutional reactions to different climate risk profiles. This facilitates a more nuanced synthesis across both physical and transition risks (Koetter et al. 2020; Xu and Xu 2023).

The typology also reveals how the visibility and expectedness of risks shape credit decisions. Acute and unexpected physical risks, such as floods or hurricanes, frequently prompt recovery lending as banks act as financial shock absorbers (e.g., Abedifar et al. 2024; Koetter et al. 2020). In contrast, chronic or expected physical risks, such as sea-level rise, are more likely to trigger risk pricing adjustments or reactive containment, often shaped by salience, availability heuristics, and bounded rationality (e.g., Ge et al. 2025; Xu and Xu 2020). Meanwhile, transition risks, especially when supported by clear policy signals, increasingly prompt forward-looking responses, including strategic reallocation and relational transformation (e.g., Houston and Shan 2022; Huang et al. 2023).

Finally, the typology functions as both a conceptual and a diagnostic framework, revealing patterns and gaps in the existing literature. The near-absence of relational transformation in response to physical risks illustrates a key asymmetry: Banks struggle to embed slow-moving, systemic risks into client engagement or portfolio strategies (e.g., Nguyen et al. 2022). This conceptual lens can inform future hypotheses on how institutional design and behavioral constraints mediate risk governance.

6.2 | Practical Contributions

The typology presented in this review offers a diagnostic instrument for financial institutions seeking to evaluate the maturity and coherence of their climate risk management. By mapping their current practices to five behavioral modes, banks can assess whether they remain in reactive containment (e.g., short-term credit restrictions) or have progressed toward strategic reallocation and relational transformation.

Beyond diagnosis, the typology offers prescriptive value. It can support the development of internal roadmaps by identifying specific levers for advancing climate integration. Moving from reactive containment to strategic reallocation may require integrating climate scenarios into credit models, revising incentive structures for client-facing teams, and aligning governance across sustainability, risk, and credit functions. A structured self-assessment could help benchmark current positioning and guide institutional development.

A central trade-off for institutions lies between compliance and adaptation. Compliance-oriented strategies may focus on minimum disclosure or capital requirements, limiting near-term costs but risking exposure to unpriced climate risks. Adaptive strategies require investments in data infrastructure, forward-looking risk metrics, and internal climate expertise. These may incur higher up-front costs but strengthen long-term resilience and competitiveness. In this context, climate stress testing plays a key role by revealing hidden exposures, testing portfolio resilience, and strengthening the case for strategic adaptation. When aligned with supervisory expectations, stress tests also signal institutional preparedness.

Regulators and supervisors can use the typology to differentiate between banks' behavioral maturity. Prudential tools such as capital buffers or green lending incentives could be linked to the degree of strategic integration, rewarding institutions that demonstrate forward-looking risk pricing and portfolio alignment. Conversely, persistent reliance on reactive or recovery lending may warrant supervisory intervention. This could take the form of enhanced disclosure mandates, scenario testing requirements, or public climate preparedness scores. Where climate risk integration stalls, more binding expectations on governance, cross-functional training mandates, or audit mechanisms may be necessary.

Finally, the typology opens avenues for bank-specific positioning models that support internal benchmarking and cross-country comparison. These applications translate the conceptual framework into a practical taxonomy for evaluating and advancing climate alignment within the financial system.

6.3 | Future Research Agenda

Building on the typology's conceptual gaps and blind spots, this section outlines five research priorities aimed at improving how financial institutions assess, price, and manage climate risks (see Figure 6 for an overview of themes and interconnections).

6.3.1 | Carbon Risk Metrics and Emission Scopes

Studies capture transition risk using diverse carbon metrics, ranging from company disclosures to regulatory violations and estimated emissions (Al-Fakir Al Rabab'a et al. 2023; Zhou et al. 2018). Scope coverage varies widely: Some focus only on Scope 1 emissions (Jung et al. 2018), and others include Scope 2 or all three (Ehlers et al. 2022). Such heterogeneity hinders cross-study comparability and limits generalizability.

Financial institutions themselves often prioritize Scope 1 data, overlooking Scope 3 emissions that may account for the bulk of value chain risk (Ehlers et al. 2022). This narrow focus can distort exposure estimates and misalign credit decisions with net-zero targets. Even where disclosure quality improves (Friedrich et al. 2023), reported data often lacks forward-looking precision,

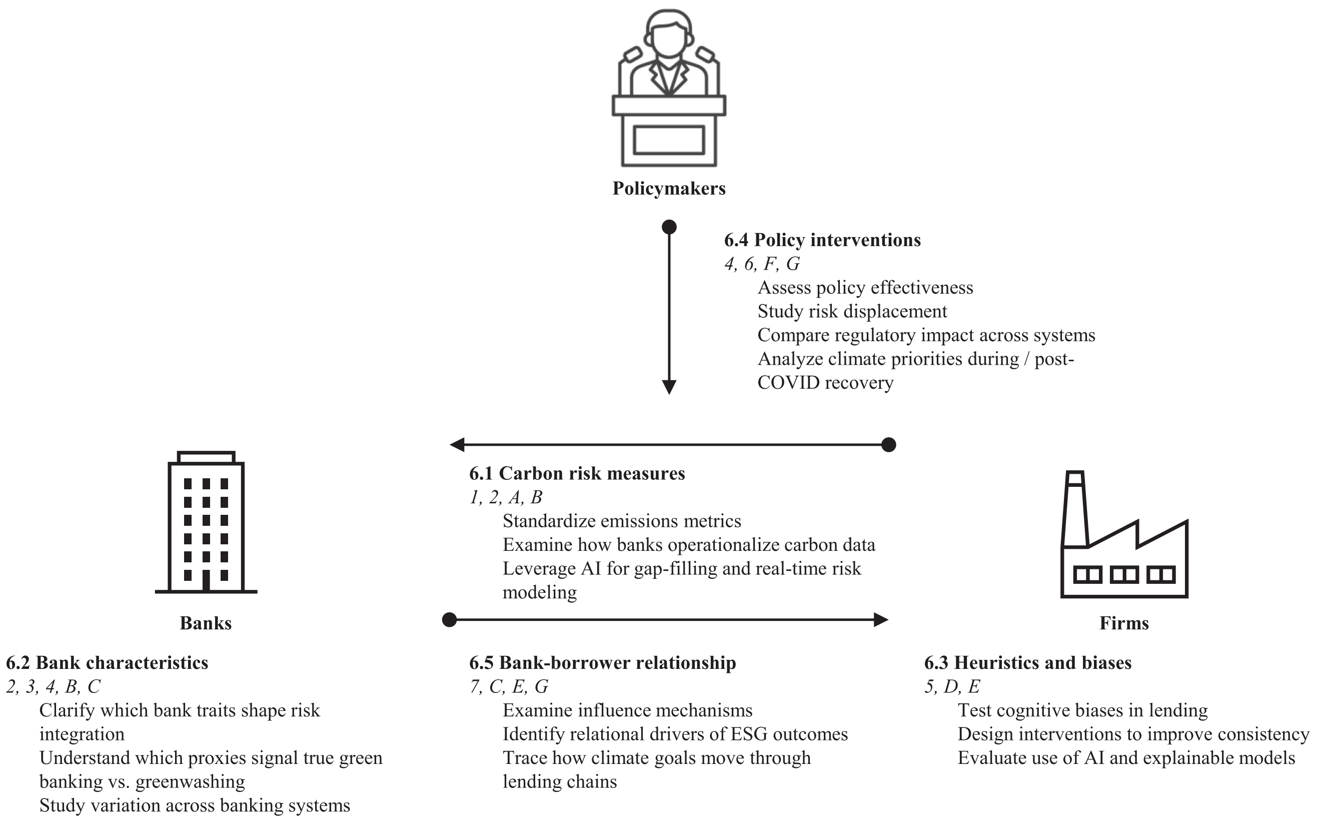

FIGURE 6 | Research priorities for advancing climate risk integration in banking The figure presents five identified research areas based on gaps observed in the empirical literature: carbon risk measures (6.1), bank characteristics (6.2), heuristics and biases (6.3), policy interventions (6.4), and bank–borrower relationships (6.5). Each area is linked to relevant actors (banks, firms, and policymakers) and associated with suggested theoretical perspectives (coded 1–7) and methodological approaches (A–G), as listed in the legend. The arrows illustrate directional relationships and interdependencies across research domains.

and ESG ratings may capture intentions rather than actions (Cregan et al. 2024).

Future research should aim to harmonize carbon metrics, develop validation protocols, and test their predictive power across contexts. Comparative studies could examine which datasets financial institutions trust, how they handle self-reported data, and whether Scope 3 inclusion materially alters credit risk assessments.

Emerging technologies such as artificial intelligence (AI) offer powerful tools to close information gaps. Natural language processing (NLP) and satellite data can enhance disclosure coverage (Jones 2024), while predictive models may simulate damage from physical hazards or anticipate pricing shocks from abrupt policy shifts (Reichstein et al. 2025)—offering capabilities beyond traditional credit models.

6.3.2 | Bank Characteristics and the Concept of Green Banking

While several studies explore how bank size, ownership, or business models influence climate risk integration (e.g., Demetriades and Politsidis 2025; Huang et al. 2021; Schüwer et al. 2019), findings remain fragmented. Some banks are better positioned to assess risks due to client proximity or policy alignment (Nguyen et al. 2022; Zhou et al. 2022), yet the enabling conditions for such capabilities are underexplored.

Cross-country institutional variation is particularly overlooked. Most studies focus on high-income countries, missing key differences in regulation, governance, and business models (Lueg et al. 2019). For example, European banks face mandatory disclosure, while Chinese banks operate under state-led policy mandates (Zhou et al. 2018). Ownership structure also shapes responses: State-owned banks may align with policy goals, cooperatives with long-term client ties. Board-level commitment appears central to integrating climate strategy into credit decisions (Rasche 2025b). Future research should compare how institutional design—regulation, ownership, or market orientation—affects climate risk management.

A related challenge is defining what constitutes a "green bank." Studies use varied proxies: green initiative participation (Delis et al. 2024), ESG commitments (Sautner et al. 2025), or performance scores (Hauptmann 2017). Recent evidence suggests that ESG scores vary less by region than by national income, with substantially lower explanatory power in less wealthy countries (Kunkel et al. 2025), calling into question the transferability of ESG-based definitions. Clearer, context-sensitive criteria are needed to distinguish genuine sustainability orientation from greenwashing.

Theoretical breadth should also expand. Most studies rely on agency and stakeholder theories, emphasizing incentives and accountability. Integrating resource dependence (Pfeffer and Salancik 1978) and legitimacy theory (Suchman 1995) could better explain why some banks adopt symbolic ESG strategies, while others embed sustainability more substantively.

6.3.3 | Heuristics, Biases, and the Role of AI

Research on physical risks shows that banks often respond reactively to salient events like floods or hurricanes, with cognitive biases leading to inconsistent lending and underestimation of long-term risks (e.g., Garbarino and Guin 2021; Nguyen et al. 2022; Xu and Xu 2023). While most evidence focuses on physical hazards, similar behavioral patterns may affect how banks perceive transition risks—particularly under policy uncertainty or limited data.

Banks tend to favor visible, quantifiable climate signals. Firms with strong disclosures often receive better loan terms (Birindelli et al. 2022; Li et al. 2022), suggesting that salience and heuristic shortcuts shape perceived risks. Yet, systematic analysis of these behavioral dynamics remains scarce.

Behavioral finance theories (Kahneman and Tversky 1979) offer valuable lenses to study how biases, such as availability heuristics, loss aversion, and temporal discounting, influence climate risk assessment. These distortions may cause overreaction to recent disasters or neglect of slow-onset threats. Future studies could deploy experiments, interviews, or credit data to test how such biases operate and how they can be countered.

AI offers promising tools to mitigate cognitive bias. Climate-adjusted credit models using historical event data, emissions trajectories, or borrower exposure can improve objectivity (Reichstein et al. 2025). NLP may extract risk signals from disclosures or media sentiment (Jones 2024). Yet, ensuring transparency and accountability will require explainable AI and careful integration of human judgment.

6.3.4 | Policy Interventions and the Post-COVID Financial Landscape

Climate policy is key in translating abstract risks into financial decisions. Evidence shows that policies like the Paris Agreement and Kyoto Protocol prompt stronger credit responses (e.g., Demetriades and Politsidis 2025; Nguyen et al. 2025), though institutional capacity influences policy effectiveness. Not all institutions can integrate long-term risk data or comply with disclosure mandates (Zhou et al. 2022).

Future research could examine which policies promote strategic integration and where regulatory gaps remain. As highlighted in the typology, financial institutions rarely engage in strategic reallocation or relational transformation, especially in less regulated contexts.

Risk displacement is another concern. Some lenders offload physical risk to GSEs rather than pricing it (Ouazad and Kahn 2022; Xu and Xu 2023), raising concerns about hidden systemic vulnerabilities. Research could investigate how policies can curb risk shifting and incentivize meaningful engagement.

The COVID-19 pandemic reprioritized risk management. Studies could assess whether climate goals were sidelined or reinforced through green recovery programs, and how banks balance short-term liquidity needs against long-term sustainability goals.

Finally, institutional (DiMaggio and Powell 1983) and public policy theory (Ramesh 2003) may illuminate how organizational behavior adapts to evolving norms, mandates, or informal pressures. Understanding what drives effective policy diffusion and uptake remains a key research priority.

6.3.5 | Bank–Borrower Relationships and Climate Alignment

The relational dynamics of climate finance remain underexplored. Initial evidence suggests that ESG-oriented banks can influence borrower behavior (Houston and Shan 2022), but the extent and mechanisms, such as the enforcement of sustainability covenants, require further investigation. Relational commitments may also soften risk-based credit terms, revealing a trade-off between climate alignment and client retention.

Future research could examine how such dynamics unfold through longitudinal case studies, network analysis, or mixed-method designs. Diffusion of innovations theory (Rogers 2003) may help explain how climate practices spread across lending networks.

An interdisciplinary approach, linking finance, organizational behavior, and sociology, could illuminate how bank–borrower relationships translate high-level climate commitments into everyday lending. This interface is critical for aligning private finance with long-term sustainability.

7 | Conclusion

This review provides the first systematic synthesis of how financial institutions respond to physical and transition climate risks, drawing on 68 empirical studies. We introduce a behavioral typology comprising five response patterns—recovery lending, reactive containment, risk pricing adjustment, strategic reallocation, and relational transformation—highlighting asymmetries in bank behavior across risk types.

Physical risks often prompt short-term, visible reactions. Acute and unexpected events like hurricanes trigger recovery lending (e.g., Abedifar et al. 2024; Koetter et al. 2020), while expected risks, whether acute or chronic, lead to temporary repricing or containment shaped by salience and heuristics (Nguyen et al. 2022; Xu and Xu 2020). In contrast, transition risks are more consistently priced when indicators are policy-aligned and quantifiable (e.g., Ehlers et al. 2022), though ESG-based signals elicit more conditional effects (e.g., Cheung et al. 2018; Desender et al. 2020). Across studies, evidence for penalizing high-emission ("brown") firms is stronger than for rewarding low-emission ("green") ones.

As with any systematic review, limitations apply. The sample is restricted to English-language publications and underrepresents banking systems outside the United States and Europe. Critically, the Global South, SIDS, or LDCs, regions highly exposed to climate risks, are largely absent, limiting the global applicability of our current findings.

Despite these gaps, the review provides a foundation for future research and policy. The behavioral typology offers a diagnostic framework to uncover blind spots in climate risk integration. Scholars can expand this framework across underrepresented regions and institutions. For policymakers and practitioners, the findings underscore the need for clearer regulatory signals, improved risk data, and incentives that promote proactive rather than reactive lending behavior.

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Endnotes

[1] The study by Ouazad and Kahn (2022) has been retracted after acceptance of this manuscript.

[2] Recovery lending refers to the maintenance or redirection of credit flows to affected regions following drastic climate-induced changes, mostly natural disasters. Reactive containment encompasses short-term credit tightening, increased collateral demands, or reduced loan maturities in response to heightened risk. Risk pricing adjustment involves changes to loan spreads, provisioning or capital buffers to reflect climate-related exposures. Strategic reallocation describes deliberate shifts in lending portfolios away from high-risk sectors or firms, often in reaction to policy signals or environmental alignment goals. Finally, relational transformation captures situations where banks use lending relationships to influence borrower behavior, align with ESG profiles, or encourage improvements in sustainability performance.

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