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Questioni di Economia e Finanza

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GEOPOLITICAL RISK, BANKS' EXPOSURE AND SUPERVISORY ASSESSMENT FRAMEWORK

by Giancarlo Mazzoni*

Abstract

Geopolitical developments have become a persistent and structurally relevant factor shaping the operating environment of banks. Their prudential significance does not arise from the existence of a distinct 'geopolitical' risk category, but from their capacity to amplify established vulnerabilities, including credit deterioration, market repricing, liquidity stress, funding instability, operational disruption, and governance weaknesses. This reading is also consistent with the broader SSM and European supervisory approach, which frames geopolitical developments as cross-cutting drivers of existing prudential risks rather than as a new standalone risk category. In this context, it is analytically more appropriate to refer to geopolitical uncertainty rather than geopolitical risk in a narrow sense. Geopolitical uncertainty is inherently cross-cutting, heterogeneous, nonlinear, and frequently transmitted through indirect channels. It therefore does not fit neatly within the traditional banking risk taxonomy but propagates through existing prudential categories and affects both sides of banks' balance sheets. This feature is particularly relevant for less significant institutions (LSIs), whose exposure is often not direct or cross-border, but embedded in domestic economic structures, sectoral concentrations, borrower vulnerabilities, and operational dependencies.

Against this background, the paper documents how the supervisory approach of Banca d'Italia integrates geopolitical considerations within the standard prudential framework, rather than treating them as a separate supervisory silo. Evidence from recent supervisory cycles suggests that geopolitical uncertainty is reflected indirectly through its impact on governance, credit quality, provisioning adequacy, liquidity, operational resilience, funding sustainability, and capital demand.

The paper also develops an original structural framework, inspired by contingent claims analysis and by the Merton approach, but adapted to the specific economics of banking. Relative to the standard Merton model, the proposed framework introduces asset-class heterogeneity, liability-class dynamics, endogenous funding costs, and a payout structure that makes it possible to model banks while preserving analytical tractability. The contribution is therefore not measurement in a narrow sense, but a consistent analytical framework to explain how geopolitical uncertainty affects asset performance, volatility, correlations, funding conditions, distance to default, and equity values. Its main aim is to support supervisory assessment and structured scenario analysis in an environment of fundamental uncertainty.

JEL Classification: G28, G32.

Keywords: geopolitical uncertainty, banking supervision, prudential risk, contingent claims analysis.

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* Banca d'Italia. The views expressed are solely those of the author and do not necessarily reflect the official position of the Banca d'Italia.

1. Introduction[1]

Geopolitical developments have become an increasingly relevant dimension of the macro-financial environment in which banks operate. Wars, sanctions, trade fragmentation, cyber conflict, energy insecurity, and broader political tensions have contributed to a structural increase in uncertainty, with direct implications for financial stability and bank resilience. Their relevance for prudential supervision lies not in the emergence of a new and separate risk category, but in their capacity to affect several components of banks' risk profiles at the same time. Geopolitical developments therefore operate as amplifiers of existing vulnerabilities, entering directly into the assessment of solvency, liquidity, operational resilience, governance, and business-model sustainability.

This issue is particularly pertinent for the Italian banking system and, within it, for Less Significant Institutions (LSIs). LSIs are typically more domestically oriented and less directly exposed to cross-border activities, complex market operations, or foreign sovereign risk. However, this does not imply limited exposure to geopolitical developments. Their vulnerability is often indirect and embedded within the domestic economy. Borrowers' dependence on exports, imported inputs, energy-intensive production, tourism, logistics, or other sectors sensitive to geopolitical developments may generate relevant prudential effects. Reliance on outsourced services, ICT infrastructures, cloud providers, and other third-party arrangements also creates operational channels through which geopolitical uncertainty may affect bank resilience.

At the European level, supervisory attention to geopolitical developments has increased, with a growing emphasis on scenario analysis, stress testing, and forward-looking risk identification. Reverse stress testing has been highlighted as a useful tool for assessing vulnerabilities under severe but plausible geopolitical scenarios, and ECB Banking Supervision has announced a dedicated geopolitical reverse stress test for 2026. More broadly, supervisory expectations increasingly frame geopolitical developments within the wider macro-financial risk environment and call for structured approaches to their assessment. This reinforces the need for analytical tools capable of linking geopolitical shocks to standard prudential categories rather than treating them as a self-contained source of risk.

Within this evolving context, the supervisory approach adopted by the Banca d'Italia is characterized by a high degree of integration with the existing prudential framework. Rather than treating geopolitical developments as a distinct supervisory category, they are incorporated into the standard risk taxonomy, including credit risk, concentration risk, market risk, liquidity and funding risk, operational resilience, and governance. This approach reflects both proportionality considerations and analytical challenges. For LSIs, the indirect and embedded nature of geopolitical exposure makes it difficult to isolate a single, clearly identifiable "geopolitical risk" measure. At the same time, the cross-cutting nature of such developments suggests that an explicit idiosyncratic treatment would be of limited practical relevance.

In this sense, the Italian supervisory approach can be described as holistic. Geopolitical uncertainty is assessed through its effects on the ordinary pillars of prudential supervision, including SREP evaluations, ICAAP and ILAAP processes, provisioning adequacy, governance frameworks, funding sustainability, and operational resilience. The focus is therefore on identifying the transmission channels through which geopolitical developments affect banks'

[1] A preliminary version of this paper has been prepared to support my intervention at the Aifirm–Sapienza Conference, "Geopolitical and Other Risks: A New Era of Risk Management" held on 17 April 2026. The purpose of this paper is to foster discussion and contribute to ongoing dialogue on these issues. I am grateful to Giuseppe Siani for his valuable inputs, and constructive comments, which greatly improved this paper. I also thank Rainer Masera, Sebastiano Laviola, Francesco Cannata, Pasqualina Porretta and Antonio Scalia for fruitful discussions, suggestions and for their encouragement in developing this work and addressing this topic. I take full responsibility for any remaining errors.

balance sheets and risk profiles, rather than on constructing a standalone quantitative indicator or deriving a dedicated capital requirement. Supervisory practice thus relies on a combination of quantitative analysis, scenario-based approaches, and expert judgment, with an emphasis on forward-looking assessment and resilience.

This approach is also consistent with a broader conceptual consideration. For prudential purposes, the notion of geopolitical uncertainty is often more appropriate than that of geopolitical risk. Geopolitical developments are difficult to represent through stable probability distributions or fully observable indicators. They are shaped by strategic interactions, discontinuities, evolving institutional frameworks, and limited historical data, which together limit the scope for precise probabilistic inference. In this environment, reliance on purely model-based quantification may be insufficient, and must be complemented by scenario analysis, judgment, and robustness considerations.

Against this background, the paper pursues three main objectives. First, it clarifies the conceptual distinction between geopolitical risk and geopolitical uncertainty and discusses its implications for prudential analysis. Second, it examines the nature of exposure of LSIs relative to Significant Institutions (SIs), with particular emphasis on the indirect and domestically embedded transmission channels relevant for LSIs. Third, it develops an original structural framework, inspired by contingent claims analysis and by the structural approach pioneered by Merton (1973, 1974), to represent analytically the main channels through which geopolitical uncertainty propagates through bank balance sheets.

The analytical contribution of the paper lies in adapting the structural framework to a banking setting in which geopolitical uncertainty affects both sides of the balance sheet. Relative to the standard Merton model, where default is driven by the terminal comparison between firm assets and debt, the proposed model introduces asset-class composition, liability-class dynamics, funding costs that depend on both the geopolitical state and the strength of the underlying assets, and payout flows that make the framework suitable for banks. The model therefore allows geopolitical uncertainty to affect asset drifts, asset volatilities, correlations, liability run-off rates, funding costs, payout pressure, distance to default, and equity values within a unified setting. A key modelling innovation is the payout specification. In the standard structural framework, debt is typically represented as a terminal obligation, and payouts do not play the same role as in a bank balance sheet. In the proposed framework, total payout is kept proportional to assets, which preserves a tractable Geometric Brownian Motion (GBM) for aggregate assets, while the internal allocation of payout is decomposed into liability redemptions/runoffs, interest payments, and residual dividends. This makes it possible to introduce bank-specific funding stress and funding costs without losing closed-form interpretability. The stylized implementation developed in Section 6 illustrates this role by showing how differences in asset and liability composition translate into different dynamics of distance to default, equity valuation, leverage, and tail outcomes.

The central argument of the paper is that geopolitical developments should be addressed within prudential supervision as a cross-cutting source of uncertainty, rather than as a separate and self-contained risk category. This position is consistent with the SSM/European supervisory orientation, which increasingly treats geopolitical developments as a factor affecting existing risk categories and supervisory processes. This requires an integrated, forward-looking, and institution-specific supervisory approach, capable of capturing both direct and indirect transmission channels and of ensuring that bank resilience is assessed in a comprehensive and consistent manner. In this context, the analytical framework proposed in the paper is not a substitute for supervisory judgment, but a formal device to organize scenario analysis, compare balance-sheet structures, and clarify how geopolitical developments propagate through existing prudential channels.

2. GPR or GPU: definition and challenges for its measurement

According to Caldara and Iacoviello (2022), Geopolitical Risk (GPR) refers to the threat, realization, and escalation of adverse events associated with wars, terrorism, and tensions among states and political actors affecting peaceful international relations. This definition is useful because it provides an empirical point of departure and underpins the best-known macro indicator of geopolitical conditions. However, for prudential purposes, it is only a first step. The more challenging issue is how such phenomena affect bank balance sheets, business models, and risk profiles.

In this context, the distinction introduced by Frank Knight (1921) and further developed by John Maynard Keynes (1921, 1936, 1937) remains analytically crucial. Knight distinguishes between risk, where probabilities are known or can be estimated, and uncertainty, where such probabilities are fundamentally unknowable. Keynes deepens this argument in *A Treatise on Probability* (1921) by questioning the measurability of probability itself, and later in *The General Theory of Employment, Interest and Money* (1936) and his *1937 Quarterly Journal of Economics* article by emphasizing that, in many economically relevant contexts, there is "*no scientific basis on which to form any calculable probability whatever*." Expectations in such environments are therefore not grounded in statistical inference but in conventions, judgment, and confidence. This Keynesian notion of fundamental uncertainty is particularly relevant for geopolitical phenomena. Geopolitical developments are not merely rare events with poorly estimated probabilities; rather, they are shaped by: i) strategic interaction among political actors; ii) discontinuities and regime shifts; iii) evolving institutional and policy frameworks; iv) limited and non-representative historical data.

Because of these characteristics, past observations provide only weak guidance for the future. The underlying stochastic process is unstable, and probability-based inference becomes inherently incomplete. In Keynesian terms, this is not simply a situation of measurable risk, but one in which the probability distribution is itself unknown and potentially unknowable. Masera (2023) highlights how evolving macro-financial conditions, geopolitical fragmentation, and institutional changes challenge the reliability of standard forecasting frameworks and call for a broader and more integrated analytical perspective.

For this reason, it is probably conceptually more appropriate to refer to Geopolitical Uncertainty (GPU) rather than Geopolitical Risk (GPR). The term "risk" implicitly suggests that events can be modeled through stable probability distributions, while "uncertainty" better captures the reality that geopolitical shocks are non-ergodic, structurally unstable, and resistant to precise quantification. The shift from GPR to GPU is therefore not merely semantic, but reflects a deeper epistemological point rooted in Keynes' analysis: the limits of probabilistic reasoning in the face of genuine uncertainty.

Against this background, the principal challenge for banks and supervisors is that GPR/GPU is cross-cutting. It does not enter the prudential framework as a separate risk category, but rather as a driver that propagates through existing risk types. Beck, Bruno and Carletti (2025) propose a useful framework distinguishing drivers, transmission channels, and manifestations (see Table 1). This framing clarifies why a separate "geopolitical risk box" may be analytically misleading. What ultimately matters is not the label, but the transmission mechanism through which geopolitical shocks affect financial institutions.

Table 1 - GPR/GPU: Drivers, Channels, and Manifestations

Drivers	*Channels*	*Manifestations (bank's risks)*
Wars, sanctions, geopolitical tensions	*Real economy*	*Credit risk*
Cyber conflict, trade fragmentation	*Financial markets*	*Market risk*
Political instability, state fragility	*Operational systems and ICT infrastructures*	*Operational risk*
Cyber threats, infrastructure disruption	*Payment systems and digital channels*	*Operational risk, reputational risk, liquidity risk (second-order)*
Policy/geoeconomic fragmentation	*Legal & regulatory environment*	*Legal and reputational risk*

Source: Author's elaboration based on Beck, Bruno and Carletti (2025).

For many banks, especially less significant institutions (LSIs), the real-economy channel is central. As highlighted by Haselmann et al. (2025), the impact of geopolitical shocks is often indirect. Banks are embedded in domestic economies that absorb the initial shock, and it is through the deterioration of borrowers' conditions, firms, households, and sectors, that the prudential consequences materialize. This is particularly relevant for portfolios concentrated in SMEs, exporters, transport, tourism, and energy-sensitive sectors. The impact may appear domestic, but its origin is geopolitical.

At the same time, geopolitical uncertainty affects financial conditions and operational resilience. Financial markets may reprice risk abruptly, increasing funding costs and volatility. Disruptions to financial infrastructure, cyber threats, and fragmentation of payment systems can directly affect banks' operations. Geopolitical tensions may increase the likelihood of cyber incidents targeting financial institutions or critical infrastructures. While the immediate impact is typically operational—affecting systems availability, data integrity, or service continuity—such events may also have broader second-order effects. Significant cyber incidents may undermine customer confidence and damage a bank's reputation, potentially triggering deposit outflows or reduced funding stability. In this way, cyber risk can propagate beyond the operational domain and become a liquidity concern, highlighting once again the cross-cutting nature of geopolitical uncertainty and the limitations of a silo-based risk classification.

As emphasized by Resti (2025), these phenomena require strong governance, robust data frameworks, and preparedness for unconventional shocks. Given these features, the key implication is methodological. Because GPR/GPU cannot be fully captured through standard probabilistic models, banks and supervisors must complement quantification with: i) scenario analysis; ii) expert judgment and overlays; iii) stress testing under structural breaks; iv) forward looking provisioning approaches. The issue is therefore not the impossibility of measurement, but the inadequacy of relying on measurement alone. This aligns with the ECB's work on novel risks and IFRS 9 overlays, as well as IMF findings that geopolitical developments can materially affect financial stability and intermediation capacity.

Adopting the concept of Geopolitical Uncertainty (GPU) better reflects the Keynesian insight (Keynes, 1921; 1936; 1937) that, in certain domains, the future cannot be meaningfully reduced to a probability distribution. This has direct implications for prudential policy: resilience must be built not only against measurable risks, but also against fundamentally uncertain and structurally unpredictable shocks.

3. GPR/GPU's exposures: SIs vs. LSIs

The main difference between LSIs and SIs lies in the structure of their respective exposure vis-à-vis Geopolitical Risk/Uncertainty (GPR/GPU). Equating geopolitical exposure with direct foreign positions would be misleading, especially in the Italian case (see Table 2).

Significant Institutions are more likely to have direct cross-border claims, larger securities portfolios, greater market and treasury sensitivity, broader wholesale funding access, and more visible exposure to financial-market channels. Their geopolitical uncertainty profile is therefore often more directly international and more immediately reflected in spreads, valuation changes, and consolidated group dynamics.

Less Significant Institutions, by contrast, tend to have more concentrated domestic lending, stronger exposure to local SMEs and households, less diversified business models, and sometimes more limited risk-modeling capacity. From a funding perspective, the distinction between LSIs and SIs should be interpreted with some caution. While Significant Institutions typically benefit from broader access to wholesale and market-based funding (including repo markets and unsecured issuance) this should not be interpreted as implying weaker funding resilience. In practice, many SIs combine such market access with a strong and diversified deposit franchise, supported by brand recognition and a broad customer base. As a result, their funding structures tend to be more diversified rather than structurally more fragile. Conversely, LSIs generally rely more heavily on retail funding, often concentrated at the local level. While this may provide stability under normal conditions, it can also imply greater sensitivity to idiosyncratic confidence shocks or concentration effects. The key difference between LSIs and SIs therefore lies less in the presence of stable funding per se and more in the composition, diversification, and elasticity of funding sources under stress.

LSIs' geopolitical exposure is therefore often less visible but not less material. It is more likely to emerge through indirect macroeconomic effects, borrower concentration, local sectoral fragility, deposit behavior, and dependence on third-party operational infrastructures. This indirect nature also has a temporal dimension: for LSIs, geopolitical shocks may become prudentially material only with a lag, as they are first absorbed by firms, households, sectors, or service providers before affecting credit quality, funding behavior, or operational resilience.

This distinction is further supported by academic and institutional evidence. While SIs typically exhibit more direct and observable exposure—stemming from their cross-border activities, diversified securities portfolios, and reliance on wholesale funding markets—LSIs are predominantly affected through indirect and structurally embedded transmission channels.

As highlighted by the European Central Bank (ECB, 2024) and corroborated by their empirical studies (Caldara *et al*., 2024), geopolitical shocks influence banks not only through immediate market repricing and funding conditions, but also via credit supply adjustments, sectoral reallocation, and shifts in risk perception. These effects are mediated by business model characteristics. Internationally active banks tend to react more strongly and immediately to global uncertainty, whereas domestically oriented institutions are primarily impacted through second-round macroeconomic effects, including borrower deterioration, local economic contraction, and changes in depositor behavior.

Table 2 - Differences in GPR/GPU Transmission and Prudential Implications: LSIs vs. SIs

Dimension	***Typical LSIs profile***	***Typical SIs profile***	***Prudential implication under geopolitical uncertainty***
Balance-sheet size and scope	*Smaller, domestic, relationship-based.*	*Larger, diversified, often cross-border.*	*LSIs are more vulnerable to indirect and often lagged domestic spillovers; SIs to more direct international and market channels.*
Funding structure	*More reliant on retail deposits, often with stronger local concentration and franchise sensitivity.*	*Broader access to wholesale and market funding (including repo), combined with a strong and diversified deposit franchise.*	*LSIs may be more sensitive to local concentration and confidence effects; SIs benefit from diversification but remain exposed to market-based funding conditions and repricing.*
Asset composition	*Larger relative weight of SME, household, and local corporate credit.*	*Larger weight of marketable securities and diversified corporate books.*	*LSIs absorb geopolitical shocks mainly through borrower deterioration; SIs through both borrower deterioration and market repricing.*
Main concentration risk	*Sectorial, geographic, and client concentration in domestic portfolios.*	*Cross-border, market, and group-level concentration.*	*Geopolitical uncertainty appears more indirect in LSIs and more direct in SIs, but may be equally material.*
Operational channel	*Greater dependence on critical shared or outsourced services relative to internal redundancy.*	*More complex infrastructures, but often stronger internal control resources.*	*LSIs may be more exposed to hidden operational fragilities; SIs to complexity and contagion across infrastructures.*

Source: Author's elaboration.

Evidence from the Banca d'Italia (2025) further indicates that geopolitical tensions reshape capital flows and investment patterns, reinforcing domestic spillovers even in the absence of direct foreign exposures. Moreover, research by Reinhardt *et al.* (2025) and the International Monetary Fund (2025) underscores that heightened geopolitical uncertainty leads to a contraction in lending—particularly cross-border credit—and amplifies systemic vulnerabilities through interconnected financial channels.

Banks respond not only to realized geopolitical events but also to perceived threats and uncertainty, with significant implications for credit allocation and risk management. In this context, LSIs' exposure—though less visible—may be equally material, as it is embedded in concentrated credit portfolios, local sectoral dependencies, and operational reliance on shared infrastructures. Many Italian LSIs are primarily domestically oriented and do not have significant direct exposures to conflict-affected jurisdictions, foreign sovereigns, or complex international market activities. However, this does not imply a low level of geopolitical exposure. On the contrary, their vulnerability is often indirect and embedded within the domestic economy. A regional or local bank may be materially exposed because its borrowers depend on exports, imported inputs, energy-intensive production, tourism, logistics, or other sectors that are sensitive to geopolitical developments. These banks may also face exposure through outsourced services, ICT dependencies, cloud concentration, and other third-party operational channels.

Therefore, especially in bank-centric systems such as Italy, a holistic analytical framework that integrates both direct and indirect transmission mechanisms is not only preferable but necessary for a comprehensive assessment of geopolitical risk.

4. Insights from supervision of Italian LSIs

The SREP framework of the Banca d'Italia is broadly aligned with the SSM approach, while incorporating proportionality and calibration to reflect national specificities. At the same time, the supervisory process has aimed to strengthen coherence between SREP assessments, benchmarking exercises, and capital decisions. Importantly, the response to an increasingly uncertain geopolitical environment has not taken the form of a standalone thematic overlay; rather, it has involved a deeper integration of vulnerabilities into the standard prudential framework.

As previously discussed, the main differences between LSIs and SIs—both on the asset and liability side—do not lie in the presence or absence of exposure to geopolitical developments, but in the way such exposure is transmitted. LSIs tend to be more domestically oriented, with a greater reliance on customer funding and a stronger concentration in local credit portfolios, implying that geopolitical effects materialize mainly through borrower performance, sectoral concentration, depositor behavior, and operational dependencies. SIs, while also benefiting from a significant deposit franchise, are typically more diversified and more exposed to market-based activities, including securities holdings, wholesale funding, and cross-border operations. As a result, geopolitical uncertainty tends to affect them more directly through market repricing, funding conditions, and international channels. The distinction is therefore best understood in terms of transmission mechanisms and resilience, rather than exposure per se.

Table 3 - Italian LSIs: Heterogeneity, SREP Outcomes, and Capital Demand (2025)

	Key Messages	***Main Implications***
Heterogeneity of Italian LSIs	*Italian LSIs are highly heterogeneous in business models and vulnerability profiles.*	*Supervisory assessments must be bank-specific; no "average" LSI adequately represents the system.*
Supervisory Outcomes 2025	*Overall stability in SREP results, but significant dispersion (both improvements and deteriorations).*	*Vulnerabilities materialize unevenly depending on balance sheet structure, governance, and exposures.*
Supervisory Focus	*Governance, provisioning adequacy, ICT/operational resilience, interest rate risk, and funding structure.*	*Weaknesses in these areas are key drivers of adverse SREP scores and capital measures.*

	Key Messages	*Main Implications*
Average Pillar 2 Requirements 2025	*Average total capital demand increased.*	*Capital requirements remain materially driven by supervisory add-ons beyond minimum requirements.*
Evolution of Capital Demand	*Capital demand increased, mainly due to higher P2R, reflecting the actual exposure profile and evolution of risks in these banks, particularly credit risk, concentration risk, IRRBB, and provisioning gaps.*	*Traditional risk channels remain dominant; geopolitical factors act indirectly through them.*
Capital Demand & SREP Scores Correlation	*Higher capital requirements are associated with weaker SREP assessments (e.g., governance, provisioning, ICT weaknesses).*	*Capital demand reflects underlying supervisory concerns in quantitative terms.*
Comparison vs. Italian SIs	*Italian LSIs show, on average, higher capital demand than Italian SIs, reflecting their actual exposure profile, risk evolution, and supervisory assessment outcomes.*	*Smaller, less diversified banks may face higher prudential sensitivity where their actual exposures, risk evolution, and risk-management capacity warrant it, despite their domestic focus.*

Source: Author's elaboration.

Recent SREP cycles confirm that Italian LSIs cannot be treated as homogeneous, either in terms of business models or vulnerability profiles. While supervisory results indicate overall system resilience, they also reveal significant dispersion across institutions. In 2025, approximately 100 LSIs received a SREP score. Benchmarking results showed general stability, but also a meaningful number of banks improving or deteriorating compared to the previous cycle. This dispersion suggests that vulnerabilities are transmitted unevenly, depending on each bank's specific characteristics, including sectoral concentrations, balance sheet composition, funding structure, governance quality, and operational dependencies.

Key areas of supervisory focus continue to include governance arrangements, provisioning adequacy, ICT and operational resilience, interest rate risk, and the robustness of funding structures. Supervisory scores have been influenced, among other factors, by governance weaknesses, under-provisioning, adverse ICT assessments, behavioral modeling assumptions in interest rate risk frameworks, and funding composition. Aggregate evidence also indicates that banks experiencing stronger growth in operating costs tend, on average, to receive less favorable supervisory outcomes, while institutions with higher reliance on operational deposits tend to show weaker liquidity assessments.

In 2025, aggregate capital demand for Italian LSIs remained primarily driven by traditional prudential risk channels, notably credit risk, concentration risk, interest rate risk, and provisioning shortfalls. Capital demand increased on average, mainly driven by Pillar 2 Requirements (P2R). Interest rate and credit-related add-ons accounted for more than 90% of aggregate P2R, with particular relevance for single-name concentration, geo-sectoral concentration, and under-provisioning. Under-provisioning add-ons remained significant for a non-negligible subset of institutions.

Over recent supervisory cycles, aggregate capital demand for Italian LSIs has remained higher than that observed for Italian SIs, reflecting the actual exposure profile, risk evolution, and supervisory assessment outcomes of the banks concerned. Supervisory evidence indicates that, for the third consecutive year, Italian SIs exhibited, on average, lower aggregate capital demand than LSIs, with P2R for LSIs exceeding that of SIs. Smaller size does not imply lower supervisory sensitivity. On the contrary, lower diversification, higher concentration in domestic exposures, greater reliance on traditional intermediation, and, in some cases, more limited internal modeling and management capacity may result in higher capital requirements for LSIs compared to larger, more diversified institutions.

The supervisory experience of the Banca d'Italia suggests that the prudential relevance of geopolitical uncertainty is already embedded within the standard supervisory framework, without requiring a separate supervisory category. Geopolitical developments are captured insofar as they affect governance quality, borrower risk, provisioning adequacy, operational resilience, and funding sustainability. In this context, geopolitical risk acts as an amplifier of pre-existing vulnerabilities rather than as a standalone, uniformly distributed risk factor.

This holistic and forward-looking supervisory approach is consistent with broader institutional reflections. As highlighted by Siani (2025), supervision of LSIs requires a proportional and forward-looking framework, capable of capturing institution-specific vulnerabilities while ensuring coherence with the overall prudential architecture. In this perspective, emerging sources of risk are addressed through their interaction with traditional risk drivers rather than through the creation of separate analytical silos.

This integrated approach is also complemented by a long-standing and proactive use of early intervention tools within the supervisory framework. In particular, supervisory practice has relied on a graduated set of measures—ranging from intensified monitoring and corrective actions to more intrusive interventions—aimed at addressing emerging weaknesses at an early stage. Among these, the use of special administration has played a key role in situations where governance or financial conditions required a more direct supervisory involvement. These interventions reflect a forward-looking approach focused on restoring sound management, stabilizing institutions, and facilitating orderly adjustment processes.

More broadly, early intervention should be considered as an additional tool of Banca d'Italia's continuous supervisory process. As a result, Banca d'Italia's supervisory action is inherently anticipatory and institution-specific, consistent with a framework in which emerging risks (including those related to geopolitical developments) are addressed through their impact on traditional prudential categories rather than through the creation of separate risk silos.

5. A Conceptual and Stylized Framework for Analyzing Geopolitical Risk in Banking

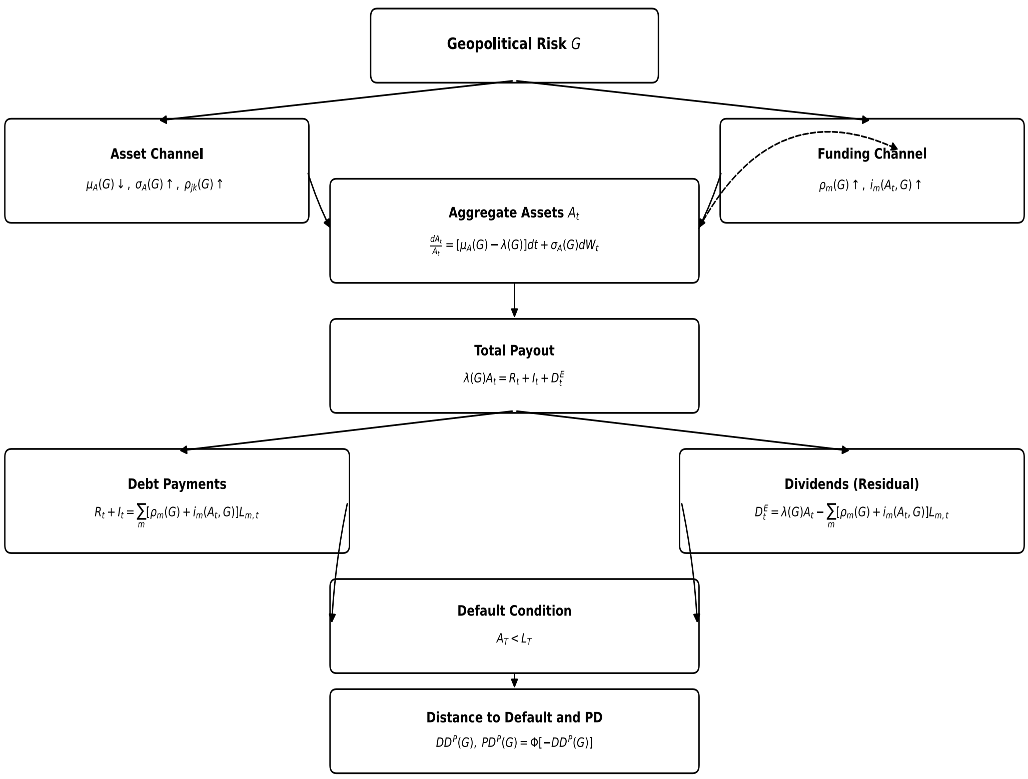
The framework developed here should be understood as a structured analytical device rather than a tool for precise measurement, fully consistent with the distinction between measurable risk and fundamental uncertainty. Geopolitical developments are not easily reducible to stable probability distributions but act as cross-cutting sources of uncertainty that propagate simultaneously through multiple dimensions of banks' balance sheets. Building on the intuition of the Merton structural model, the framework introduces a geopolitical state variable, G, that affects asset returns, volatility, correlations, and—crucially—funding conditions within a unified and internally consistent setting.

The originality of the model lies in modifying the standard Merton structure so that it can represent banking activity. In the classic framework, firm value follows a stochastic process and equity can be interpreted as a call option on assets, with debt mainly represented by a terminal claim. This paper preserves the structural intuition but extends it by introducing bank-specific assets, liability classes, run-off rates, interest costs, and a payout identity. Total payout remains proportional to assets, preserving the tractability of a GBM and closed-form pricing, while the composition of payout is made economically meaningful for banks through redemptions, funding costs, and residual dividends.

A central feature of the model is that funding stress and funding costs are not imposed exogenously, but emerge from the interaction between assets, liabilities, and geopolitical conditions. Liability dynamics are explicitly modeled through class-specific run-off rates and interest costs that depend on both the geopolitical state and the strength of the asset base. As a result, increases in geopolitical stress simultaneously worsen funding conditions—through higher effective rates, faster run-off, or tighter constraints—while deteriorating asset performance. This creates an intrinsic feedback mechanism whereby weaker assets increase funding costs, and higher funding costs further compress resilience.

Within this structure, geopolitical uncertainty does not operate through a single channel, but interacts with asset composition, funding structure, and diversification in ways that differ systematically across institutions. By decomposing assets into economically meaningful classes, such as mortgages, SME loans, corporate loans, securities, and liquid assets, and liabilities into distinct funding sources, such as retail deposits and wholesale funding, the model makes explicit how balance-sheet structure determines sensitivity to geopolitical stress. The framework therefore provides a bridge between the supervisory taxonomy of risks and the structural valuation logic of contingent claims analysis.

Fig. 1 - GPR/GPU transmission channels modeled in the proposed framework



Source: Author's elaboration.

These effects are nonlinear and become particularly relevant near distress, reinforcing the importance of balance-sheet composition and institutional heterogeneity. This provides a natural analytical distinction between LSIs and SIs, not in terms of exposure per se, but in terms of transmission channels. LSIs are primarily affected through borrower deterioration, domestic concentration, deposit behavior, and relationship-based credit exposures, while SIs are more exposed to market volatility, securities repricing, common correlations, and wholesale funding conditions.

Overall, the framework should be interpreted as an explanatory and supervisory tool. Its purpose is not to generate point estimates, but to clarify the channels through which geopolitical and traditional financial risks interact. Its original contribution is to retain the discipline and tractability of the Merton framework while modifying it to account for the banking-specific role of payout, liability structure, and endogenous funding costs. This supports a holistic, forward-looking assessment of bank resilience in an environment characterized by fundamental uncertainty.

5.1 Asset-class dynamics without payouts

Let aggregate assets (A_t) at time t be denoted by:

$$A_t = \sum_{k=1}^{K} A_{k,t}\,. \qquad [1]$$

The index k identifies each asset class on the bank balance sheet: $k \in \{M, SME, C, CC, S, L\}$. In the stylized application considered here, the relevant asset classes are: mortgages (M), loans to small and medium-sized enterprises (SME), corporate exposures (C), consumer credit (CC), securities portfolios (S), and liquid assets and reserves (L).

Assume the evolution of each asset class k is given by:

$$\frac{dA_{k,t}}{A_{k,t}} = \mu_k(G)\,dt + \sigma_k(G)\,dW_{k,t}. \qquad [2]$$

Let:

$$\mu_k(G) = \mu_{k,0} - \beta_k^{\mu} G, \qquad [3]$$

$$\sigma_k(G) = \sigma_{k,0} + \beta_k^{\sigma} G. \qquad [4]$$

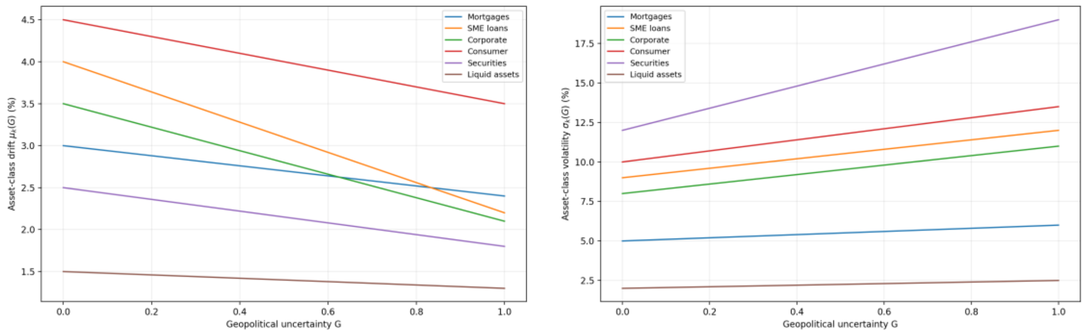
The parameters $\beta_k^{\mu}$and β_k^{σ} capture the sensitivity of each asset class to geopolitical stress. A higher β_k^{μ}means that the drift of asset class k deteriorates more rapidly as G rises. A higher β_k^{σ} means that the volatility of asset class k increases more strongly under geopolitical stress.

The Brownian motions satisfy:

$$dW_{j,t}dW_{k,t} = \rho_{jk}(G)\,dt, \qquad \rho_{kk}(G) = 1.$$

The dependence of $\rho_{jk}(G)$ on G captures the fact that geopolitical stress may increase co-movement across exposures. Under normal conditions, different asset classes may provide diversification benefits. Under geopolitical stress, however, common macro-financial shocks may raise correlations and reduce the effectiveness of diversification.

Fig. 2 - Asset class drifts and volatilities: stylized sensitivities to *G*



Source: Author's elaboration.

Assume weights continuously maintained constant:

$$w_k = \frac{A_{k,t}}{A_t}, \qquad \sum_{k=1}^{K} w_k = 1.$$

Then:

$$\frac{dA_t}{A_t} = \sum_{k=1}^{K} w_k \frac{dA_{k,t}}{A_{k,t}}. \tag{5}$$

Therefore:

$$\frac{dA_t}{A_t} = \sum_{k=1}^{K} w_k\, \mu_k(G)\, dt + \sum_{k=1}^{K} w_k\, \sigma_k(G)\, dW_{k,t}. \tag{5bis}$$

The aggregate drift is:

$$\mu_A(G) = \sum_{k=1}^{K} w_k\, \mu_k(G). \tag{6}$$

The aggregate variance is:

$$\sigma_A^2(G) = \sum_{k=1}^{K} w_k^2\, \sigma_k^2(G) + 2\sum_{j<k} w_j\, w_k \rho_{jk}(G)\sigma_j(G)\sigma_k(G). \tag{7}$$

Equivalently:

$$\sigma_A^2(G) = w'\Sigma(G)w. \tag{7bis}$$

Where $\Sigma(G)$ is the covariance matrix of asset-class returns. Define:

$$dW_{A,t} = \frac{1}{\sigma_A(G)} \sum_{k=1}^{K} w_k\, \sigma_k(G) dW_{k,t}. \tag{8}$$

Then:

$$\left(dW_{A,t}\right)^2 = dt.$$

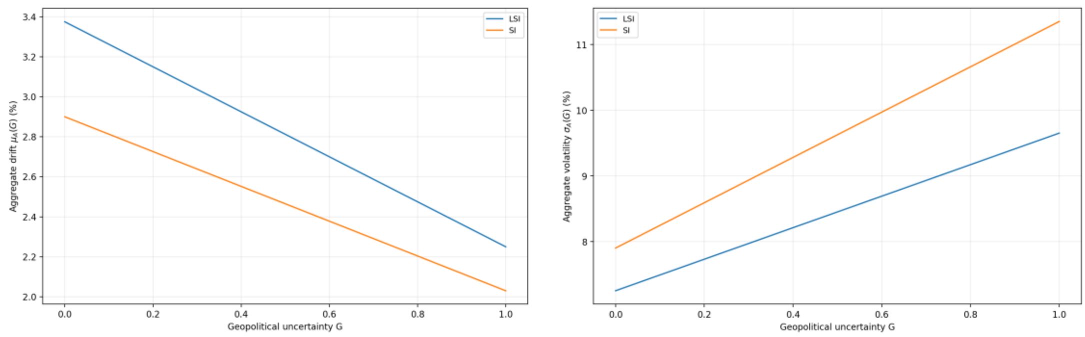
So also aggregate assets follow a GBM:

$$\frac{dA_t}{A_t} = \mu_A(G)\, dt + \sigma_A(G)\, dW_{A,t}. \qquad [5ter]$$

The model proposed here distinguishes between credit-driven exposures, such as mortgages, SME loans, corporate loans, and consumer credit, and market-sensitive exposures, such as securities portfolios.

This distinction is relevant because geopolitical uncertainty may affect these components in different ways. For example, SME and corporate loans may be affected mainly through borrower cash-flow deterioration, energy costs, export disruption, or sectoral concentration. Securities portfolios may instead be affected more directly through spread widening, repricing, and market volatility. Liquid assets may be affected through the need to preserve buffers or monetize liquidity under stress. LSIs and SIs have heterogeneous exposures depending on their actual assets and liability structure.

Fig. 3 - Total assets' drift and volatility: stylized sensitivities to *G* (LSIs vs. SIs)



Source: Author's elaboration.

5.2 Liability structure

Liabilities are decomposed into M funding buckets:

$$L_t = \sum_{m=1}^{M} L_{m,t}\,. \qquad [9]$$

The index m identifies the main liability or funding classes; $m \in \{SR, LR, OD, SW, UW\}$. In the stylized banking application considered here, these are: stable retail deposits (SR), less stable retail deposits (LR), operational deposits (OD), secured wholesale funding (SW), and unsecured wholesale funding (UW).

Each liability class evolves as:

$$L_{m,t} = L_{m,0} e^{-\rho_m(G)t}. \qquad [10]$$

Here $\rho_m(G)$ is the effective redemption, amortization, rollover or run-off rate of liability class m. This dependence captures the idea that the stability of funding sources may deteriorate under geopolitical stress. For example, wholesale funding may become harder to roll over, secured funding may become more sensitive to collateral haircuts, and operational deposits may become more mobile if corporate clients face liquidity pressure.

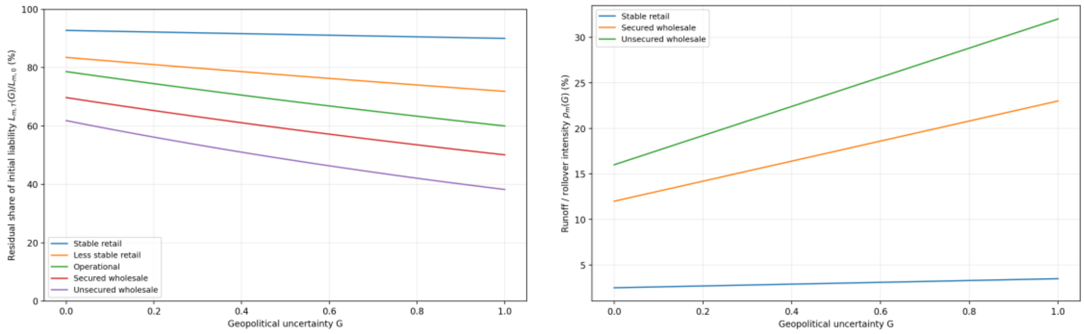
The parameter β_m^ρ, which captures the sensitivity of each liability class to geopolitical stress, is specified as:

$$\rho_m(G) = \rho_{m,0} + \beta_m^\rho G, \tag{11}$$

with:

$$\beta_m^\rho \geq 0.$$

Fig. 4 - Stylized runoffs/rollover sensitivities to *G* for different liabilities



Source: Author's elaboration.

Thus, residual liabilities at maturity, T, for funding sources m are:

$$L_{m,T} = L_{m,0}e^{-\rho_m(G)T}. \tag{12}$$

Total residual liabilities at maturity, T are:

$$L_T = \sum_{m=1}^{M} L_{m,T} = \sum_{m=1}^{M} L_{m,0}\, e^{-\rho_m(G)T}. \tag{13}$$

<u>*5.3 Redemption/runoffs, interest and dividend payments*</u>

The redemption/runoff for liability class m is:

$$R_{m,t} = \rho_m(G)L_{m,t}. \tag{14}$$

Aggregate redemption/runoffs are:

$$R_t = \sum_{m=1}^{M} R_{m,t} = \sum_{m=1}^{M} \rho_m\,(G)L_{m,t}. \tag{15}$$

Substituting liability dynamics we obtain:

$$R_t = \sum_{m=1}^{M} \rho_m\,(G)L_{m,0}e^{-\rho_m(G)t}. \tag{15bis}$$

Interest payments for liability class m are linked to the outstanding liability amount:

$$I_{m,t} = i_m(A_t, G)L_{m,t}. \tag{16}$$

The interest rate satisfies:

$$\frac{\partial i_m(A_t, G)}{\partial A_t} < 0,$$

$$\frac{\partial i_m(A_t, G)}{\partial G} > 0.$$

Funding costs, in line with economic intuition, are higher when geopolitical stress rises and lower when, as in any structural model, the value of the bank's assets improves (bank's own credit risk is reduced). A convenient specification for interest rates due to liability class m is:

$$i_m(A_t, G) = i_{m,0} + \gamma_m^G G - \gamma_m^A \ln\left(\frac{A_t}{A_0}\right), \qquad [17]$$

with:

$$\gamma_m^G > 0, \qquad \gamma_m^A > 0.$$

Then:

$$\frac{\partial i_m(A_t, G)}{\partial G} = \gamma_m^G > 0,$$

and:

$$\frac{\partial i_m(A_t, G)}{\partial A_t} = -\frac{\gamma_m^A}{A_t} < 0.$$

Finally aggregate interest is:

$$I_t = \sum_{m=1}^{M} I_{m,t} = \sum_{m=1}^{M} i_m\,(A_t, G) L_{m,t}. \qquad [18]$$

5.4 Total payout

To maintain analytical tractability without jeopardizing the economic plausibility of the proposed framework, total payout remains proportional to assets:

$$P_t = \lambda(G) A_t. \qquad [19]$$

Hence:

$$\lambda(G) A_t = R_t + I_t + D_t^E. \qquad [20]$$

Therefore, dividends can be defined residually as:

$$D_t^E = \lambda(G) A_t - R_t - I_t. \qquad [21]$$

Substituting:

$$D_t^E = \lambda(G) A_t - \sum_{m=1}^{M} [\rho_m(G) + i_m(A_t, G)]\, L_{m,t}. \qquad [21bis]$$

Since dividends cannot normally be negative, a natural admissibility condition is: $D_t^E \geq 0$.

Equivalently: $\lambda(G) A_t \geq \sum_{m=1}^{M} [\rho_m(G) + i_m(A_t, G)]\, L_{m,t}$.

In any case, if this condition fails, the model has two possible interpretations. First, dividends are set to zero and the residual shortfall represents stress pressure. Second, negative residual dividends can be interpreted as external capital needs or an internal liquidity shortfall.

5.5 Asset dynamics after payouts and terminal asset distribution

Post-payout asset dynamics are:

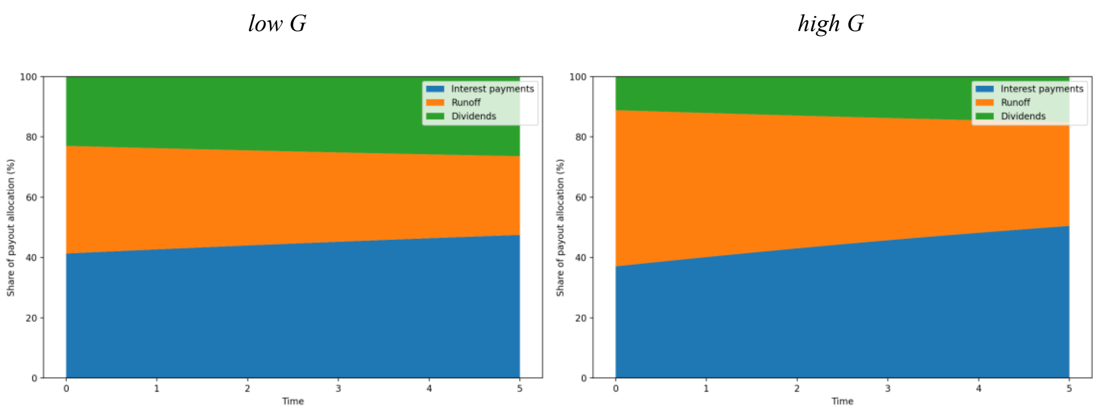
$$dA_t = \mu_A(G)A_t dt - \lambda(G)A_t dt + \sigma_A(G)A_t dW_{A,t}. \quad [22]$$

Hence:

$$\frac{dA_t}{A_t} = [\mu_A(G) - \lambda(G)]dt + \sigma_A(G)dW_{A,t}. \quad [22bis]$$

This is still a GBM. Although redemption, interest, and dividends have richer internal meanings, the aggregate payout remains proportional to assets, so the aggregate asset process remains analytically tractable.

Fig. 5 - Stylized shares of payout allocation through time for low and high *G*



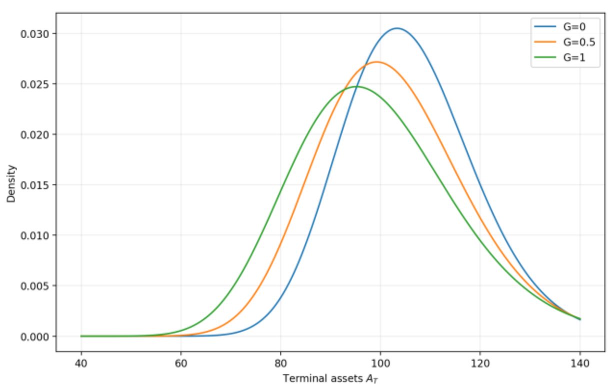
Source: Author's elaboration.

Since A_t follows a GBM:

$$A_T = A_0 \exp\left([\mu_A(G) - \lambda(G) - 1/2\, \sigma_A^2(G)]T + \sigma_A(G)\sqrt{T}Z\right), \quad [23]$$

where: $Z \sim \mathcal{N}(0,1)$. Thus A_T is lognormal conditional on G.

Fig. 6 - A_T distribution conditional on *G*



Source: Author's elaboration.

5.6 Default condition, distance to default, and probability of default

In this model default occurs when:

$$A_T < L_T$$

That is:

$$A_T < \sum_{m=1}^{M} L_{m,0}\, e^{-\rho_m(G)T}.$$

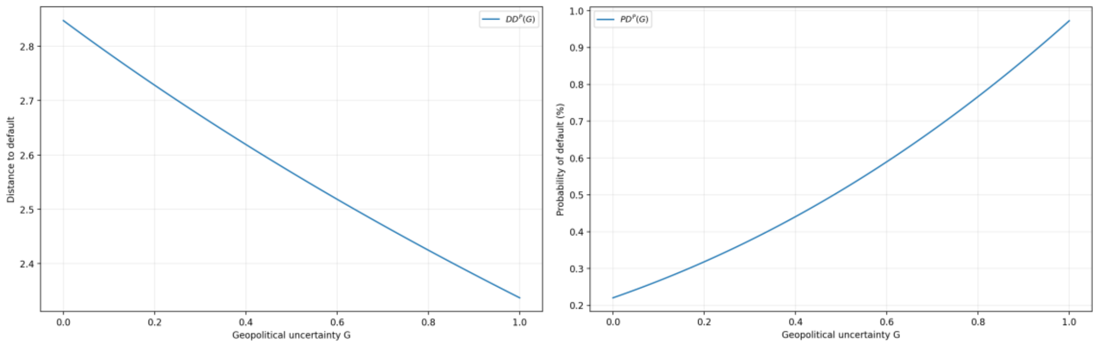
The physical (i.e. non-risk neutral) distance to default is:

$$DD^P(G) = \frac{\ln(A_0/L_T) + [\mu_A(G) - \lambda(G) - 1/2\,\sigma_A^2(G)]T}{\sigma_A(G)\sqrt{T}}. \qquad [24]$$

The physical probability of default is:

$$PD^P(G) = \Phi[-DD^P(G)]. \qquad [25]$$

Fig. 7 - G's impact on stylized $DD^P(G)$ and $PD^P(G)$



Source: Author's elaboration.

The impact of the geopolitical state, G, operates through multiple, mutually reinforcing channels. First, G deteriorates the asset side by lowering expected returns $\mu_A(G)$ and increasing volatility $\sigma_A(G)$ thereby weakening the distribution of future assets. Second, it raises the aggregate payout pressure $\lambda(G)$, which directly reduces the drift of assets through higher cash outflows. Third, on the liability side, higher G increases run-off or refinancing intensity $\rho_m(G)$, accelerating the depletion or repricing of funding sources. This, in turn, affects the level of residual liabilities $L_T(G)$, which determines the default threshold at maturity.

Taken together, these channels imply that geopolitical stress simultaneously reduces asset quality, increases uncertainty, tightens funding conditions, and shifts the liability structure, leading to a higher probability that terminal assets fall short of residual obligations.

5.7 Decomposition of the $DD^P(G)$

The distance-to-default formula can be used to decompose the effect of geopolitical stress into analytically meaningful components. A first-order decomposition of the change in distance to default from a baseline $G = 0$ to a stress level $G > 0$ can be written as:

$$\Delta DD^P \approx \frac{\partial DD^P}{\partial \mu_A}\Delta\mu_A + \frac{\partial DD^P}{\partial \sigma_A}\Delta\sigma_A + \frac{\partial DD^P}{\partial \lambda}\Delta\lambda + \frac{\partial DD^P}{\partial L_T}\Delta L_T. \qquad [26]$$

The main sensitivities are:

$$\frac{\partial DD^P}{\partial \mu_A} = \frac{\sqrt{T}}{\sigma_A(G)},$$

$$\frac{\partial DD^P}{\partial \lambda} = -\frac{\sqrt{T}}{\sigma_A(G)},$$

and:

$$\frac{\partial DD^P}{\partial L_T} = -\frac{1}{L_T \sigma_A(G)\sqrt{T}},$$

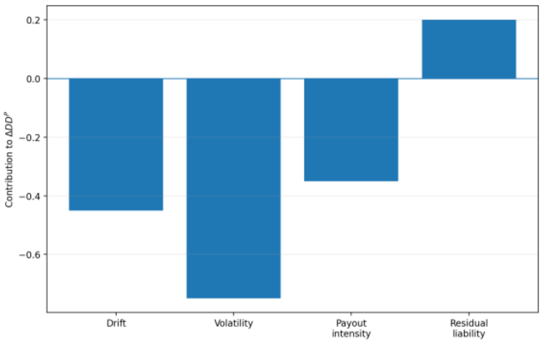
$$\frac{\partial DD^P}{\partial \sigma_A} = -\frac{\ln(A_0/L_T) + [\mu_A(G) - \lambda(G)]T}{\sigma_A^2(G)\sqrt{T}} - \frac{1}{2}\sqrt{T}.$$

And we have:

$$\frac{\partial L_T}{\partial \rho_m} = -TL_{m,0}e^{-\rho_m(G)T}.$$

This decomposition has a clear supervisory interpretation. The drift effect captures the deterioration in borrower quality, profitability, collateral values, and macroeconomic performance. The volatility effect captures the widening of uncertainty around asset values and cash flows. The payout effect captures the drain generated by the total distribution of resources from the asset pool. The residual-liability effect captures changes in the amount of debt still outstanding at maturity. The sign of these effects is economically meaningful. A higher G lowers distance to default because it reduces net asset growth. A higher L_T also lowers distance to default because it raises the default boundary. A higher $\rho_m(G)$, by reducing residual liabilities, tends to increase distance to default, although this effect must be interpreted jointly with its possible impact on payout pressure and funding conditions.

Fig. 8 – Decomposition of the $DD^P(G)$



Source: Author's elaboration.

5.8 Correlation and common geopolitical shocks

Geopolitical shocks are rarely purely idiosyncratic. They tend to affect many borrowers, sectors, asset classes, and institutions at the same time. This is why correlation plays an important role in the transmission of geopolitical uncertainty.

For two banks i and j, suppose that their asset dynamics after payouts are:

$$\frac{dA_{i,t}}{A_{i,t}} = [\mu_i(G) - \lambda_i(G)]dt + \sigma_i(G)dW_{i,t} \quad [27]$$

and:

$$\frac{dA_{j,t}}{A_{j,t}} = [\mu_j(G) - \lambda_j(G)]dt + \sigma_j(G)dW_{j,t} \quad [28]$$

with:

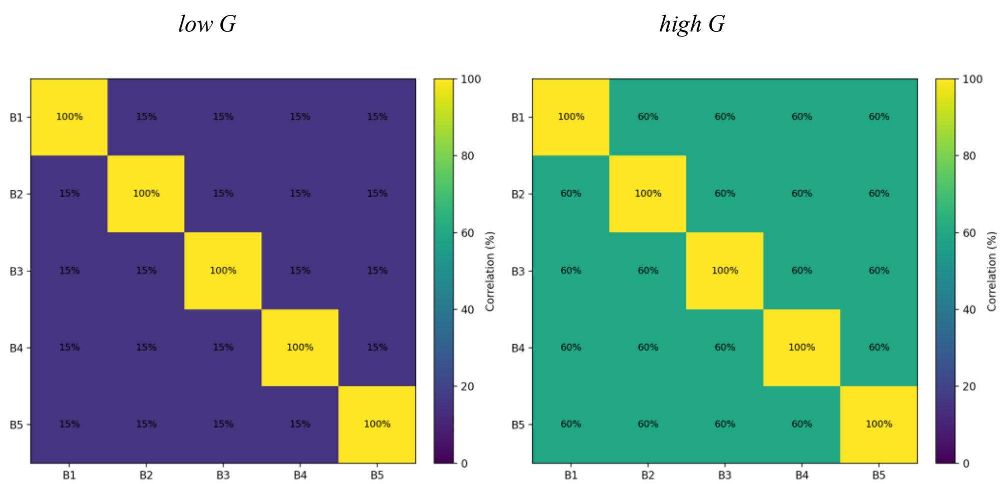
$$dW_{i,t}dW_{j,t} = \rho_{ij}(G)dt$$

and:

$$\frac{\partial \rho_{ij}(G)}{\partial G} > 0$$

The assumption that $\rho_{ij}(G)$ increases with geopolitical stress captures the idea that diversification becomes less effective during common shocks. Under normal conditions, banks may appear diversified because their borrowers, sectors, or market exposures are imperfectly correlated. Under geopolitical stress, however, common macro-financial drivers may dominate idiosyncratic differences, causing correlations to rise.

Fig. 9 - Stylized Correlation heatmap for assets of a stylized bank



Source: Author's elaboration.

This effect is particularly important for supervision. Even if individual probabilities of default increase only moderately, the probability of several banks deteriorating simultaneously may rise materially if cross-bank correlations increase. Geopolitical uncertainty is therefore not only a driver of individual default probabilities; it is also a driver of joint fragility.

This framework can be extended to a system with N^B banks. For each bank i, default occurs when:

$$A_{i,T} < L_{i,T}$$

The distance to default of bank i is:

$$DD_i^P(G) = \frac{\ln\left(A_{i,0}/L_{i,T}\right) + \left[\mu_i(G) - \lambda_i(G) - \frac{1}{2}\sigma_i(G)^2\right]T}{\sigma_i(G)\sqrt{T}} \quad [29]$$

For two banks, the joint default probability can be represented as:

$$P\left(D_i = 1, D_j = 1 \mid G\right) = \Phi_2\left[-DD_i^P(G), -DD_j^P(G); \rho_{ij}(G)\right] \quad [30]$$

where Φ_2 is the bivariate standard normal distribution with correlation $\rho_{ij}(G)$.

For N^B banks, the probability that at least one bank defaults is:

$$P\left(\sum_{i=1}^{N^B} D_i \geq 1 \mid G\right). \quad [31]$$

While the probability that at least q banks default is:

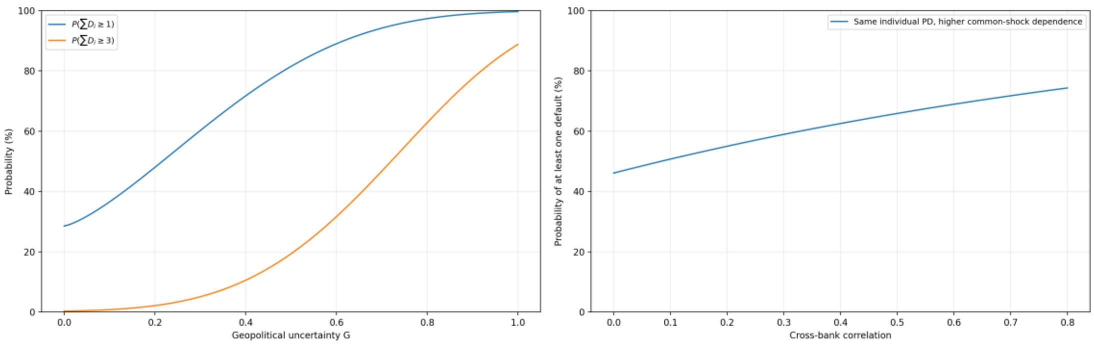
$$P\left(\sum_{i=1}^{N^B} D_i \geq q \mid G\right). \quad [32]$$

In a Gaussian approximation, the joint distribution of the default indicators is driven by the vector of distances to default and the correlation matrix:

$$\Sigma(G) = \{\rho_{ij}(G)\}_{i,j=1}^{N^B}. \quad [33]$$

This representation highlights the systemic dimension of geopolitical uncertainty. A rise in G can increase system-wide fragility through three mutually reinforcing mechanisms: lower individual distances to default, higher individual probabilities of default, and higher cross-bank correlations. Geopolitical stress may increase the probability of simultaneous deterioration even when the average bank remains above the default threshold.

Fig. 10 - G's impact on systemic risk



Source: Author's elaboration.

5.9 Pricing of bank's equity and liabilities

The analytical model presented here allows a closed form solution for bank's equity and liabilities. Under the risk-neutral measure Q:

$$\frac{dA_t}{A_t} = [r - \lambda(G)]dt + \sigma_A(G)dW_t^Q. \quad [34]$$

Therefore:

$$A_T = A_0 \exp\left([r - \lambda(G) - 1/2\, \sigma_A^2(G)]T + \sigma_A(G)\sqrt{T} Z^Q\right). \qquad [35]$$

Here, for the sake of simplicity we assume that all liability classes are *pari passu* at maturity (see Appendix for the analytical, closed form, pricing of a more realistic liability structure with liabilities with different payment seniorities).

The aggregate terminal debt payoff is:

$$B_T = \min(A_T, L_T). \qquad [36]$$

Equity payoff is:

$$E_T = max(A_T - L_T, 0), \qquad [37]$$

Total liabilities' payments before time T (flow payments) are the sum of redemption/runoffs and interests:

$$C_t^B = R_t + I_t. \qquad [38]$$

Hence:

$$C_t^B = \sum_{m=1}^{M} [\rho_m(G) + i_m(A_t, G)]\, L_{m,t}. \qquad [38bis]$$

Equity holders receive before time T:

$$D_t^E = \lambda(G)A_t - \sum_{m=1}^{M} [\rho_m(G) + i_m(A_t, G)]\, L_{m,t.} \qquad [39]$$

The current values of total liabilities and equity (under the *pari passu* assumption) are given respectively by:

$$B_0 = \sum_{m=1}^{M} L_{m,0} \left[a_m(G) \frac{1 - e^{-q_m(G)T}}{q_m(G)} - b_m(G) \frac{1 - e^{-q_m(G)T}(1 + q_m(G)T)}{q_m^2(G)}\right] +$$

$$+ L_T e^{-rT} N(d_2) + A_0 e^{-\lambda(G)T} N(-d_1), \qquad [40]$$

and:

$$E_0 = A_0\left(1 - e^{-\lambda(G)T}\right) - B_0^{\text{flow}} + A_0 e^{-\lambda(G)T} N(d_1) - L_T e^{-rT} N(d_2). \qquad [41]$$

with:

$$B_0^{\text{flow}} = \sum_{m=1}^{M} L_{m,0} \left[a_m(G) \frac{1 - e^{-q_m(G)T}}{q_m(G)} - b_m(G) \frac{1 - e^{-q_m(G)T}(1 + q_m(G)T)}{q_m^2(G)}\right],$$

$$a_m(G) = \rho_m(G) + i_{m,0} + \gamma_m^G G,$$

$$b_m(G) = \gamma_m^A [r - \lambda(G) - 1/2\, \sigma_A^2(G)],$$

$$q_m(G) = r + \rho_m(G),$$

$$d_1 = \frac{\ln(A_0/L_T) + [r - \lambda(G) + 1/2\, \sigma_A^2(G)]T}{\sigma_A(G)\sqrt{T}},$$

$$d_2 = d_1 - \sigma_A(G)\sqrt{T}.$$

The model satisfies the balance sheet valuation identity $B_0 + E_0 = A_0$ consistent with Modigliani-Miller value conservation under the maintained payout assumptions.

5.10 Key takeaways of this model and interpretation for supervision

As argued, the primary contribution of the framework is not precise quantification, but the provision of a structured analytical device to interpret how geopolitical risk and uncertainty operate as cross-cutting drivers of banks' balance-sheet dynamics. In particular, the model shows that geopolitical uncertainty may affect several parameters simultaneously, generate nonlinear effects that become more relevant near distress, weaken diversification through higher correlations, and produce heterogeneous impacts depending on institutional structure. This is particularly important because the framework adapts the Merton structural intuition to the economics of banking, including asset-class heterogeneity, liability dynamics, endogenous funding costs, and payout flows.

From a supervisory perspective, these insights have direct and practical implications. They suggest that geopolitical risk should not be treated as a separate and self-contained risk category, nor as a variable that can be adequately summarized by a single quantitative indicator. Rather, it should be incorporated into a holistic supervisory assessment as a cross-cutting source of uncertainty that amplifies traditional prudential risk categories, including credit risk, market risk, liquidity and funding risk, operational risk, concentration risk, and governance-related vulnerabilities. In operational terms, the framework can support supervision in several ways. First, it provides a structured lens to identify the balance-sheet components most sensitive to geopolitical deterioration, including sectoral credit exposures, securities portfolios, funding structures, payout pressure, and operational dependencies. Second, it can inform the design of scenario analysis and stress-testing exercises by clarifying how a geopolitical shock may simultaneously affect multiple risk drivers rather than acting through a single channel. Third, it supports a more consistent interpretation of heterogeneity across institutions, helping supervisors distinguish between differences in exposure, transmission mechanisms, and resilience.

Table 4 - Main asset-side channels through which geopolitical uncertainty affects banks

Asset class	**Main GPR transmission channel**	**Stylized impact on (A_k)**	**Relevance for LSIs and SIs**	**Why**
Mortgages	Inflation, employment, household confidence, property liquidity	Higher arrears risk, weaker collateral liquidity	More relevant for LSIs	LSIs tend to have larger relative exposure to domestic retail lending
SME loans	Energy costs, supply-chain disruption, export weakness, local sector stress	Higher expected losses and stronger concentration effects	Strongly relevant for LSIs	SME and local business concentration is often central in LSI books
Corporate loans	Trade fragmentation, sanctions, refinancing pressure, sector concentration	Borrower deterioration and covenant stress	Relevant for both, but differently	LSIs via domestic concentration; SIs via larger corporate and cross-border books

Asset class	Main GPR transmission channel	Stylized impact on (A_k)	Relevance for LSIs and SIs	Why
Consumer credit	Inflation shock, weaker labour market, household cash-flow pressure	Faster arrears migration and provisioning need	More relevant for LSIs	More direct transmission through domestic households
Securities	Spread widening, repricing, liquidity discounts	Mark-to-market losses and capital volatility	More relevant for SIs	SIs usually have larger and more market-sensitive securities books

Source: Author's elaboration.

More broadly, the framework is consistent with a supervisory approach that places greater emphasis on resilience, adaptability, and forward-looking assessment rather than on precise point estimation. In the presence of fundamental uncertainty, the key supervisory objective is not to measure geopolitical risk with accuracy, but to ensure that institutions are able to identify relevant vulnerabilities, assess them using both quantitative and qualitative tools, and translate them into appropriate capital, liquidity, governance, and risk management responses. In this sense, the framework provides a disciplined analytical basis for supervisory dialogue, internal risk assessment processes, and the integration of geopolitical considerations within existing prudential frameworks.

Table 5 - Main liability-side channels through which geopolitical uncertainty affects banks

Liability class	Main GPR transmission channel	Stylized impact on (L_m)	Relevance for LSIs and SIs	Why
Stable retail deposits	Confidence erosion under severe stress	Usually limited direct increase in effective liability burden	More relevant for LSIs, but usually moderate	Local franchise strength often stabilizes funding unless confidence shock is severe
Less stable retail deposits	Confidence-sensitive outflows	Higher effective funding burden	More relevant for LSIs	LSIs may be more exposed to local reputation and deposit concentration
Operational deposits	Corporate cash management stress, payment disruption	Faster outflows and reduced stickiness	Relevant for both	Especially sensitive where sectoral concentration is high
Secured wholesale funding	Haircuts, collateral stress, market dysfunction	Higher rollover burden and margin pressure	More relevant for SIs	SIs rely more on market-based funding and collateralized transactions
Unsecured wholesale funding	Spread widening, market access disruption	Higher refinancing cost and rollover risk	More relevant for SIs	Broader wholesale market access is an SI strength in normal times but a stress channel in shocks

Source: Author's elaboration.

6. A stylized application of the proposed framework

This section implements the analytical framework developed in this paper. The exercise is deliberately stylized. It is not intended to estimate actual banks, nor to assign bank-specific ratings or default probabilities. Its purpose is to show how the model can organize a consistent scenario analysis in which geopolitical uncertainty affects assets, liabilities, distance to default, equity value, and leverage through transparent economic channels.

6.1 The geopolitical state variable and rationale of the exercise

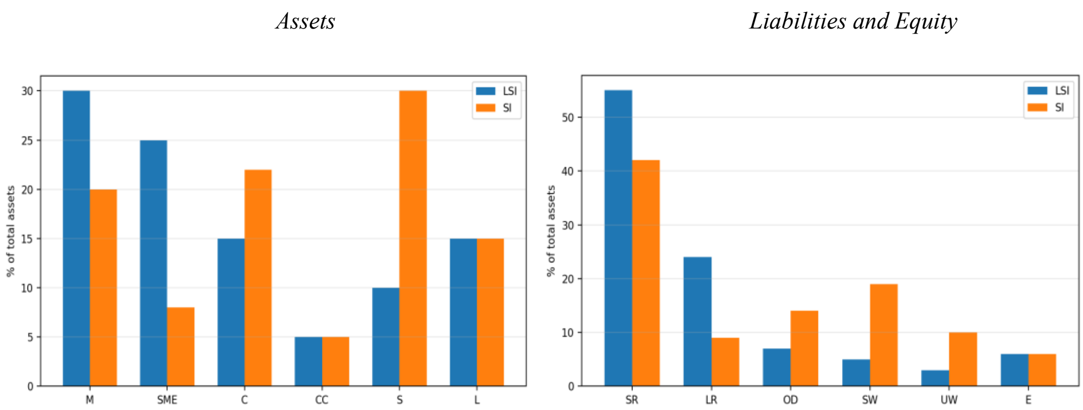
The geopolitical state variable is treated as a normalized scenario-generating indicator rather than as an observed geopolitical-risk index. It is not a direct transformation of an external indicator such as the Caldara-Iacoviello geopolitical risk index. Instead, it is used to generate internally consistent shocks to asset drifts, volatilities, correlations, liability run-off rates, funding costs and payout pressure.

In particular: $G \in \{0, 0.5, 1\}$. The value $G = 0$ represents normal geopolitical conditions, $G = 0.5$ represents an adverse but intermediate geopolitical-stress scenario, and $G = 1$ represents a severe geopolitical-stress scenario. This construction is consistent with the conceptual objective of the paper: geopolitical uncertainty is not summarized by a single point estimate but is translated into a coherent set of balance-sheet shocks. The exercise compares a stylized less significant institution (LSI) with a stylized significant institution (SI). Both banks are normalized to total assets equal to 100. This normalization makes the comparison transparent: differences in outcomes reflect balance-sheet composition and parameter sensitivities rather than scale.

6.2 Stylized balance sheets

The LSI has been assumed to be more credit and deposit oriented, with larger weights on mortgages and SME loans and a funding structure more heavily based on retail deposits. The SI has been assumed to be more diversified, with a larger securities portfolio and greater reliance on secured and unsecured wholesale funding.

Fig. 11 - Stylized balance sheet of the banks



Source: Author's elaboration.

6.3 Calibration strategy, PD anchors and par-debt condition

The calibration has followed the following criteria:

- the normal scenario is treated as a going-concern state;
- geopolitical stress deteriorates the bank through economically interpretable channels (lower asset drift, higher volatility, stronger correlations, faster liability runoffs, higher funding costs and greater payout pressure);
- LSIs and SIs are assigned different balance-sheet structures and different sensitivity parameters;
- the initial distance to default is anchored through stylized rating-implied probabilities of default. The representative LSI is assigned a conservative lower-investment-grade/crossover anchor, between BBB- and BB+, with an illustrative one-year probability of default of 0.60 percent. The representative SI is assigned a stronger BBB+ anchor, with an illustrative one-year probability of default of 0.15 percent. These anchors are not bank-specific rating estimates. They are used only to initialize the distance to default: $DD_0 = -\Phi^{-1}(PD_0)$.

The baseline payout parameter λ_0 is calibrated so that the physical distance to default at $G = 0$ matches the rating-implied distance to default. This links the physical solvency side of the model to the rating-implied PD anchor.

$$DD^P(0) = \frac{\ln\left(A_0/L_T(0)\right) + \left[\mu_A(0) - \lambda_0 - \frac{1}{2}\sigma_A^2(0)\right]T}{\sigma_A(0)\sqrt{T}}. \quad [42]$$

The risk-free rate used in the risk-neutral valuation formulas has been set equal to 3% and kept fixed across scenarios. The par-debt condition has been imposed using the analytical *pari passu* debt-pricing formula derived in the proposed model. Therefore, debt is not assumed to be at par by construction. Instead, the model computes the analytical value of debt as the sum of the value of debt-side flows and the terminal *pari passu* debt claim. The baseline funding-cost level is then chosen so that this analytical value equals the initial book value of debt.

The baseline liability-rate intercepts are written as:

$$B_0^{pari}(0) = B_0^{flow}(0) + B_0^{terminal}(0) = L_0. \quad [43]$$

In the analytical model, $\lambda(G)A_t$ denotes the aggregate payout envelope and satisfies: $\lambda(G)A_t = R_t + I_t + D_t^E$. For calibration purposes, this envelope is parameterized as

$$\lambda(G) = \lambda_0 + \beta_\lambda G, \quad [44]$$

where β_λ measures the sensitivity of total payout pressure to geopolitical stress. Similarly, the baseline funding-cost intercept is written as:

$$i_{m,0}^{(b)} = i_{m,0}^{raw} + \theta_b, \quad [45]$$

where θ_b is a bank-specific calibration adjustment introduced only to satisfy the analytical par-debt condition: $B_0^{pari}(0; \theta_b) = L_0$. These specifications do not add new theoretical mechanisms; they operationalize, for the stylized implementation, the payout and funding-cost functions already present in the model. The parameter θ_b makes the analytical *pari passu* value of debt equal to par at $G = 0$.

Table 6 - Calibration summary: PD anchor, payout parameter, par-debt parameter and initial valuation

Bank	Rating anchor	PD anchor	DD target	λ_0	β_λ	θ_b	r	$B_0(0)$	L_0	$E_0(0)$	Book equity
LSI	*BBB-/BB+ stylized anchor*	*0.60%*	*2.5121*	*0.0388*	*0.0060*	*0.0211*	*0.0300*	*94.0000*	*94.0000*	*6.0000*	*6.0000*

Bank	Rating anchor	PD anchor	DD target	λ_0	β_λ	θ_b	r	$B_0(0)$	L_0	$E_0(0)$	Book equity
SI	*BBB+ stylized anchor*	*0.15%*	*2.9677*	*0.0222*	*0.0120*	*0.0162*	*0.0300*	*94.0000*	*94.0000*	*6.0000*	*6.0000*

Source: Author's elaboration.

6.4 Calibration parameters and economic rationale

The asset-side sensitivities are bank-specific and remain different across the LSI and SI. In this stylized calibration, the LSI has been assigned relatively stronger drift sensitivities for credit exposures, especially SME loans and domestic corporate loans, reflecting its more relationship-based and domestic credit structure. The SI has been assigned stronger market-volatility sensitivity for securities and stronger correlation sensitivity between corporate and securities exposures, reflecting the larger role of mark-to-market and market-liquidity channels. Correlations rise with G for both institutions, reducing diversification benefits under stress.

Table 7 – Stylized asset-side calibration parameters

Bank	Class	Description	$\mu_{k,0}$	$\sigma_{k,0}$	β_k^μ	β_k^σ
LSI	M	Mortgages	0.0250	0.0400	0.0065	0.0080
LSI	SME	SME loans	0.0350	0.0800	0.0180	0.0240
LSI	C	Corporate loans	0.0400	0.0700	0.0150	0.0210
LSI	CC	Consumer credit	0.0450	0.0900	0.0130	0.0200
LSI	S	Securities	0.0300	0.1200	0.0070	0.0300
LSI	L	Liquid assets	0.0150	0.0100	0.0020	0.0030
SI	M	Mortgages	0.0250	0.0400	0.0055	0.0100
SI	SME	SME loans	0.0350	0.0800	0.0120	0.0250
SI	C	Corporate loans	0.0400	0.0700	0.0140	0.0280
SI	CC	Consumer credit	0.0450	0.0900	0.0100	0.0220
SI	S	Securities	0.0300	0.1200	0.0145	0.0600
SI	L	Liquid assets	0.0150	0.0100	0.0020	0.0030

Source: Author's elaboration.

The liability-side sensitivities are also bank-specific. In this stylized calibration, the LSI has been assumed to be more exposed to retail and operational funding frictions, while the SI has been assumed to be more exposed to wholesale funding repricing and rollover pressure.

Table 8 - Stylized liability-side calibration parameters

Bank	Class	Description	$\rho_{m,0}$	$i_{m,0}^{raw}$	β_m^ρ	γ_m^G	γ_m^A
LSI	SR	Stable retail deposits	0.0200	0.0050	0.0030	0.0015	0.0040
LSI	LR	Less stable retail deposits	0.0500	0.0100	0.0140	0.0045	0.0050
LSI	OD	Operational deposits	0.0800	0.0150	0.0250	0.0065	0.0060
LSI	SW	Secured wholesale funding	0.1500	0.0250	0.0350	0.0080	0.0060
LSI	UW	Unsecured wholesale funding	0.2000	0.0350	0.0450	0.0100	0.0080
SI	SR	Stable retail deposits	0.0200	0.0050	0.0030	0.0015	0.0035
SI	LR	Less stable retail deposits	0.0500	0.0100	0.0120	0.0035	0.0045
SI	OD	Operational deposits	0.0800	0.0150	0.0250	0.0070	0.0065
SI	SW	Secured wholesale funding	0.1500	0.0250	0.0550	0.0110	0.0080
SI	UW	Unsecured wholesale funding	0.2000	0.0350	0.0700	0.0140	0.0090

Source: Author's elaboration.

6.5 Main simulation results

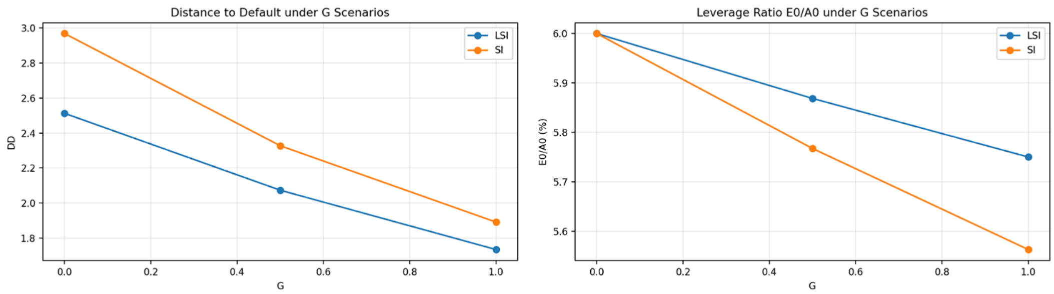
The simulation confirms the main intuition of the theoretical model. As G increases, the distribution of terminal assets deteriorates because aggregate drift declines, aggregate volatility increases, correlations rise and payout pressure becomes stronger. The distance to default falls for both institutions, while the physical probability of default increases. The effect is not generated by a single parameter, but by the joint deterioration of asset-side and liability-side conditions.

Table 9 - Stylized scenario results

Bank	Scenario	G	μ_A	σ_A	λ	L_T	DD	$Delta\ DD$	PD	$lev.$
LSI	Normal	0.0000	0.0297	0.0382	0.0388	89.9620	2.5121	0.0000	0.60%	6.00%
LSI	Adverse	0.5000	0.0246	0.0446	0.0418	89.5124	2.0732	-0.4390	1.91%	5.87%
LSI	Severe	1.0000	0.0194	0.0513	0.0448	89.0675	1.7346	-0.7776	4.14%	5.75%
SI	Normal	0.0000	0.0301	0.0485	0.0222	87.1938	2.9677	0.0000	0.15%	6.00%
SI	Adverse	0.5000	0.0250	0.0617	0.0282	86.1951	2.3269	-0.6408	1.00%	5.77%
SI	Severe	1.0000	0.0198	0.0755	0.0342	85.2206	1.8912	-1.0765	2.93%	5.56%

Source: Author's elaboration.

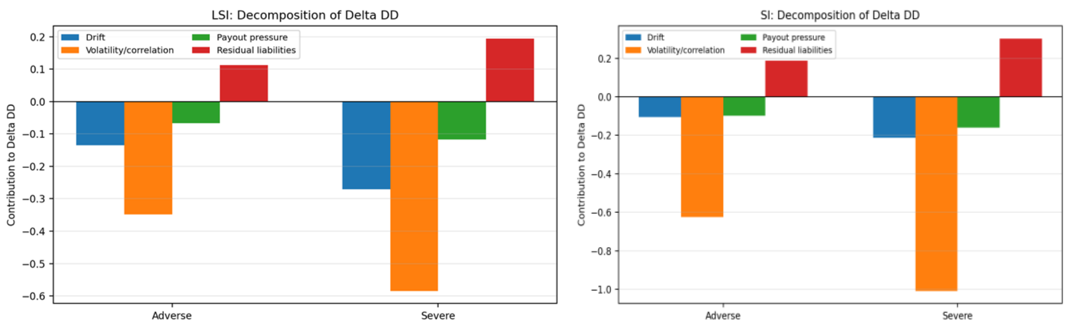
Fig. 12 - Stylized scenario results



Source: Author's elaboration.

As previously explained, the change in distance to default can be decomposed into four drivers: the drift effect, the volatility/correlation effect, the payout-pressure effect and the residual-liability effect. The drift effect captures deterioration in borrower quality and expected asset performance. The volatility/correlation effect captures the widening of uncertainty and the weakening of diversification. The payout effect captures the additional balance-sheet leakage generated by higher payouts and funding pressure. The liability effect captures the movement in residual liabilities at maturity.

Fig. 13 – Stylized scenario results: drivers of the *Delta DD*



Source: Author's elaboration.

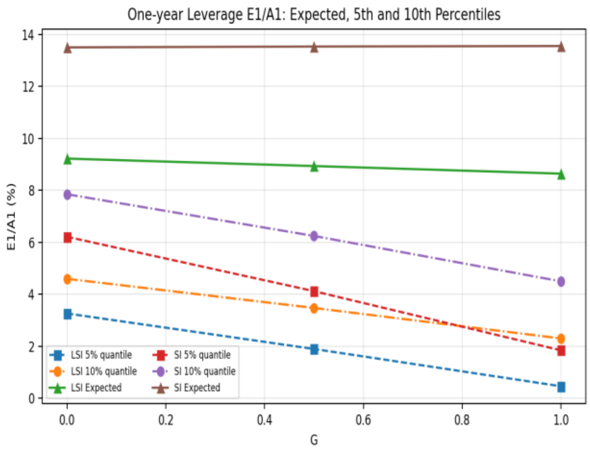
The proposed framework also makes it possible to perform an analysis of future equity and leverage outcomes under expected and tail states. A stylized one-year exercise has been implemented. The analysis distinguishes between expected outcomes and tail outcomes. The expected outcome is useful to assess the average balance-sheet position. The 5th and 10th percentiles are more informative from a prudential perspective because default risk is driven by the lower tail of the asset distribution, not by its mean.

Table 10 – Stylized one-year analysis results

Bank	*Scenario*	*G*	*State*	*E1/A1*
LSI	*Normal*	*0.0000*	*5% quantile*	*3.26%*
LSI	*Normal*	*0.0000*	*10% quantile*	*4.59%*
LSI	*Normal*	*0.0000*	*Expected*	*9.22%*
LSI	*Adverse*	*0.5000*	*5% quantile*	*1.89%*
LSI	*Adverse*	*0.5000*	*10% quantile*	*3.47%*
LSI	*Adverse*	*0.5000*	*Expected*	*8.93%*
LSI	*Severe*	*1.0000*	*5% quantile*	*0.46%*
LSI	*Severe*	*1.0000*	*10% quantile*	*2.30%*
LSI	*Severe*	*1.0000*	*Expected*	*8.64%*
SI	*Normal*	*0.0000*	*5% quantile*	*6.21%*
SI	*Normal*	*0.0000*	*10% quantile*	*7.85%*
SI	*Normal*	*0.0000*	*Expected*	*13.50%*
SI	*Adverse*	*0.5000*	*5% quantile*	*4.12%*
SI	*Adverse*	*0.5000*	*10% quantile*	*6.24%*
SI	*Adverse*	*0.5000*	*Expected*	*13.53%*
SI	*Severe*	*1.0000*	*5% quantile*	*1.84%*
SI	*Severe*	*1.0000*	*10% quantile*	*4.50%*
SI	*Severe*	*1.0000*	*Expected*	*13.55%*

Source: Author's elaboration.

Fig. 14 - Stylized one-year analysis results



Source: Author's elaboration.

7. Concluding remarks

This paper has argued that, for prudential purposes, geopolitical developments are more appropriately understood as a form of uncertainty rather than as a standalone and neatly measurable risk factor. Their relevance stems from their cross-cutting, heterogeneous, nonlinear, and often indirect nature. As such, they do not constitute a separate supervisory silo but instead affect the traditional pillars of bank resilience: credit quality, market valuations, liquidity conditions, funding stability, operational continuity, governance, and business-model sustainability. These features are common to both Less Significant Institutions (LSIs) and

Significant Institutions (SIs), although the specific transmission mechanisms differ across institutions.

In this respect, the distinction between LSIs and SIs is not in terms of exposure versus non-exposure, but rather in terms of how geopolitical uncertainty is transmitted through the balance sheet. For LSIs, exposure is often less direct and more embedded in domestic economic conditions, materializing through borrower performance, sectoral and geographic concentration, depositor behavior, and operational dependencies. For SIs, while indirect channels remain relevant, geopolitical uncertainty is also more likely to affect balance sheets through market-based activities, securities valuation, wholesale funding conditions, cross-border exposures, and common market shocks. In both cases, the key prudential issue is not the identification of a discrete "geopolitical exposure," but the extent to which geopolitical deterioration amplifies existing vulnerabilities within the institution's risk profile.

Against this background, the evidence considered in the paper suggests that the supervisory approach of the Banca d'Italia can be characterized as holistic, aligned with the broader SSM/European orientation, and embedded within the standard prudential framework. Geopolitical uncertainty is not addressed through a dedicated capital requirement or a separate supervisory compartment. Rather, it is assessed through its implications for established risk categories and supervisory processes, including governance review, SREP assessments, ICAAP and ILAAP analysis, provisioning adequacy, ICT and operational resilience, and the evaluation of funding sustainability. This approach applies across both LSIs and SIs, while allowing for proportionality and institution-specific calibration. The overall supervisory stance is therefore centered on integration, forward-looking assessment, and informed supervisory judgment.

The analytical framework developed in the paper supports this policy message by providing a structured representation of the main balance-sheet channels through which geopolitical uncertainty may affect banks. Its contribution is not to produce precise point estimates of geopolitical risk. Rather, it formalizes the interaction between geopolitical conditions and traditional banking risks within a modified structural framework. Compared with the standard Merton model, the framework preserves the logic of distance to default and contingent claims valuation, but extends it to incorporate the specific features of banks: heterogeneous asset portfolios, liability run-off, endogenous funding costs, and payout flows.

The payout structure is central to this contribution. By keeping total payout proportional to assets, the model preserves lognormal asset dynamics and closed-form solutions. At the same time, by decomposing payout into redemptions, interest payments, and residual dividends, it makes the internal cash-flow structure compatible with banking activity. This allows funding stress and funding costs to arise within the model, rather than being imposed as an external add-on. The framework therefore explains how geopolitical stress can reduce asset performance, increase volatility and correlations, tighten funding conditions, and affect equity value through a common balance-sheet mechanism.

The model also highlights the importance of distinguishing expected outcomes from tail outcomes. A bank may appear resilient under expected values while becoming materially more vulnerable in the lower tail of the asset distribution. This is particularly relevant under geopolitical uncertainty, where volatility, correlations, and funding conditions may deteriorate jointly. The distance-to-default decomposition and the equity/leverage analysis developed in the stylized implementation provide a transparent way to identify the relative contribution of asset drift, volatility, payout pressure, residual liabilities, and funding costs. These tools are useful not because they deliver definitive estimates, but because they discipline the supervisory interpretation of stress channels.

More broadly, the analysis points to the need for supervisory frameworks that place greater emphasis on resilience, adaptability, and forward-looking judgment. Where uncertainty is fundamental and not fully reducible to stable probability distributions, the robustness of governance, the adequacy of scenario analysis, and preparedness for severe but plausible shocks become at least as important as model-based precision. In this sense, the paper supports the view that the prudential treatment of geopolitical developments should remain firmly anchored in the existing supervisory architecture, while ensuring that their cross-cutting nature is consistently and effectively reflected in supervisory assessment and dialogue across all types of institutions.

The proposed analytical framework should therefore be read as a complement to, not a replacement for, supervisory judgment. It provides a formal language for connecting geopolitical uncertainty to the ordinary risk categories already used in prudential supervision. This is its main contribution: to make explicit the channels through which geopolitical developments affect bank resilience, to support structured comparison between LSIs and SIs, and to strengthen the analytical basis for forward-looking supervisory assessment in an environment in which uncertainty cannot be fully measured but must nevertheless be governed.

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Appendix 1: analytical pricing of bank's liabilities

Pari passu

Under the risk-neutral measure:

$$\frac{dA_t}{A_t} = [r - \lambda(G)]dt + \sigma_A(G)dW_t^Q. \qquad \text{[A1]}$$

Therefore:

$$A_T = A_0 \exp\left([r - \lambda(G) - 1/2\, \sigma_A^2(G)]T + \sigma_A(G)\sqrt{T}Z^Q\right). \qquad \text{[A2]}$$

The aggregate terminal debt payoff is:

$$B_T = \min(A_T, L_T). \qquad \text{[A3]}$$

Equity payoff is:

$$E_T = max(A_T - L_T, 0). \qquad \text{[A4]}$$

The value in 0 of the terminal component of aggregate liabilities is:

$$B_0^{\text{terminal}} = L_T e^{-rT} N(d_2) + A_0 e^{-\lambda(G)T} N(-d_1), \qquad \text{[A5]}$$

with:

$$d_1 = \frac{\ln(A_0/L_T) + [r - \lambda(G) + 1/2\, \sigma_A^2(G)]T}{\sigma_A(G)\sqrt{T}},$$

$$d_2 = d_1 - \sigma_A(G)\sqrt{T}.$$

Total liabilities' payments before time T (flow payments) are the sum of redemption/runoffs and interests:

$$C_t^B = R_t + I_t. \qquad \text{[A6]}$$

Hence:

$$C_t^B = \sum_{m=1}^{M} [\rho_m(G) + i_m(A_t, G)]\, L_{m,t}. \qquad \text{[A6bis]}$$

The present value of these payments is:

$$B_0^{\text{flow}} = \mathbb{E}_0^Q \left[\int_0^T e^{-rt} \sum_{m=1}^{M} [\rho_m(G) + i_m(A_t, G)]\, L_{m,t} dt \right]. \qquad \text{[A7]}$$

Since:

$$L_{m,t} = L_{m,0} e^{-\rho_m(G)t},$$

we can write:

$$B_0^{\text{flow}} = \sum_{m=1}^{M} L_{m,0} \int_0^T e^{-[r+\rho_m(G)]t}\, \mathbb{E}_0^Q [\rho_m(G) + i_m(A_t, G)] dt. \qquad \text{[A7bis]}$$

With:

$$i_m(A_t, G) = i_{m,0} + \gamma_m^G G - \gamma_m^A \ln\left(\frac{A_t}{A_0}\right), \qquad \text{[A8]}$$

and under the risk neutral measure Q:

$$\mathbb{E}_0^Q\left[\ln\left(\frac{A_t}{A_0}\right)\right] = [r - \lambda(G) - 1/2\, \sigma_A^2(G)]t.$$

Therefore:

$$\mathbb{E}_0^Q[i_m(A_t, G)] = i_{m,0} + \gamma_m^G G - \gamma_m^A [r - \lambda(G) - 1/2\, \sigma_A^2(G)]t. \qquad \text{[A9]}$$

Define:

$$a_m(G) = \rho_m(G) + i_{m,0} + \gamma_m^G G, \qquad \text{[A10]}$$

and:

$$b_m(G) = \gamma_m^A [r - \lambda(G) - 1/2\, \sigma_A^2(G)]. \qquad \text{[A11]}$$

Then:

$$\mathbb{E}_0^Q[\rho_m(G) + i_m(A_t, G)] = a_m(G) - b_m(G)t. \qquad \text{[A12]}$$

Hence:

$$B_0^{\text{flow}} = \sum_{m=1}^{M} L_{m,0} \int_0^T e^{-[r+\rho_m(G)]t}\, [a_m(G) - b_m(G)t] dt. \qquad \text{[A13]}$$

Let:

$$q_m(G) = r + \rho_m(G). \qquad \text{[A14]}$$

Then: $\int_0^T e^{-q_m t}\, dt = \frac{1-e^{-q_m T}}{q_m}$, and $\int_0^T t\, e^{-q_m t} dt = \frac{1-e^{-q_m T}(1+q_m T)}{q_m^2}$.

Therefore:

$$B_0^{\text{flow}} = \sum_{m=1}^{M} L_{m,0} \left[a_m(G) \frac{1 - e^{-q_m(G)T}}{q_m(G)} - b_m(G) \frac{1 - e^{-q_m(G)T}(1 + q_m(G)T)}{q_m^2(G)}\right]. \qquad \text{[A7ter]}$$

Thus, aggregate debt value under *pari passu* terminal recovery is:

$$B_0 = B_0^{\text{flow}} + L_T e^{-rT} N(d_2) + A_0 e^{-\lambda(G)T} N(-d_1) =$$

$$= \sum_{m=1}^{M} L_{m,0} \left[a_m(G) \frac{1 - e^{-q_m(G)T}}{q_m(G)} - b_m(G) \frac{1 - e^{-q_m(G)T}(1 + q_m(G)T)}{q_m^2(G)}\right] +$$

$$+ L_T e^{-rT} N(d_2) + A_0 e^{-\lambda(G)T} N(-d_1). \qquad \text{[A15]}$$

Equity receives residual dividends:

$$D_t^E = \lambda(G) A_t - \sum_{m=1}^{M} [\rho_m(G) + i_m(A_t, G)]\, L_{m,t}. \qquad \text{[A16]}$$

The present value of total payout from assets is:

$$PV(P) = \mathbb{E}_0^Q\left[\int_0^T e^{-rt}\,\lambda(G)A_t dt\right]. \qquad \text{[A17]}$$

Under Q:

$$\mathbb{E}_0^Q[A_t] = A_0 e^{[r-\lambda(G)]t}.$$

Thus:

$$PV(P) = A_0\left(1 - e^{-\lambda(G)T}\right). \qquad \text{[A17bis]}$$

Since:

$$D_t^E = P_t - C_t^B,$$

the present value of dividends is:

$$PV(D^E) = A_0\left(1 - e^{-\lambda(G)T}\right) - B_0^{\text{flow}}. \qquad \text{[A18]}$$

The terminal equity value is:

$$A_0 e^{-\lambda(G)T} N(d_1) - L_T e^{-rT} N(d_2). \qquad \text{[A19]}$$

Therefore:

$$E_0 = A_0\left(1 - e^{-\lambda(G)T}\right) - B_0^{\text{flow}} + A_0 e^{-\lambda(G)T} N(d_1) - L_T e^{-rT} N(d_2). \qquad \text{[A20]}$$

And:

$$B_0 + E_0 = A_0.$$

At maturity, under *pari passu* recovery:

$$B_{m,T} = \frac{L_{m,T}}{L_T}\min(A_T, L_T). \qquad \text{[A21]}$$

Thus the terminal value of class m is:

$$B_{m,0}^{\text{terminal}} = \frac{L_{m,T}}{L_T}\left[L_T e^{-rT} N(d_2) + A_0 e^{-\lambda(G)T} N(-d_1)\right]. \qquad \text{[A22]}$$

The class-specific flow value is direct:

$$B_{m,0}^{\text{flow}} = \mathbb{E}_0^Q\left[\int_0^T e^{-rt}\,[\rho_m(G) + i_m(A_t, G)]L_{m,t} dt\right]. \qquad \text{[A23]}$$

Using the log-linear interest-rate specification:

$$B_{m,0}^{\text{flow}} = L_{m,0}\left[a_m(G)\frac{1 - e^{-q_m(G)T}}{q_m(G)} - b_m(G)\frac{1 - e^{-q_m(G)T}(1 + q_m(G)T)}{q_m^2(G)}\right]. \qquad \text{[A23bis]}$$

Hence:

$$B_{m,0} = B_{m,0}^{\text{flow}} + B_{m,0}^{\text{terminal}}. \qquad \text{[A24]}$$

Hierarchy / waterfall

Now suppose liabilities are ordered by seniority:

$$m = 1, \dots, M,$$

where $m = 1$ is the most senior class.

Define cumulative thresholds:

$$K_m = \sum_{\ell=1}^{m} L_{\ell,T}\,, \qquad K_0 = 0. \tag{A25}$$

The terminal payoff to class m is:

$$B_{m,T} = \min\left(L_{m,T}, [A_T - K_{m-1}]^{+}\right). \tag{A26}$$

Equivalently:

$$B_{m,T} = (A_T - K_{m-1})^{+} - (A_T - K_m)^{+}. \tag{A26bis}$$

Define the call value:

$$C_0(K) = A_0 e^{-\lambda(G)T} N\big(d_1(K)\big) - K e^{-rT} N\big(d_2(K)\big), \tag{A27}$$

where:

$$d_1(K) = \frac{\ln(A_0/K) + [r - \lambda(G) + 1/2\,\sigma_A^2(G)]T}{\sigma_A(G)\sqrt{T}},$$

$$d_2(K) = d_1(K) - \sigma_A(G)\sqrt{T}.$$

With convention:

$$C_0(0) = A_0 e^{-\lambda(G)T}. \tag{A28}$$

Then:

$$B_{m,0}^{\text{terminal}} = C_0(K_{m-1}) - C_0(K_m). \tag{A29}$$

The full value of class m under the waterfall is:

$$B_{m,0} = B_{m,0}^{\text{flow}} + C_0(K_{m-1}) - C_0(K_m). \tag{A30}$$

where:

$$B_{m,0}^{\text{flow}} = L_{m,0}\left[a_m(G)\frac{1 - e^{-q_m(G)T}}{q_m(G)} - b_m(G)\frac{1 - e^{-q_m(G)T}(1 + q_m(G)T)}{q_m^2(G)}\right].$$

Equity is:

$$E_T = (A_T - K_M)^{+}. \tag{A31}$$

Therefore:

$$E_0 = PV(D^E) + C_0(K_M). \tag{A32}$$

where:

$$PV(D^E) = A_0\left(1 - e^{-\lambda(G)T}\right) - \sum_{m=1}^{M} B_{m,0}^{\text{flow}}.$$

In economic terms, and abstracting from the full complexity of legal resolution regimes, a stylized seniority hierarchy can be represented as follows:

$$SW_{\text{secured}} \succ SR \succ LR \succ OD \succ UW \succ E. \quad \text{[A33]}$$

where $\succ$ means "is senior to". This ordering should be interpreted as an economic seniority ranking rather than a complete legal waterfall. Actual creditor hierarchies depend on jurisdiction-specific insolvency law, depositor preference rules, deposit-guarantee schemes, collateralization, encumbrance, and resolution authority decisions. Thus:

$$K_0 = 0,$$

$$K_1 = L_T^{SW},$$

$$K_2 = L_T^{SW} + L_T^{SR},$$

$$K_3 = L_T^{SW} + L_T^{SR} + L_T^{LR},$$

$$K_4 = L_T^{SW} + L_T^{SR} + L_T^{LR} + L_T^{OD},$$

$$K_5 = L_T^{SW} + L_T^{SR} + L_T^{LR} + L_T^{OD} + L_T^{UW} = L_T.$$

Each layer is priced as:

$$B_{m,0}^{\text{terminal}} = C_0(K_{m-1}) - C_0(K_m). \quad \text{[A34]}$$

Appendix 2: List of symbols and definitions used

The following table summarizes the main notation used in the paper.

Symbol	Meaning
G	Geopolitical state variable: higher values indicate stronger geopolitical stress.
t	Generic time index.
T	Maturity horizon.
A_t	Aggregate asset value at time t.
A_0	Initial aggregate asset value.
A_T	Aggregate asset value at maturity T.
$A_{k,t}$	Value of asset class k at time t.
$k \in \{M, SME, C, CC, S, L\}$	Asset-class index: mortgages, SME loans, corporate loans, consumer credit, securities, and liquid assets.
w_k	Constant weight of asset class k in aggregate assets.
$\mu_k(G)$	Drift of asset class k as a function of geopolitical stress.
$\mu_{k,0}$	Baseline drift of asset class k when geopolitical stress is absent or normalized.
β_k^{μ}	Sensitivity of the drift of asset class k to geopolitical stress.
$\sigma_k(G)$	Volatility of asset class k as a function of geopolitical stress.
$\sigma_{k,0}$	Baseline volatility of asset class k.
β_k^{σ}	Sensitivity of the volatility of asset class k to geopolitical stress.
$dW_{k,t}$	Brownian shock affecting asset class k.
$\rho_{jk}(G)$	Correlation between Brownian shocks of asset classes j and k, possibly increasing with G.
$\Sigma(G)$	Covariance matrix of asset-class returns.
$\mu_A(G)$	Aggregate asset drift obtained from the weighted asset-class drifts.
$\sigma_A(G)$	Aggregate asset volatility obtained from asset-class volatilities, weights, and correlations.
$dW_{A,t}$	Aggregate Brownian motion driving total asset dynamics.
$\lambda(G)$	Total payout rate over assets; total payout is $\lambda(G)A_t$.
P_t	Total payout from assets at time t.
$m \in \{SR, LR, OD, SW, UW\}$	Liability-class index: stable retail deposits, less stable retail deposits, operational deposits, secured wholesale funding, and unsecured wholesale funding.
$L_{m,t}$	Outstanding amount of liability class m at time t.
$L_{m,0}$	Initial amount of liability class m.
$L_{m,T}$	Residual amount of liability class m at maturity.
L_t	Total outstanding liabilities at time t.
L_T	Total residual liabilities at maturity.
$\rho_m(G)$	Effective redemption, amortization, or run-off rate of liability class m.

Symbol	Meaning
$\rho_{m,0}$	Baseline redemption or run-off rate of liability class m.
β_m^{ρ}	Sensitivity of liability run-off rate $\rho_m(G)$ to geopolitical stress.
$R_{m,t}$	Redemption payment associated with liability class m at time t.
R_t	Aggregate redemption payment across all liability classes.
$i_m(A_t, G)$	Interest rate or funding cost associated with liability class m; it depends on asset strength and geopolitical stress.
$i_{m,0}$	Baseline interest rate or funding cost of liability class m.
γ_m^G	Sensitivity of the interest rate of liability class m to geopolitical stress.
γ_m^A	Sensitivity of the interest rate of liability class m to the strength of the asset base.
$I_{m,t}$	Interest payment associated with liability class m at time t.
I_t	Aggregate interest payment across all liability classes.
D_t^E	Dividend payout to equity holders; in the revised model this is the residual component.
$DD^P(G)$	Physical distance to default conditional on geopolitical state G.
$PD^P(G)$	Physical probability of default conditional on geopolitical state G.
$\Phi(\cdot)$	Standard normal cumulative distribution function.
r	Risk-free rate used under the pricing measure.
$\mathbb{Q}$	Risk-neutral pricing measure.
dW_t^Q	Brownian motion under the risk-neutral measure.
d_1	Black-Scholes auxiliary variable for the aggregate debt/equity valuation.
d_2	Black-Scholes auxiliary variable, equal to $d_1 - \sigma_A(G)\sqrt{T}$.
$N(\cdot)$	Standard normal cumulative distribution function used in pricing formulas.
B_T	Terminal payoff to aggregate debt holders.
B_0	Time-zero value of aggregate debt.
B_0^{terminal}	Terminal component of debt value.
B_0^{flow}	Present value of debt-side flows, i.e. redemption plus interest.
$B_{m,T}$	Terminal payoff to liability class m.
$B_{m,0}$	Time-zero value of liability class m.
$B_{m,0}^{\text{terminal}}$	Terminal component of the value of liability class m.
$B_{m,0}^{\text{flow}}$	Present value of class-specific redemption and interest flows.
E_T	Terminal equity payoff.
E_0	Time-zero equity value.
$PV(P)$	Present value of total payout from assets.
$PV(D^E)$	Present value of residual dividends paid to equity holders.

Symbol	Meaning
$a_m(G)$	Auxiliary term collecting the deterministic part of the expected debt-flow rate for class m.
$b_m(G)$	Auxiliary term capturing the asset-dependent component of the expected interest cost for class m.
$q_m(G)$	Discount-adjusted run-off rate, defined as $q_m(G) = r + \rho_m(G)$.
K_m	Cumulative seniority threshold in the waterfall structure.
K_0	Initial cumulative threshold, equal to zero.
K_M	Total residual debt threshold in the waterfall, equal to L_T.
$C_0(K)$	Value at time zero of a call option on aggregate assets with strike K.
$SW_{\text{secured}} \succ SR \succ LR \succ OD \succ UW \succ E$	Stylized waterfall ranking: secured wholesale funding, stable retail deposits, less stable retail deposits, operational deposits, unsecured wholesale funding, and equity.
θ_b	Calibrated level of baseline funding costs for the stylized bank.
$i_{m,0}^{raw}$	Raw class-specific baseline funding cost for liability class m, before any bank-specific calibration adjustment is applied.
$B_0^{pari}(0; \theta_b)$	denotes the time-zero analytical value of aggregate bank debt under the pari passu liability specification, evaluated at the baseline geopolitical state $G = 0$ and conditional on the bank-specific funding-cost adjustment θ_b.