GENEVA ASSOCIATION

An Integrated Analytical Model of the Effects of Financial Fragmentation on Re/insurance

A technical appendix to the Geneva Association report *Global Financial Fragmentation: Implications for the insurance and reinsurance industries*

September 2026

Geneva Association

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An Integrated Analytical Model of the Effects of Financial Fragmentation on Re/insurance

A.1 Overview of the modelling framework

The model is designed to capture the principal channels through which financial fragmentation may affect re/insurers. It combines three interacting modules that are solved simultaneously each period. The first module describes the allocation of global reinsurance capacity. The second models the balance-sheet dynamics of representative insurers, including liabilities, liquidity, capital, and surrender behaviour. The third describes the broader macro-financial environment, including interest rates, credit spreads, market liquidity, and asset prices.

Rather than operating sequentially, the three modules interact through multiple feedback mechanisms. Changes in macro-financial conditions affect insurer balance sheets; balance-sheet pressures alter the demand for reinsurance; changes in reinsurance pricing and recoveries feed back into insurer capital and liquidity; and forced asset sales influence financial market prices. The model therefore captures both the direct effects of financial fragmentation and the endogenous amplification mechanisms that may arise under stress.

To model the impact of geopolitically driven financial fragmentation, we consider a three-bloc world consisting of **Home** (H), **Partner** (P), and **Rival** (R) countries. In the benchmark integrated system, capital, risk-bearing capacity, and financial claims move relatively freely across blocs. Increasing financial fragmentation is modelled as an increase in various frictions that impede cross-border risk transfer, capital mobility, asset allocation, and liquidity management.

Alongside the three inter-linked modules, this country designation permits a quantitative assessment of how financial fragmentation affects the four channels developed in Section 3 of the main report:

- The business of cross-border insurance and risk diversification
- Risk transfer and reinsurance networks
- Asset allocation and investment strategy
- Liquidity and balance-sheet dynamics

The model largely focuses on the last three channels. The first channel identified in Section 3 – direct cross-border insurance and risk diversification – is discussed qualitatively but is not expressly represented in the model. This reflects the fact the cross-border insurance is a relatively small proportion of most primary insurers' activity, especially life insurers.

Table A1 summarises how the model is structured, how the modules interact with one another, the key endogenous variables in each, and the economic intuition of how fragmentation frictions transmit through the model.

TABLE A1: SUMMARY OF THE MODEL

Module	Economic question	Key endogenous variables	Key feedback mechanism
1. Reinsurance allocation to H, P, and R: how a global reinsurer allocates risk-bearing capacity across blocs	How is global risk-bearing capacity allocated across regions?	Reinsurance capacity, reinsurance prices, recoverables	Fragmentation raises the cost of supplying cross-border reinsurance and reduces effective reinsurance recoverables
2. Insurer balance sheets in H, P, and R: how insurers in the country blocs manage liabilities, policy surrender risk, liquidity, and demand for reinsurance	How do insurers respond to fragmentation and market shocks or shifts?	Assets, liabilities, capital, liquidity, financial stress	Liquidity shortages, surrenders, and recapitalisation determine balance sheet resilience and feed back into reinsurance demand
3. Macro-financial environment: how capital and funding conditions and market depth evolve under financial fragmentation	How do financial markets transmit and amplify shocks?	Interest rates, spreads, market depth, asset prices	More segmented financial markets and forced sales influence asset valuations and reinforce balance sheet stress

Source: Geneva Association

Although highly stylised, the model captures the principal interactions that are likely to become increasingly important in a more fragmented global financial system. The emphasis is not on forecasting precise quantitative outcomes but on identifying the mechanisms through which fragmentation may alter the allocation of reinsurance capacity, the resilience of insurer balance sheets, and the propagation of financial market shocks. In this way, the specification is intended to balance economic realism with transparency and computational tractability.

A.2 Details of the model

Module 1: Global reinsurer allocation across blocs

The first module captures a representative global reinsurer allocating available risk-bearing capacity across three geopolitical blocs. The reinsurer behaves like a forward-looking profit-maximising firm, choosing the quantity of reinsurance supplied in each market to maximise the discounted value of expected profits subject to increasing marginal costs of capacity provision and fragmentation-related frictions.

Formally, a representative global reinsurer allocates underwriting capacity $q_{i,t}$ across blocs $i \in \{H,P,R\}$, choosing exposures to maximise the discounted value of net cash flows:

$$\max_{\{q_{H,t}, q_{P,t}, q_{R,t}\}} \mathbb{E}_t \sum_{j=0}^{\infty} \beta^j \frac{\Lambda_{t+j}}{\Lambda_t} D_{t+j},$$

where $\beta \in (0,1)$ is the discount factor and Λ_t is the stochastic discount factor. Per-period net cash flow is:

$$D_t = \sum_{i \in \{H,P,R\}} \left[P_{i,t} q_{i,t} - \mu_{i,t} q_{i,t} - \frac{\phi}{2} q_{i,t}^2 \right] - \mathcal{T}_t(q_{R,t}),$$

where:

- $P_{i,t}$ is the premium rate for reinsurance in bloc i;
- $\mu_{i,t}$ is expected actuarial loss per unit of exposure;
- $\phi>0$ is a convex cost of allocating risk-bearing capacity; and
- $Tt\ (q_{R,t})$ is a fragmentation-related friction applied to rival-bloc exposures.

To make pricing endogenous, we assume (inverse) demand for reinsurance in each bloc is governed by:

$$P_{i,t} = \bar{P}_{i,t} - \eta_i q_{i,t}, \eta_i > 0.$$

The demand intercept $P_{i,t}$ is determined in Module 2 and rises when primary insurers experience stress.

Fragmentation frictions in the Rival bloc are represented by:

$$\mathcal{T}_t(q_{R,t}) = \tau_t^{comp} q_{R,t} + \frac{\tau_t^{cap}}{2} q_{R,t}^2,$$

where:

- τ_t^{comp} captures compliance, sanctions or geopolitical costs; and
- τ_t^{cap} captures ring-fencing, collateralisation and capital-localisation frictions.

The reinsurer faces an aggregate capacity constraint:

$$q_{H,t} + q_{P,t} + q_{R,t} \leq \bar{Q}_t, q_{i,t} \geq 0,$$

where $\bar{Q}_t$ denotes total available reinsurance capacity.

First-order conditions

Solving for the allocation of reinsurance capacity across the three blocs suggests the following first-order optimality conditions:

For $i \in \{H,P\}$:

$$\bar{P}_{i,t} - 2\eta_i q_{i,t} - \mu_{i,t} - \phi q_{i,t} = 0,$$

so that

$$q_{i,t}^* = \frac{\bar{P}_{i,t} - \mu_{i,t}}{2\eta_i + \phi}.$$

For the Rival bloc:

$$\bar{P}_{R,t} - 2\eta_R q_{R,t} - \mu_{R,t} - \phi q_{R,t} - \tau_t^{comp} - \tau_t^{cap} q_{R,t} = 0,$$

so that

$$q_{R,t}^* = \frac{\bar{P}_{R,t} - \mu_{R,t} - \tau_t^{comp}}{2\eta_R + \phi + \tau_t^{cap}}.$$

The first-order conditions imply that capacity is allocated until the expected marginal revenue from writing an additional unit of reinsurance equals its expected marginal cost. Financial fragmentation alters this allocation by increasing regulatory costs, settlement frictions, and local capital requirements, thereby reducing the attractiveness of supplying reinsurance to more fragmented jurisdictions.

Current capacity decisions depend not only on current profitability but also on expected future market conditions. Anticipated increases in fragmentation costs or capital constraints reduce the incentive to commit capacity today, while expectations of future profitability encourage greater current capacity provision. In the calibrated model, these forward-looking decisions are represented through reduced-form pricing and capacity equations, which preserve the same economic intuition while remaining tractable for simulation.

Settlement and recoverables impairment

To incorporate fragmentation of payment systems and settlement channels, realised recoveries (i.e. receivables) may be impaired by a settlement wedge:

$$Rec_{i\leftarrow j,t} = (1 - \delta_{i\leftarrow j,t}) Due_{i\leftarrow j,t},$$

with

$$\delta_{i\leftarrow j,t} = \delta_0 + \delta_P \tau_{b(i)\rightarrow b(j),t}^P + \delta_S SysStress_t.$$

Higher settlement frictions therefore reduce the effective value of cross-border recoveries and can, through pricing, demand, and capital allocation decisions, reduce effective reinsurance capacity in stressed markets.

Module 2: Primary insurer balance sheets, surrenders, and liquidity stress

The second module follows the balance sheet of a representative insurer in each region. Assets evolve through investment returns, premium income, and valuation changes, while the stock of liabilities responds to new business, claims, and policyholder surrenders. Fragmentation affects balance sheets indirectly by reducing reinsurance recoveries, increasing collateral requirements, and limiting the movement of capital across jurisdictions.

The key feature of this module is that liquidity and capital are jointly determined. Higher interest rates and wider credit spreads reduce asset values while simultaneously increasing surrender incentives and collateral calls. If liquid assets become insufficient to meet these obligations, insurers are forced to sell assets, potentially amplifying market stress.

Specifically, the second module models a representative primary insurer in each bloc. The insurer holds assets $A_{i,t}$, liabilities $L_{i,t}$, and capital $K_{i,t}$:

$$K_{i,t} = A_{i,t} - L_{i,t}.$$

Assets are allocated across domestic and foreign securities, cash, and illiquid assets; liabilities consist primarily of technical reserves.

Portfolio structure and duration gap

Let asset duration be:

$$D_{i,t}^A = \sum_a w_{i,a,t} Dur_{a,t},$$

where $w_{i,a,t}$ is the portfolio weight on asset a.

Liability duration is reduced by policyholder surrender optionality:

$$D_{i,t}^{L} = \bar{D}_i^{L} - \eta_D(r_{i,t}^{long} - \bar{r}).$$

Hence the duration gap is:

$$DG_{i,t} = D_{i,t}^{A} - D_{i,t}^{L}.$$

This captures the convexity mechanism (i.e. sensitivity of duration to changes in interest rates) discussed in Section 3: when interest rates rise, liability duration shortens, but fragmentation may prevent asset duration from adjusting at the same speed.

Surrender behaviour

Let the surrender rate be determined by the spread between market yields and credited rates, plus insurer-specific stress:

$$s_{i,t} = s_0 + \alpha_s\left(r_{i,t}^{long} - r_{i,t}^{cred}\right) + \beta_s Stress_{i,t},$$

with $s_{i,t} \in [0,1]$.

This specification assumes that higher long-term rates raise surrender activity by making legacy products less attractive relative to market alternatives.

The liability stock evolves according to:

$$L_{i,t+1} = (1 - s_{i,t})L_{i,t} + NewBiz_{i,t} - Claims_{i,t}.$$

Collateral needs and liquidity shortfall

The insurer's short-term funding need is:

$$Need_{i,t} = Outflow_{i,t} + C_{i,t} + Claims_{i,t} - Premiums_{i,t},$$

where outflows include surrender payments:

$$Outflow_{i,t} = s_{i,t}L_{i,t}.$$

Collateral requirements rise with market moves and fragmentation in derivatives and FX funding markets:

$$C_{i,t} = C_0 + \chi_r \mid \Delta r_{i,t} \mid + \chi_\sigma \sigma_{mkt,t} + \chi_{FX}\tau_{i,t}^{FX}.$$

Available liquid assets are denoted $LA_{i,t.}$ The insurer's liquidity shortfall is therefore:

$$Short_{i,t} = \max\{0, Need_{i,t} - LA_{i,t}\}.$$

This is the core liquidity channel: fragmentation raises collateral needs and limits balance-sheet flexibility, while higher rates raise surrender outflows.

Available liquid assets are adjusted in stressed states to reflect the possibility that assets, which are liquid under normal market conditions, cannot be monetised immediately at full value. Fragmentation, market disruption, collateral trapping, and increased haircuts can therefore reduce *effective* usable liquidity. A liquidity shortfall arises when funding needs exceed this effective liquidity buffer. Only when that buffer is exhausted are longer-duration assets sold, activating the fire-sale mechanism.

Stress index and demand for reinsurance

The stress index is not intended to measure financial distress directly. Instead, it summarises the extent to which an insurer experiences simultaneous liquidity shortages and capital impairment. Higher stress reduces new business generation, increases policy surrenders, and raises demand for reinsurance, thereby generating endogenous feedback between insurer balance sheets and financial markets, though it is subject to a bounded response that prevents stress-induced demand from dominating the capacity-allocation mechanism.

Primary insurer stress is summarised through the following metric:

$$Stress_{i,t} = \omega_L \frac{Short_{i,t}}{A_{i,t}} + \omega_K \max\left\{0, \frac{\bar{K}_{i,t} - K_{i,t}}{A_{i,t}}\right\}.$$

Stress raises the willingness to pay for reinsurance:

$$\bar{P}_{i,t} = \bar{P}_i^0 + \zeta_1 Stress_{i,t} + \zeta_2 CatShock_{i,t}.$$

This closes the loop between Modules 2 and 1: when primary insurers are under pressure, demand for reinsurance rises.

Emergency recapitalisation (Rival)

The recapitalisation equation represents management and regulatory actions that rebuild capital following periods of stress. In practice, recapitalisation may occur through retained earnings, new equity issuance, reductions in dividends, balance-sheet restructuring, or injections of capital from parent companies. The reduced-form representation avoids prolonged negative capital positions while capturing the gradual restoration of financial resilience observed following major financial shocks. In the disorderly scenario, emergency recapitalisation is most important in the Rival bloc, where capital impairment is greatest.

$$recapr = \psi rc * \max\left(0, \bar{K}_{r,t} - K_{r,t}\right) + emergencyrecap_r$$
$$emergencyrecap_r = \max\left(0, .01 * l_r(-1) - k_r(-1)\right)$$

In other words, emergency recapitalisation measures kick in whenever capital threatens to fall below 1% of liabilities.

Module 3: Macro-financial asset pricing and market depth

The macro-financial module determines the external environment in which insurers operate. Interest rates, credit spreads, market depth, and asset prices evolve jointly with the fragmentation wedges. Market prices respond not only to fundamental changes in interest rates and credit risk but also to endogenous price pressure generated by forced asset sales. Consequently, financial fragmentation influences markets both directly, through higher risk premia, and indirectly, through balance-sheet amplification.

Specifically, the third module determines interest rates, credit spreads, asset prices, and market liquidity.

Interest rates and spreads

For bloc i:

$$r_{i,t+1} = (1-\rho_r)\bar{r}_i + \rho_r r_{i,t} + \sigma_r \varepsilon^r_{i,t+1},$$
$$s_{i,t+1} = (1-\rho_s)\bar{s}_i + \rho_s s_{i,t} + \sigma_s \varepsilon^s_{i,t+1}.$$

These reduced-form processes allow fragmentation shocks to affect rates and spreads through scenario-dependent parameters.

Cross-border asset wedge

Let fragmentation raise the effective cost of holding foreign risky assets:

$$R^{eff}_{a,j|i,t+1} = R_{a,j,t+1} - \tau^A_{i\to j,t}.$$

Higher τ^A induces home bias in insurer portfolios.

Market depth and price impact

Market depth falls under fragmentation and system stress:

$$\lambda_{i,t} = \bar{\lambda}_i \exp\left(-\upsilon_\tau \tau^A_{i,t} - \upsilon_S SysStress_t\right).$$

Forced asset sales $Q_{i,t}^{sell}$ then affect prices through:

$$\Delta \ln P_{i,t+1} = \Delta \ln P^{fund}_{i,t+1} - \kappa \frac{Q^{sell}_{i,t}}{M_i}\frac{1}{\lambda_{i,t}},$$

where M_i is market size. Lower market depth amplifies the price impact of insurer sales.

This captures the mechanism highlighted in Section 3: fragmentation makes asset markets shallower and increases the severity of fire-sale externalities.

A.3 Transmission of a fragmentation shock

A fragmentation shock is modelled as a joint increase in:

- Cross-border capital wedges τ^A.
- FX funding wedges τ^{FX}.
- Payment and settlement wedges τ^P.
- Reductions in market depth λ.

The principal transmission and feedback mechanisms can be summarised as follows (although the numbering is expositional rather than sequential, since the three modules are solved simultaneously):

1. Higher wedges reduce the cross-border deployment of reinsurance capital;
2. Reinsurance prices rise and effective recoveries fall;
3. Primary insurers face greater retained risk and larger liquidity needs;
4. Higher rates and lower liquidity raise surrender activity;
5. Forced sales depress asset prices, weakening capital positions;
6. Higher insurer stress feeds back into reinsurance demand and settlement risk, while endogenous recapitalisation and balance-sheet repair gradually restore capital following severe stress.

This framework therefore links the four channels outlined in Section 3 into a single integrated system.

A.4 Scenario outputs

The model can be used to generate several indicators relevant to the main report:

- Regional allocation of reinsurance capacity
- Reinsurance pricing by bloc
- Capital fungibility
- Surrender-driven liquidity shortfalls
- Duration gaps and convexity measures
- Forced asset sales and price impacts

These outputs provide the basis for the scenario analysis in Section 4.

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