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A MULTILEVEL CONCEPTUAL MODEL LINKING CLIMATE RISK, FINANCIAL STABILITY, AND INVESTOR BEHAVIOUR IN EMERGING MARKETS

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ABSTRACT
This paper introduces a multilevel conceptual model to explore the complex linkages of climate risks, financial stability, and investor behaviour in relation to the context of emerging markets (EMs). Emerging economies currently face a "triple challenge" of social, fiscal and growth constraints that severely restrict their ability to respond to external shocks (Galindo, 2023) . Also, many of these countries are in a situation of "double jeopardy," where their overall high exposure to physical climate risks coincides with systemic macro-financial vulnerabilities (Feyen, 2020) . By combining Institutional Theory, Modern Portfolio Theory (MPT) and Behavioural Finance, this paper develops a framework that traces the transmission of climate shocks through three distinct levels: the macro-level regulatory and environmental context, the meso-level stability of the financial system, and the micro-level individual and institutional decisions of investors. The model suggests that physical and transition risk act as systemically precarious stressors that devalue national financial health, while financial stability is a mediator that converts volatility in the environment into signals in the market. The paper also examines how the regulatory environment and information asymmetry moderate those relationships, creating the conditions for whether investors are able to rationally rebalance their portfolios or instead succumb to behavioural biases like herding and the affect heuristic. This conceptual synthesis creates an empirical base for future testing and also provides public policy implications for managing financial resiliency in the face of a rapidly changing climate.

Keywords: *Climate Risk; Financial Stability; Investor Behaviour; Emerging Markets; Multilevel Modeling; ESG Preferences; Macro-financial Governance*

1. INTRODUCTION

The climate change and finance nexus has emerged over the past decade as one of the most urgent disciplinary and policy conversations in the twenty-first century. With rising temperatures globally and billion-dollar weather disasters increasing rapidly, the financial sector is increasingly recognized as both victim to and participant in the climate crisis (Curcio, 2023) . For emerging markets, this nexus of climate change and finance is complex. Unlike developed economies, EMs tend not to have the fiscal buffers or diversified economic activity to absorb large environmental shocks, meaning climate-related events can lead to systemic financial instability (Galindo, 2023) .

The current global financial landscape for EMs is tenuous: the need for renewed growth is matched by the necessity of responding to rising debt levels and inflationary pressures. Many regions, especially Latin America and the Caribbean, are contending with poverty and inequality exacerbated by COVID-19, leaving public coffers depleted and growth trapped (Galindo, 2023) . In the context of precarious macroeconomic stability, climate risk complicates the financial system by layering "non-linear" volatility. Research demonstrates that when climate physical risks, like hurricanes, combine with other systemic shocks, like a pandemic, economic losses are intensified through procyclical lending and credit market constraints.

Even with the increasing recognition of these risks, the literature often discusses climate risk, financial stability, and investor behaviour as if they are separate issues. There is an urgent need for a multilevel approach that considers how macro-level changes in environmental conditions percolate through the institutional layers of the financial system to inform the investor behaviour at the micro level. The "double whammy" that many developing countries face—being both climate vulnerable and macro-financially weak—also indicates that the financial stability itself is not just an outcome, but rather the key mechanism that shapes how market actors perceive and price risk.

In this paper, we aim to fill this gap using a multilevel conceptual model. At the macro level, we examine the dynamics of physical and transition risks and how the institutional frameworks contribute to market norms. At the meso level, we assess the stability of the financial system and how climate shocks will shift the key components of bank balance sheets, sustainability of sovereign debt, and valuations of assets. At the micro level, we investigate the factors of investor behaviour and utilize behavioural observations to explore how climate-related information is interpreted in environments with great uncertainty.

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The contribution of this research will be in its holistic approach. We address the disparate theoretical traditions to provide a more integrative assessment of the "finance-economy feedbacks" that are entangled with climate risk. This is especially true for EMs, where the sovereign-bank relationship is tight, and any degradation of sovereign creditworthiness through climate vulnerability can have immediate and dire implications for the entire domestic financial system. This paper ultimately seeks to lay out a roadmap for policymakers and institutional investors to transition to a low carbon economy while ensuring systemic stability.

2. LITERATURE REVIEW

2.1 Climate Risk Dynamics: Physical and Transition Pressures in Emerging Economies

Climate risk is typically bifurcated into two main categories: physical risk and transition risk. Physical risk is defined as the economic costs and financial losses from the rising costs and frequencies of extreme weather events and climate-induced weather events, such as drought, floods, and hurricanes, as well as longer-term climate patterns. In emerging markets, these risks are not secondary, they are primary to economic survival. For example, in countries with high exposure to hurricanes, like Mexico, physical shocks can rapidly lower the value of physical collateral and generate a surge in non-performing loans (NPLs) while diminishing the bank capital buffer.

In contrast, transition risks are associated with the actions involved in transitioning to a low-carbon economy, which encompasses changes to public policy, technological changes, and changes to consumer and investor preferences that could be a catalyst for the abrupt revaluation of carbon-intense assets (Semieniuk, 2020) . For many EMs, transition risk presents a unique risk challenge because their economies are often heavily reliant on fossil fuel exports or carbon-intense manufacturing. The restructuring of "sunset" industries associated with high-carbon production could result in stranded assets and obligations to default on associated sovereign debt which would ultimately threaten systemic risk in financial institutions (Semieniuk, 2020).

The literature suggests these risks may not affect all sectors uniformly. Extreme weather events have been found to amplify financial systemic risk in both banking and insurance sectors, however, the timing and magnitude of the reaction may differ (Curcio, 2023) . With respect to EMs, the transmission channels are often more direct. A significant share of GDP in EMs is often associated with climate-sensitive sectors, including agriculture and transport infrastructure (Volz, 2020) . As such, it is possible for a single major climate event to impair a nation's fiscal revenue, while simultaneously increasing a nation's expenditures for post-event reconstruction, thus raising sovereign risk premiums and borrowing costs (Volz, 2020) .

In addition, the interdependencies of physical risks and transition risks create a complex dynamic for macro-financial management. While physical risks can only be addressed with transition policies to climate-proof nations in the long term, the transition can itself create short-term financial instability if not planned properly. The "tragedy of the horizon," is more acute in EMs, where the developmental pressure to sustain short-term economic growth is often at odds with the long-term stressors of climate resilience (Feyen, 2020) . New literature emphasizes the need for forward-looking methodologies for estimating future price changes in assets, as recent records of historical price changes may not be applicable with the rapid change in climate patterns (Campiglio, 2022) .

2.2 Financial Stability and Systemic Vulnerabilities in Developing Markets

Financial stability of emerging markets is increasingly regarded and viewed from climate-related perspectives in the macroprudential risk paradigm. The financial stability of financial systems depend upon the resiliency of its financial systems components - banks, insurers, and capital markets - from shocks generated by climate change (Acharya, 2023) . In EMs, the banking sector primarily remains the primary source of credit, thus, it serves a central role in the climate risk transmission mechanism. Compelling evidence from research has used stock-flow consistent models to suggest that procyclical lending behaviour of banks may amplify the initial climate shock as constraints to the credit market may lead firms to be unable to spend any time reallocating capital investment in recovery and adaptation (Dunz, 2021) .

A prominent risk in developing markets is the "sovereign-bank nexus." Climate change affects sovereign creditworthiness directly by eroding the balance sheets of governments through lower tax receipts and higher spending on climate-driven disasters (Feyen, 2020) . When the sovereign's credit rating is downgraded with respect to climate risk, the domestic banks with vast amounts of sovereign debt experience a loss in asset value that can lead to a systemic liquidity crisis (Volz, 2020) . This feedback loop is characteristic of the "double jeopardy," in which climate risks reinforce each other and macro-financial risks (Feyen, 2020) .

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Additionally, transitioning to a low-carbon economy introduces risks in "sunset" industries. The systemic shift required for decarbonization could also involve sudden asset revaluations and defaults on debt in sectors such as coal, oil, and gas (Semieniuk, 2020) . In contrast to offering a home for new capital and potential bubbles, as do "sunrise" industries (i.e., renewables), carbon intensive industries pose an immediate risk to the solvency of the financial institutions that have historically financed these sunset industries (Semieniuk, 2020) . Understanding the risks from declining industries is not yet conceptualized as part of the current macroprudential framework (Semieniuk, 2020) .

Climate stress testing has become an important tool for regulators to evaluate the systemic vulnerabilities of climate change. These tests are intended to map climate stress scenarios to outcomes for financial firms, and they have proved challenging in EMs due to the limited availability of necessary data and the requisite of incorporating dynamic policy decisions (Acharya, 2023) . Stress testing requires an understanding of how market participants form climate risk expectations and how climate risk expectations impact financial stability (Acharya, 2023) . Without stress testing, EMs are vulnerable to "sudden stops" in capital flows as global investors reformulate their portfolio after observing instability from perceived climate risks (Volz, 2020) .

2.3 Determinants of Investor Behaviour: Risk Perception and ESG Preferences

Investor behaviour in the context of climate change is a function of assessed rational risk assessment and psychological heuristics. Investors, according to Modern Portfolio Theory (MPT), should price climate risks into the valuation of assets based on returns and volatility. However, data suggest that optimal policies to combat climate change can significantly shift the risk profile of different asset classes, including that green indexes may often significantly reduce systemic risk than are brown indexes, particularly true during tail conditions (Curcio, 2023)

In developing markets, the determinants of investor behaviour are compounded by high levels of uncertainty and asymmetrical information. When the data related to their climate exposure is not clear, investors typically rely on heuristics—mental shortcuts—to inform their decision. The resultant behaviour is often herd behaviour, where investors follow others and ignore their own fundamental analysis, leading to volatility and mispricing in markets (Acharya, 2023) . The "affect heuristic," where emotional engagement with visible disasters or financial instability inform their investment decisions, is often found to be salient in places regularly impacted by extreme weather patterns (Dunz, 2021) .

The emergence of Environmental, Social, and Governance (ESG) preferences represents a pivotal development regarding investor behaviour. ESG measures increasingly serve as a signal of a firm's or a nation's resilience toward climate risks. In a recent study, it was revealed that the number of publications and an interest in environmental finance, such as green bonds and sustainable finance, has risen exponentially in the last decade (Tao, 2022) . For investors in emerging markets (EMs), it is believed that a high ESG score indicates better risk management, as well as a lower chance of experiencing "double jeopardy" during climate and financial stress events (Feyen, 2020) .

However, any useful return that ESG can provide to financial stability and risk will depend on the accuracy of climate risk pricing. There remains substantial debate regarding whether financial markets are currently overpricing or underpricing climate risks (Acharya, 2023) . In the EM context, and where market maturity is lower, mispricing of "green" assets, or "greenwashing," can result in new systemic risks, such as bubbles being created in sunrise industries (Semieniuk, 2020) . Furthermore, the absence of standardized disclosure requirements in many developing nations inhibits investors from being able to assess their portfolio climate risks appropriately, as they rely on personal risk perceptions (Campiglio, 2022) .

Additionally, the interaction between individual behaviour and institutional pressures is important. As regulatory regimes, such as those articulated in the Sustainable Development Goals (SDGs), can motivate investor behaviour by changing capital adequacy ratios, or imposing a green bond regulatory framework (Lagoarde-Segot, 2020) , these institutional changes can compel a revaluation of prices and/or induce investments to be more sustainable. However, the effectiveness of the new policy will depend on how "behavioural realities" of the market participants account for either rational adaptation to the regulatory change or defensive short-termism (Acharya, 2023) .

Overall, the literature shows a complex interaction where climate risks impair financial stability, which in turn drives investor behavioural responses. For EMs, these factors are amplified by existing macroeconomic vulnerabilities and the absence of stricter institutional buffers. The subsequent sections will build on the literature in order to construct a formal conceptual model and hypotheses to develop the relationships.

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3. THEORETICAL FRAMEWORK

Emerging markets' climate-induced financial risks complexity requires a multi-pronged theoretical lens. Financial theory often struggles to encompass non-linear, systemic impacts of climate shocks, alongside behavioural idiosyncrasies of market participants in a volatile economy. By inserting behavioural finance, modern portfolio theory, and institution theory, this research provides a deeper theoretical basis for how climate risk relates to and evolves in financial systems as well as investor behaviour.

3.1 Behavioural Finance Theory and Heuristic Decision-Making

Behavioural finance challenges the traditional assumption of rationality in decision-making by investors in the presence of uncertainty and complexity like climate change. In emerging markets where information often exists in silos and the overall transparency of the market is less than more developed economies, investors commonly rely on cognitive short cuts or heuristics. The rich volume of data, often contradictory, related to physical and transition climate risks necessitates mental short cuts. Non-rational factors can indeed exert a powerful controlling influence on outcomes of decision-making under uncertainty, requiring a decision-making model requiring not just investors risk preferences, but an element of distorted probability (Su, 2023) .

One major behavioural driver in climate finance is the "affect heuristic," where investors base risk on emotional responses to climate observable events, for example, extreme weather or sudden policy action. In emerging markets, these emotional responses can be extraordinary. When climate risks manifests themselves and creates a risk to financial stability, the investor oftentimes will ignore their individual fundamental analysis of value and follow the collective "exit" and "entry" patterns of larger institutional players. The emotional response of the investor displays herding behaviour, but this behaviour more accurately reflects an emotional response to perceived systemic vulnerability and less an assessment of the asset value.

The emotional element in investment-decision making can further be articulated through Cumulative Prospect Theory (CPT) that tells us that investors will not weight outcomes linearly but rather be calculated by non-rational outcomes to the extent of showing loss aversion and an excess weighting of small probabilities of catastrophic events. In the climate impact space, decision-making models based in part on CPT are reflective of individuals in a risk-averse solution- space with the size downside of climate exposure reflected in not just to the physical risk, but often the perception of risk, (Su, 2023) that even more subtle changes, relative to a specific firm climate`s resiliency, can create asymmetric changes in sentiment and capital allocation.

3.2 Modern Portfolio Theory and Climate-adjusted Risk-Returns

Modern Portfolio Theory (MPT) provides a mathematical base for understanding the risk-return trade-off, although all components will require substantial re-calibration to incorporate climate relative externalities. Traditional finance theory specifically MPT, suggested the way to deal with idiosyncratic risk was through diverse portfolios. Climate risk in fact is not an idiosyncratic risk in emerging markets and increasingly is recognized as a systemic, undiversifiable risk factor for which the entire market beta is impacted. As a matter of fact, recent studies have shown companies with higher corporate social responsibility (CSR) and ESG performance actually have a beta below the market beta for too large of shares of the market, particularly in developed Anglophone mature markets like the United States (Martínez, 2022) .

Within emerging economies, MPT involves modifying the expected payoffs of assets based on physical and transition risks. Physical risks, such as degradation of infrastructure (e.g. roads, transportation, power supply) or harvest yields, directly impact cash flows and firm valuations. Transition risks include costs incurred as a result of carbon taxes, shifts in regulatory environments, innovation, technology change, or overall change in the costs to firms operating in carbon intensive industries. The 'value relevance' of the risks in this approach of MPT is observed as a result of stock market's reaction and 'investor assessment' to sustainability reports and whether an organization has a negative or positive value perception based on their environmental reputation (Pandey, 2024) . Or risk averse investors, a portfolio composed of socially responsible companies can function as a defensive strategy. Evidence exists that sustainability practices lead to lower stock volatility, suggesting that sustainable assets with ESG characteristics are more desirable during turbulent market environments (Martínez, 2022) . A key factor limiting the impact of risk averse investor strategies in contexts of emerging markets is a lack of standardization, and the present issue of 'greenwashing' where companies claim to have environmental goals to lessen scrutiny without an underlying component to their operations to effect based change (Rajan, 2023) . Thus, MPT in this conceptual model builds toward explaining the meso level mechanism where stable markets are achieved through ration-based—even if data limited—figure, relative balancing of risk and return.

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3.3 Institutional Theory and Regulatory Isomorphism

Institutional theory allows us to think about the macro level of how external pressures shape how financial institutions and companies behave. Institutional theory posits companies are driven by legitimacy in their institutional frameworks rather than strict economic efficiency. In climate finance, we see this 'isomorphism' emerge— the extent to which organizations become more similar as a response to common pressures.

Coercive isomorphism occurs when governmental regulatory authorities compel companies to disclose climate-related information or use environmental frameworks. For example, in India, mandatory sustainability reporting has included reporting by a diverse group of company's disclosed environmental costs that have been associated with stock market impacts (Pandey, 2024) . Mimetic isomorphism occurs when firms mimic "best practices" of industry leaders to reduce uncertainty. As global institutional investor demand ESG accountability, firms' in emerging markets, many of which originally adopted ESG framework metrics simply to retain access to international capital markets, will publicly embrace ESG standards of firms implementing these measures to maintain alignment with international capital demands.

The importance of institutional theory is helpful when firms create a 'legitimacy gap' when announcing social and environmental imperatives. Firms publicly announce and embed ambitious social and environmental goals not as a core way of creating strategy change, but primarily as a response of key constituencies to redistribute power preferences or to reduce demands on managerial decisions about organizational direction (Rajan, 2023) . Legitimacy gaps create complexity for investors that must evaluate not only the difference between substantive sustainability practices and practices symbolizing compliance. Institutions' frameworks are critical as they illuminate factors that do allow for standardization and appropriate oversight that would demonstrate that ESG standards are implemented and understand their impact on performance and systemic stability (Marie, 2024) .

4. CONCEPTUAL MODEL DEVELOPMENT

The conceptual model presented connects climate risk and investor behaviour through financial stability as a mediating variable, taking into consideration the moderating effects of the regulatory environment and information asymmetry. This multilevel framework recognizes that climate shocks are macro-level events which filter through meso-level market mechanisms to influence individual decisions on a micro-level.

4.1 Definition and Operationalization of Multilevel Constructs

To achieve empirical validity, the model constructs need to be defined and operationalized within the context of emerging markets.

Independent Variable: Climate Risk

Climate risk is bifurcated into physical risk and transition risk. Physical risk is operationalized the direct economic risk posed by extreme weather events (e.g., floods, droughts) and chronic climate changes. In the context of an emerging market, this risk is typically measured by the impact on agricultural production, infrastructure damage, and with it, non-performing loans (NPLs) in the banking sector. Transition risk is operationalized as the financial volatility posed by the transition to a low-carbon economy, including changes in polices, technology disruption, and the declining value of normalized "stranded assets" in carbon-intensive industries.

Mediating Variable: Financial Stability

Financial stability is defined as the ability for the entire financial system to absorb internal and external shocks. Financial stability can be operationalized as a construct through the indicators of capital adequacy in the banking sector, sovereign credit spreads, and market volatility. Financial stability acts as a vital filter; it determines whether a climate shock remains a localized environmental issue or expands into a systemic financial crisis.

Dependent Variable: Investor Behaviour

Investor behaviour is operationalized as portfolio allocation changes, ESG-based investment strategies, or herding/flight-to-quality behaviours. Research has established green investment is being adopted as a corporate strategy for profit maximization and competitive advantage (An, 2023) . In this case, investor behaviour is operationalized through the capital flowing into and out of climate exposed assets.

Moderating Variables: Regulatory Environment and Information Asymmetry The regulatory environment is operationalized by if climate disclosure laws and environmental standards exist and whether they are enforced or not (Pandey, 2024) .

Information asymmetry is operationalized by the difference between a firm's internal knowledge about climate exposure and the knowledge the public has available to them. The use of alternative data such as satellite imaging and social media sentiment is an emerging proxy for measuring and mitigating this issue (Sun, 2024) .

4.2 Integration of Independent, Mediating, and Dependent Variables

Integration of the independent, mediating, and dependent variables should follow a causal pathway whereby climate risk is first observed. When a physical or transition risk event occurs it first manifests as an impact on the fundamental value of existing assets and the solvency of borrowers. This will be communicated to the stakeholder community and aggregated at the market level impacting the overall financial stability of the emerging economy.

The model suggests that although there is a relationship between climate risk and investor behaviour, this relationship is not linear, and it is conditioned by the health of the financial system. If the financial system is perceived to be stable and resilient, perhaps due to strong capital buffers or government guarantees, investors will engage in rational rebalancing consistent with the principles of MPT. If climate risk presents a threat to that systemic floor, behavioural biases such as the affect heuristic and herding should dominate, which will lead to rapid capital flight and increased market volatility.

The regulatory framework serves as a buffer in this process. Strong institutional frameworks can trigger an early recognition of risks and avert the coiled spring from unfolding, where risks accumulate unnoticed until they trigger a crisis. Proxy, information asymmetry acts as a magnifier of risk; high levels of information asymmetry ultimately yield a delayed but much more violent response when climate risk is actually realized. This integrated flow connects the biophysical implications of environmental shocks, the structures of the markets, and the psychology of human behaviour in the unique context of emerging markets.

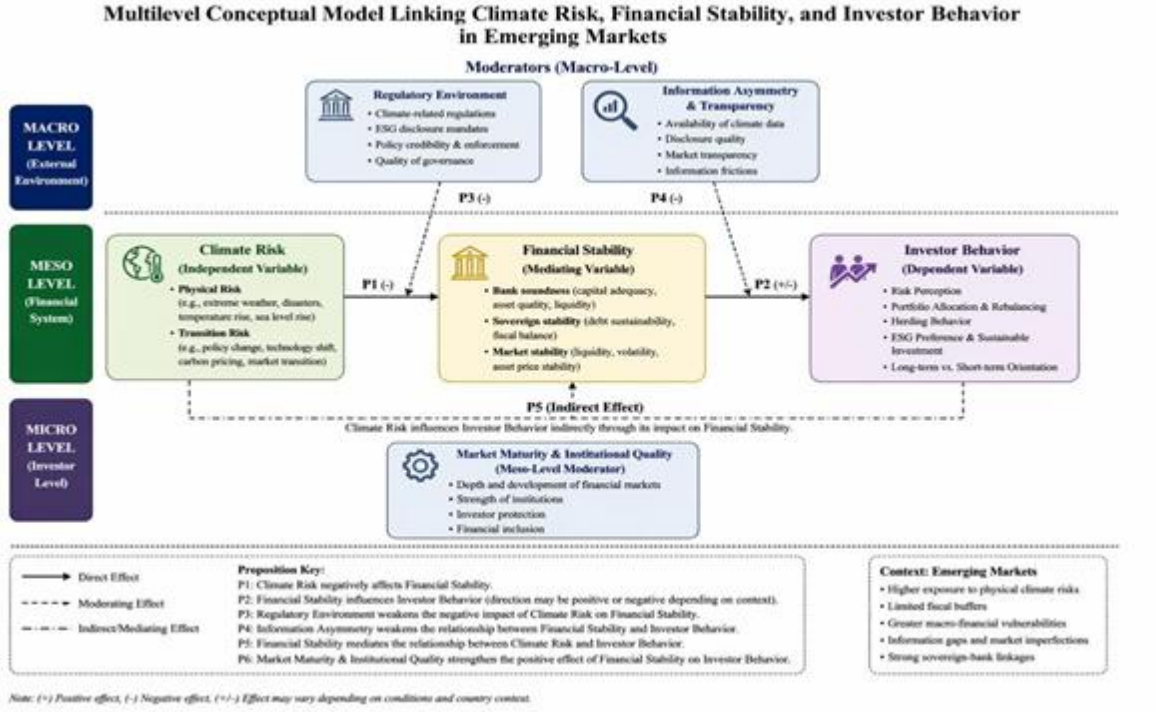

Figure 1: Multilevel Conceptual Model Linking Climate Risk, Financial Stability, and Investor Behaviour in Emerging Markets

The model illustrates the mediating role of financial stability in transmitting climate risk to investor behavior, while regulatory environment and information asymmetry act as boundary conditions influencing the strength of these relationships.

5. PROPOSITION DEVELOPMENT

Informed from the theoretical framework, and the conceptual model, the subsequent propositions are developed to encourage future empirical research. The propositions are grounded in vulnerabilities and behavioural expressions observed in emerging economies.

The key theoretical relationships derived from the conceptual model are summarized in Table 1.

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Table 1: Summary of Propositions, Theoretical Basis, and Expected Relationships

Proposition	Relationship	Type	Supporting Theory	Expected Direction
P1	Climate Risk → Financial Stability	Direct	Institutional Theory	Negative
P2	Financial Stability → Investor Behaviour	Mediated Path	MPT	+/-
P3	Regulation moderates CR → FS	Moderation	Institutional Theory	Weakens negative effect
P4	Info Asymmetry moderates FS → IB	Moderation	Behavioural Finance	Strengthens bias

5.1 The Impacts of Physical and Transition Climate Risks on Financial Stability (P1)

Emerging markets are particularly vulnerable to climate shocks as they often have a high dependency on climate-sensitive sectors, and they also have limited fiscal space to respond and recover. For example, physical risks such as extreme weather can immediately damage the collateral base of the banking system. Research suggests that environmental degradation prevents sustainable and/or inclusive development within BRICS-11 countries, and indicates the negative economic impacts of physical climate risk in undermining the pillars of financial stability (Işık, 2024) .

Transition risks also hold equal weight. If our trading partners have sufficient capital to impose carbon border adjustments, or if they accelerate the transition to green energy, they could threaten the fiscal revenue of emerging economies dependent on carbon-intensive export revenues, meaning there will be an abrupt deterioration in the fiscal position of an emerging economy. This leads to higher sovereign risk premiums, and the domestic financial system will be destabilized through the sovereign–bank nexus. Proposition 1 sets out the first proposition addressing the direct relationship between climate stressors and systemic health.

Proposition 1 (P1): An increase in exposure to physical and transition climate risks results in a significant decrease in financial stability of emerging markets, reflected in increases in credit risk and the volatility of sovereign debt.

5.2 The Mediating Role of Financial Stability in Developing Investor Behaviour (P2)

The relationship between climate risk and investor behaviour is not straightforward. Investors may not react to the "climate" event, but may respond to "financial" signals emerging from that climate event. Financial stability is the primary communication channel for financial signals. If the banking sector is deemed resilient due to a climate shock, investors will assess climactic exposures as manageable. If a shock leads to liquidity freezes or bank failures, the investor response will turn from rational rebalancing to defensive flight. Research suggests that green investments can positively influence firms' social, economic, and environmental performance, thus enhancing market stability (An, 2023) . Investors view the overall stability of market performance as proxies for climate adaptation strategies. If stability is maintained, then investors will be encouraged to maintain their long-term green investments. If stability is disrupted, the "tragedy of the horizon" will occur as investors switch to investing in shorter-term, liquid assets to escape with their capital.

Proposition 2 (P2): Financial stability mediates the relationship between climate risk and investor behaviour, such that the impact of climate risk on portfolio allocation is transmitted through changes in systemic financial stability.

5.3 Moderating Role of Regulatory Environment and Market Maturity (P3)

The institutional nature of an emerging market shapes the absorption and processing of climate risk. A strong regulatory environment, driven by mandatory disclosure and environmental controls, can reduce climate shocks, through a gradual pricing mechanism. For instance, the market reaction to mandatory sustainability reporting in India reinforces that regulation can provide salient signals that allow investors to adjust their predicted return on investment parameters before disasters occur (Pandey, 2024) .

Market maturity also plays a role. More mature emerging markets that have diverse institutional investor bases and highly developed financial instruments are better equipped at dealing with climate-induced volatility. The "coercive isomorphism" of global ESG standards will push firms in mature emerging markets to adopt increasingly resilient corporate strategies (Marie, 2024) . Conversely, the gaps in oversight of less mature markets will mask climate risk and create more severe stability collapses when risks are exposed.

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Proposition 3 (P3): The regulatory environment and market maturity moderate the relationship between climate risk and financial stability, such that stronger regulation and maturity reduce the systemic effect of climate shocks.

5.4 Impact of Information Asymmetry on Behavioural Outcomes (P4)

Information asymmetry is a common and persistent problem within emerging market finance. When the investors do not have a high degree of confidence in the data about a firm's actual carbon footprint or physical risk exposure, they will depend on heuristics and herd behaviour. The lack of standardized ESG measures exacerbates the problem of information asymmetry by making it difficult for investor's to differentiate between sustainable corporate practices and greenwashing (Marie, 2024) .

The rise of alternative data sources—manned measurement methodologies including satellite imagery, sensor data, and personal behaviour patterns—creates a potential answer to information asymmetry. Nontraditional data could provide more timely and objective assessments of a enterprises' climate risk profile (Sun, 2024) . However, until alternate data sources become ubiquitous, information asymmetry will remain a contributing factor to behavioural volatility. In high asymmetrical environments, a single climate-related news story can cause investors to react quickly and "jump-to-default." While even if more minor news events or social signals occur, investors would still produce a reaction based on information asymmetry.

Proposition 4 (P4): Information asymmetry is a significant moderator of investor behaviour where increasing information asymmetry would contribute to behavioural biases and herd behaviour during periods of climate-induced financial stress.

In conclusion, the theoretical framework and propositions we present here provide a solid basis for investigating the climate-finance nexus in emerging markets. By going beyond linear models and taking into account the psychological, institutional, and systemic dimensions of risk, our conceptual model sets out how the global climate crisis is being translated into financial realities on the ground. The synthesis of rational optimization of MPT, and behavioural realities of heuristic decision-making, all amid a changing institutional environment captures the essence of the challenge facing both investors and policy-makers.

6. METHODOLOGY FOR FUTURE EMPIRICAL VALIDATION

6.1 Proposed Data Collection Methods and Proxy Selection

In order to empirically validate the multilevel conceptual model that links climate risk, financial stability, and investor behaviour in emerging markets (EMs), a multi-source data collection method is needed. Due to the natural information asymmetry and data opacity associated with many developing economies, researchers' data collection strategy should combine traditional financial data sources with innovative alternative data sources. In terms of the independent variable climate risk, the data collection process will need to be bifurcated with indicators for physical and transition risks. Physical risk can be proxied with geospatial data on extreme weather events, agricultural yield volatility, and records of past climate-related damage to infrastructure. For transition risk, we need proxies that quantify policy transitions and the potential disruption of technologies. Researchers can utilize crawler technologies to scrape climate policy key terms related to corporate annual reports and government white papers on carbon taxes and "green transformation," which has been used successfully in studies of digital transformation (Zhao, 2024) .

Financial stability will act as the mediating variable with proxies needed for systemic and institutional levels of stability. For systemic stability, sovereign credit default swap (CDS) spread and volatility of a country stock index would give us a macro-view of stability. For institutional stability, bank-specific indicators such as Non-Performing Loan (NPL) ratios, capital adequacy ratios (CAR), and "sovereign-bank nexus" exposure. For the dependent variable, investor behaviour, we would look to the shift in capital allocation in portfolios, specifically the flows of capital toward and away from carbon-intensive and ESG-compliant assets. ESG scores and ratings can be proxied for investor preference and risk and provide evidence of the market perception of a firm's resilience to climate-related shocks (Zhang, 2023).

For firm-level data, we suggest using publicly listed companies in major emerging markets, such as the A-share market in China or the Growth Enterprise Market (GEM), where the required disclosure of information is rapidly changing (Zheng, 2022) . Furthermore, for green innovation proxy data, the number of green patent applications and citations can proxy both proactive management of climate risk by the firm and the financial return that would follow (Zhang, 2023) . In addition, the quality of environmental, social, and governance (ESG) disclosure may also proxy for transparency and in contexts like ASEAN we might expect family-run businesses to disclose differently from non-family businesses (Ardianto, 2024) .

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6.2 Recommended Statistical Methods: Multilevel Modeling and SEM

In order to validate a multilevel model requires statistical methods that accommodate nested (within individuals, among investors and firm-level performance) data structures, nested in the regulatory and economic environments. We recommend using Multilevel Modeling (MLM), also known as Hierarchical Linear Modeling (HLM), to account for this variance at the different levels. This method provides a way to simultaneously estimate firm-level effects (for example, how a firms ESG efficiency affects its innovation output) and country-level effects (for example, how national green financial reform moderates that effect) (Li, 2024) . Structural Equation Modeling (SEM) is the best analytic method for evaluating the various complex mediating and moderating pathways put forth in the model. More specifically, a partial mediation analysis is useful for determining how much financial stability mediates the relationship between climate risk and investor behaviour. This often involves the "causal steps approach" as well as Sobel-Goodman or Bootstrap tests to confirm mediation is statistically robust (Zheng, 2022) . Addressing endogeneity issues, including a bidirectional mediated relationship between green innovation and financial performance, requires the use of instrumental variables, and Two-Stage Least Squares (2SLS) or Generalized Method of Moments (GMM) to test these in a dynamic panel of firms (Zheng, 2022) .

The Difference-in-Differences (DID) model is another effective policy-validated quasi-experimental methodology. The DID model can test specific interventions, such as developing regional green financial reform pilot zones, to assess their impact on firms' ESG performance and financial stability (Chen, 2022) . Alternatively, if the outcomes are categorical, the Ordered Logistic Model can be employed when looking at specific categories, such as ESG scores or digital transformation levels. This would identify levels of corporate behaviour that move incrementally (Zhang, 2023) . By utilizing advanced, and more rigorous, analytical methods, future research can build an empirical foundation for the conceptual linkages between environmental stressors and financial stability.

7. DISCUSSION

7.1 Synthesis of Theoretical Relationships and Model Pathing

The proposed multilevel model captures and synthesizes Institutional Theory, Modern Portfolio Theory (MPT), and Behavioural Finance to provide a cohesive construct for evaluating the climate-finance nexus in emerging markets (EMs). At the institutional (macro) level, institutional theory serves to explain how regulatory environments and social expectations represent a type of "coercive isomorphism," compelling firms and financial institutions to adapt to pressures for green finance adoption in order to conform to legitimacy in the marketplace. It is relevant to consider how green financial reforms in China have influenced firms' corporate ESG scores, mostly through social responsibility (Chen, 2022) . These institutional pressures would have defined the rules of engagement, which are reflective of the financial stability (meso) level.

At the meso (financial stability) level, finance theory through MPT serves to describe the rational, recalibrating of risk and return in light of climate risk—physical and transition—acting as systemic stressors that impair the value of assets and raise return variability. Interestingly, the synthesis posits that this rational process is mediated through overall stability in the financial system. If stability is impacted, then the risk-return frontier shifts unpredictably and this leads to an investor behaviour pattern observed in "flight-to-quality." Ultimately, this research has shown that ESG efficiency and green innovation were not just ethical decisions, but strategic mechanisms to enhance resource utilization and financial performance; both of which contribute to financial or systemic stability (Li, 2024) . The micro-level of the model is centered on the Behavioural Finance conceptualization of the "human pulse" of the market. In EMs, where information is often asymmetric and the market has lower maturity, investors often rely on heuristics while being prone to herd behaviour. Stability in financial markets is an important signal to investors; whereas in times of instability caused by climate shocks, the "affect heuristic" takes precedence, leading to panic driven divestment, rather than rational behaviour to rebalance investments. The model suggests that other factors, such as the digitalization of the economy, moderate investor behaviour to either inform or re-inforce strategies to reduce agency costs and risk tolerance in relation to volatile investment returns (Zhao, 2024) .

7.2 Contextualizing Findings in the Context of Emerging Market Volatility

Emerging markets provide a unique context characterized by high growth potential and high structural vulnerabilities. The impact of climate risk in EMs is exacerbated by lower adaptive capacities as well as the presence of energy intensive industries. For example, in the oil and gas sector, which is a foundational industry in many EM economies, establishing the execution of a green governance framework is critical to both managing economic and environmental risks while preserving shareholder value (Shah, 2022) . The model

suggests that in contexts such as these, the link from climate risk to fluctuations in financial stability is more direct and could be more catastrophic, than in established markets.

Market heterogeneity in EMs also shapes behaviour. For instance, the impact of digital transformation on ESG performance is heightened in state-owned enterprises (SOEs) undergoing mixed-ownership reform, suggesting that the "type" of ownership enterprise and governance moderates the resiliency of enterprises to climate-related financial shocks (Zhang, 2023) . Regional variations in economic development and stringency of environmental regulation moderate the relationship between ESG practices and corporate innovation (Li, 2024) . In some ASEAN (Association of Southeast Asian Nations) countries, family members of the executive board are associated with superior ESG disclosure, particularly during unforeseen circumstances such as the COVID-19 pandemic that could act as a buffer against volatility of market conditions (Ardianto, 2024) .

The “sovereign-bank nexus” is more volatile for EMs. Climate risks and climate impacts on the sovereign's fiscal health threaten financial stability of the country's domestic banking sector which could lead to disenfranchised government funding options, especially if the banking sector is a major holder of domestic sovereign debt. This systemic fragility indicates that behaviour in EMs is not only a response to perceived firm performance, but generally to perceived solvency of a national economic framework. The model suggests that firms’ “green” attributes may inturn support further contributions of ESG to green innovation, providing firms an opportunity to become decoupled from systemic instability (Zhang, 2023) .

8. IMPLICATIONS

8.1 Theoretical Contributions to Climate Finance and Behavioural Economics

The framework that is presented offers some tangible contributions to the body of literature. First, it establishes a linkage between macro-level environmental economics and micro-level behavioural finance literature. Prior research has often assumed climate risk as an exogenous event that shocks an asset’s pricing. However, this model acknowledges and evidences climate risk, shocks, being internalized within a multilevel framework, showing how institutional structures and behavioural biases impact the shock’s transmission. The designation of financial stability as a mediator adds another level of consideration into the effects of environmental issues that can bring into a market's influence.

Second, it expands the applicability of Institutional Theory to green finance. The research shows that green finance reforms, the structuring of institutional ownership are not simply regulatory hurdles - they are constituents responsible for driving innovation and ESG efficiency [id:62/70]. This indicates, as theorists have previously suggested, that "legitimacy-seeking" behaviours can translate into effective environmental and social performance. Additionally, incorporating digital transformation in the model introduces a modernized theoretical perspective about technology’s role in reducing agency costs to promote risk-taking of firms, even in conditions of climate uncertainty (Zhao, 2024) .

Third, by introducing the role of "information as a moderator," the research contributes to our understanding of behavioural economics. In EMs, the process of ESG disclosure, and the increased transparency and accountability of green governance frameworks can act, as "behavioural friction," decreasing irrational herding and risk of financial distress due to climate risk (Li, 2024) . The study's finding of the importance of green performance for improving ESG scores, and subsequently financial performance offers an iterative and credible theoretical basis for many claims of "win-win" strategies typically seen in the literature of sustainable finance (Zheng, 2022) .

8.2 Practical Implications for Institutional Investors and Policy Makers

For institutional investors, the model adds more sophisticated risk approaches in EM contexts. Investors need to move beyond headline ESG scores and research "ESG efficiency," defined as a firm's efficiency in using its resources to achieve achievement of environmental and social outcomes (Li, 2024) ="value from waste"> . The research suggests that (high) green innovation performance improves a firm's market-utility of earnings, bettering the odds that investors of high performing firms will earn financial returns over the long-term makes them highly attractive on the sustainable investment front (Zheng, 2022) . Additionally, investors should take ownership structure and regional development into consideration as moderators when considering risk-return propositions for EM assets (Li, 2024) .

For policy makers, the implications are apparent, that green finance reforms are viable drivers of corporate sustainability, contributing to financial stability. Results from pilot-zones for green finance reform frameworks in China provide insights that targeted policy interventions at the sub-central government levels, particularly in focusing on micro-level financial and regulatory considerations can lead to enhanced scores for ESG and

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progressions in green performance across the landscape (Chen, 2022) . Other EMs, as policymakers, should consider a similar framework, focusing on information disclosure improvements regarding environmental outcomes to mitigate market-wide information asymmetry (Feng, 2023) . In addition, the adoption of frameworks for green governance in sectors that are traditionally high risk, such as oil and gas, is also very important. Regulators can promote green board committees, and invite boards of directors to adopt sustainability metrics as part of enterprise risk management (Shah, 2022) . For SOEs, the introduction of mixed-ownership reform can leverage the improvement on ESG through digital transformation, and thus good governance reforms should occur alongside climate/environmental policies (Zhang, 2023) . Finally, considering family-based firms in regions like ASEAN, should provide regulators with more targeted, effective disclosure requirements (Ardianto, 2024) .

9. LIMITATIONS AND FUTURE DIRECTIONS FOR RESEARCH

9.1 Conceptual Limitations and Generalizability Concerns

Although it is comprehensive, this proposed model has its own conceptual limitations. The most significant limitation is the presence of a "data gap" in many emerging markets. The model is based on proxies such as ESG scores and citations of green patents, yet validity and comparability with ESG data and measures in different EMs is a major issue. Methodologies for establishing ESG ratings are often inconsistent, and "greenwashing" serves to muddy the relationship between reported performance and environmental impact. This often holds true in markets where "black attributes" of firms may hinder the potential for "contribution" to ESG practices (Zhang, 2023) .

Another important limitation is the generalizability of the model in all EMs. As this research relied heavily on evidence from A-share and GEM markets in China, which include unique characteristics (e.g. high levels of state interference), these characteristics may not apply to emerging economies such as Brazil, India, or South Africa. The "sovereign-bank nexus" may function differently as well in relation to the development of financial markets in each of these countries. Also, relying on Institutional Theory, presumes a response level of regulation that may not be present in other more fragile, or politically unstable EMs.

9.2 Opportunities for Longitudinal and Comparative Empirical Studies

Future studies should focus on longitudinal studies in order to capture appropriately the "time lag effect" associated with climate related interventions. As noted in the study of digital transformation, there is often time for the influence on ESG performance to materialize (Zhang, 2023) . Longitudinal data would allow researchers to observe how investor behaviour shifts when climate risks evolve from theoretical expectations to physical realities. Comparative studies between regions, such as ASEAN, Latin America, and Eastern Europe would also contribute to understanding whether and how various institutional and cultural contexts moderate the climate-finance relationship.

Additionally, there is an alternate significant opportunity to study the role of "green Sukuk" etc. and other specialized financial instruments that are focused on economic growth and social development in certain EM contexts (e.g. Indonesia) (Ali, 2023) . To assess how these create the alternatives to non-green capital flows would help to create a more nuanced understanding of "green" capital flows and how these financial instruments relates to the proposed model. Additionally, future studies could investigate, more deeply the impact of "digital transformation" as an enabling factor for environmental information disclosure, and its impact on green innovation subsequently (Feng, 2023) . With these future investigations the academic community can seek to elaborate on the model, while continuing to investigate and socialize valuable insights for the world to transform more equitably to a sustainable financial system.

10. CONCLUSION

This conceptual research paper has formulated a multilevel model that conveys the interdependencies involving climate risk, financial stability, and investor behaviour in emerging markets. By drawing together Institutional Theory, Modern Portfolio Theory, and Behavioural Finance, the model creates a multifaceted basis for thinking about how macro-level environmental stressors are filtered through meso-level stability mechanisms to produce micro-level behavioural outcomes. The research supports the idea that climate risk is not simply an environmental issue, but a key financial and behavioural dilemma, which must receive a multilevel response.

The literature review suggests that climate risk is a significant financial stability risk to EMs, but there may be proactive responses available, such as green innovation, ESG efficiency, and digital transformation [id:61/62/68]. These responses can both enhance corporate performance and resilience in the financial system. However, these attributes are heavily moderated by the regulatory environment, ownership regimes, and information asymmetries in the market [id:62/65/70].

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In conclusion, the transition to a climate resilient financial system in emerging markets must identify a "triple alignment": the national policy alignment to international green standards, corporate governance alignment to sustainability goal, and investor perception alignment to climate adjusted risk reality. The increasing importance of EMs to the global economy says that this multilevel model can help researchers, investors, and policy makers chart the volatility issues of the important, yet tricky, intersection of climate change and finance. The next step is to translate these conceptual links into strong, evidence-based tools for sustainable development through empirical study.

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