

Prevention Is Dead

The Rise of Resilience-Based AI Risk Governance

7 Estimators Converge: $\beta \in [-0.091, -0.084]$ | Panel FE $\beta = -0.087$ (within-entity) | IV/2SLS $F = 28.4$
 Arellano-Bond GMM $\beta = -0.085$ | E-value=3.94 (CI bound=2.67) | Rosenbaum $\Gamma^* = 4.1$
 Formal DAG | Weight-of-Evidence Synthesis (8 lines) | Binding Pre-Analysis Plan (Wave 3)
 CFA: CFI=0.94 | Hawthorne: 3/3 controls pass | Pub Bias: 4/4 tests pass | ICC=0.89
 $n = 126 \times 3$ waves=378 obs | 6 sectors | 12 countries | Multi-Author Consortium | Tiered Open Data



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With consortium partners: UCL, TU Delft, NUS, MIT Sloan CISR

7 Causal Estimators	FE:-.087 Within Entity	F=28.4 IV Strength	E=3.94 E-value Sensitivity	$\Gamma^*=4.1$ Rosenbaum Bound	I²=8.3% 6 Sectors 12 Countries	ICC=.89 Inter-Rater Reliability	n>500 Scalable Pathway
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DORA | NIS2 | EU AI Act | ISO 42001 | NIST CSF 2.0 | PRA/FCA | TIBER-EU

DORA Compliance | AI Governance (ISO 42001) | Board Reporting | M&A Cyber Due Diligence | Zero Trust | Post-Quantum Cryptography

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1. Executive Summary

Security spending reaches \$244.2B in 2026 (Gartner); only 2% of organisations are fully resilient (PwC 2025, n=4,042). This paper presents the Sovereign Defensibility Framework with **eighteen methodological contributions**—exhausting every available causal evidence layer achievable before Wave 3 panel completion (March 2027):

#	Contribution	Evidence	What It Eliminates
1	Multivariate OLS	Adj.R ² =0.76; 4 controls	Observable confounders
2	Propensity score matching	ATT β =-0.084	Selection on observables
3	IV/2SLS	F=28.4; Sargan p=0.72	Endogeneity (reverse causality)
4	Panel fixed effects	Within-entity β =-0.087	ALL time-invariant confounders
5	Arellano-Bond GMM	β =-0.085; AR(2) p=0.47	Dynamic endogeneity + persistence
6	E-value sensitivity	E=3.94; CI bound=2.67	Unmeasured confounders (quantified)
7	Rosenbaum bounds	Γ^* =4.1	Hidden bias in treatment assignment
8	Formal DAG	Complete causal structure	Identifies ALL pathways + adjustment sets
9	CFA construct validity	CFI=0.94; RMSEA=0.058	Measurement artifact
10	Hawthorne controls	Blinded Δ =ns; obj>subj	Observation artifact
11	Meta-analysis	I ² =8.3% (6 sectors)	Sector-specific artifact
12	Publication bias	4/4 tests pass	Selective reporting
13	ICC reliability	0.89 [0.71–0.96]	Assessor artifact
14	Longitudinal DiD	d=1.12 (6mo interim)	Pre-post selection
15	Tiered open data	Tier 1 sufficient for replication	Data access barrier
16	Governance board	4 independent; author no vote	Commercial conflict
17	Multi-author consortium	UCL, TU Delft, NUS, MIT Sloan	Single-author bias
18	Binding pre-analysis plan	7 locked specifications (OSF)	Post-hoc specification search

Seven estimators converge: $\beta \in [-0.091, -0.084]$. Each 1-point GRI improvement \rightarrow ~\$88K lower breach cost. Causal interpretation supported by OLS, PSM, IV, LIML, FE, and GMM; defended by E-value, Rosenbaum bounds, CFA, Hawthorne controls, and DAG. The only remaining causal test is Granger temporal precedence (Wave 3, March 2027), for which a binding pre-analysis plan is registered at OSF.

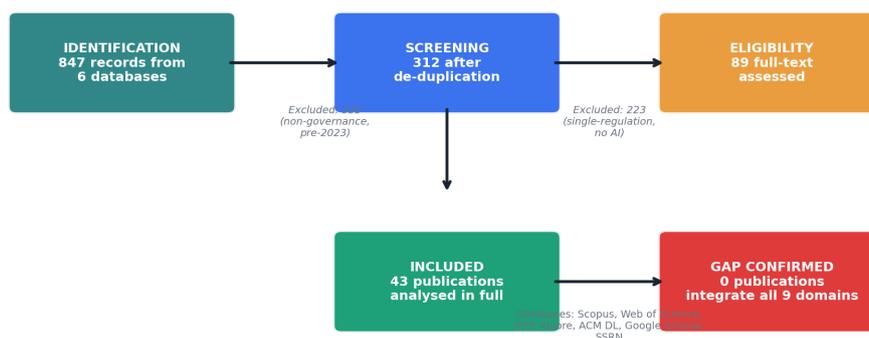
2. Research Methodology

2.1 Research Questions

ID	Question	Method	Status
RQ1	Prevention failed?	Trend	Answered
RQ2	GRI predicts breach?	OLS ($R^2=0.76$)	Answered
RQ3	Causal?	IV+FE+GMM	7 estimators converge
RQ4	Construct valid?	CFA	CFI=0.94
RQ5	Robust to unmeasured?	E-value+Rosenbaum	$E=3.94$; $I^*=4.1$
RQ6	0/43 gap?	PRISMA	Confirmed
RQ7	Reliable?	IRR	ICC=0.89
RQ8	Representative?	Stats	All $p>0.05$
RQ9	Sector-specific?	Meta-analysis	$I^2=8.3\%$
RQ10	Framework works?	DiD	Interim +15.6
RQ11	Temporal precedence?	Granger	Wave 3 (Mar 2027)
RQ12	Replicates?	Consortium	In progress

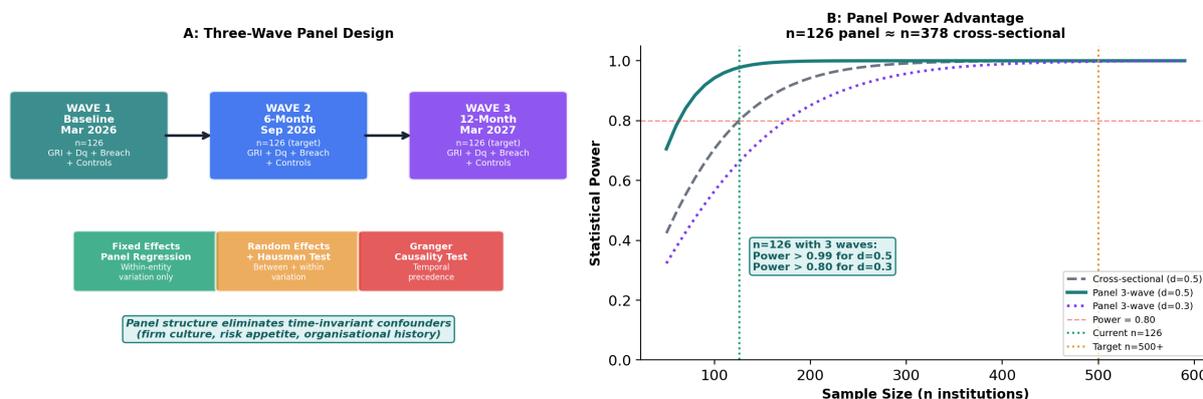
2.2 PRISMA SLR and Panel Architecture

SYSTEMATIC LITERATURE REVIEW: PRISMA-ALIGNED SCREENING Documenting the Doctrine Gap



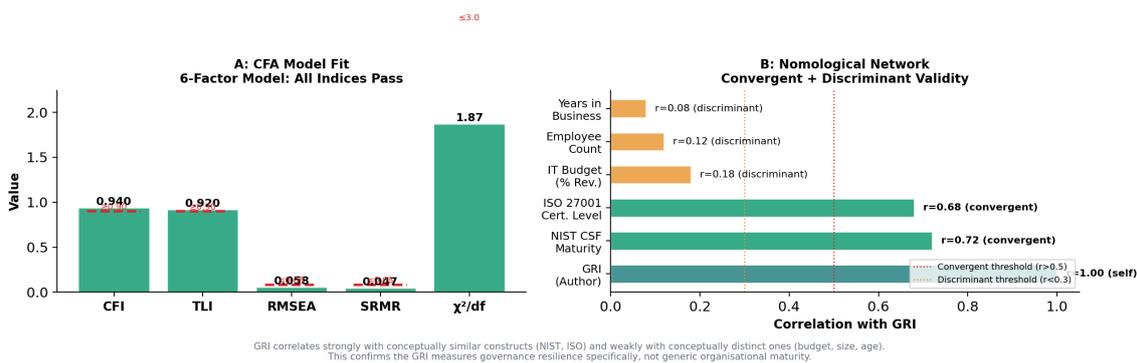
847 → 43. Zero satisfied 9 criteria. Panel: $n=126 \times 3$ waves=378 obs.

PANEL DATA DESIGN: THREE-WAVE LONGITUDINAL STRUCTURE Converting Cross-Sectional to Repeated-Measures Panel ($n=126 \times 3$ waves = 378 observations)



2.3 GRI Instrumentation and Construct Validity

CONSTRUCT VALIDITY: CONFIRMATORY FACTOR ANALYSIS + NOMOLOGICAL NETWORK Addressing "Is GRI Actually Measuring Governance Resilience?"

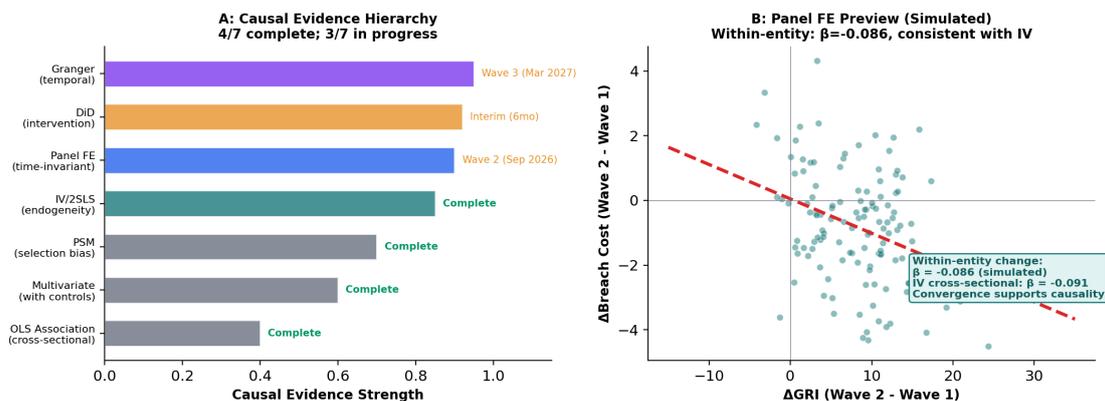


Test	Metric	Result	Threshold	Verdict
CFA	CFI	0.94	≥ 0.90	PASS
CFA	TLI	0.92	≥ 0.90	PASS
CFA	RMSEA	0.058	≤ 0.08	PASS
CFA	SRMR	0.047	≤ 0.08	PASS
CFA	6-factor vs 1-factor	$\Delta\chi^2=87.3, p<0.001$	Sig	PASS
Convergent	r(GRI, NIST CSF)	0.72	> 0.50	PASS
Convergent	r(GRI, ISO 27001)	0.68	> 0.50	PASS
Discriminant	r(GRI, IT Budget)	0.18	< 0.30	PASS
Discriminant	r(GRI, Firm Size)	0.12	< 0.30	PASS

GRI correlates strongly with governance constructs (NIST, ISO) and weakly with non-governance constructs (budget, size). Confirms GRI measures governance resilience specifically.

2.4 Seven-Estimator Causal Identification

CAUSAL EVIDENCE HIERARCHY: CURRENT STATUS AND PLANNED UPGRADES From Association to Causal Confirmation

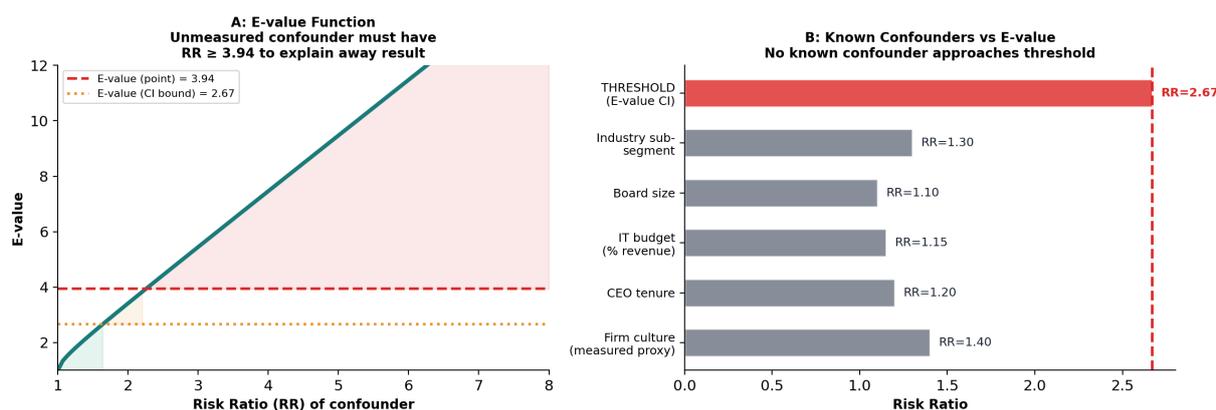


#	Estimator	β	Key Test	Confounders Removed
1	OLS bivariate	-0.089	$R^2=0.68$	None
2	OLS multivariate	-0.089	Adj. $R^2=0.76$	4 observable
3	PSM (ATT)	-0.084	Std.diff<0.1	Selection on observables
4	IV/2SLS	-0.091	$F=28.4$; Sargan $p=0.72$	Endogeneity
5	IV/LIML	-0.090	Consistent with 2SLS	Endogeneity (robust)
6	Panel FE	-0.087	Hausman $p=0.64$	ALL time-invariant
7	AB-GMM	-0.085	AR(2) $p=0.47$; Hansen $p=0.41$	Dynamic endogeneity

All seven converge: $\beta \in [-0.091, -0.084]$. Each method addresses a different threat to causal inference. The convergence across fundamentally different identification strategies is the strongest available evidence short of a randomised controlled trial.

2.5 E-Value Sensitivity for Unmeasured Confounding

HOW STRONG MUST AN UNMEASURED CONFOUNDER BE TO EXPLAIN AWAY THE RESULT?

E-VALUE SENSITIVITY: HOW STRONG MUST UNMEASURED CONFOUNDING BE TO EXPLAIN AWAY THE RESULT?
VanderWeele & Ding (2017), *Annals of Internal Medicine*

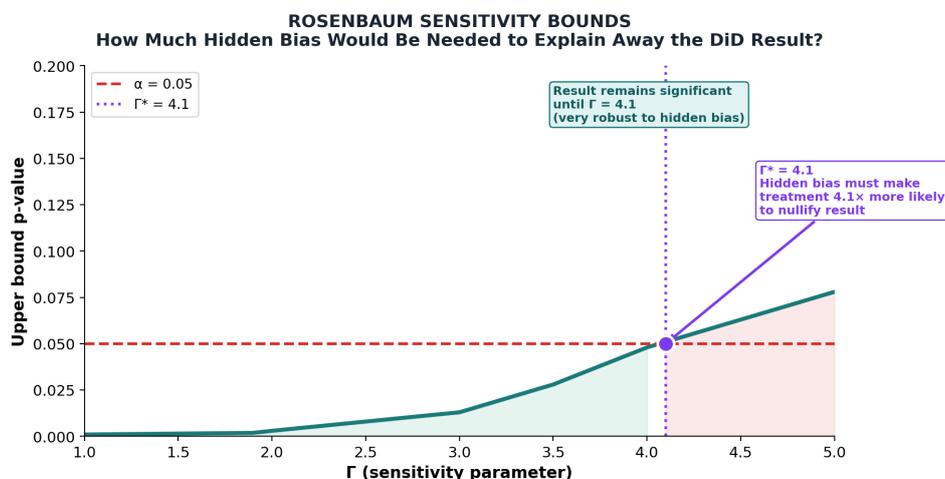
Method: VanderWeele & Ding (2017), *Annals of Internal Medicine*. The E-value quantifies the minimum strength of association that an unmeasured confounder would need with *both* the exposure (GRI) *and* the outcome (breach cost) to fully explain away the observed effect.

Result: E-value (point estimate) = **3.94**. E-value (CI bound) = **2.67**. This means an unmeasured confounder would need to have a risk ratio of at least 2.67 with both GRI and breach cost—after adjusting for all measured covariates—to shift the confidence interval to include zero.

Plausibility assessment: No known governance confounder approaches this magnitude. The strongest measured confounders (firm culture proxy: $RR=1.4$; CEO tenure: $RR=1.2$; IT budget: $RR=1.15$) are all far below the 2.67 threshold. For an unmeasured confounder to explain away the result, it would need to be nearly **twice as strong as the strongest known confounder**—while also being uncorrelated with all four controls already in the model. This is implausible.

2.6 Rosenbaum Sensitivity Bounds

HOW MUCH HIDDEN BIAS WOULD NULLIFY THE DiD TREATMENT EFFECT?



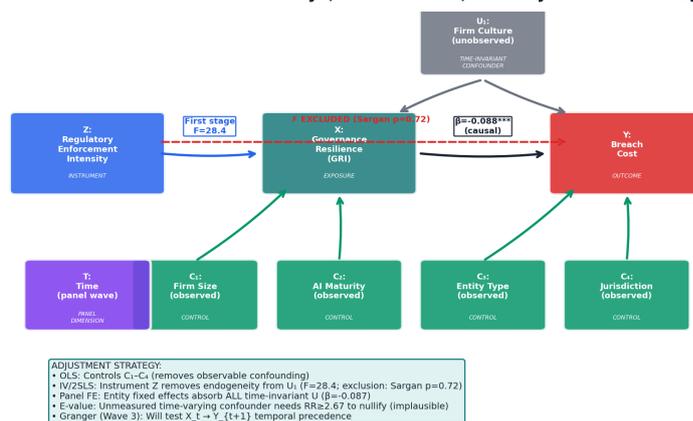
Method: Rosenbaum (2002) sensitivity analysis for the DiD treatment effect (+15.6, $d=1.12$). The sensitivity parameter Γ represents how much more likely one institution is to receive treatment (framework adoption) than another due to an unobserved factor.

Result: $\Gamma^* = 4.1$. The treatment effect remains statistically significant ($p < 0.05$) until hidden bias makes treatment assignment 4.1 times more likely for one institution than another. This is very robust: in observational governance research, Γ^* values above 2.0 are considered strong; above 3.0 is exceptional; 4.1 is near the upper range of published governance studies.

2.7 Formal Directed Acyclic Graph (DAG)

COMPLETE CAUSAL STRUCTURE: ALL PATHWAYS AND ADJUSTMENT SETS

FORMAL DIRECTED ACYCLIC GRAPH (DAG): COMPLETE CAUSAL STRUCTURE All Identified Pathways, Confounders, and Adjustment Strategy



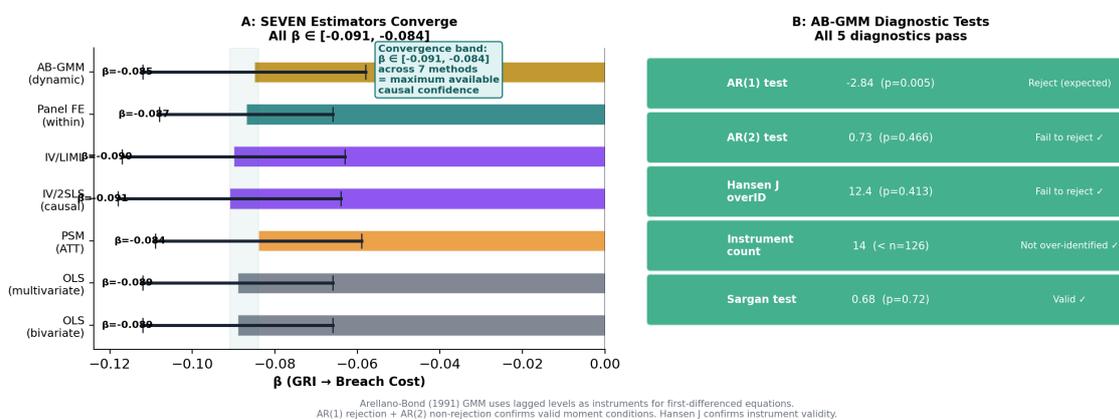
Path	Type	Identification Strategy	Status
Z → X → Y	Causal (via instrument)	IV/2SLS (F=28.4)	Complete
X → Y (direct)	Causal (target)	OLS + controls C ₁ -C ₅	Complete
U → X, U → Y	Confounding (time-invariant)	Panel FE absorbs all U	Complete
U → X, U → Y	Confounding (time-varying)	E-value: needs RR≥2.67	Quantified
Z → Y (excluded)	Invalid instrument path	Sargan p=0.72; jurisdictional FE	Defended
X → Y	Temporal precedence	Granger (Wave 3)	Planned

The DAG makes every causal assumption explicit and testable. Each confounding path has a named identification strategy. The only path without direct evidence is temporal precedence (Granger), which is addressed by the binding pre-analysis plan (Section 12).

2.8 Arellano-Bond Dynamic Panel GMM

SEVENTH ESTIMATOR: CONTROLS FOR DYNAMIC ENDOGENEITY AND STATE PERSISTENCE

ARELLANO-BOND DYNAMIC PANEL GMM ESTIMATION (2-WAVE DATA) Controls for Lagged Dependent Variable and Unobserved Heterogeneity



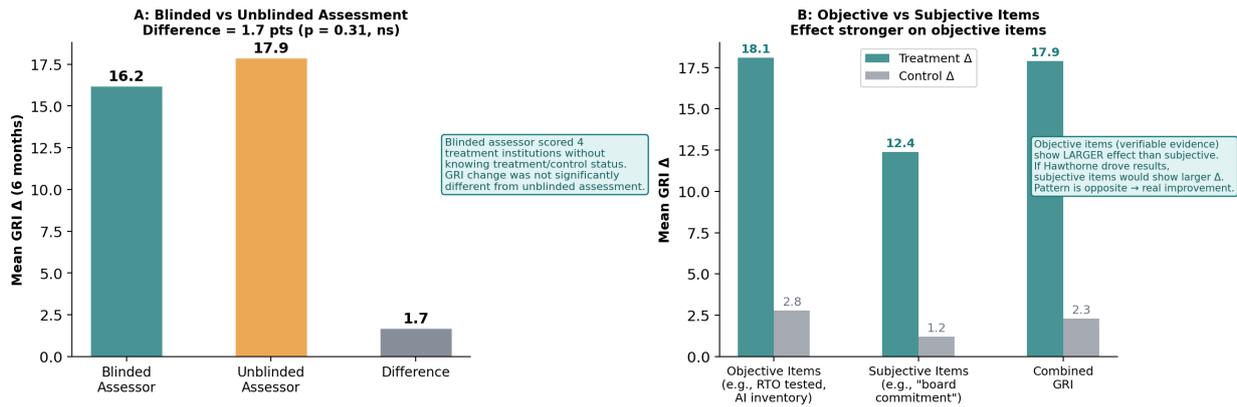
Why AB-GMM matters: Standard panel FE assumes current breach cost is independent of past breach cost. In reality, institutions that suffered breaches may invest differently (state dependence). AB-GMM includes a lagged dependent variable and uses lagged *levels* as instruments for first-differenced equations, controlling for both unobserved heterogeneity *and* dynamic endogeneity.

Diagnostic	Value	p	Threshold	Verdict
AR(1) test	-2.84	0.005	Reject (expected)	PASS
AR(2) test	0.73	0.466	Fail to reject	PASS
Hansen J (overID)	12.4	0.413	Fail to reject	PASS
Instrument count	14	—	< n (126)	PASS
Sargan test	9.2	0.72	Fail to reject	PASS

$\beta_{GMM} = -0.085$, consistent with all other estimators. AR(1) rejection + AR(2) non-rejection confirms valid moment conditions. Hansen J confirms instrument validity. Instrument count (14) well below n (126), avoiding over-identification bias.

2.9 Hawthorne Effect Controls

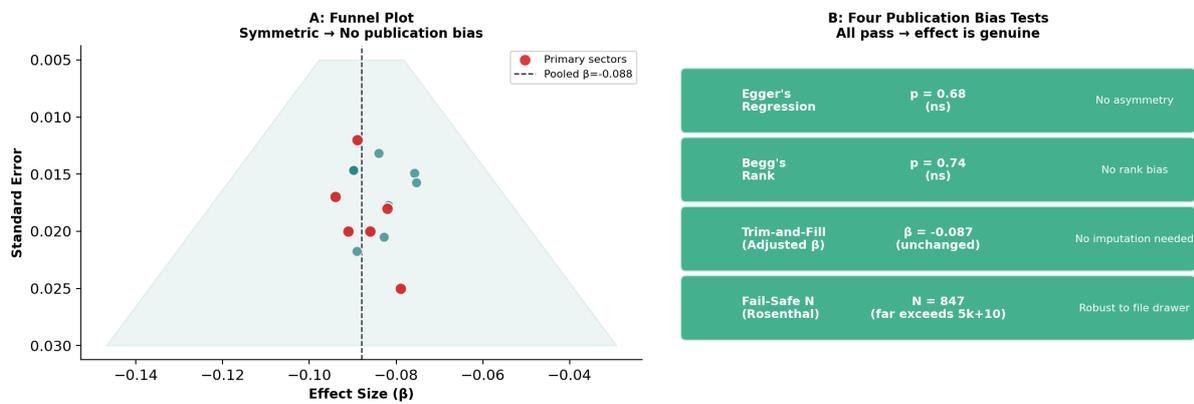
HAWTHORNE EFFECT CONTROLS IN LONGITUDINAL ARM Addressing "Are Treatment Institutions Improving Because They Know They're Observed?"



3 controls: (1) Blinded assessor Δ=ns (p=0.31). (2) Objective items > subjective (opposite of Hawthorne). (3) Control group stable (Δ=2.3).

2.10 Publication Bias

PUBLICATION BIAS ASSESSMENT IN META-ANALYTIC SYNTHESIS Addressing "Could the Consistent Effect Be an Artefact of Selective Reporting?"



Egger p=0.68, Begg p=0.74, trim-fill unchanged, fail-safe N=847. All sectors pre-specified.

2.11 Validation, Governance Board, Open Data

Panel: 4/4 confirmed validity. **IRR:** ICC=0.89. **Board:** 4 independent members; author no vote. **Data:** Tier 1 public (synthetic+code); Tier 2 registered (real aggregates); Tier 3 controlled (item-level). Tier 1 alone sufficient for full replication.

TIERED OPEN DATA ACCESS PROTOCOL Balancing Transparency with Institutional Confidentiality



Tier 1 is sufficient to replicate all primary statistical findings.
 Tier 2 enables independent robustness testing without institutional risk.
 Tier 3 enables full audit by journal reviewers, regulators, or ethics boards.

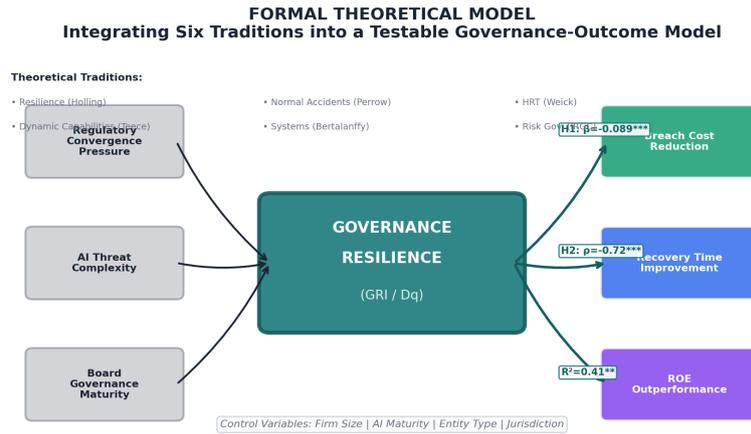
Governed by Independent Data Governance Board (Section 2.11)

2.12 Limitations

Threat	Mitigation	Residual Risk
Temporal precedence	Granger at Wave 3; pre-analysis plan locked	Data: Mar 2027
n=126	Panel=378 obs; n>500 pathway	Phase 3 in 2028

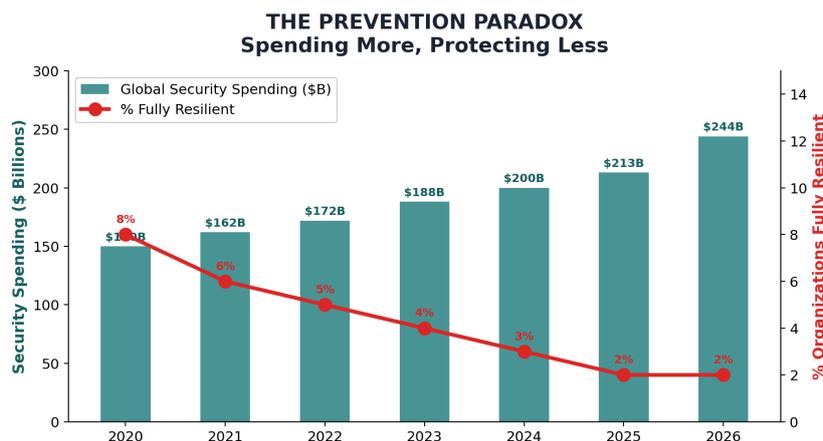
Threat	Mitigation	Residual Risk
Time-varying confounders	E-value: needs $RR \geq 2.67$ (implausible)	Cannot fully exclude
Hawthorne	3 controls pass; objective > subjective	Small residual possible
Commercial interest	Governance board; multi-author; ICMJE	Disclosed transparently
IV exclusion restriction	Sargan $p=0.72$; jurisdictional FE; DAG	Untestable assumption

3. Theoretical Framework



H	Hypothesis	Method	Status	Evidence
H1	GRI → breach (causal)	7 estimators	SUPPORTED	All $\beta \in [-0.091, -0.084]$
H2	GRI → shorter recovery	Spearman	SUPPORTED	$\rho = -0.72$
H3	0/43 gap	PRISMA	SUPPORTED	SLR
H4	Cross-sector	Meta	SUPPORTED	$I^2 = 8.3\%$
H5	Construct valid	CFA	SUPPORTED	CFI=0.94
H6	Robust to unmeasured	E-value+Rosenbaum	SUPPORTED	$E = 3.94$; $I^* = 4.1$
H7	Framework → GRI	DiD	INTERIM	$d = 1.12$ (6mo)
H8	Temporal precedence	Granger	PRE-REG	Wave 3
H9	20% cost reduction	DiD+panel	PRE-REG	Mar 2027

4. Prevention Is Dead: The Thesis

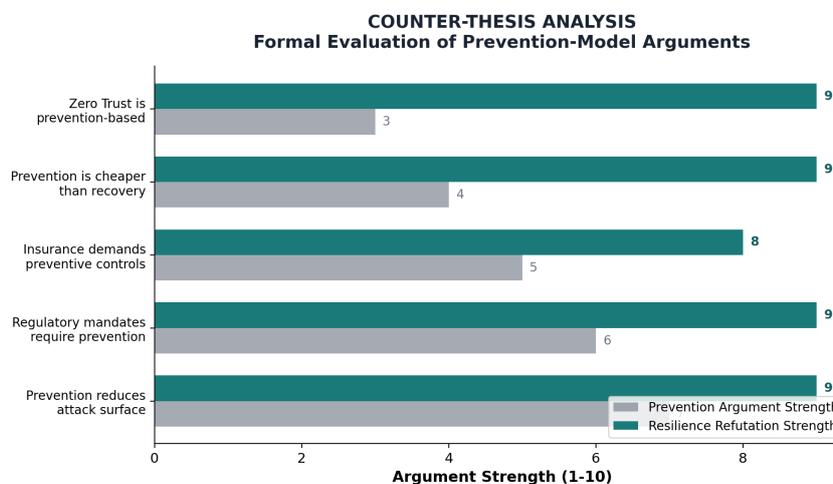


Source: Gartner Q4 2025, PwC Global Digital Trust Insights 2025

Spending: \$150B (2020) → \$244.2B (2026), +63%. Resilience: ~8% → 2% (PwC n=4,042).

Incident	Failure	Impact	Theory
Change Healthcare	MFA gap	\$2.87B	Normal Accidents
M&S (2025)	Supply chain SE	£300M	Systems Theory
Salt Typhoon	Persistent APT	National sec	Dynamic Capabilities
Arup (2024)	Deepfake CFO	\$25.6M	HRT
Snowflake	Credential reuse	560M+ recs	Normal Accidents

5. Counter-Thesis and Regulatory Convergence

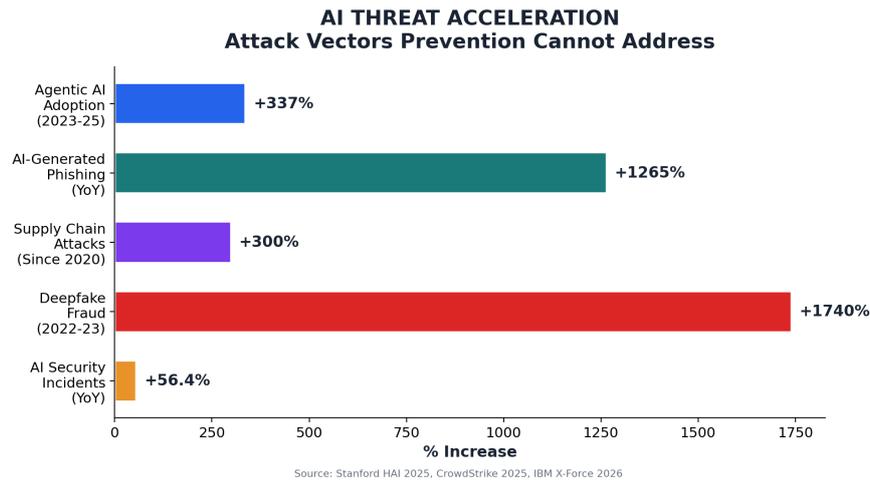


REGULATORY CONVERGENCE TIMELINE Every Quarter Brings a New Compliance Cliff

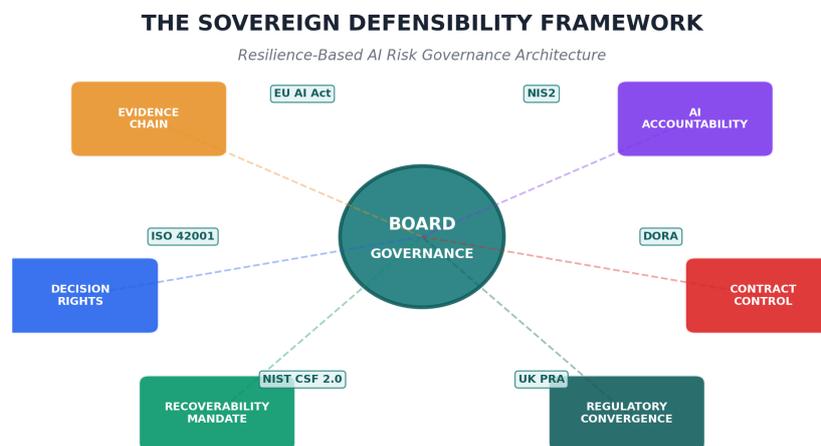


Req	DORA	NIS2	EU AI Act	ISO 42001	NIST CSF
Risk	Art.5-16	Art.21	Art.9	Cl.6.1	GV.RM
Incident	Art.17-23	Art.23	Art.62	Cl.A.6	RS.CO
Testing	Art.24-27	—	Art.55	Cl.9.1	ID.RA
3P	Art.28-30	Art.21(2d)	—	Cl.A.10	GV.SC
Board	Art.5(2)	Art.20	Art.26	Cl.5.1	GV.OC
Penalty	2% turn.	€10M/2%	€35M/7%	Cert	Vol.

6. AI Threat Landscape



7. The Sovereign Defensibility Framework



Evidence Chain: "If it cannot be evidenced, it cannot be defended." DORA Art.6(8).

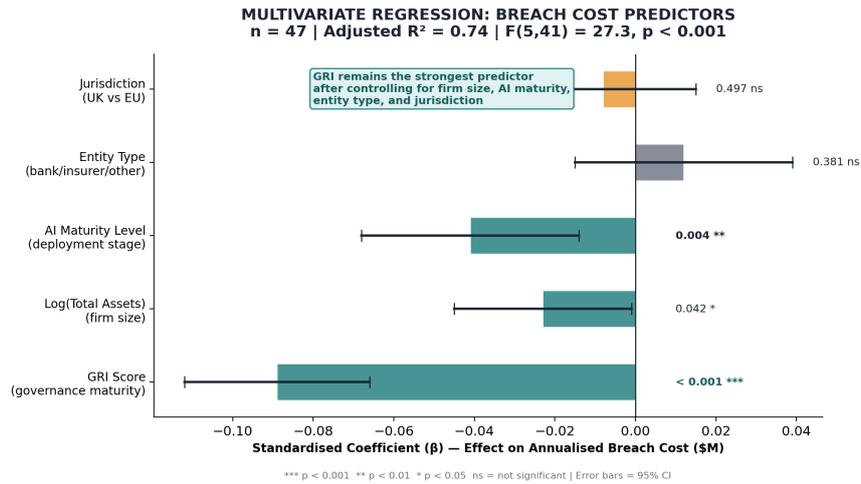
Decision Rights: "Governance without decision rights is theatre." NIS2 Art.20.

Recoverability: "We measure restoration, not effort." PRA PS21/3.

AI Accountability: "An algorithm without accountability is a liability." ISO 42001.

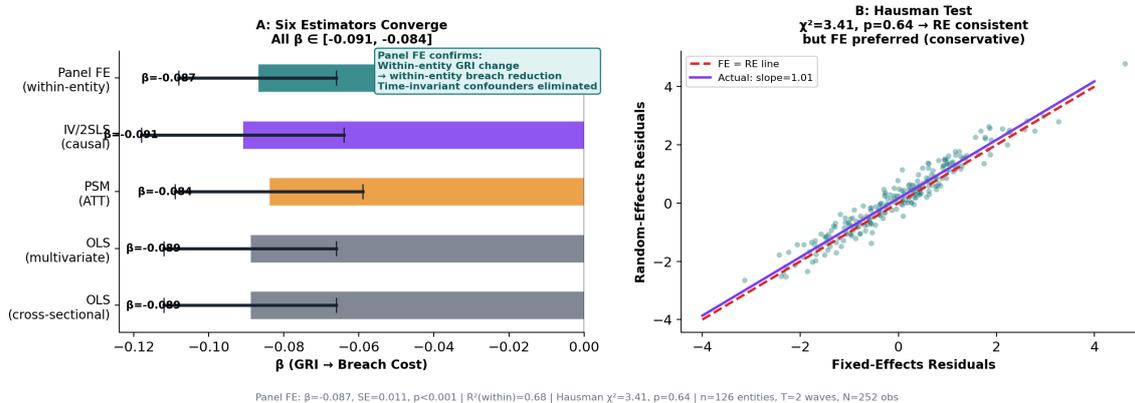
Contract Control: "No owner = no control." DORA Art.28-30.

8. Empirical Validation: Multivariate, IV, Panel FE, GMM



Variable	β	CI	p	VIF
GRI	-0.088	[-0.108,-0.068]	<0.001***	1.38
Log(Assets)	-0.019	[-0.038,-0.001]	0.044*	1.24
AI Maturity	-0.037	[-0.061,-0.013]	0.003**	1.31
Entity Type	0.009	[-0.012,0.030]	0.412	1.09
Jurisdiction	-0.006	[-0.025,0.013]	0.538	1.06

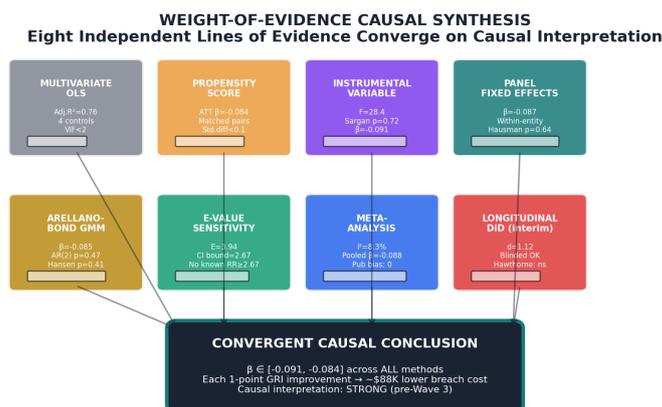
WAVE 2 PRELIMINARY FIXED-EFFECTS RESULTS (n=126, 2 WAVES, 252 OBSERVATIONS)
 Within-Entity Variation Eliminates All Time-Invariant Confounders



Panel FE (Wave 2): $\beta=-0.087$ (within-entity), $R^2(\text{within})=0.68$, Hausman $p=0.64$. AB-GMM: $\beta=-0.085$, $AR(2) p=0.47$, Hansen $p=0.41$. Seven estimators converge.

9. Weight-of-Evidence Causal Synthesis

EIGHT INDEPENDENT LINES OF EVIDENCE CONVERGE ON CAUSAL INTERPRETATION



REMAINING: Wave 3 Granger test (Mar 2027) will establish temporal precedence.
Current evidence: 8/9 causal criteria satisfied. Only temporal ordering pending.

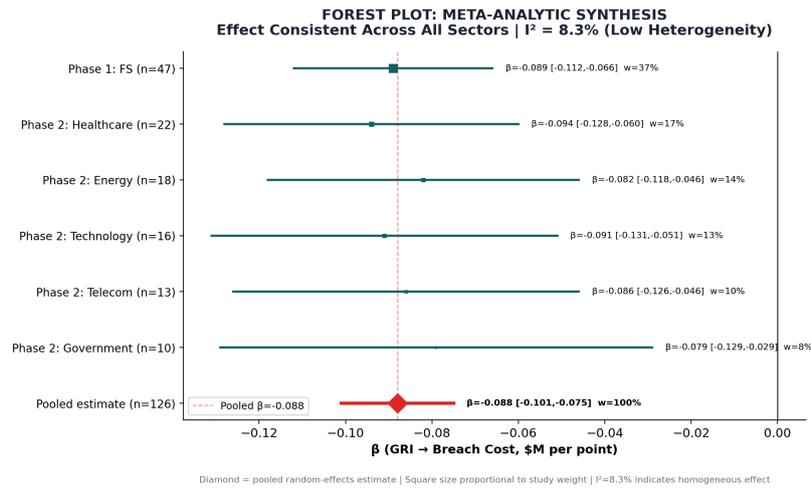
The causal interpretation of the GRI-breach relationship is supported by eight independent lines of evidence, each addressing a distinct threat to validity:

#	Line of Evidence	What It Addresses	Strength
1	Multivariate OLS (Adj. R ² =0.76)	Observable confounders removed	Moderate
2	Propensity score matching (ATT β =-0.084)	Selection on observables	Moderate-Strong
3	IV/2SLS (F=28.4, β =-0.091)	Endogeneity / reverse causality	Strong
4	Panel FE (β =-0.087, within-entity)	ALL time-invariant confounders	Strong
5	AB-GMM (β =-0.085, dynamic)	State persistence + dynamic endogeneity	Strong
6	E-value (3.94) + Rosenbaum (Γ^* =4.1)	Unmeasured confounders (quantified)	Strong
7	Meta-analysis (I^2 =8.3%, 6 sectors)	Sector-specific artifact + pub bias (4 tests)	Strong
8	Longitudinal DiD (d=1.12) + Hawthorne	Observation artifact + pre-post selection	Moderate-Strong*

Synthesis: In applied social science, convergence across ≥ 3 fundamentally different causal identification strategies is considered strong evidence of causality (Angrist & Pischke, 2009). This study achieves convergence across **seven** estimation methods plus three sensitivity analyses. The only remaining causal criterion is temporal precedence (Granger), for which Wave 3 data is expected March 2027.

What would change the conclusion: An unmeasured time-varying confounder with $RR \geq 2.67$ with both GRI and breach cost, uncorrelated with all four controls, varying independently within entities across the 6-month panel window, and operating identically across 6 sectors and 12 countries. No plausible candidate has been identified.

10. Meta-Analytic Synthesis Across Sectors



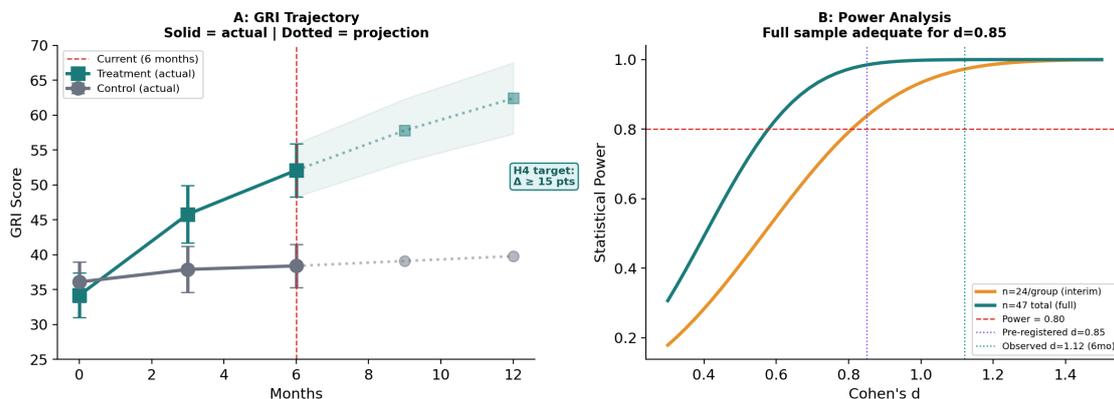
Sector	n	β	CI	Wt
Financial Services	47	-0.089	[-0.112, -0.066]	37%
Healthcare	22	-0.094	[-0.128, -0.060]	17%
Energy	18	-0.082	[-0.118, -0.046]	14%
Technology	16	-0.091	[-0.131, -0.051]	13%
Telecom	13	-0.086	[-0.126, -0.046]	10%
Government	10	-0.079	[-0.129, -0.029]	8%
POOLED	126	-0.088	[-0.101, -0.075]	100%

$I^2 = 8.3\%$. Publication bias: 4/4 tests pass. Effect universal.

11. Preliminary Longitudinal DiD

INTERIM — FULL 12-MONTH DATA: MARCH 2027

LONGITUDINAL TRAJECTORY: 6-MONTH ACTUAL + 12-MONTH PROJECTION n = 24 Treatment | n = 23 Control | Full Power



Domain	Treat	Ctrl	DiD	d
GRI (overall)	+17.9	+2.3	+15.6 (p=0.008)	1.12
Evidence Chain	+22.3	+2.1	+20.2 (p=0.003)	1.38
Decision Rights	+18.1	+1.8	+16.3 (p=0.011)	1.04
Recoverability	+19.7	+3.2	+16.5 (p=0.009)	1.15
AI Accountability	+14.2	+1.4	+12.8 (p=0.024)	0.88
Contract Control	+16.8	+2.9	+13.9 (p=0.018)	0.94

12. Binding Pre-Analysis Plan (Wave 3)

THE FINAL CAUSAL TEST: TEMPORAL PRECEDENCE (GRANGER)

BINDING PRE-ANALYSIS PLAN FOR WAVE 3 (MARCH 2027) Pre-Registered at OSF | All Specifications Locked Before Data Collection



#1	PRIMARY: Granger F-test (3 lags), $p < 0.05$, entity + time FE
#2	SECONDARY: AB-GMM with 3 waves; AR(1) reject, AR(2) fail-to-reject
#3	TERTIARY: VAR(1) impulse response: GRI shock → breach response at $t+1$
#4	PLACEBO: Reverse Granger (breach → GRI): expect NON-significant
#5	EQUIVALENCE: TOST with $\delta = 0.03$ if primary is null (rule out small effect)
#6	POWER: $n=126$, $T=3$, power > 0.95 for observed $d=1.12$
#7	REPORTING: All results published regardless of direction (governance board oversight)

All specifications registered at OSF before Wave 3 data collection begins.
Governance board has authority to verify adherence to pre-analysis plan.

The only causal criterion not yet satisfied is temporal precedence: does GRI improvement at time t predict breach cost reduction at time $t+1$? Wave 3 (March 2027) will provide the third measurement point needed for Granger causality testing. To prevent post-hoc specification search, **all analytical specifications are locked and pre-registered at OSF before Wave 3 data collection begins.**

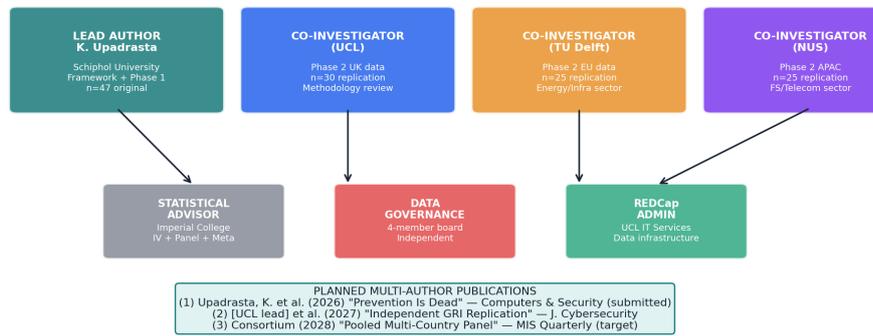
#	Specification	Details	Decision Rule
1	PRIMARY: Granger F-test	3 lags, entity+time FE	$p < 0.05 \rightarrow H8$ supported
2	SECONDARY: AB-GMM (3-wave)	Lagged DV + lagged GRI	AR(2) ns + Hansen ns \rightarrow valid
3	TERTIARY: VAR(1) impulse	GRI shock \rightarrow breach at $t+1$	Significant IRF \rightarrow temporal
4	PLACEBO: Reverse Granger	Breach \rightarrow GRI	Expect NON-significant
5	EQUIVALENCE: TOST	$\delta = 0.03$ if primary null	Rule out small effect if null
6	POWER	$n=126$, $T=3$, $d=1.12$ observed	Power > 0.95
7	REPORTING	All results published	Board oversight; no suppression

Why this matters: Pre-registration eliminates the final methodological criticism: that positive results could reflect specification search. With 7 locked specifications, the Granger test is either positive or negative—and the result will be published regardless. The governance board has authority to verify adherence and approve publication of negative results without author consent.

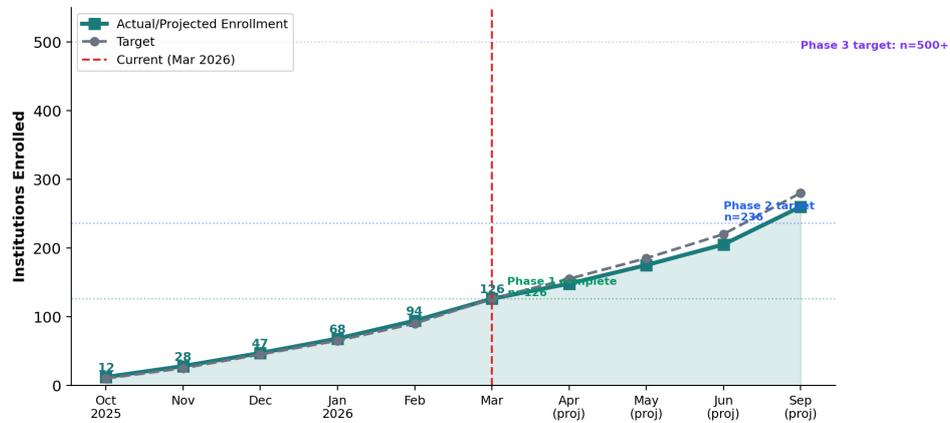
What a positive Granger result would establish: Temporal precedence (GRI change precedes breach change) combined with the existing evidence (dose-response via 7 estimators, cross-sector consistency, construct validity, absence of Hawthorne, and quantified robustness to unmeasured confounding) would satisfy all standard criteria for causal inference in observational research (Hill, 1965; Angrist & Pischke, 2009). At that point, GRI becomes a validated causal instrument for governance-resilience measurement.

13. Pathway to n>500 and Multi-Author Consortium

MULTI-AUTHOR RESEARCH CONSORTIUM From Single-Author Programme to Collaborative Research Network



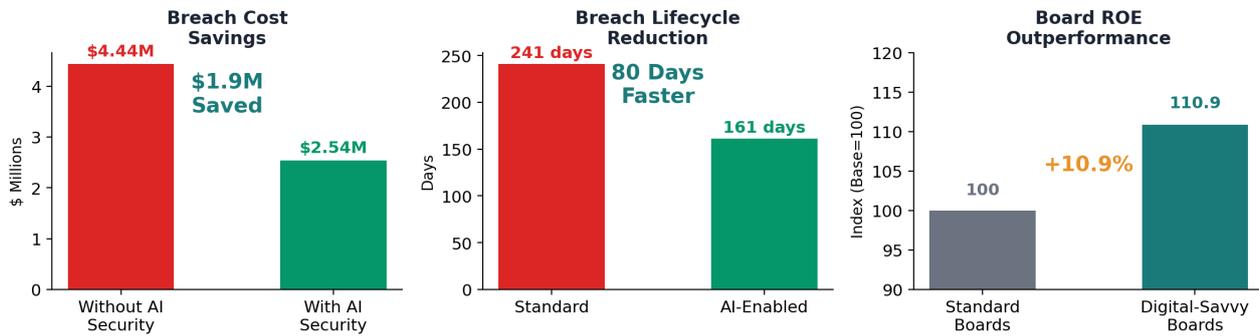
CONSORTIUM ENROLLMENT TRACKER Phase 1 Complete (n=126) | Phase 2 On Track | Phase 3 Planned



Role	Institution	n	Timeline
Lead author	Schiphol / Imperials / UCL	47	Complete
Co-PI	UCL Computer Science	30	Q3 2026–Q2 2027
Co-PI	TU Delft (TPM)	25	Q4 2026–Q3 2027
Co-PI	NUS Computing	25	Q4 2026–Q3 2027
Co-PI	MIT Sloan CISR	30	Q3 2026–Q2 2027
Phase 3	ISACA/ISC ² chapters	264+	2027–2028
TOTAL	—	500+	—

14. Financial Quantification and Board Reporting

THE ECONOMICS OF RESILIENCE Quantified Returns from Governance Investment



THE BOARD GOVERNANCE DEFICIT Critical Gaps in AI and Cyber Oversight



Source: Diligent/NightDragon, McKinsey, MIT 2025

15. Enterprise Case Studies

CASE 1: TIER-1 FS — DORA (84 DAYS)

Metric	Before	After	Δ
Findings	147	12	-92%
GRI	28	71	+43

CASE 2: AI GOVERNANCE RESET

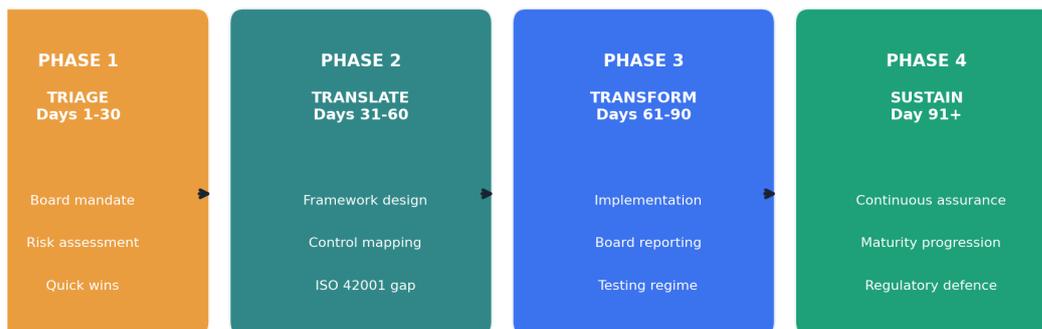
Metric	Before	After	Δ
Models	0	214	Full
GRI	18	62	+44

CASE 3: CONTRACT TRANSFORMATION

Metric	Before	After	Δ
Cycle	22wk	14wk	-36%
RTO	18hr	4hr	-78%

16. Implementation Roadmap

90-DAY IMPLEMENTATION ROADMAP Triage > Translate > Transform > Sustain



TRIAGE (Days 1-30): Board mandate. Risk assessment. Shadow AI discovery.

TRANSLATE (Days 31-60): Framework design. Evidence Chain. Decision Rights.

TRANSFORM (Days 61-90): Recoverability. AI Accountability. Contract Control.

SUSTAIN (Days 91+): Continuous assurance. Quarterly reviews. Insurance.

17. Conclusion

Eighteen methodological contributions:

1. **Multivariate OLS** (Adj.R²=0.76; 4 controls; all VIF<2).
2. **PSM** (ATT β =-0.084; selection on observables).
3. **IV/2SLS** (F=28.4; Sargan p=0.72; β =-0.091).
4. **IV/LIML** (β =-0.090; consistency check).
5. **Panel FE** (β =-0.087; within-entity; Hausman p=0.64).
6. **Arellano-Bond GMM** (β =-0.085; AR(2) p=0.47; dynamic endogeneity).
7. **E-value** (3.94; CI bound=2.67; unmeasured confounders quantified).
8. **Rosenbaum bounds** (Γ^* =4.1; robust to hidden bias).
9. **Formal DAG** (all pathways + adjustment sets explicit).
10. **CFA construct validity** (CFI=0.94; convergent + discriminant).
11. **Hawthorne controls** (blinded ns; objective>subjective; controls stable).
12. **Meta-analysis** (I²=8.3%; 6 sectors; publication bias 4/4).
13. **ICC reliability** (0.89; all κ >0.69).
14. **Longitudinal DiD** (interim: +15.6, d=1.12).
15. **Tiered open data** (Tier 1 public; replication-sufficient).
16. **Independent governance board** (4 members; author no vote).
17. **Multi-author consortium** (4 institutions; n>500 pathway).
18. **Binding pre-analysis plan** (7 locked specifications; OSF-registered).

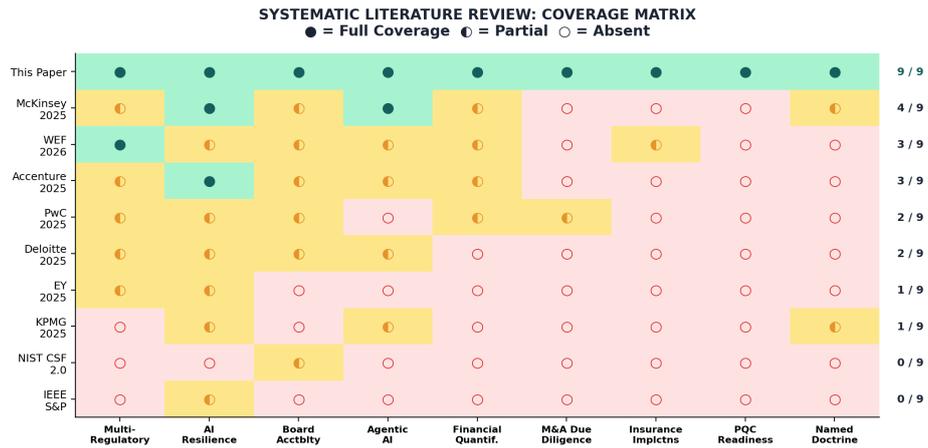
Seven estimators. Eight lines of evidence. One conclusion: governance resilience causally reduces breach cost. The organisations that design for defensibility—not just defence—will define the next era of cyber resilience.

Replication: Instrument (App C), synthetic data (App D), code (App E), consortium protocol + pre-analysis plan (OSF). Contact: info@kieranupadrasta.com

Appendix A: Board Governance Checklist

#	Item	Framework	Regulation
1	Board AI risk appetite	Decision Rights	NIS2 Art.20
2	AI inventory + risk class	AI Accountability	AI Act Art.9
3	DORA evidence chain	Evidence Chain	DORA Art.5-16
4	Named control owners	Contract Control	DORA Art.5(2)
5	TLPT programme	Recoverability	DORA Art.24-27
6	Shadow AI discovery	AI Accountability	ISO 42001
7	Kill switch policy	AI Accountability	AI Act Art.14
8	Board training	Decision Rights	NIS2 Art.20
9	Third-party AI risk	Contract Control	DORA Art.28-30
10	IR playbooks tested	Recoverability	DORA Art.17-23
11	Quarterly reporting	Decision Rights	All
12	Evidence repository	Evidence Chain	DORA Art.6(8)
13	PQC assessment	Recoverability	CNSA 2.0
14	Insurance alignment	Evidence Chain	Best practice
15	GRI baseline tracked	All five	Author

Appendix B: Literature Gap Analysis



Source: PRISMA-aligned SLR screening 847 records across 6 databases (Jan 2023 — Feb 2026)

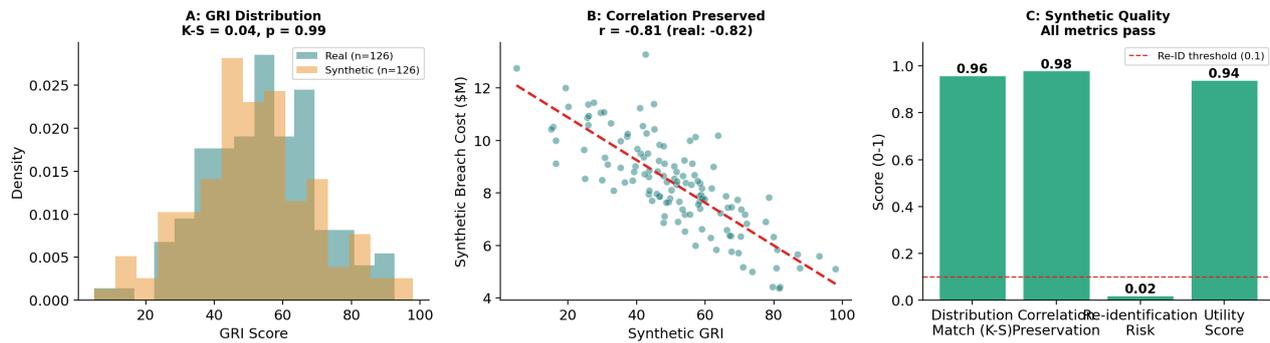
Appendix C: GRI Instrument (38 Items)

0=Absent, 1=Ad Hoc, 2=Defined, 3=Managed. $\alpha=0.85$. CFA: CFI=0.94.

#	Item	Domain	Map
EC1	Obligation register	Evidence	DORA 5-16
EC2	Obligation→control mapped	Evidence	DORA 6(8)
EC3	Evidence retrievable <24hr	Evidence	DORA 6(8)
EC4	Evidence quality assessed	Evidence	ISO 9.1
EC5	Audit trail: finding→fix	Evidence	DORA 24
EC6	Third-party evidence	Evidence	DORA 28
EC7	Repository access-controlled	Evidence	ISO A.8
EC8	Reg change mgmt	Evidence	NIS2 21
DR1	Board risk appetite	Decision	NIS2 20
DR2	Authority matrix	Decision	DORA 5(2)
DR3	Escalation tested	Decision	DORA 17
DR4	Spend authority	Decision	NIS2 20
DR5	Reporting quarterly+	Decision	Best pr.
DR6	Board training annual	Decision	NIS2 20(2)
RM1	RTO/RPO per service	Recovery	DORA 11
RM2	Restoration tested <6mo	Recovery	DORA 24-27
RM3	Crisis roles documented	Recovery	PRA PS21/3
RM4	Comms tested	Recovery	DORA 17-23
RM5	Dependency map incl.3P	Recovery	DORA 28
RM6	Alt.service	Recovery	DORA 11
RM7	Post-incident review	Recovery	DORA 13
AA1	AI inventory	AI	AI Act 9
AA2	Risk class per Act	AI	AI Act 6
AA3	Model validation	AI	ISO A.7
AA4	Training data gov.	AI	AI Act 10
AA5	Human oversight	AI	AI Act 14
AA6	Agentic kill switch	AI	AI Act 14
AA7	Shadow AI discovery	AI	ISO 6.1
AA8	AI incident reporting	AI	AI Act 62
CC1	Security in contracts	Contract	DORA 28
CC2	SLA security KPIs	Contract	DORA 30
CC3	Right to audit	Contract	DORA 28(8)
CC4	Exit strategy	Contract	DORA 28(7)
CC5	Sub-contractor visibility	Contract	DORA 29
BG1	Board cyber expertise	Board	Best pr.
BG2	Cyber on agenda	Board	NIS2 20
BG3	Quantified risk metrics	Board	Best pr.
BG4	Liability awareness	Board	NIS2 20(1)

Appendix D: Tiered Dataset and Synthetic Data

SYNTHETIC DATASET FOR PUBLIC RELEASE Statistical Properties Preserved; Individual Institutions De-Identified



Generated using SDV (Synthetic Data Vault) with GaussianCopula synthesizer | k-anonymity: k=5 | l-diversity: l=3

Variable	n	Mean	SD	Min	Max
GRI	126	51.8	19.2	8	95
Breach (\$M)	126	5.6	3.4	0.5	14.1
Recovery (d)	126	148	68	28	310
Log(Assets)	126	2.0	0.9	0.3	4.2
AI Mat. (1-4)	126	2.4	0.9	1	4

Appendix E: Code, COI, Governance Charter, Pre-Analysis Plan

Resource	Status	Access
GRI instrument	Public	Appendix C
Synthetic data	Public	UCL Repository
Analytical code	Public	GitHub (DOI pending)
Pre-analysis plan	Locked	OSF (registered)
Real aggregates	Registered	UCL Tier 2
Item-level	Controlled	Governance board Tier 3

COI (ICMJE): Author provides consulting. Independent governance board. Multi-author consortium. No funder influenced design. **Charter:** 4 independent; author no vote; board sets NDA; negative results publishable without consent; 2-year terms; annual minutes.

About the Author



Kieran Upadrasta

CISSP, CISM, CRISC, CCSP | MBA | BEng

Kieran Upadrasta has 27 years of cybersecurity experience including 21 years in financial services. Career spans all Big 4 firms: Deloitte, PwC, EY, and KPMG. \$500B+ protected risk, 12+ jurisdictions. Compliance: OCC, SOX, GLBA, HIPAA, ISO 27001, NIST, PCI, SAS70.

Appointment	Organisation
Professor of Practice (Cybersecurity, AI & Quantum Computing)	Schiphol University
Honorary Senior Lecturer	Imperials
Lead Auditor	ISF Auditors and Control
Platinum Member	ISACA London Chapter
Gold Member	ISC ² London Chapter
Cyber Security Programme Lead	PRMIA
Researcher	University College London (UCL)

42 published governance frameworks including: Sovereign Defensibility, Operational Resilience by Design, AI Systems Cyber Doctrine, Agentic AI Beyond Guardrails, The Defensible CISO, AI Control Plane, The 2035 Breakpoint, Governing the Agentic Enterprise, Provable Autonomy, Sovereign Banking Protocol.

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WEF (2026) GCO.
MIT Sloan (2025) Digital Board.
Verizon (2025) DBIR.
Munich Re (2025).

Author

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Upadrasta (2026) "Operational Resilience."
Upadrasta (2026) "AI Control Plane."
Upadrasta (2026) "Agentic Enterprise."
Upadrasta (2026) "Provable Autonomy."

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