Structure and Resolution in Banking: Are They Substitutes?*

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Abstract

Can bank resolution replace ring-fencing? We develop a simple framework of expected systemic loss in which structural separability and resolvability interact. When either of two common realities holds—structure makes resolution work better, or it reduces the support needed during failure—resolution and ring-fencing become complements, not substitutes. A dual welfare/target formulation gives the same policy choice. We obtain an "inverted" comparative static: as the credibility of using resolution rises, the optimal degree of separation often increases; easing is warranted only in knife-edge cases where structure brings no marginal benefit. A private–social comparison predicts under-investment in structure and preparedness. In general, better resolvability *strengthens* the case for ring-fencing.

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1 Introduction

The UK's regime of retail–investment bank separation is at a crossroads. Established in the aftermath of the global financial crisis, the ring-fencing framework was designed to insulate core retail banking functions—household deposits, SME lending, and payments—from the risks of global investment banking. Its intellectual and institutional roots reach back in the modern era to debates around Glass–Steagall in the United States. More recently, in the UK the Report of the Independent Commission on Banking (the Vickers Report, 2011), the European Union's Liikanen proposals, and the Volcker Rule revived the issue. Yet, despite its centrality to post-crisis financial architecture in the UK, the policy now faces erosion.

The Skeoch Review (2022)[1] criticised the regime's rigidity and questioned its efficiency costs.[2]. It recommended retaining but recalibrating ring-fencing and suggested that, if resolution capability improves, the marginal benefit of ring-fencing would fall—implicitly treating resolution and structure as substitutes—hence its proposal to disapply the fence where resolvability is demonstrated. The Bank of England, the UK resolution authority, is confident that the resolution regime is now effective.[3] Along with most banks, the UK government appears sympathetic to those Skeoch Review conclusions, announcing reforms that weaken the fence by allowing broader exemptions, expanding permissible activities inside the ring-fence, and reducing the obligations imposed on ring-fenced entities. But there is an alternative view. We do not seek to comment on the specific features of the UK ring-fence, nor indeed on those of the resolution regime. Instead, this paper argues that resolution and ring-fencing are not substitutes in financial regulation, as in effect The Skeoch Review asserts, but complements. As Sir John Vickers

[1]Report of the Independent Panel on Ring-fencing and Proprietary Trading—Final Report, March 2022.

[2]Most bankers have been critical of ring-fencing. See for example Ervin (2018)

[3]See for example Bank of England (2023).

suggested: "You need a package of measures. You need structural reform, good common equity capital buffers and resolution regimes. ... [Ring-fencing] assists resolution ... The modularity and subsidiary structure that ring-fencing gives you could be an enormous assistance if and when it came to resolution. ... One could imagine some crises where [resolution] would probably work and some where it would not."[4]

2 Context and History

Across jurisdictions, the appeal of structural separation has reflected experience with crises. Glass–Steagall (1933) barred US commercial banks from investment banking for six decades before repeal ushered in universal conglomerates; the 2007–08 crisis revived structural ideas, but the US opted for the narrower, activity-based Volcker Rule, while the EU's Liikanen plan–closer to the Vickers proposal in some ways–ultimately stalled. The UK chose ring-fencing—keep group synergies, but place essential retail services in separately capitalised, independently governed, operationally self-sufficient entities so they can be kept open if trading arms fail. That made the UK a rare post-crisis case of enacted structural reform.[5]

Since implementation in 2019, pressure has grown to relax the fence. The Skeoch Review argued for that on grounds of proportionality and efficiency, and recent reforms have widened exemptions and blurred perimeters. The policy question is whether weakening separation is prudent, premature or a mistake. Hellwig (2021) suggests that, in the round, post-crisis reforms have *improved safety* but have not yet *made safe* the financial system; large cross-border banks still face doubtful resolution in stress, liquidity-in-resolution remains fragile, and politics can derail bail-in.[6] Read against that backdrop,

[4]Professor Sir John Vickers, oral evidence to the Treasury Committee, *The Edinburgh Reforms*, HC 1079, 1 February 2023. Ordered to be published 1 February 2023.

[5]Damjanovic et al (2020) studies the break up of retail from investment banking identifying a potential trade-off between bank lending volume and bailout frequency.

[6]Whether or not bail-outs have a role in optimal macroprudential policies remains

ring-fencing looks less like an emergent anachronism and more like a design layer that supports resolvability and protects core services when resolution is delayed, partial, or politically constrained, which is what Vickers appeared to be suggesting in his recent Parliamentary evidence.

This paper develops the argument that ring-fencing and resolution are not rival blueprints so much as 'design-time' and 'run-time' layers of the same safety architecture. In a sense our argument is obvious: Ring-fencers explicitly accept that banks must be resolvable and they recommend building modular balance sheets, service contracts and liquidity bridges precisely so that bail-in or transfer can be executed 'on the day'. Resolution, by contrast, can only succeed if those modular preconditions already exist. Every credible resolution plan presupposes separability of critical functions, clean loss-absorbing stacks at the right legal entities, operational continuity of shared services, and pre-arranged liquidity in resolution–all of which are the substance of ring-fencing by another name. In short, ring-fencing openly embeds resolution; resolution implicitly relies on ring-fencing.

Much of what resolution assumes is in place is what a good ring-fence is designed to supply:[7] First, a clear, legal perimeter, that is entities that match operating reality so that liabilities can be bailed-in and assets/branches transferred without cross-guarantee legal complications. Second, pre-positioned loss-absorbing capacity–internal and external MREL at material subsidiaries, so equity and debt buffers sit where the risk resides. Third, operational continuity in resolution (OCIR)–service-company contracts, data-room readiness, and tested "weekend" playbook (i.e. modular service layers). Fourth, liquidity-in-resolution (LIR)–entity-level collateral mapping and pre-arranged funding lines sufficient for the ring-fenced perimeter. Fifth,

contentious. A recent, interesting contribution is Zaretski (2025).

[7] Thus criticism that 'ring-fencing' is far from easy to design in practice, see for example Schwarcz (2013), is in our view correct. Bur effective resolution faces the same–and more–challenges as we discuss in the text. For some of the ring-fence complexity in the UK context, see the PRA (2016a,b)

booking and financial market infrastructure (FMI) modularity–flows, netting sets and margin are partitioned so transfers are feasible without system-wide breaks.[8] That these features might pose serious hurdles to successful resolution is apparent from several recent events.[9] For example, it was announced in 2022 that the British bank, TSB, was fined by the UK regulators (the Financial Conduct Authority and the Prudential Regulation Authority) on account of a 2018 IT migration. This large-scale core-banking cutover triggered weeks of service outages. The regulators later fined TSB for "operational resilience failings," highlighting poor outsourcing control and inadequate rehearsals—the sort of OCIR weakness that might materially hinder a weekend resolution.[10] Another example is the failure of Lehman Brothers in 2008. The broker-dealer collapse exposed tangled service/booking dependencies and data gaps; authorities scrambled to keep key operations alive while counterparties exercised termination rights—an early lesson in the need for executable OCIR playbooks.[11]

Lehman's 2008 collapse showed how weak booking and FMI modularity can complicate resolution. Over the failure, tri-party repo mechanics and CCP workflows slowed settlement; collateral was not mobilised quickly, some CCPs took days to liquidate, and margin/settlement queues built up. The delays triggered cash calls and fire-sale pressures, not just at Lehman.[12]

[8] Where trades sit and how they settle matters for resolvability. Booking modularity means positions are recorded in the entities you can actually resolve or transfer; FMI modularity means clearing, settlement, and margining can continue if a group is split. Done well, this avoids trapped netting sets, broken collateral chains, and payment gridlock—so operational separation and market plumbing line up with the legal perimeter you plan to use.

[9] IMF (2011) outlines some of the many complexities involved in winding up a failed bank. The failures we are now about to review in the text identify many more.

[10] See: https://www.fca.org.uk/news/press-releases/tsb-fined -48m-operational-resilience-failings

[11] George, Ayodeji and Kelly, Steven (2025) "United States: Lehman Brothers Broker-Dealer Emergency Liquidity Program, 2008," *Journal of Financial Crises*: Vol. 7: Iss. 1, 654-682.

[12] Adam Copeland, Antoine Martin, and Michael Walker (2011, 2014) Repo Runs: Evidence from the Tri-Party Repo, *Market Federal Reserve Bank of New York Staff*

Booking choices and collateral pools interacted with FMI processes under stress. Arguably, poor modularity magnified the shock.[13]

An example of the importance of liquidity-in-resolution (LIR) occurred in 2023. Credit Suisse suffered massive outflows (around $69bn[14] in a matter of weeks) and daily liquidity stress forced an emergency state-engineered takeover by UBS rather than testing bail-in. FINMA's post-mortem underscores that credibility gaps plus run-dynamics can overwhelm plans unless assured LIR is in place.[15] In 2017 the Italian banks Veneto Banca and Banca Popolare di Vicenza were deemed by the Single Resolution Board of the European Banking Union as "failing or likely to fail," but the SRB deemed EU resolution not in the public interest.[16] The wind-down proceeded under national insolvency with state aid—politics and funding backstops dominated, illustrating how, without reliable LIR and clear political commitment, formal resolution can be bypassed.

On 6 June 2017 the ECB judged Banco Popular 'failing or likely to fail'. On 7 June the SRB resolved the bank—writing down/converting capital instruments and transferring the shares to Banco Santander for €1—implemented by Spain's FROB. Popular remained open as a solvent, liquid member of the Santander Group with immediate effect. This is a useful an

Reports, no. 506.

[13]BIS *Committee on Payment and Settlement Systems: Strengthening repo clearing and settlement arrangements* September 2010.

[14]Financial Times April 24, 2023: *Credit Suisse suffered $69bn in outflows during first-quarter crisis.*

[15]See *FINMA Report: Lessons Learned from the CS Crisis* Bern, 19 December 2023 available on FINMA's (Swiss Financial Market Supervisory Authority) website.

[16]See the SRB's decision here: https://www.srb.europa.eu/system/files/media/document /srb-ees-2017-12_non-confidential.pdf

The Italian Government's explanation to the European Commission re state aid and orderly resolution is here: https://ec.europa.eu/competition/state_aid/cases/264765/ 264765_1997498_221_2.pdf

A briefing overview published by the European Parliamnt is very helpful: https://www.europarl.europa.eu/RegData/etudes/BRIE/ 2017/602094/IPOL_BRI%282017%29602094_EN.pdf example of how, when legal perimeters and operational arrangements line up, execution is feasible.[17] To be clear, Banco Popular was not a (Vickers) ring-fenced entity, yet it exhibited the practical hallmarks of separability—clean perimeter, a transferable retail book, and aligned FMI access—so resolution "gripped" in hours. The lesson is not that *formal* ring-fencing was present, but that the operational content of ring-fencing was: the SRB could execute swiftly because the perimeter to be sold was already coherent. One of our claims is that UK-style ring-fencing aims to industrialise these preconditions across large groups, raising the probability—and lowering the cost—of creditor-loss-absorbing resolution without recourse to guarantees.[18]

SVB UK is a recent case where resolution 'gripped'. Over the failure weekend the Bank of England transferred SVB UK to HSBC UK Bank plc (the ring-fenced bank), wrote down capital instruments, and maintained continuity without taxpayer support. HM Treasury temporarily modified ring-fencing to let the purchaser provide liquidity, and the Bank has since published its statutory report. This looks closer to Banco Popular's overnight sale to Santander than to the US approach to SVB, where a systemic-risk exception protected all deposits and the Fed launched the BTFP—effective crisis containment, but not a creditor-loss-absorbing resolution.

These cases show the same pattern from different angles. Without rehearsed OCIR, assured LIR, and booking/FMI modularity, legal "resolution" struggles to grip in practice—so ring-fencing that pre-builds

[17] SRB notice of 7 June 2017: https://www.srb.europa.eu/system/files/media/document/note_summarising_effects_07062017.pdf

See also, Carey K Mott (2024) "Spain: Banco Popular Restructuring, 2017," *Journal of Financial Crises*: Vol. 6 : Iss. 1, 486-534.

[18] Two caveats follow. First, an immediate private buyer (Santander) was available; ring-fencing cannot guarantee a buyer, but by creating a clean, stand-alone perimeter it increases that likelihood and reduces the discount required. Second, this was not a full system-wide panic; our broader argument is precisely that separability is most valuable when political or market stress raises the chance that resolution will not be used or will prove fragile elsewhere.

those preconditions is not a rival to resolution but its enabler. Or to put it slightly differently, every resolution regime contains an implicit ring-fence; the only question is whether it is designed ex-ante, or discovered under duress over a 'weekend'.

The lesson from these cases, we argue, is that one should treat resolution as a mechanism that thrives on modular structure; if one wants more credible, cheaper resolution, one needs more (not less) of the separability that provides the traction. We turn now to develop a model to reflect these real-world interdependencies.

Our key results We start from a neutral benchmark in which structure and resolution buy the same resilience. Then we introduce frictions grounded in reality—structure makes execution work better, reduces the liquidity needed on the day, and resources face diminishing returns. Next, the planner's choice is shown to be invariant to how the objective is written: welfare and target formulations deliver the same policy mix (duality result). Once any one of those frictions just mentioned is present, structure and resolution become strict complements—our main result. Following this, a central comparative static then flips the usual narrative; improving the credibility of actually using resolution can justify tightening—not loosening—the ring-fence. Privately optimal structure is shown to differ from the planner's as banks internalise only part of the systemic loss, which also drags down resolvability. Finally, a simple multi-task microfoundation makes the mechanism explicit. Tighter structure raises the return to real, hard-to-contract preparedness and cleanly separates "serious" from "glossy" banks. We conclude with a discussion of our results and their policy implications. Proofs and derivations are in the appendices.

3 The model

We model structure (ring-fence tightness) and resolution capability (or effectiveness) as inter-dependent features. Structure determines the execution efficacy and liquidity needs of resolution, so the marginal product of resolution depends on structure, and the marginal value of structure depends on resolution preparedness. When a large bank tips from stress to non-viability, the damage is not just to shareholders. The system loses services that must remain continuous—payments processing, deposit access, committed credit lines, and market-making in key assets. At the same time, short-term funders run; collateral haircuts widen; prime brokers and CCPs demand variation margin; and subsidiaries in other jurisdictions pull back to protect their own balance sheets. Authorities face a binary execution choice, under a hard weekend clock, either to keep the firm open using the resolution toolkit (transfers, bridge bank, bail-in, temporary public backstops) or revert to ad-hoc fixes (guarantees, shotgun mergers, bailout). The first path tends to preserve services but only if the firm is separable and liquid-on-arrival. The second path can avoid a cliff-edge but often socialises risk and can leave the system more fragile.

Recent episodes illustrate that menu. The 2007 run on Northern Rock combined service-continuity risk with no modern toolkit. Thus, liquidity dried up, official support replaced market funding, and taxpayers absorbed tail risk. Lehman's failure (2008) made clear how intermediation chains transmit distress even without obvious bilateral exposures—money-market funds broke the buck; wholesale funding froze; otherwise solvent banks were pulled into fire-sale deleveraging. By contrast, as noted earlier, SVB UK was transferred over a weekend, preserving access for depositors and corporates—an example of rapid continuity when execution is feasible. Credit Suisse's rescue the same year shows the other branch. There, political and legal constraints forced a merger rather than a pure bail-in, preserving continuity but reminding markets that the formal resolution playbook is not always used. [19]

These experiences motivate a simple aggregator for expected systemic loss that captures the risks to the key actors who are under the clock. Structure (how cleanly critical services, assets, and liabilities can be separated) and resolution capability (how much capacity and pre-positioned tooling exists to keep the bank open) jointly shape outcomes. Thus, bank-specific preparedness matters. Specifically, structure $\phi \in [0, 1]$ (ring-fence tightness) and resolution capability $R \geq 0$ produce resilience, potentially assisted by non-contractible preparedness effort (on the part of the bank) $e \geq 0$. However, there is always some probability that the formal playbook is not actually used. We combine these considerations in an expected systemic loss as follows,

$$S(\phi, R, e; \theta) = S_0 - a\,\phi - (1-\theta)\,b\,\Xi(\phi)\,\Phi\Big(\frac{R+\gamma e}{\Lambda(\phi)}\Big), \tag{1}$$

where $\Phi'(x) > 0$, $\Phi''(x) \leq 0$, $\Lambda'(\phi) \leq 0$, and $\Xi'(\phi) \geq 0$. The factor $(1-\theta)$ captures political execution risk, so that with probability θ, policymakers (politicians) back off from implementing resolution. a, b, γ are strictly positive scalars. S_0 is baseline loss without intervention. $\phi \in [0, 1]$ indexes structural separability (reflecting a choice over clean legal-entity maps, operational continuity preparedness, custody/payment ring-fencing); $R \geq 0$ is resolution capacity (e.g. MREL/TLAC, transfer options, playbooks, assured liquidity-in-resolution); $e \geq 0$ is non-contractible preparedness by the banking firm (tested drills, data rooms, service disentanglement). $\Xi(\phi)$ is an efficacy shifter (how structure makes resolution bite when it is used); $\Lambda(\phi)$ is the size of the liquidity bridge needed to execute resolution (structure shrinks it); $\Phi(\cdot)$ maps available resources into coverage with diminishing returns.

[19] And during the UK gilt turmoil in 2022, core retail services continued; losses were concentrated in leveraged LDI funds rather than deposit-taking banks, a reminder that the location of fragility matters for systemic loss.

The $-a\,\phi$ term says that better structure reduces background spillovers even if resolution is not used (for example, cleanly siloed retail payments keep running).[20]

The final bracketed term works only when authorities execute the playbook (with probability $(1-\theta)$). Then, structure raises the bite of resolution via $\Xi(\phi)$ (legal/operational clarity makes transfers and bail-in work), and reduces the liquidity needed on the day via $\Lambda(\phi)$ (fewer complex inter-affiliate dependencies, say). Preparedness e shows up in the same numerator as formal capacity R, because both are what the bank can 'bring to the table' at 5pm on Friday. We discuss all these features further below. However, first we say something more about ϕ and R as they are central to the model and lie at the core of the Vickers-Skeoch debate.

What is ϕ? We take ϕ to be an index of structural separability at design time. It captures the extent to which a group is pre-partitioned into stand-alone, serviceable units, with clean legal perimeters; pre-positioned loss-absorbing capacity at material subsidiaries (internal/external MREL); OCIR contracts and service maps; disciplined, booking hygiene; prudent intragroup exposure plumbing; and FMI access aligned to the intended perimeter.[21] In

[20] Imagine a Friday 5pm bank failure. By 7pm the Chancellor rules out bail-in and opts for temporary support to keep services running. A low-ϕ group, is one that is loosely separated so that retail payments, SME lending, treasury ops, and shared services sit in tangled entities. To stop outages on Monday, the Government has to guarantee a broad perimeter (group-wide repo/clearing lines, shared-service contracts, intraday facilities); big gross backstops, messy waivers, wider moral hazard. For a high-ϕ group, the retail bank has its own treasury, FMI access, OCIR contracts, and ring-fenced liquidity buffers. Even without bail-in, the state can confine support to that perimeter (smaller guarantee, fewer exemptions, faster stabilisation, cleaner sale later). So, higher ϕ lowers spillovers, backstop size, and time-to-stabilise even when no weekend resolution tool is used–that is what $a\phi$ captures. With $a=0$ the implication would be that structure has no value when resolution is not used. That erases the "insurance" logic regulators seem to care about—structure pays out both when resolution works and when it does not.

[21] By "booking hygiene" we mean entity-clean, transferable books and records; by "alignment with FMIs" we mean each resolvable entity can clear, settle, and post margin in its own right (or via robust sponsorship), with collateral and netting sets confined to the perimeter intended for resolution. Both are preconditions for the legal tools to grip in

the model, higher ϕ raises execution efficacy $\Xi(\phi)$ and shrinks the liquidity bridge $\Lambda(\phi)$ that must be spanned at failure, so expected loss falls even before any run-time tool is used. We do not treat ϕ as an "activity index" (e.g. trading limits, exposures to financial firms). Such activity choices can be absorbed into baseline risk (the linear loss term) without changing our comparative statics. Empirically, ϕ might map to observables such as the within-group RF vs non-RF money-market wedge in stress and measured LIR/OCIR sensitivities to perimeter changes.

What is R? R is run-time[22] resolvability capacity—the bank-specific, usable stock one can actually deploy over the weekend. It bundles clean, subordinated loss-absorbing liabilities that can be bailed in; assured liquidity-in-resolution sized to the perimeter; rehearsed OCIR playbooks, data-room/valuation readiness; and legally executable transfer options (SPOE/MPOE) with cross-border plumbing in place. In the model, higher R increases the bite of resolution through $z = (R + \gamma e)/\Lambda(\phi)$. Preparedness effort e is the bank's non-contractible investment that makes R usable; ϕ governs the channels—$\Xi(\phi)$ and $\Lambda(\phi)$—through which R translates into lower loss. "Doing less R" means thinner/weaker MREL and subordination, looser pre-positioning, softer LIR expectations, fewer OCIR drills, and unresolved dependencies; "doing more R" is the mirror image.

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practice.

[22] By "run-time" we mean the failure weekend itself—the hours and days when authorities and the firm are actually executing resolution. So when we say "R is run-time resolvability capacity," we mean the usable stock of tools and readiness deployable on the day: clean, subordinated MREL that can be bailed-in; pre-arranged liquidity-in-resolution that can be drawn before markets open; rehearsed OCIR playbooks and service contracts that keep payments, margining and data flowing; data rooms and valuation agents who can price the bank overnight; and legally executable transfer options (SPOE/MPOE) that counterparties and FMIs will recognise immediately.

And so the contrast is with ϕ, the design-time architecture (how modular the group has been made in advance). R is what actually bites at run-time given that architecture. In the model, ϕ improves the grip (efficacy Ξ up, liquidity bridge Λ down); R supplies the force applied at the moment of failure via $z = (R + \gamma e)/\Lambda(\phi)$.

In short, ϕ sets the boundaries and interfaces in advance; R is what can be done quickly and credibly when those boundaries matter. If design is monolithic, run-time tools have little to grip; as ϕ rises, the same tools become cleaner, faster, and cheaper to execute.

Our social loss function also aligns with recent work. Using confidential, transaction-level gilt-repo data from the UK, Erten, Neamtu and Thanassoulis (2025) document a persistent "ring-fencing bonus" where groups with ring-fenced subsidiaries borrow more cheaply overnight, with the effect concentrated in the RFB entity and amplified in stress (e.g. Covid-19). That is consistent with our approach when structure raises execution efficacy (Ξ rises) and shrinks the liquidity bridge (Λ falls). The implication in the data is that markets price the safer, more liquid perimeter. Identification is also consistent—the wedge appears at legal implementation (design-time separability), is absorbed by objective risk controls rather than "too-vital-to-fail," and on the asset side RFBs price reverse-repo more dearly (consistent with a safer, lower-risk appetite book). In short, the findings of Erten et al. suggest an observable proxy for the marginal value of structure; its stress-state amplification is arguably the empirical footprint of complementarities, not substitution.

We turn now to characterise the general problem of optimal choices of ϕ and R in the presence of these non-neutralities. Regulators sometimes talk in terms of cost–benefit (welfare) terms of regulations and sometimes in terms of minimum standards and tests (target) terms. We characterise both problems show one is the dual of the other.

4 Planner's problem: welfare and target form duality

Let banks choose a non-contractible preparedness effort $e \geq 0$ at private cost $c(e)$.[23] Expected systemic loss is given by (1), with bank preparedness optimally chosen, given ϕ:

$$S(\phi, R, e; \theta) = S_0 - a\,\phi - (1-\theta)\, b\, \Xi(\phi)\, \Phi\Big(\frac{R + \gamma e}{\Lambda(\phi)}\Big), \qquad c'\big(e^*(\phi)\big) = (1-\theta)\, \alpha\, F\, \Xi(\phi),$$

where $a, b, \gamma, \alpha, F > 0$. $F > 0$ denotes the marginal private value of preparedness (e) to the bank when resolution is executed. To recall, $\Xi'(\phi) \geq 0$ (structure raises the efficacy of resolution), $\Lambda'(\phi) \leq 0$ (structure shrinks the liquidity bridge to execute), and $\Phi'(\cdot) > 0$, $\Phi''(\cdot) \leq 0$ (diminishing returns in resources). Political execution risk is $\theta \in [0, 1)$ so that with probability θ, authorities do not execute resolution. The planner takes $e^*(\phi)$ as induced by ϕ.

Implementation/organisation costs are captured by two convex functions. First is $E(\phi)$, (structural costs, such as duplication, trapped liquidity, governance frictions). Second is $C(R)$ (carrying costs of resolution capacity, such as eligible debt, legal/operational readiness). The scalar $\lambda \in (0, 1)$ is a social weight on expected systemic loss relative to implementation costs. It can be read either as a welfare weight (societal aversion to systemic loss) or, in the dual representation below, as the shadow price on a resilience target.

For notational ease, define the *resilience index* with bank preparedness

[23] We discuss this part of the model in more detail below. But the idea is that a bank chooses two tasks: (i) real resolution preparedness $e \geq 0$ which is hard to contract on with regulators; and (ii) a verifiable level of structural separation $\phi \geq 0$ (ring-fence tightness).
The probability, $p(\cdot)$, that resolution works is

$$\begin{aligned} p(e, \phi) &= \pi_0 + \alpha\, e\, \psi(\phi), \\ \psi'(\phi) &> 0,\ \psi(\phi) \geq 0,\ \pi_0 \in [0, 1). \end{aligned}$$

Here $F > 0$ is the bank's marginal private value of successful resolution at the evaluation point.

already substituted:

$$M(\phi, R) \equiv a\phi + (1-\theta) b \Xi(\phi) \Phi\Big(\frac{R + \gamma e^*(\phi)}{\Lambda(\phi)}\Big), \qquad G(\phi, R) \equiv (1-\lambda) E(\phi) + C(R).$$

Then $S(\phi, R, e^*; \theta) = S_0 - M(\phi, R)$ and the planner's trade-off is between M and G.

The dual formulation is convenient as sometimes regulators talk of choosing instrument levels by weighing marginal benefits and costs (a welfare trade-off). At other times, they seem more to talk of setting a resilience *target* and of picking the least-cost instrument mix to hit it. The two formulations should agree. The welfare form is convenient for comparative statics (e.g. how θ or $\Xi'(\phi)$ move the optimum). The target form mirrors operational policy (capital and resolvability floors, system-wide tests). Showing they are dual ensures our positive results do not depend on a particular objective representation.

In the welfare formulation, the planner chooses instruments to equate marginal implementation cost to a shadow value of resilience ($\nabla G = \lambda \nabla M$).[24] In the target formulation, the planner minimises implementation cost subject to a resilience requirement, yielding the same stationarity condition with multiplier μ^*. Under convexity and Slater's condition, $\mu^* = \lambda$ and the two programmes are dual, so all comparative-statics results (e.g. with respect to θ or $\Xi'(\phi)$) are invariant to the choice of objective

[24] Our notation is standard here and below: With policy vector $x \equiv (\phi, R)$, the gradient ∇G is the column vector of first partial derivatives

$$\nabla G(x) = \begin{bmatrix} \partial G/\partial \phi \\ \partial G/\partial R \end{bmatrix}, \qquad \nabla M(x) = \begin{bmatrix} \partial M/\partial \phi \\ \partial M/\partial R \end{bmatrix}.$$

Interior first-order conditions are vector equalities. In the welfare problem,

$$\nabla G(\phi^*, R^*) = \lambda \, \nabla M(\phi^*, R^*).$$

In the target problem with an active constraint and multiplier μ^*,

$$\nabla G(\phi^*, R^*) = \mu^* \, \nabla M(\phi^*, R^*).$$

representation. We employ the welfare form for analytic derivations (FOCs, cross-partials) and the target form to map directly to policy instruments (minimum capital/resolvability floors and system-wide tests). The Lagrange multiplier μ in the target form is the "shadow price of resilience"—the marginal social value of tightening the target by one unit. In the welfare form, the weight λ plays the same role inside the first order conditions.

The welfare form problem is

$$\min_{\phi,R} \mathcal{L}(\phi, R) = \lambda\, S(\phi, R, e^{*}(\phi); \theta) + (1-\lambda)\, E(\phi) + C(R). \tag{2}$$

The target form problem is

$$\min_{\phi,R} L(\phi, R, \mu) \;=\; G(\phi, R) \;-\; \mu\,[\, M(\phi, R) - \bar{m}\,], \qquad \mu \geq 0. \tag{3}$$

$\bar{m}$ is a resilience requirement (e.g. a pass threshold in a system-wide test). That these forms are equivalent is readily established, in the appendix, using standard arguments . The intuition for the equivalence is clear. The welfare problem trades off marginal cost ∇G against marginal benefit $\lambda\,\nabla M$. The target problem trades off the same objects through a multiplier μ. Picking $\bar{m}$ equal to the resilience actually delivered at the welfare optimum makes the target constraint bind at the same point; identifying $\mu^{\star}$ with λ aligns the marginal rate of substitution with the constraint's shadow price. Thus the two representations are different parameterisations of the same policy choice.

5 Private vs social choices of structure and preparedness

Private choices differ from the planner's because banks bear their own costs but only a portion of the losses their failure imposes on others. That makes them underinvest, from a social perspective, in hard, verifiable separability and on real preparedness, especially because structure and resolution work better together than alone. This section proceeds in three steps. First, it shows a bank's privately optimal ring-fence is below the planner's. Second, it shows the wedge grows exactly when "structure makes resolution bite" (the structural amplifier is strong). Third, anticipating our more general argument below, it shows that under-investing in structure drags down investment in resolution too, because the two are complements. Taken together, these results explain why a social planner wants more separability and more usable resolvability than banks will choose on their own.

The bank chooses e given ϕ. If failure in the executed case entails expected sanction $F > 0$, the first-order condition is

$$c'(e^*(\phi)) = (1-\theta)\,\alpha\,F\,\Xi(\phi), \qquad c''(e) > 0, \tag{4}$$

so e^* is well defined by strict convexity of $c(\cdot)$. The social planner minimises

$$L(\phi, R) = (1-\lambda)\,E(\phi) + C(R) + \lambda\,S(\phi, R, e^*(\phi); \theta)\,, \tag{5}$$

with $E''(\phi) > 0$, $C''(R) > 0$, $\lambda \in (0, 1)$. A *private* objective is[25]

$$L^P(\phi, e) = \kappa\,E(\phi) + c(e) + \rho\,S(\phi, R, e; \theta), \qquad \rho \in [0, 1),\ \kappa > 0, \tag{6}$$

where ρ is the fraction of social loss internalised (guarantees, spillovers), and κ scales perceived structural cost. We normalise $\kappa = 1 - \lambda$.

First, we make some interiority and local convexity assumptions. Assume a compact policy set and continuity. Interior solutions exist when the first-order conditions hold at some $(\bar{\phi}, \bar{R}) \in (0, 1) \times (0, \infty)$ and the Hessian of L in (ϕ, R) is positive definite there. Local positive definiteness obtains if $E''(\phi)$ and $C''(R)$ are strictly positive and the modulus of the cross-partial of S is not too large; this ensures strict local minima and validates the implicit-function derivatives used below. It follows then:

[25] Recall that $E(\phi)$ is the price of making the bank modular ex ante; $C(R)$ is the price of ensuring you can actually use the tools ex post. In other words, if the expense arises from partitioning/unwinding integrations to create clean, stand-alone entities, it comes under E. If the expense arises from stocking, funding, and testing the resolution toolkit deployed at failure, it is accounted for in C.

Lemma 1 ($e^{*\prime}(\phi) \geq 0$) From (4) and $c'' > 0$,

$$e^{*\prime}(\phi) = \frac{(1-\theta)\,\alpha\,F\,\Xi'(\phi)}{c''^{*}(\phi))} \;\geq\; 0. \tag{7}$$

Thus preparedness rises with separability; omitting $e^{*\prime}(\phi)$ in marginal effects understates the benefits of structure.

Next, define $z := (R + \gamma e^{*}(\phi))/\Lambda(\phi)$. The exact marginal effect of structure on loss is

$$-\,S_\phi = a + (1-\theta)\,b\left\{\Xi'(\phi)\,\Phi(z) + \Xi(\phi)\,\Phi'(z)\,\frac{\gamma e^{*\prime}(\phi))\,\Lambda'(\phi)}{\Lambda(\phi)^2}\right\}. \tag{8}$$

We call the braces the *full structural amplifier*, $A_{\text{full}}(\phi, R)$. For transparent sufficient conditions we also use a *conservative amplifier* that drops the nonnegative $e^{*\prime}(\phi)$ term,

$$\tilde{A}(\phi, R) := \Xi'(\phi)\,\Phi(z) + \Xi(\phi)\,\Phi'(z)\,z\left(-\frac{\Lambda'(\phi)}{\Lambda(\phi)}\right) \;\leq\; A_{\text{full}}(\phi, R). \tag{9}$$

With these preliminaries we may now establish that banks choose 'too little' structure:

Lemma 2 (Banks choose too little structure) Assume $E''(\cdot) > 0$, $-S_\phi > 0$ on the relevant region, and $0 \leq \rho < \lambda$. Any interior solutions satisfy $\phi^P < \phi^*$.

Proof. First-order conditions at interior points are

$$(1-\lambda)\,E'(\phi^P) = \rho\left[-S_\phi\big(\phi^P, R, e^{*}(\phi^P); \theta\big)\right], \tag{10}$$

$$(1-\lambda)\,E'(\phi^*) = \lambda\left[-S_\phi(\phi^*, R, e^{*}(\phi^*); \theta)\right]. \tag{11}$$

Let $B(\phi) := -S_\phi(\phi, R, e^{*}(\phi); \theta) > 0$. Since $\lambda > \rho$ and E' is strictly increasing, (11) requires a larger argument than (10), hence $\phi^* > \phi^P$. $\square$

Remark (general cost scale). If the bank perceives a structural-cost scale $\kappa \neq 1-\lambda$, replace $(1-\lambda)E'(\cdot)$ on the left of (10) by $\kappa E'(\cdot)$. The conclusion still holds whenever $\lambda/(1-\lambda) > \rho/\kappa$.

Moreover, the wedge grows with the amplifier:

Lemma 3 Let $-S_\phi = a + (1-\theta)\, b\, \mu\, \tilde{A}(\phi, R)$ with scale $\mu \geq 0$. Evaluate at strict local minima (Hessian positive definite). Then

$$\frac{d\phi^*}{d\mu} = \frac{\lambda(1-\theta)b\,\tilde{A}}{(1-\lambda)E''(\phi^*) - \lambda S_{\phi\phi}(\phi^*)} > 0, \qquad \frac{d\phi^P}{d\mu} = \frac{\rho(1-\theta)b\,\tilde{A}}{(1-\lambda)E''(\phi^P) - \rho S_{\phi\phi}(\phi^P)} > 0, \tag{12}$$

so $d(\phi^* - \phi^P)/d\mu > 0$. Evaluated at $\mu = 1$, the wedge increases with the (conservative) amplifier $\tilde{A}$. Since $A_{\text{full}} \geq \tilde{A}$, the statement *a fortiori* holds with A_{full}.

Sketch. Differentiate (11) and (10) with respect to μ and apply the implicit function theorem. Denominators are positive at strict local minima.

The central implication of the above is that there is under-investment in R to the extent that it is a private choice:

Proposition 1 Suppose the bank also chooses R with $C''(R) > 0$. If $S_{\phi R} < 0$ (strategic complements in loss reduction), then $\phi^P < \phi^*$ implies $R^P < R^*$ locally.

Sketch. The additional FOCs are

$$(1-\lambda)\, C'^{P}) = \rho\big[-S_R(\phi^P, R^P, e^*(\phi^P); \theta)\big], \qquad (1-\lambda)\, C'^{*}) = \lambda\big[-S_R(\phi^*, R^*, e^*(\phi^*); \theta)\big]. \tag{13}$$

With $S_{\phi R} < 0$, lowering ϕ reduces $-S_R$; strict convexity of $C(\cdot)$ then gives $R^P < R^*$.

The economic intuition is obvious. Banks internalise only a fraction of the social loss ($\rho < \lambda$). Because structure increases the productivity of resolution (the amplifier), the private choice under-invests in ϕ–and, under complementarity, under-invests in R as well.

6 Systemic loss aggregator and the no-frictions case

Having introduced the general loss aggregator in (1), it is useful to identify the friction-free variant that our specification generalises. In this limiting case: (i) structural separability does not alter the efficacy of resolution; (ii) separability does not reduce the liquidity needed to execute resolution; (iii) resources buy linear coverage; and (iv) authorities are fully committed to execute resolution. Formally, impose the neutral restrictions

$$\Xi(\phi) \equiv 1, \qquad \Lambda(\phi) \equiv \Lambda_0, \qquad \Phi(x) = x, \qquad \theta = 0. \tag{14}$$

Under (14), (1) collapses to

$$\begin{aligned} S(\phi, R, e; 0) &= S_0 - a\phi - b\,\frac{R + \gamma e}{\Lambda_0} \\ &= \underbrace{S_0 - \tfrac{b\gamma e}{\Lambda_0}}_{\text{constant}} - a\,\phi \; - \; \tfrac{b}{\Lambda_0}\,R\;, \end{aligned} \tag{15}$$

so treating e as fixed (not a policy instrument) shifts the baseline and rescales b without affecting the trade-off between ϕ and R. Hence S depends on (ϕ, R) only through the linear index

$$m(\phi, R) := a\,\phi + \frac{b}{\Lambda_0}\,R.$$

Any two policy mixes with the same m are outcome–equivalent for S. Choice therefore collapses to minimising implementation cost $(1 - \lambda)E(\phi) + C(R)$ along an iso–m set.

This is the precise sense in which "resolution can substitute for structure" in our framework: one unit of ϕ and $(b/\Lambda_0)/a$ units of R buy identical, linear reductions in loss. It also makes clear what must hold simultaneously for that substitutability to be valid: no efficacy effect ($\Xi'(\phi) = 0$), no liquidity effect ($\Lambda'(\phi) = 0$), no diminishing returns ($\Phi'' = 0$), and no execution risk ($\theta = 0$). The no-frictions case reveals when a pure cost-minimisation over instruments is legitimate—namely, when structure and resolution buy identical resilience units at fixed rates. This case is important for a key conclusion of the Skeoch Review that resolution should, in effect, substitute for ring-fencing. Our framework makes explicit some of the central assumptions on which that conclusion rests. Where structure measurably raises the effectiveness of execution, reduces the liquidity required on the day, or where politics makes execution uncertain, the neutral case fails and structure and resolution become strict complements, as we show below. Once one admits even small, empirically grounded frictions—structure helping resolution to bite, structure shrinking the liquidity bridge, diminishing returns, or uncertain execution—the "same-good, fixed-price" logic breaks, and the value of structure rises precisely because it makes resolution more effective and more usable when it counts. Indeed as we show, improved resolution typically implies a *tighter* ringfence. First, however, we state two arguments that formalise the intuitive discussion of this section.

Proposition (No frictions) *Under the no-friction restrictions* (14)*, expected loss depends only on the linear index*

$$I(\phi, R) \equiv a\,\phi + \widetilde{b}\,R, \qquad \widetilde{b} \equiv \frac{b}{\Lambda_0}, \tag{16}$$

and any pair (ϕ, R) *with the same index is outcome-equivalent. Policy therefore reduces to pure cost minimisation: Among all* (ϕ, R) *delivering the same* I*, pick the least-cost pair according to* $(1-\lambda)E(\phi) + C(R)$*, where* E *and* C *are convex.*

Proof. Impose (14) on (1) and treat e as a fixed constant. Then

$$S(\phi, R, e; 0) = \underbrace{\left(S_0 - b\,\tfrac{\gamma e}{\Lambda_0}\right)}_{\widetilde{S}_0} - a\,\phi \;-\; \frac{b}{\Lambda_0}\,R = \widetilde{S}_0 - I(\phi, R). \tag{17}$$

Hence S depends on (ϕ, R) only through $I(\phi, R)$ in (16).

(i) Welfare form. The planner minimises

$$\mathcal{L}(\phi, R) = \lambda\, S(\phi, R, e; 0) + (1-\lambda)E(\phi) + C(R) = \lambda \widetilde{S}_0 + \Big[(1-\lambda)E(\phi) + C(R)\Big] - \lambda\, I(\phi, R). \tag{18}$$

Fix any target index $\bar{I}$. Among all (ϕ, R) with $I(\phi, R) = \bar{I}$, the first and third terms are constant; therefore the welfare problem is equivalent to

$$\min_{\phi,R}\ (1-\lambda)E(\phi) + C(R) \quad \text{subject to} \quad I(\phi, R) = \bar{I}. \tag{19}$$

If the optimum is interior, the Lagrange multiplier rule yields $E'(\phi) = \mu\, a/(1-\lambda)$ and $C'(R) = \mu\, \widetilde{b}$, i.e. equalised marginal cost per unit of index across instruments. With linear E, C the solution is a corner on the cheaper instrument per unit of index.

(ii) Target form. The least-cost way to reach a resilience requirement $\bar{m}$ solves

$$\min_{\phi,R}\ (1-\lambda)E(\phi) + C(R) \quad \text{subject to} \quad I(\phi, R) \geq \bar{m}. \tag{20}$$

At the solution the constraint binds (otherwise reduce both instruments and lower cost), so (20) reduces to (19) with $\bar{I} = \bar{m}$. Convexity of E, C and linearity of the constraint ensure existence and global optimality. Thus all (ϕ, R) with $I(\phi, R) = \bar{m}$ are outcome-equivalent for S, and the planner chooses the least-cost point along that iso-index. $\square$

In the irrelevance baseline, the cross-partial vanishes ($\partial^2 S/\partial\phi\, \partial R = 0$) and the marginal rate of substitution along $I(\phi, R)$ is constant, and $dR/d\phi = -(a/\widetilde{b})$. Instruments are perfect substitutes for systemic loss and only their costs break the tie.

Theorem (Generic Complementarity) Let Φ be increasing and concave, Λ nonincreasing, and Ξ nondecreasing. Fix a compact policy domain $\mathcal{K} = [\underline{\phi}, \overline{\phi}] \times [0, \overline{R}] \times [0, \overline{e}]$ with $\underline{\phi} \geq 0$ and $\overline{R}, \overline{e} < \infty$. If either $\Xi'(\phi) > 0$ on a set of positive measure in $[\underline{\phi}, \overline{\phi}]$ or $\Lambda'(\phi) < 0$ on a set of positive measure there, then there exists a nonempty open set $U \subset \mathcal{K}$ on which

$$\frac{\partial^2 S}{\partial\phi\,\partial R}(\phi, R, e; \theta) < 0 \quad \text{and} \quad \frac{\partial^2 S}{\partial\phi\,\partial e}(\phi, R, e; \theta) < 0. \tag{21}$$

Moreover, if $\Phi'' < 0$ and $\Lambda'(\phi) < 0$ on a set of positive measure, the open set U can be chosen larger (concavity amplifies the effect).

Proof See the Appendix

Note, that in the case, $\Xi'(\phi) \equiv 0$, $\Lambda'(\phi) \equiv 0$, and $\Phi''(\cdot) \equiv 0$, crucial cross-partials derived in the appendix are zero. This is the friction-free "perfect substitutes" case.

Tightening structure raises the marginal effectiveness of both formal resolution capacity R and non-contractible preparedness e. It does so directly (better *efficacy*, $\Xi'(\phi) > 0$) and indirectly by shrinking the liquidity bridge (more slack per unit of resources when $\Lambda'(\phi) < 0$). With diminishing returns $\Phi'' < 0$, the slack channel is especially powerful since when the bridge is smaller, the system operates on a steeper portion of Φ, so each unit of R or e yields more loss reduction at the margin. Complementarity is generic in the sense that apart from the knife-edge linear-neutral case, structure and resolution/preparedness reinforce each other. This implies (i) marginal *crowding-in*—investing in structure increases the payoff to investing in resolution and preparedness, and vice versa; and (ii) comparative statics that can run counter to "substitution" narratives (e.g., strengthening resolvability may *raise* the optimal level of structure when the amplifier terms are strong).

The mathematical conditions that deliver these results arguably correspond to widely observed facts; structure improves executability and reduces liquidity needs, and resources face diminishing returns. Under those conditions, the cross-partials are negative on a nontrivial region, so instruments are *not* substitutes. This is the sense in which the Skeoch argument ("resolution can substitute for ring-fencing") rests on the knife-edge equalities; once real-world frictions are admitted, the policy mix becomes complementary rather than substitutable.

Indeed, one can go further and show that, typically, better resolution implies a *tighter* optimal ring-fence (as Lemma 1 above implied).

Recall, the planner chooses (ϕ, R) to minimise

$$\mathcal{L}(\phi, R; \theta) = \lambda\, S(\phi, R, e; \theta) + (1 - \lambda)\, E(\phi) + C(R), \tag{22}$$

where E and C are convex implementation costs, and $\lambda \in (0, 1)$ is the welfare weight on expected loss. Thus,

Theorem (Better resolution can tighten the optimal ring fence) Suppose E and C are twice continuously differentiable with $E''(\phi) \geq \underline{e} > 0$ and $C''(R) \geq \underline{c} > 0$ on a compact domain, and (14) holds with at least one strict inequality on a set of positive measure. Let $(\phi^*(\theta), R^*(\theta))$ be an interior solution to the planner's problem. Then the optimal structure is *increasing* in resolution credibility:

$$\frac{\partial \phi^*}{\partial(1-\theta)}(\theta) \;>\; 0 \qquad \text{equivalently} \qquad \frac{\partial \phi^*}{\partial \theta}(\theta) \;<\; 0. \tag{23}$$

Proof See the Appendix.

If all three amplifier channels are exactly neutral (the knife-edge case $\Xi' \equiv 0$, $\Lambda' \equiv 0$, $\Phi'' \equiv 0$), then $F_\theta = G_\theta = 0$ and $F_R = 0$, so equation (75) in the appendix gives $\partial\phi^*/\partial\theta = 0$. Any strict departure (on a set of positive measure) restores $N > 0$ and hence (23) (proved as (68) in the appendix.

Note, that the effect is local. If ϕ is already so tight that the amplifier saturates at the current ϕ^* (i.e. $\Xi'(\phi^*)) \approx 0$ and $-\Lambda'(\phi^*)) \approx 0$), then a fall in θ can justify easing ϕ at the margin. This is not a contradiction; it is the boundary where structure has "done its work" and remaining gains are dominated by cost. The Appendix provides fuller details on this case.

7 Multi-tasking, endogenous complementarity, and screening

The earlier sections established that structural separability (ϕ) and resolvability capacity (R) are *generic complements* in reducing expected systemic loss. This section adds a simple *multi-tasking* micro-foundation to show two things: (i) why complementarity emerges endogenously when resolution requires both real—hard-to-contract—preparedness effort (e) and verifiable structure (ϕ), and (ii) how a simple *single-crossing* logic lets a regulator separate "serious" from "glossy-plan" banks using a menu of structural choices paired with charges (or reliefs). Technically, ϕ raises the marginal productivity of e, which feeds back into the planner's objective; and with costly effort, the benefit of the high-ϕ option increases *more* for the low-cost (serious) type, delivering standard single-crossing and self-selection.

There is private information in this environment. The effort-cost parameter k (how expensive it is to turn paper plans into real capability) is privately known to the bank, and actual preparedness effort e is only imperfectly observable and contractible. The regulator therefore faces both adverse selection (unknown k) and moral hazard (hidden e). The single-crossing property gives a way to screen despite those frictions. As we show, legal ring-fencing is not the only conceivable fix, but it is a bundled, enforceable way to make the preparedness technology productive and to screen types when supervisory capacity (or efficacy) is limited. It complements our earlier analysis by showing, with a minimal multi-task structure, how separability raises the return to real effort and how a simple menu can separate banks that invest in substance from those that do not.

A bank chooses two tasks: an unobservable preparedness effort $e \geq 0$ (tests, OCIR, LIR arrangements, drills) and a verifiable separation level $\phi \geq 0$ (ring-fence tightness). The probability that resolution *works* is

$$p(e, \phi) = \pi_0 + \alpha\, e\, \psi(\phi), \qquad \psi'(\phi) > 0,\ \psi(\phi) \geq 0,\ \pi_0 \in [0, 1). \tag{24}$$

Let $F > 0$ denote the bank's private marginal value of successful execution (e.g., survival/avoided sanction/franchise value). Given ϕ, the bank chooses e to

$$\max_{e \geq 0} \; (1-\theta)\,\alpha\,F\,e\,\psi(\phi) \;-\; c(e), \qquad c''(e) > 0, \tag{25}$$

with first-order condition

$$c'\big(e^*(\phi)\big) = (1-\theta)\,\alpha\,F\,\psi(\phi). \tag{26}$$

By $c'' > 0$ and $\psi'(\phi) > 0$,

$$e^{*\prime}(\phi) = \frac{(1-\theta)\,\alpha\,F\,\psi'(\phi)}{c''\big(e^*(\phi)\big)} \;\geq\; 0. \tag{27}$$

More separability increases the *return* to real preparedness ($\psi'(\phi) > 0$), so banks optimally exert more real effort; leaving $e^{*\prime}(\phi)$ out of marginal effects is conservative.

Now we consider the Planner's loss and endogenous complementarity. Let $L > 0$ be the loss if resolution fails; allow a direct structural loss-reduction $a\phi$ even holding e fixed. With implementation cost $E(\phi)$ and weight $\lambda \in (0,1)$,

$$\mathcal{L}(\phi) = \lambda\Big[L\big(1 - p(e^*(\phi),\phi)\big) - a\,\phi\Big] \;+\; (1-\lambda)E(\phi). \tag{28}$$

Using the above relations and differentiating we get that

$$\frac{d}{d\phi}p\big(e^*(\phi),\phi\big) = \underbrace{\alpha\,e^*(\phi)\,\psi'(\phi)}_{\text{direct efficacy}} \;+\; \underbrace{\alpha\,\psi(\phi)\,e^{*\prime}(\phi)}_{\text{induced effort}}, \tag{29}$$

$$\frac{d\mathcal{L}}{d\phi} = -\,\lambda\Big[L\,\frac{d}{d\phi}p\big(e^*(\phi),\phi\big) + a\Big] \;+\; (1-\lambda)E'(\phi). \tag{30}$$

The induced-effort term makes the marginal social benefit of structure larger than the direct efficacy effect alone. Thus, complementarity is *endogenous.*

Now consider the 'decentralised' outcomes with two-type screening and single-crossing. Let types $i \in \{S, G\}$ (serious vs. glossy) have quadratic effort costs $c_i(e) = \frac{1}{2}\,k_i e^2$ with $0 < k_S < k_G$. From the first order condition for preparedness:

$$e_i^*(\phi) = \frac{(1-\theta)\,\alpha\,F}{k_i}\,\psi(\phi). \tag{31}$$

Type-i value at $(e_i^*(\phi), \phi)$ is

$$U_i(\phi;\tau) = \frac{\big((1-\theta)\,\alpha\,F\,\psi(\phi)\big)^2}{2k_i} \;-\; \tau(\phi), \tag{32}$$

where $\tau(\phi)$ is a verifiable add-on paired with ϕ (e.g. a fee or requirement adjustment). Consider a menu (ϕ_H, τ_H) vs. (ϕ_L, τ_L) with $\phi_H > \phi_L \geq 0$. Incentive compatibility (IC) requires

$$\text{Serious picks } H\text{:} \quad \frac{\psi(\phi_H)^2 - \psi(\phi_L)^2}{k_S} \;\geq\; \frac{2(\tau_H - \tau_L)}{\big((1-\theta)\,\alpha\,F\big)^2}, \tag{33}$$

$$\text{Glossy picks } L\text{:} \quad \frac{\psi(\phi_H)^2 - \psi(\phi_L)^2}{k_G} \;\leq\; \frac{2(\tau_H - \tau_L)}{\big((1-\theta)\,\alpha\,F\big)^2}. \tag{34}$$

Because $k_S < k_G$, the left-hand side gain from moving to ϕ_H is larger for the serious type, so there is a non-empty set of $(\phi_H, \phi_L, \tau_H - \tau_L)$ that satisfies both IC constraints: the menu *separates* types by standard single-crossing. The single-crossing is the Spence–Mirrlees condition (type-specific indifference curves cross once and only once). With serious vs. glossy types $i \in \{S, G\}$ and utility

$$U_i(\phi;\tau) = \frac{K}{2k_i}\,\psi(\phi)^2 - \tau(\phi), \qquad K = \big((1-\theta)\alpha F\big)^2, \quad k_S < k_G,$$

the marginal utility of structure is

$$\frac{\partial U_i}{\partial \phi} = \frac{K}{k_i}\,\psi(\phi)\psi'(\phi) - \tau'(\phi).$$

Therefore

$$\frac{d}{d\phi}\big[U_S(\phi;\tau) - U_G(\phi;\tau)\big] = K\left(\frac{1}{k_S} - \frac{1}{k_G}\right)\psi(\phi)\psi'(\phi) \;>\; 0.$$

The serious type's marginal gain from tighter structure is always larger than the glossy type's. This strict monotone ordering guarantees separation with a simple menu: Offer a higher-ϕ option paired with a lighter add-on and a lower-ϕ option paired with a heavier add-on; the serious bank self-selects into the tighter structure.[26]

The intuition is straightforward. Tighter structure (higher ϕ) makes real preparedness e more productive. A bank for whom genuine preparedness is relatively cheap (low k) values ϕ more than a bank for whom preparedness is costly (high k). A two-option menu—tight ϕ with lighter extras versus looser ϕ with heavier extras—therefore sorts types without needing to observe k or e directly. The crossing happens once, so the sorting is clean. The key takeaways then are (i) *Endogenous complementarity:* ϕ raises the productivity of real preparedness e, so the social marginal value of structure includes induced effort—tightening the ring-fence increases the effectiveness of resolution in equilibrium. (ii) *Screening:* a simple two-option menu (ϕ_H vs. ϕ_L separates serious from glossy banks because the benefit of ϕ_H rises more for the low-cost type. Both mechanisms map back to the main framework in which ϕ increases execution efficacy and shrinks the liquidity bridge.

Can some form of regulation fix the problem without legal ring-fencing? In principle, yes. In practice, most fixes would have to reproduce ring-fence elements one by one. A first route is to use menus that trade tighter ϕ for relief elsewhere. For example, a bank can opt into a tighter separability perimeter in exchange for lighter add-ons such as lower capital or MREL surcharges or lighter reporting burdens. A second route is outcome-based incentives whereby the resolution authority/prudential regulator might

[26] The two main technical arguments of this section can be verified as follows. Argument 1 (Crowd-in of preparedness). If $\Xi'(\phi) > 0$ and $c''(e) > 0$, then $e^{*\prime}(\phi) \geq 0$. To show this, differentiate the FOC for e w.r.t. ϕ: $c''\big(e^*(\phi)\big)\, e^{*\prime}(\phi) = (1-\theta)\alpha F\, \Xi'(\phi)$. The RHS is nonnegative; divide by $c'' > 0$. Argument 2 (Screening by structure). With $c_i(e) = \frac{1}{2}k_i e^2$, $0 < k_S < k_G$, and $\Xi'(\phi) > 0$, the menu $\{(\phi_H, \tau_H), (\phi_L, \tau_L)\}$ with $\phi_H > \phi_L$ can be made separating by choosing $\tau_H - \tau_L$ to satisfy the two incentive compatibility relations. To verify thus, plug the expression for type-i utility into the two IC constraints. Because $k_S < k_G$, the RHS bounds define a nonempty interval for $(\tau_H - \tau_L)$. Ultimately, the connection to the main model is that the equation above for $e^{*\prime}(\phi)$ microfounds the assumption that the efficacy channel rises with ϕ. The screening result explains why a verifiable ϕ is a useful supervisory lever even when preparedness is unobservable.

impose stricter liquidity-in-resolution and operational-continuity tests with credible pass/fail consequences. That would incentivise banks with low k voluntarily to invest and pass while high-k banks would face heavier requirements. A third route is to price the externalities. That would mean somehow differentiating deposit-insurance premia, systemic-risk surcharges, or MREL calibration, making them rise when ϕ is low so that the private cost 'curve' tilts toward the social one. A fourth route is to mandate verifiable proxies such as OCIR contracts, internal MREL pre-positioning at material subsidiaries, booking hygiene, FMI alignment, and periodic live drills. All of these push in the direction of higher ϕ and higher real preparedness, but they require many separate rules and constant monitoring. Legal ring-fencing is the bundled version: it fixes the separability perimeter ex ante, raises the return to real preparedness on day one, and screens types with fewer moving parts.

In short, single-crossing provides the technical backbone for a very practical insight. When structure makes real preparedness productive, banks that can cheaply produce preparedness always value tighter structure more than those that cannot. A simple menu can sort them, and a legal ring-fence is the most compact way to implement that menu at scale. Other regulatory mixes can mimic it, but they may tend to be leakier and costlier to supervise—and they rebuild, piece by piece, the very separability that the ring-fence provides in one stroke.

8 Discussion

Our framework yields a simple organising principle: Ring-fenced separability (ϕ) and run-time resolvability (R) are strategic complements once either of two empirically plausible channels is active—structure raises execution efficacy or shrinks the liquidity bridge. That generic complementarity result, together with the dual welfare/target formulation, gives a robust policy lens that does not depend on how the objective is written. Two further results matter for design. First, the "inverted" comparative static (credibly better resolution often *raises* the optimal ϕ). And, second, the private–social wedge as banks under-invest in ϕ and, therefore, in R when they do not internalise systemic loss. A simple multi-task micro-foundation delivers single-crossing where tighter ϕ raises the return to real, hard-to-contract preparedness, allowing simple menus to separate "serious" from "glossy" banks.

The substitution view–easing ϕ as R improves–can be locally justified in our framework. It requires both (i) a flat structural amplifier at the margin (structure neither increases execution efficacy nor reduces the liquidity bridge around the operating point), and (ii) steep marginal implementation costs of structure. In practice this corresponds to very high ϕ, or to regimes where observable stress wedges between ring-fenced and non-ring-fenced entities are negligible and liquidity-in-resolution/OCIR metrics are insensitive to perimeter alterations. If supervisors are content that these are facts around today's operating point, easing ϕ is coherent in our framework. However, in our view there are substantive reasons for believing that substitution is fragile as a design principle. Outside that knife-edge, the case for "R instead of ϕ" runs into five problems. First, resolution "grips" only if ϕ-like preconditions already exist (clean perimeters, pre-positioned loss-absorbing capacity where needed, OCIR contracts, booking hygiene, FMI alignment). Starving ϕ risks having to recreate it piecemeal inside R; that, in fact, would not be substitution. Second, with lower ϕ the liquidity bridge is likely to be larger. Substituting with R then demands very high assured liquidity-in-resolution—leaning on central-bank/fiscal backstops and legal waivers exactly when politics is least accommodating. The substitution view implicitly assumes authorities will always use bail-in; experience suggests the opposite in bad states. Third, if the policy position is "more R, less ϕ," banks face weaker incentives to invest in verifiable separability and can meet checks with glossy plans. In our multi-task model, low ϕ lowers the marginal productivity of real preparedness; the risk is pretence over substance. Meanwhile, the cost story can invert, meaning that relaxing ϕ raises the liquidity bridge and lowers efficacy, so holding resilience constant requires more bail-in, more pre-positioning, and more LIR—real costs that may be omitted in any narrative that "ϕ is costly, R is cheap." Fourth, market plumbing and irreversibility risks attend a low ϕ that might leave entanglement across entities, transmitting resolution actions via FMIs, netting sets, and intraday queues. The risk is one of externalities–one might swap a firm-level fix for system-level fragility. Moreover, it is worth noting that ϕ has an option value. It can be dismantled quite quickly but rebuilt only slowly if at all. So even if a static snapshot suggested $\phi^* = 0$, reactivation costs and time-to-build give the current ϕ (option) value. Fifth, there are important considerations regarding cross-border dependence and market signals. Heavier reliance on single-point-of-entry and foreign recognition increases exposure to legal/political blocks abroad. If R truly substituted for ϕ, stress-period funding spreads of ring-fenced vs non-ring-fenced entities should converge; where they do not, markets are pricing ϕ's safety/liquidity edge, not its redundancy.

9 Conclusion and policy implications

Resolution is a powerful tool, but only in the states where it is used. Political uncertainty (our θ) makes those states less likely just when it matters most. Ring-fencing is state-contingent insurance—it reduces loss whether or not resolution is executed. The right design question, we suggest, is joint calibration, not replacement. Easing ϕ as R improves is appropriate only once supervisors can show the amplifier is locally exhausted—i.e., stress wedges are small and LIR/OCIR metrics are flat in ϕ around the current regime—and remains flat under stress. Otherwise, better R strengthens the case for tighter ϕ. For the UK, this argues for refinement rather than ultimate repeal.

That is, align the perimeter with the preferred resolution strategy; remove avoidable duplication, and preserve the firewall where it buys the largest reduction in expected systemic loss.

Our framework is deliberately stylised, but its testable implication would to try to document whether structure still improves execution efficacy or reduces the liquidity bridge at the margin, and whether those gains persist in stress. Two further extensions seem important. First, endogenise perimeter arbitrage (risk migration into non-banks) to gauge how ϕ and R should adapt in a system with shifting boundaries. Second, bring home/host heterogeneity into the framework and examine the complementarity cross-partial in cross-country data.

10 Appendix

10.1 Planner's problem and welfare and target form duality

Recall that in the main text for notational ease, we defined the *resilience index* as:

$$M(\phi, R) \equiv a\phi + (1-\theta) b \Xi(\phi) \Phi\Big(\frac{R + \gamma e^*(\phi)}{\Lambda(\phi)}\Big), \qquad G(\phi, R) \equiv (1-\lambda) E(\phi) + C(R).$$

Then $S(\phi, R, e^*; \theta) = S_0 - M(\phi, R)$ and the planner's trade-off is between M and G.

The planner chooses instruments, in the welfare formulation, to equate marginal implementation cost to a shadow value of resilience ($\nabla G = \lambda \nabla M$). In the target formulation, the planner minimises implementation cost subject to a resilience requirement, yielding the same stationarity condition with multiplier μ^*. We need to establish that under convexity and Slater's condition, $\mu^* = \lambda$ and the two programmes are dual.

The welfare form problem is

$$\min_{\phi, R} \ \mathcal{L}(\phi, R) = \lambda\, S(\phi, R, e^*(\phi); \theta) + (1-\lambda)\, E(\phi) + C(R) = \lambda S_0 + G(\phi, R) - \lambda\, M(\phi, R). \tag{35}$$

Since λS_0 is constant, the welfare problem is equivalent to

$$\min_{\phi, R} \ \Psi_\lambda(\phi, R) \ \equiv \ G(\phi, R) - \lambda\, M(\phi, R).$$

The target form problem is

$$\min_{\phi, R} \ G(\phi, R) \quad \text{subject to} \quad M(\phi, R) \ \geq \ \bar{m}, \tag{36}$$

where $\bar{m}$ is a resilience requirement (e.g. a pass threshold in a system-wide test). The Lagrangian is

$$L(\phi, R, \mu) \ = \ G(\phi, R) \ - \ \mu\, [\, M(\phi, R) - \bar{m}\,], \qquad \mu \geq 0.$$

Duality (equivalence) result and proof *Assumptions.* E, C are convex and differentiable; M is concave in (ϕ, R) (monotone with diminishing returns) so that $-M$ is convex; Slater holds for (36) (there exists (ϕ, R) with $M(\phi, R) > \bar{m}$).

Claim. For any $\lambda \in (0, 1)$, let $(\phi^\star, R^\star)$ solve the welfare problem. Set $\bar{m} := M(\phi^\star, R^\star)$ and $\mu^\star := \lambda$. Then $(\phi^\star, R^\star)$ solves the target problem with multiplier $\mu^\star$, and conversely any solution of the target problem with active constraint and multiplier $\mu^\star$ solves the welfare problem with $\lambda = \mu^\star$.

Proof. Consider $\mathcal{L}(\phi, R)$ in the equivalent form $\min_{\phi,R} G(\phi, R) - \lambda M(\phi, R)$. First-order conditions (sufficient by convexity) at $(\phi^\star, R^\star)$ are

$$\nabla_\phi G(\phi^\star, R^\star) - \lambda \nabla_\phi M(\phi^\star, R^\star) = 0, \qquad \nabla_R G(\phi^\star, R^\star) - \lambda \nabla_R M(\phi^\star, R^\star) = 0.$$

Now form the target problem (36) with $\bar{m} := M(\phi^\star, R^\star)$ and Lagrangian $L(\phi, R, \mu)$. The Karush-Kuhn-Tucker (KKT) conditions are:

$$\nabla_\phi G(\phi, R) - \mu \nabla_\phi M(\phi, R) = 0, \quad \nabla_R G(\phi, R) - \mu \nabla_R M(\phi, R) = 0,$$

$$\mu \, [\, M(\phi, R) - \bar{m} \,] = 0, \quad M(\phi, R) \geq \bar{m}, \ \mu \geq 0.$$

At $(\phi^\star, R^\star)$ with $\mu^\star = \lambda$ we have stationarity and feasibility with $M(\phi^\star, R^\star) = \bar{m}$, so complementary slackness holds. By convexity and Slater,[27] KKT are sufficient; hence $(\phi^\star, R^\star)$ solves (36). The converse is identical: if $(\hat{\phi}, \hat{R}, \mu^\star)$ satisfies the KKT with active constraint, then $(\hat{\phi}, \hat{R})$ minimises $G - \mu^\star M$, which is $\mathcal{L}(\phi, R)$ with $\lambda = \mu^\star$. $\square$

The intuition is obvious. The welfare problem trades off marginal cost ∇G against marginal benefit $\lambda \nabla M$. The target problem trades off the same

[27]By 'convexity and Slater' is meant: (i) the target problem $\min_{\phi,R} G(\phi, R)$ s.t. $g(\phi, R) \leq 0$, with $G(\phi, R) = (1-\lambda)E(\phi) + C(R)$ convex and $g(\phi, R) \equiv \bar{m} - M(\phi, R)$ convex (since M is concave), is a convex program; (ii) Slater's condition holds, i.e. there exists $(\hat{\phi}, \hat{R})$ with $M(\hat{\phi}, \hat{R}) > \bar{m}$ (strict feasibility). Hence strong duality and KKT sufficiency obtain: any (ϕ, R, μ) satisfying KKT is a global optimum. Setting $\bar{m} = M(\phi^\star, R^\star)$ and $\mu^\star = \lambda$ shows the welfare optimum solves the target problem, and conversely. If Slater failed, KKT need not be sufficient; in our setting, $\bar{m}$ is chosen attainable and small increases in ϕ or R give strict slack, so Slater is satisfied. See Boyd and Vandenbergh (2009), pp.226ff.

objects through a multiplier μ. Picking $\bar{m}$ equal to the resilience actually delivered at the welfare optimum makes the target constraint bind at the same point; identifying $\mu^\star$ with λ aligns the marginal rate of substitution with the constraint's shadow price. Thus the two representations are different parameterisations of the same policy choice.[28]

Remarks on $e^*(\phi)$. Because preparedness is induced by ϕ, it is already embedded in $M(\phi, R)$: the chain rule ensures that ∇M carries the $e^*(\phi)$ dependence via

$$\frac{\partial M}{\partial \phi} = a + (1{-}\theta)b\left[\Xi'(\phi)\,\Phi(\cdot) + \Xi(\phi)\,\Phi'(\cdot)\,\frac{R+\gamma e^*(\phi)}{\Lambda(\phi)}\Big(-\frac{\Lambda'(\phi)}{\Lambda(\phi)}\Big) + \Xi(\phi)\,\Phi'(\cdot)\,\frac{\gamma\, e^{*\prime}(\phi)}{\Lambda(\phi)}\right],$$

with $e^{*\prime}(\phi)$ pinned down by $c^{\prime\prime *}(\phi)\, e^{*\prime}(\phi) = (1-\theta)\alpha F\,\Xi'(\phi)$. This affects marginal terms inside ∇M that enter both formulations symmetrically; it does not affect the duality result. Replace Ξ with ψ in the multi-tasking notation—they are the same "efficacy" channel.

[28] On welfare–target duality, as our claims in the text make clear, we rely on standard convex-programming regularity: smooth objectives, convex implementation costs $E(\cdot)$, $C(\cdot)$, a resilience aggregator $S(\phi, R)$ that is increasing and (locally) concave in (ϕ, R), and a strictly feasible point (Slater). The "two" problems then give the same (ϕ^*, R^*). Under these conditions KKT holds, the duality 'gap' is zero, and there is a one-to-one mapping between the welfare weight on resilience and the tightness of the target; the Lagrange multiplier in the target form is the shadow price of tightening the resilience requirement. Three caveats matter in practice. (i) Stepwise or thresholded rules (e.g., scope thresholds, pass/fail resolvability findings, minimum MREL floors) introduce kinks and can make costs non-convex; then shadow prices should be read as subgradients, and the mapping can be piecewise rather than global. (ii) Corners ($\phi = 0$ or $R = 0$) and binding hard floors yield set-valued multipliers; duality still guides comparative statics, but locally around the active face. (iii) Irreversibilities/time-to-build (fixed set-up costs for structure, one-off IT/OCIR remediation) are mixed-integer features; a common approach is to work with smoothed or "average" costs for policy design and report results as local (interior) comparative statics. Our proofs are explicitly local: we verify positive definiteness of the Hessian around the operating point and interpret multipliers as shadow prices only when the target binds and the solution is interior; at thresholds we revert to subgradient language and piecewise analysis.

10.2 The planning problem solution

We begin by studying the planning problem. Recall the basis: Structure $\phi \in [0,1]$ indexes ring-fence tightness; $R \geq 0$ is formal resolution capacity; $e \geq 0$ is non-contractible preparedness effort; $\theta \in [0,1)$ is the probability that resolution is *not* executed. Expected systemic loss is

$$S(\phi, R, e; \theta) = S_0 - a\,\phi - (1-\theta)\,b\,\Xi(\phi)\,\Phi\Big(\frac{R+\gamma e}{\Lambda(\phi)}\Big),$$

with $a, b, \gamma > 0$, $\Phi' > 0$, $\Phi'' \leq 0$, $\Lambda' \leq 0$, and $\Xi' \geq 0$. Implementation costs are convex: $E''(\phi) \geq \underline{e} > 0$, $C''(R) \geq \underline{c} > 0$. The planner minimises

$$\mathcal{L}(\phi, R; \theta) = \lambda\, S(\phi, R, e; \theta) + (1-\lambda)\, E(\phi) + C(R), \qquad \lambda \in (0,1).$$

Let $z(\phi, R, e) = (R+\gamma e)/\Lambda(\phi)$ and define the *structural amplifier*

$$\mathcal{A}(\phi, R) := \Xi'(\phi)\,\Phi(z) \;+\; \Xi(\phi)\,\Phi'(z)\,z\Big(-\frac{\Lambda'(\phi)}{\Lambda(\phi)}\Big).$$

The interior first-order conditions (FOCs) are

$$F(\phi, R, \theta) := \lambda\,\frac{\partial S}{\partial \phi}(\phi, R, e; \theta) + (1-\lambda)E'(\phi) = 0, \tag{37}$$

$$G(\phi, R, \theta) := \lambda\,\frac{\partial S}{\partial R}(\phi, R, e; \theta) + C'(R) = 0. \tag{38}$$

With the shape restrictions and strictly convex costs, the local Hessian of $\mathcal{L}$ is positive definite at any interior solution.

Cramer's Rule Using these first-order conditions, we collect all required partial derivatives. Using $z_R = \partial z/\partial R = 1/\Lambda(\phi)$ and

$$z_\phi = \frac{\partial z}{\partial \phi} = -\frac{(R+\gamma e)\Lambda'(\phi)}{\Lambda(\phi)^2}, \qquad z_{\phi\phi} = \frac{\partial^2 z}{\partial \phi^2} = -\frac{(R+\gamma e)\big(\Lambda''(\phi)\Lambda(\phi) - 2(\Lambda'^2\big)}{\Lambda(\phi)^3}, \tag{39}$$

we have

$$S_\phi = -a - (1-\theta)b\Big[\Xi'(\phi)\Phi(z) + \Xi(\phi)\Phi'(z)\,z_\phi\Big], \tag{40}$$

$$S_R = -(1-\theta)b\,\Xi(\phi)\,\Phi'(z)\,z_R = -(1-\theta)b\,\Xi(\phi)\,\frac{\Phi'(z)}{\Lambda(\phi)}. \tag{41}$$

The second derivatives in (ϕ, R) are:

$$S_{\phi\phi} = -(1-\theta)b\Big[\Xi''(\phi)\Phi(z) + 2\Xi'(\phi)\Phi'(z)\,z_\phi + \Xi(\phi)\big(\Phi''(z)\,z_\phi^2 + \Phi'(z)\,z_{\phi\phi}\big)\Big], \tag{42}$$

$$S_{RR} = -(1-\theta)b\,\Xi(\phi)\,\Phi''(z)\,z_R^2 = -(1-\theta)b\,\Xi(\phi)\,\frac{\Phi''(z)}{\Lambda(\phi)^2}, \tag{43}$$

$$S_{\phi R} = \frac{\partial}{\partial R}S_\phi = -(1-\theta)b\Big[\Xi'(\phi)\Phi'(z)\,z_R + \Xi(\phi)\big(\Phi''(z)\,z_R z_\phi + \Phi'(z)\,z_{\phi R}\big)\Big], \tag{44}$$

with $z_{\phi R} = \partial z_R/\partial\phi = -\Lambda'^2$. Finally, the cross-derivatives with respect to θ are:

$$S_{\phi\theta} = \frac{\partial}{\partial\theta}S_\phi = b\Big[\Xi'(\phi)\Phi(z) + \Xi(\phi)\Phi'(z)\,z_\phi\Big], \tag{45}$$

$$S_{R\theta} = \frac{\partial}{\partial\theta}S_R = b\,\Xi(\phi)\,\frac{\Phi'(z)}{\Lambda(\phi)}. \tag{46}$$

Hessian, positive definiteness, and a sufficient dominance bound The following are regularity checks to certify that our local optimum exists and that the comparative statics behind our main propositions are valid under standard convexity and bounded-curvature conditions. They confirm our results are not knife-edge artefacts of a particular functional form. Specifically, recall that the welfare problem chooses instrument levels (ϕ, R) by minimizing a smooth loss. To use Cramer's rule for comparative statics (e.g. signs of $\partial\phi^*/\partial\theta$), we need the 2×2 matrix of second derivatives with respect to (ϕ, R)—the Hessian—to be positive definite (PD) at the optimum. PD guarantees a strict local minimum, a unique local solution, and an invertible Jacobian of FOCs, so small parameter changes translate into well-defined, signed responses. In terms of the bounds we calculate, our diagonal terms combine the curvature of implementation costs with any curvature from the loss aggregator: $F_\phi = (1-\lambda)E''(\phi) + \lambda S_{\phi\phi}$ and $G_R = C''(R) + \lambda S_{RR}$. Strict convexity of E and C is structural—it reflects duplication, trapped-liquidity, and funding costs that rise at the margin.

Cross-partials $S_{\phi R}$ capture complementarity; they can be negative but cannot be allowed to overwhelm own-curvature. The inequalities simply ensure that the own-curvature dominates the cross-pull locally. The small-gain lemma (Sylvester) and the diagonal-dominance corollary (Gershgorin) are standard to establish PD. They ensure: (i) $F_\phi > 0$ and $G_R > 0$; (ii) the determinant $\Delta = F_\phi G_R - F_R^2$ is strictly positive; hence (iii) the comparative statics we report—like the 'inverted-Skeoch' result—are locally well-posed and robust to bounded misspecification of S. We are not making global claims and only require PD on a neighbourhood of the optimum.

In terms of the inequalities, F_ϕ and G_R may be thought of as "net own-curvature" and $|F_R|$ as the "cross-pull".[29] The sufficient conditions demand that F_ϕ and G_R are each bigger than a small positive number while $|F_R|$ stays modest relative to their product. Intuitively: costs put enough curvature on each instrument that the complementarity between them does not create a flat direction.

Let the Hessian of $\mathcal{L}$ in (ϕ, R) be

$$H(\phi, R; \theta) := \begin{bmatrix} F_\phi & F_R \\ F_R & G_R \end{bmatrix} = \begin{bmatrix} \lambda S_{\phi\phi} + (1-\lambda)E''(\phi) & \lambda S_{\phi R} \\ \lambda S_{\phi R} & \lambda S_{RR} + C''(R) \end{bmatrix}. \quad (47)$$

By $\Phi'(x) > 0$, $\Phi''(x) \le 0$, $\Lambda'(\phi) \le 0$, and $\Xi'(\phi) \ge 0$, we have that $S_{RR} \ge 0$ (since $\Phi'' \le 0$) and, generically, $S_{\phi R} < 0$ (strategic complementarity). The local second-order condition for a strict minimum requires H positive definite:

[29] That is to say, net own–curvature follows from the diagonal terms F_ϕ and G_R as they measure how "bowl–shaped" the objective is in each instrument *on its own*. They add implementation–cost curvature (E'', C'') to any curvature from the system–loss aggregator $(S_{\phi\phi}, S_{RR})$. Larger $F_\phi, G_R \Rightarrow$ stronger local pull back toward the optimum when nudging a single instrument. On the other hand, cross–pull, the off–diagonal term $F_R = \lambda S_{\phi R}$, measures how changing one instrument tilts the marginal payoff of the other. If $S_{\phi R} < 0$ they are strategic complements (tightening the ring–fence raises the return to resolution capacity, and vice versa); if $S_{\phi R} > 0$ they are substitutes. A large $|F_R|$ tries to rotate the bowl into a valley that mixes ϕ and R. In other words, own–curvature dominates cross–pull, so the local minimum is strict and comparative statics (via Cramer's rule) are well–posed.

$F_\phi > 0$, $G_R > 0$, and

$$\Delta := F_\phi G_R - F_R^2 > 0. \tag{48}$$

Because $E'' \geq \underline{e} > 0$ and $C'' \geq \underline{c} > 0$, continuity of S implies the following diagonal-dominance lemma.

Lemma Diagonal dominance via convex costs Fix a compact policy set. There exist positive constants $(\varepsilon_\phi, \varepsilon_R)$ such that if

$$(1-\lambda)E''(\phi) \geq \varepsilon_\phi, \qquad C''(R) \geq \varepsilon_R, \qquad |\lambda S_{\phi R}| \leq \tfrac{1}{2}\sqrt{\varepsilon_\phi \varepsilon_R}, \tag{49}$$

then H is positive definite and (48) holds. In particular, the strict convexity of E and C ensures existence of a neighborhood of any interior optimum in which $H \succ 0$.
Sketch. Gershgorin or Sylvester: $F_\phi \geq (1-\lambda)\varepsilon_\phi - \lambda M_{\phi\phi}$ and $G_R \geq \varepsilon_R - \lambda M_{RR}$ locally.

Let

$$H(\phi, R) = \begin{bmatrix} F_\phi & F_R \\ F_R & G_R \end{bmatrix}, \qquad F_\phi = \lambda S_{\phi\phi} + (1-\lambda)E''(\phi),\ G_R = \lambda S_{RR} + C''(R),\ F_R = \lambda S_{\phi R}, \tag{50}$$

with $\lambda \in (0,1)$. We seek simple, verifiable conditions under which $H \succ 0$ so that the determinant $\Delta := F_\phi G_R - F_R^2$ is strictly positive (and hence that Cramer's rule is applicable).

Assumptions (local bounds). There exist constants $\varepsilon_\phi, \varepsilon_R > 0$ and $M_{\phi\phi}, M_{RR}, M_{\phi R} \geq 0$ such that, locally,

$$E''(\phi) \geq \varepsilon_\phi, \quad C''(R) \geq \varepsilon_R, \quad |S_{\phi\phi}| \leq M_{\phi\phi}, \quad |S_{RR}| \leq M_{RR}, \quad |S_{\phi R}| \leq M_{\phi R}. \tag{51}$$

Small-gain PD test If

$$(1-\lambda)\varepsilon_\phi > \lambda M_{\phi\phi}, \qquad \varepsilon_R > \lambda M_{RR}, \qquad \lambda^2 M_{\phi R}^2 < \big((1-\lambda)\varepsilon_\phi - \lambda M_{\phi\phi}\big)\big(\varepsilon_R - \lambda M_{RR}\big), \tag{52}$$

then $H(\phi, R) \succ 0$, hence $\Delta > 0$.

Proof sketch (Sylvester's criterion). From (51),

$$F_\phi \geq (1-\lambda)\varepsilon_\phi - \lambda M_{\phi\phi}, \qquad G_R \geq \varepsilon_R - \lambda M_{RR}, \qquad |F_R| \leq \lambda M_{\phi R}. \tag{53}$$

The inequalities in (52) imply $F_\phi > 0$, $G_R > 0$, and $\Delta \geq \big((1-\lambda)\varepsilon_\phi - \lambda M_{\phi\phi}\big)\big(\varepsilon_R - \lambda M_{RR}\big) - \lambda^2 M_{\phi R}^2 > 0$. Thus $H \succ 0$ by Sylvester's criterion. $\square$

Corollary Diagonal dominance/Gershgorin A convenient sufficient alternative is: for some $\varepsilon_\phi, \varepsilon_R > 0$,

$$F_\phi \geq \varepsilon_\phi, \qquad G_R \geq \varepsilon_R, \qquad |F_R| \leq \frac{1}{\sqrt{2}}\sqrt{\varepsilon_\phi \varepsilon_R}. \tag{54}$$

Then $\Delta \geq \frac{1}{2}\varepsilon_\phi\varepsilon_R > 0$, hence $H \succ 0$.

Either Lemma 10.2 or Corollary 10.2 provides a statement of standard positive definiteness.

Matrix formulation and Cramer's rule Differentiate (72)–(73) with respect to θ:

$$F_\phi \frac{\partial \phi^*}{\partial \theta} + F_R \frac{\partial R^*}{\partial \theta} + F_\theta = 0, \tag{55}$$

$$F_R \frac{\partial \phi^*}{\partial \theta} + G_R \frac{\partial R^*}{\partial \theta} + G_\theta = 0. \tag{56}$$

In matrix form,

$$\underbrace{\begin{bmatrix} F_\phi & F_R \\ F_R & G_R \end{bmatrix}}_{H(\phi^*, R^*; \theta)} \begin{bmatrix} \dfrac{\partial \phi^*}{\partial \theta} \\ \dfrac{\partial R^*}{\partial \theta} \end{bmatrix} = - \underbrace{\begin{bmatrix} F_\theta \\ G_\theta \end{bmatrix}}_{\lambda\,[S_{\phi\theta}, S_{R\theta}]^\top} = -\lambda \begin{bmatrix} b\big[\Xi'(\phi)\Phi(z) + \Xi(\phi)\Phi'(z)\, z_\phi\big] \\ b\,\Xi(\phi)\,\dfrac{\Phi'(z)}{\Lambda(\phi)} \end{bmatrix}_{(\phi^*, R^*)}. \tag{57}$$

When H is positive definite, it is invertible, and Cramer's rule gives

$$\frac{\partial \phi^*}{\partial \theta} = -\frac{F_\theta G_R - F_R G_\theta}{\Delta}, \qquad \frac{\partial R^*}{\partial \theta} = -\frac{F_\phi G_\theta - F_R F_\theta}{\Delta}, \tag{58}$$

with Δ as in (48). Using (45)–(46) we have explicit

$$F_\theta = \lambda\, b\Big[\Xi'^*)\Phi(z^*) + \Xi(\phi^*)\Phi'^*)\, z_\phi(\phi^*, R^*)\Big], \tag{59}$$

$$G_\theta = \lambda\, b\,\Xi(\phi^*)\,\frac{\Phi'^*)}{\Lambda(\phi^*)}. \tag{60}$$

This is where the main result in the text–reproduced below as equation (82)–comes from.

10.3 Theorem (Generic Complementarity)

Let Φ be increasing and concave, Λ nonincreasing, and Ξ nondecreasing. Fix a compact policy domain $\mathcal{K} = [\underline{\phi}, \overline{\phi}] \times [0, \overline{R}] \times [0, \overline{e}]$ with $\underline{\phi} \geq 0$ and $\overline{R}, \overline{e} < \infty$. If either $\Xi'(\phi) > 0$ on a set of positive measure in $[\underline{\phi}, \overline{\phi}]$ or $\Lambda'(\phi) < 0$ on a set of positive measure there, then there exists a nonempty open set $U \subset \mathcal{K}$ on which

$$\frac{\partial^2 S}{\partial\phi\,\partial R}(\phi, R, e; \theta) < 0 \quad \text{and} \quad \frac{\partial^2 S}{\partial\phi\,\partial e}(\phi, R, e; \theta) < 0. \tag{61}$$

Moreover, if $\Phi'' < 0$ and $\Lambda'(\phi) < 0$ on a set of positive measure, the open set U can be chosen larger (concavity amplifies the effect).

Derivatives. Before setting out the proof it is useful to note the following. Let

$$z(\phi, R, e) \;\equiv\; \frac{R + \gamma e}{\Lambda(\phi)}, \qquad \Lambda(\phi) > 0. \tag{62}$$

Then

$$\frac{\partial S}{\partial R} = -(1-\theta) b\, \Xi(\phi)\, \Phi'\big(z\big)\, \frac{1}{\Lambda(\phi)}, \tag{63}$$

$$\frac{\partial^2 S}{\partial\phi\,\partial R} = -(1-\theta) b \Bigg[\underbrace{\Xi'(\phi)\, \Phi'\big(z\big)\, \frac{1}{\Lambda(\phi)}}_{\text{(A)}} \;+\; \underbrace{\Xi(\phi)\, \Phi''\big(z\big)\, \frac{\partial z/\partial\phi}{\Lambda(\phi)}}_{\text{(B)}} \;+\; \underbrace{\Xi(\phi)\, \Phi'\big(z\big)\, \frac{\partial}{\partial\phi}\Big(\frac{1}{\Lambda(\phi)}\Big)}_{\text{(C)}} \Bigg], \tag{64}$$

and similarly

$$\frac{\partial^2 S}{\partial\phi\,\partial e} = -(1-\theta) b\, \gamma \Bigg[\Xi'(\phi)\, \Phi'\big(z\big)\, \frac{1}{\Lambda(\phi)} + \Xi(\phi)\, \Phi''\big(z\big)\, \frac{\partial z/\partial\phi}{\Lambda(\phi)} + \Xi(\phi)\, \Phi'\big(z\big)\, \frac{\partial}{\partial\phi}\Big(\frac{1}{\Lambda(\phi)}\Big) \Bigg]. \tag{65}$$

Using $\partial z/\partial\phi = -(R+\gamma e)\Lambda'(\phi)/\Lambda(\phi)^2$ and $\frac{\partial}{\partial\phi}\big(1/\Lambda(\phi)\big) = -\Lambda'(\phi)/\Lambda(\phi)^2$, the bracket in (64) equals

$$B(\phi, R, e) \;=\; \Xi'(\phi)\,\Phi'\big(z\big)\,\frac{1}{\Lambda(\phi)} - \Xi(\phi)\,\Phi''\big(z\big)\,\frac{(R+\gamma e)\,\Lambda'(\phi)}{\Lambda(\phi)^3} - \Xi(\phi)\,\Phi'\big(z\big)\,\frac{\Lambda'(\phi)}{\Lambda(\phi)^2}. \tag{66}$$

Proof $\Phi' > 0$, $\Xi \geq 0$, and $\Lambda > 0$ imply all coefficients are well-defined and continuous on $\mathcal{K}$. Consider two cases.

Case 1: $\Xi'(\phi) > 0$ on a set of positive measure. Pick (ϕ_0, R_0, e_0) with $\Xi'(\phi_0) > 0$. By continuity, there exists a neighborhood U_1 of ϕ_0 on which $\Xi'(\phi) \geq c > 0$. Pick $\varepsilon > 0$ such that $R + \gamma e \leq \varepsilon$ on a small box V around (R_0, e_0). On $U_1 \times V$, the second term of B in (66) is bounded in magnitude by a constant times ε, while the first term is bounded below by $c\,\underline{\Phi'}/\overline{\Lambda}$ with $\underline{\Phi'} \equiv \inf \Phi'(z) > 0$ and $\overline{\Lambda} \equiv \sup \Lambda(\phi) < \infty$ (both exist on the compact set). The third term is nonnegative because $\Lambda'(\phi) \leq 0$. Choosing ε small makes $B > 0$ on an open subset $U \subset U_1 \times V$, hence (64) and (65) are strictly negative there.

Case 2: $\Lambda'(\phi) < 0$ on a set of positive measure. Pick ϕ_0 with $\Lambda'(\phi_0) \leq -k < 0$. By continuity, there exists a neighborhood U_2 of ϕ_0 on which $-\Lambda'(\phi) \geq k/2 > 0$. The third term of B in (66) then satisfies $\Xi(\phi)\,\Phi'(z)\,[-\Lambda'(\phi)]/\Lambda(\phi)^2 \;\geq\; \underline{\Xi}\,\underline{\Phi'}\,\frac{k}{2}\,/\overline{\Lambda}^2 > 0$ with $\underline{\Xi} \equiv \inf \Xi(\phi) \geq 0$. The (potentially) negative middle term scales with $(R+\gamma e)$; as in Case 1, pick a small box V around some (R_0, e_0) with $R+\gamma e \leq \varepsilon$ so that the third (positive) term dominates, making $B > 0$ on an open $U \subset U_2 \times V$. Again (64) and (65) are strictly negative there.

Since at least one of the two cases holds on a set of positive measure by hypothesis, there exists a nonempty open set $U \subset \mathcal{K}$ where (61) obtains. The final statement follows because $\Phi'' < 0$ and $\Lambda' < 0$ enlarge the positive contribution from the third term and reduce the magnitude of the middle term, so the region where $B > 0$ can be chosen larger. $\square$

Note, that if $\Xi'(\phi) \equiv 0$, $\Lambda'(\phi) \equiv 0$, and $\Phi''(\cdot) \equiv 0$, then $B(\phi, R, e) \equiv 0$ and both cross-partials in (61) are zero everywhere. This is the friction-free "perfect substitutes" case.

Tightening structure raises the marginal effectiveness of both formal resolution capacity R and non-contractible preparedness e. It does so directly (better *efficacy*, $\Xi'(\phi) > 0$) and indirectly by shrinking the liquidity bridge (more slack per unit of resources when $\Lambda'(\phi) < 0$). With diminishing returns $\Phi'' < 0$, the slack channel is especially powerful when the bridge is smaller, the system operates on a steeper portion of Φ, so each unit of R or e yields more loss reduction at the margin. Complementarity is generic in the sense that apart from the knife-edge linear-neutral case, structure and resolution/preparedness reinforce each other. This implies (i) marginal *crowding-in* as investing in structure increases the payoff to investing in resolution and preparedness, and vice versa; and (ii) comparative statics that can run counter to "substitution" narratives (e.g., strengthening resolvability may *raise* the optimal level of structure when the amplifier terms are strong).

We suggest that the mathematical conditions that deliver these results arguably correspond to widely observed facts—structure improves executability and reduces liquidity needs; resources face diminishing returns. Under those conditions, the cross-partials are negative on a nontrivial region, so instruments are *not* substitutes. This is the sense in which the 'Skeoch argument' ("resolution can substitute for ring-fencing") rests on the knife-edge equalities; once real-world frictions are admitted, the policy mix becomes complementary rather than substitutable.

As we noted in the main text, one can go further and show that better resolution typically implies a *tighter* optimal ring-fence (as Lemma 1 above implied).

The planner chooses (ϕ, R) to minimise

$$\mathcal{L}(\phi, R; \theta) = \lambda\, S(\phi, R, e; \theta) + (1 - \lambda)\, E(\phi) + C(R), \tag{67}$$

where E and C are convex implementation costs, and $\lambda \in (0,1)$ is the welfare weight on expected loss.

10.4 Theorem (Better resolution can tighten the optimal ring fence)

Suppose E and C are twice continuously differentiable with $E''(\phi) \geq \underline{e} > 0$ and $C''(R) \geq \underline{c} > 0$ on a compact domain, and (14) holds with at least one strict inequality on a set of positive measure. Let $(\phi^*(\theta), R^*(\theta))$ be an interior solution to the planner's problem. Then the optimal structure is *increasing* in resolution credibility:

$$\frac{\partial \phi^*}{\partial(1-\theta)}(\theta) \; > \; 0 \qquad \text{equivalently} \qquad \frac{\partial \phi^*}{\partial \theta}(\theta) \; < \; 0. \tag{68}$$

Proof Let $z(\phi, R, e) = \big(R + \gamma e\big)/\Lambda(\phi)$ and note

$$\frac{\partial S}{\partial \phi} = -a - (1-\theta)\, b \left[\Xi'(\phi)\, \Phi(z) + \Xi(\phi)\, \Phi'(z)\, \frac{\partial z}{\partial \phi} \right], \tag{69}$$

$$\frac{\partial S}{\partial R} = -(1-\theta)\, b\, \Xi(\phi)\, \Phi'(z)\, \frac{1}{\Lambda(\phi)}, \tag{70}$$

$$\frac{\partial z}{\partial \phi} = -\frac{(R+\gamma e)\, \Lambda'(\phi)}{\Lambda(\phi)^2} \;\; \geq \; 0 \quad \text{since } \Lambda' \leq 0. \tag{71}$$

The welfare FOCs (interior) are

$$F(\phi, R, \theta) := \lambda\, \frac{\partial S}{\partial \phi}(\phi, R, e; \theta) + (1-\lambda)\, E'(\phi) = 0, \tag{72}$$

$$G(\phi, R, \theta) := \lambda\, \frac{\partial S}{\partial R}(\phi, R, e; \theta) + C'(R) = 0. \tag{73}$$

Differentiate the system (72)–(73) w.r.t. θ and apply the Implicit Function Theorem. Write partials at the optimum (ϕ^*, R^*, θ), and denote second derivatives of $\mathcal{L}$ by

$$F_\phi = \frac{\partial^2 \mathcal{L}}{\partial \phi^2}, \quad F_R = \frac{\partial^2 \mathcal{L}}{\partial \phi\, \partial R}, \quad G_R = \frac{\partial^2 \mathcal{L}}{\partial R^2}. \tag{74}$$

Under the stated curvature ($E'', C'' > 0$ and (14)), the Hessian is positive definite locally: $F_\phi > 0$, $G_R > 0$, and $\Delta := F_\phi G_R - F_R^2 > 0$. Cramer's rule yields

$$\frac{\partial \phi^*}{\partial \theta} = -\frac{F_\theta\, G_R - F_R\, G_\theta}{\Delta}. \tag{75}$$

We sign each term:

$$F_\theta = \lambda \frac{\partial^2 S}{\partial \phi\, \partial \theta} = \lambda\, b \left[\Xi'(\phi)\, \Phi(z) + \Xi(\phi)\, \Phi'(z)\, \frac{\partial z}{\partial \phi} \right] \;\geq\; 0, \tag{76}$$

$$G_\theta = \lambda \frac{\partial^2 S}{\partial R\, \partial \theta} = \lambda\, b\, \Xi(\phi)\, \Phi'(z)\, \frac{1}{\Lambda(\phi)} \;\geq\; 0, \tag{77}$$

$$F_R = \frac{\partial^2 \mathcal{L}}{\partial \phi\, \partial R} = \lambda \frac{\partial^2 S}{\partial \phi\, \partial R} \;<\; 0 \quad \text{(generic complementarity from (??))}, \tag{78}$$

$$G_R = \frac{\partial^2 \mathcal{L}}{\partial R^2} = \lambda \frac{\partial^2 S}{\partial R^2} + C''(R) \;>\; 0 \quad \text{since } \frac{\partial^2 S}{\partial R^2} = -(1-\theta) b\, \Xi(\phi)\, \frac{\Phi''(z)}{\Lambda(\phi)^2} \geq 0. \tag{79}$$

Therefore the numerator in (75) is $N := F_\theta G_R - F_R G_\theta \;>\; 0$ (both terms are nonnegative and at least one strict by assumption). Since $\Delta > 0$, we conclude $\partial \phi^* / \partial \theta < 0$, which proves (68). □

10.5 The Substitution (Skeoch) result

Our comparative static is *local*: in other words, it signs $\partial \phi^* / \partial (1-\theta)$ at a given interior optimum (ϕ^*, R^*) by inspecting slopes at that point.

Proposition (Local monotonicity region) Let (ϕ^*, R^*) solve (67) with interior FOCs (72)–(73) and a positive-definite Hessian. Then

$$\operatorname{sign}\!\left(\frac{\partial \phi^*}{\partial (1-\theta)} \right) = \operatorname{sign}\!\left(b\, \mathcal{A}(\phi^*, R^*) - \frac{1}{1-\theta}\, \frac{1-\lambda}{\lambda}\, E'(\phi^*) \right). \tag{80}$$

In particular, if

$$\mathcal{A}(\phi^*, R^*) \;>\; \frac{1}{1-\theta}\, \frac{1-\lambda}{\lambda}\, \frac{E'(\phi^*)}{b}, \tag{81}$$

then $\partial \phi^* / \partial (1-\theta) > 0$ ("inverted Skeoch"). If the inequality reverses, the classic substitution sign obtains. If $\mathcal{A}(\phi^*, R^*) = 0$ and $E'(\phi^*) > 0$, then $\partial \phi^* / \partial (1-\theta) < 0$.

Proof. Differentiate the FOCs (72)–(73) w.r.t. θ and apply the Implicit Function Theorem. With H the 2×2 Hessian of $\mathcal{L}$ in (ϕ, R), positive definite by assumption, Cramer's rule gives

$$\frac{\partial \phi^*}{\partial \theta} = -\frac{F_\theta G_R - F_R G_\theta}{\det H}, \qquad \frac{\partial \phi^*}{\partial (1-\theta)} = -\frac{\partial \phi^*}{\partial \theta}. \tag{82}$$

Compute the terms at (ϕ^*, R^*):

$$F_\theta = \lambda \frac{\partial^2 S}{\partial \phi \, \partial \theta} = \lambda \, b \, \mathcal{A}(\phi^*, R^*), \tag{83}$$

$$G_\theta = \lambda \frac{\partial^2 S}{\partial R \, \partial \theta} = \lambda \, b \, \Xi(\phi^*) \, \Phi'(z^*) \, \frac{1}{\Lambda(\phi^*)} \;\geq 0, \tag{84}$$

$$F_R = \frac{\partial^2 \mathcal{L}}{\partial \phi \, \partial R} = \lambda \frac{\partial^2 S}{\partial \phi \, \partial R} \;<\; 0 \quad \text{(generic complementarity)}, \tag{85}$$

$$G_R = \frac{\partial^2 \mathcal{L}}{\partial R^2} = \lambda \frac{\partial^2 S}{\partial R^2} + C''(R^*) \;>\; 0. \tag{86}$$

Hence the numerator $N := F_\theta G_R - F_R G_\theta$ is positive iff F_θ dominates the (nonnegative) $-F_R G_\theta$ term; this yields (80) after dividing by $\det H > 0$ and using $F_\theta = \lambda b \, \mathcal{A}(\phi^*, R^*)$. The statement follows. $\square$

Corollary (Saturation threshold) Define $\bar{\phi}$ implicitly by equality in (81) at $(\bar{\phi}, \bar{R})$. If $\phi^* < \bar{\phi}$, then $\partial \phi^* / \partial (1-\theta) > 0$; if $\phi^* > \bar{\phi}$, the sign may reverse. As $\phi \to 1$, it is natural that $\Xi'(\phi) \to 0$ and $-\Lambda'(\phi) \to 0$ (structural amplifier saturates), so $\bar{\phi}$ is finite under mild conditions.

Intuition. The structural amplifier $\mathcal{A}$ measures how much structure multiplies the effectiveness of resolution resources (efficacy channel via Ξ', liquidity-bridge channel via $-\Lambda'/\Lambda$). Where $\mathcal{A}$ is still material, making resolution more credible raises the payoff to structure, so optimal ϕ rises. Once $\mathcal{A}$ has largely shut down (very tight fence), improving credibility may justify easing ϕ—a local, not global, effect.

Boundary optimality at $\phi^* = 0$ We now characterise when it is optimal to drop the ring-fence entirely.

Proposition (KKT boundary condition) Consider the constrained problem $\min_{\phi\geq 0, R\geq 0} \mathcal{L}(\phi, R; \theta)$. Under convexity, a boundary optimum with $\phi^* = 0$ is optimal if and only if

$$\left.\frac{\partial \mathcal{L}}{\partial \phi}\right|_{\phi=0, R=R^*} = \lambda \left.\frac{\partial S}{\partial \phi}\right|_{\phi=0, R=R^*} + (1-\lambda)\, E'_+(0) \;\geq\; 0, \tag{87}$$

i.e. the marginal social value of structure at the boundary does not exceed its marginal implementation cost:

$$\underbrace{-\lambda \left.\frac{\partial S}{\partial \phi}\right|_{\phi=0, R=R^*}}_{\mathrm{MB}_\phi(0)} \;\leq\; \underbrace{(1-\lambda)\, E'_+(0)}_{\mathrm{MC}_\phi(0)}. \tag{88}$$

Proof. KKT conditions for the inequality constraint $\phi \geq 0$ are: there exists $\mu \geq 0$ with stationarity $\partial\mathcal{L}/\partial\phi + \mu = 0$, complementarity $\mu\,\phi^* = 0$, feasibility $\phi^* \geq 0$. At $\phi^* = 0$, $\mu = -\partial\mathcal{L}/\partial\phi \geq 0$ is equivalent to $\partial\mathcal{L}/\partial\phi \geq 0$, which is (87). Convexity ensures necessity and sufficiency. Rearranging yields (88). □

Interpretation. The boundary is optimal only if the first increment of structure—clean entity maps, basic OCIR, minimal separability—delivers no more social value (loss reduction) than it costs to implement. With any positive amplifier at the boundary ($\Xi'(0) > 0$ or $-\Lambda'(0) > 0$), the left-hand side of (88) is strictly positive, so dropping the fence is *not* optimal.

Why these are minor qualifications in practice The local and boundary caveats above are conceptually important but likely empirically narrow. First, the amplifier is unlikely to be zero at today's ϕ**.** Within-group RF–NRF money-market wedges, resolvability assessments, and LIR metrics indicate that structure still improves execution efficacy and reduces required liquidity. Second, political execution risk is not zero. Any $\theta > 0$ gives structure state-contingent value even when resolution is not used. That preserves complementarity and raises MB_ϕ. Third, early increments are high-return, low-cost. The first units of structure typically will have low $E'(\phi)$ but large effects on Ξ and Λ (clean maps, OCIR basics), making (81) more easy to satisfy. Fourth, cross-border and FMI frictions persist. Dependencies on payment systems, CCPs, and cross-jurisdictional coordination mean $\Lambda'(\phi)$ is materially negative until quite far along the structural programme. Fifth, generic complementarity is an open-set property. As shown in the main text, $\partial^2 S/\partial\phi\,\partial R < 0$ on a nonempty open set whenever at least one amplifier channel is active on a set of positive measure. Knife-edge linearity is a measure-zero case. Finally, ambiguity about θ and stress execution pushes optimal policy toward instruments that work in both political states; structure does, resolution mainly does when used. In short, our 'inverted Skeoch' result is *local* and our drop-the-fence condition *possible* in theory, but the empirical configuration in which either undermines the case for a meaningful ring-fence seems rather narrow. In the regions that matter for UK policy today, complementarity arguably is active and stronger resolution credibility strengthens the case for tightening structure at the margin.

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