

# Supplementary Materials

## Systems Modeling and Numerical Simulation of Financial Reporting Oversight Mechanisms

### S1. Parameter Sources, Equation Notation, and Baseline Values

Table S1 summarizes the parameter-source classifications, evidence scope, equation notation, and baseline values.

**Table S1.** Parameter-source categories, evidence scope, equation notation, and baseline values.

*Panel A. Directional source.*

| Code | Count | Source basis                                                                                  | Evidence scope                                      |
|------|-------|-----------------------------------------------------------------------------------------------|-----------------------------------------------------|
| L    | 79    | Theory or prior literature supports the mechanism direction                                   | Mechanism direction                                 |
| I/L  | 24    | Institution defines the role or timing; literature supports the mechanism direction           | Institutional role, timing, and mechanism direction |
| L/D  | 12    | Literature supports the algorithm or functional form; I specify the diagnostic implementation | Functional-form basis and declared design choice    |
| D    | 122   | I specify a diagnostic or computational design item                                           | Diagnostic or computational control                 |

*Panel B. Numerical source.*

| Code | Count | Source basis                                  | Evidence scope                                                                |
|------|-------|-----------------------------------------------|-------------------------------------------------------------------------------|
| A    | 112   | I set the standardized value or tested range  | Declared value or uncertainty range                                           |
| D    | 125   | I specify a diagnostic or computational value | Threshold, seed, sample size, environment, learning, or structural diagnostic |

*Panel C. Equation notation and baseline values.*

| Equation block         | Parameter notation       | Ordered terms                                                                     | Baseline values           |
|------------------------|--------------------------|-----------------------------------------------------------------------------------|---------------------------|
| EM initialization      | $\mathbf{b}_{EM}^{init}$ | (1,MP,CP)                                                                         | (0.45,0.30,−0.18)         |
| DQ initialization      | $\mathbf{b}_{DQ}^{init}$ | (1,IT,EM <sub>0</sub> )                                                           | (0.55,0.20,−0.28)         |
| AR initialization      | $\mathbf{b}_{AR}^{init}$ | (1,EM <sub>0</sub> ,AQ)                                                           | (0.35,0.45,−0.20)         |
| RI initialization      | $\mathbf{b}_{RI}^{init}$ | (1,AR <sub>0</sub> · RG)                                                          | (0.18,0.40)               |
| GQ initialization      | $\mathbf{b}_{GQ}^{init}$ | (1,DQ <sub>0</sub> ,EM <sub>0</sub> ,AR <sub>0</sub> )                            | (0.40,0.35,−0.25,−0.18)   |
| PR initialization      | $\mathbf{b}_{PR}^{init}$ | (1,AD,RG)                                                                         | (0.20,0.45,0.35)          |
| MT initialization      | $\mathbf{b}_{MT}^{init}$ | (1,DQ <sub>0</sub> ,AR <sub>0</sub> )                                             | (0.50,0.35,−0.25)         |
| Initial disturbances   | $\sigma^{init}$          | (EM,DQ,AR,RI)                                                                     | (0.035,0.030,0.025,0.020) |
| Institutional pressure | $\omega^{IP}$            | (DP <sub>t</sub> ,RC <sub>t</sub> <sup>e</sup> ,BO,IT <sub>t</sub> <sup>e</sup> ) | (0.34,0.28,0.20,0.18)     |

| Equation block                   | Parameter notation                                                                                       | Ordered terms                                                                                                   | Baseline values                                      |
|----------------------------------|----------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|------------------------------------------------------|
| Market feedback strength         | $\omega^{\text{FS}}$                                                                                     | $(1, \text{IT}_t^e)$                                                                                            | $(0.45, 0.55)$                                       |
| Perceived-risk updating score    | $\omega^{\text{RL}}$                                                                                     | $(\text{RI}_{t-1}, \widetilde{\text{AR}}_{t-\tau}, \text{FS}_t, \text{PR}_{t-1})$                               | $(0.18, 0.16, 0.12, 0.10)$                           |
| Opportunistic reporting tendency | $\omega^{\text{OPP}}$                                                                                    | $(\text{MP}, 1 - \text{CP}, 1 - \text{MT}_{t-1}, \widetilde{\text{EM}}_{t-\tau})$                               | $(0.52, 0.18, 0.12, 0.10)$                           |
| EM target coefficients           | $\mathbf{b}^{\text{EM}}$                                                                                 | $(\text{IP}_t, \text{RL}_{t-1})$                                                                                | $(-0.58, -0.20)$                                     |
| DQ target coefficients           | $\mathbf{b}^{\text{DQ}}$                                                                                 | $(1, \text{IT}_t^e, \text{CP}, \text{BO}, \text{RI}_{t-1}, \text{EM}_t)$                                        | $(0.34, 0.34, 0.24, 0.16, 0.12, -0.42)$              |
| AR target coefficients           | $\mathbf{b}^{\text{AR}}$                                                                                 | $(1, \text{EM}_t, 1 - \text{DQ}_t, \text{DP}_t, \text{BO})$                                                     | $(0.20, 0.58, 0.18, -0.36, -0.12)$                   |
| RI target coefficients           | $\mathbf{b}^{\text{RI}}$                                                                                 | $(1, \text{RC}_t^e L(\cdot), \text{IT}_t^e \text{AR}_t, \max(0, \text{EM}_t - \theta_{\text{RI,EM}}), d(\tau))$ | $(0.08, 0.50, 0.25, 0.15, -0.08)$                    |
| MT target coefficients           | $\mathbf{b}^{\text{MT}}$                                                                                 | $(1, \text{DQ}_t, \text{IT}_t^e, \text{BO}, \text{AR}_t, \text{EM}_t)$                                          | $(0.26, 0.42, 0.16, 0.10, -0.30, -0.18)$             |
| GQ coefficients                  | $\mathbf{b}^{\text{GQ}}$                                                                                 | $(\text{DQ}_t, \text{BO}, \text{RC}_t^e, \text{IT}_t^e, \text{MT}_t, \text{EM}_t, \text{AR}_t, 1 - d(\tau))$    | $(0.26, 0.20, 0.18, 0.16, 0.12, -0.18, -0.14, 0.06)$ |
| Perceived-risk update            | $\omega^{\text{PR}}$                                                                                     | $(\text{AR}_t, \text{IP}_t)$                                                                                    | $(0.45, 0.55)$                                       |
| Prior-state shares               | $\rho$                                                                                                   | $(\text{EM}, \text{DQ}, \text{AR}, \text{RI}, \text{MT}, \text{PR})$                                            | $(0.68, 0.70, 0.66, 0.58, 0.72, 0.70)$               |
| Recursive disturbances           | $\sigma$                                                                                                 | $(\text{EM}, \text{DQ}, \text{AR}, \text{RI}, \text{MT})$                                                       | $(0.025, 0.022, 0.023, 0.020, 0.020)$                |
| Regulatory risk response         | $(\theta_{\text{RI,AR}}, \kappa_{\text{RI}})$                                                            | $(\text{center}, \text{slope})$                                                                                 | $(0.35, 4)$                                          |
| Regulatory EM activation         | $\theta_{\text{RI,EM}}$                                                                                  | EM threshold                                                                                                    | 0.35                                                 |
| Nonlinear target                 | $(\theta_{\text{NT}}, \kappa_{\text{NT}})$                                                               | $(\text{center}, \text{slope})$                                                                                 | $(0.50, 5)$                                          |
| Soft boundary                    | $(\theta_{\text{SB}}, \kappa_{\text{SB}})$                                                               | $(\text{center}, \text{slope})$                                                                                 | $(0.50, 8)$                                          |
| Diagnostic joint event           | $(\theta_{\text{EM}}^{\text{Tail}}, \theta_{\text{AR}}^{\text{Tail}}, \theta_{\text{DQ}}^{\text{Tail}})$ | $(\text{EM}, \text{AR}, \text{DQ})$                                                                             | $(0.62, 0.55, 0.45)$                                 |
| Firm reward                      | $\omega^F$                                                                                               | $(\text{EM}_t, \text{MT}_t, \text{RI}_t, \text{AR}_t)$                                                          | $(0.45, 0.20, -0.20, -0.15)$                         |
| Auditor reward                   | $\omega^A$                                                                                               | $(1 - \text{AR}_t, \text{DQ}_t)$                                                                                | $(0.70, 0.30)$                                       |
| Regulator reward                 | $\omega^R$                                                                                               | $(\text{OOG}_t, \text{Tail}_t)$                                                                                 | $(1.00, -0.50)$                                      |
| Higher-action effort cost        | $\lambda$                                                                                                | $c_i e_{i,t}^2$                                                                                                 | 0.05                                                 |

Note: L, literature; I/L, institution and literature; L/D, literature and diagnostic design; D, diagnostic or computational design; A, an author-set value or range. Directional and numerical sources are counted separately. Panel C follows equation order; negative entries indicate inverse terms.  $\rho_X$  and  $1 - \rho_X$  are prior-state and target shares; IP weights sum to one; RL entries are recursive scaling coefficients.  $\tau$  denotes governance delay, and  $d(\tau)$  is the scaled governance-delay term.

## S2. Detailed Results for Initialization, Interaction, and Local Robustness

Table S2 reports event occurrence, timing, and persistence for the seven scenarios under three initialization regimes, together with ASI and terminal governance results.

**Table S2.** Scenario results across initialization regimes.

*Panel A. Event timing and persistence.*

| Initialization regime and scenario                                               | Event at $S_0$ | New event after $t = 0$ | Mean event rate, windows 1–4 | Mean event rate, windows 5–32 | Persistence through window 4 |
|----------------------------------------------------------------------------------|----------------|-------------------------|------------------------------|-------------------------------|------------------------------|
| Scenario-conditioned initialization — High-transparency coordination             | 0.000000       | 0.000000                | 0.000000                     | 0.000000                      | 0.000000                     |
| Scenario-conditioned initialization — Strong regulation                          | 0.000000       | 0.000000                | 0.000000                     | 0.000000                      | 0.000000                     |
| Scenario-conditioned initialization — Strong audit                               | 0.000000       | 0.000000                | 0.000000                     | 0.000000                      | 0.000000                     |
| Scenario-conditioned initialization — Reduced governance delay                   | 0.009000       | 0.000000                | 0.000000                     | 0.000000                      | 0.000000                     |
| Scenario-conditioned initialization — Moderate baseline                          | 0.009000       | 0.000000                | 0.000000                     | 0.000000                      | 0.000000                     |
| Scenario-conditioned initialization — Audit upgrade with weak regulatory penalty | 0.000000       | 0.000000                | 0.000000                     | 0.000000                      | 0.000000                     |
| Scenario-conditioned initialization — Weak governance                            | 0.429000       | 0.109000                | 0.086750                     | 0.005893                      | 0.003000                     |
| Common-moderate initialization — High-transparency coordination                  | 0.009000       | 0.000000                | 0.000000                     | 0.000000                      | 0.000000                     |
| Common-moderate initialization — Strong regulation                               | 0.009000       | 0.000000                | 0.000000                     | 0.000000                      | 0.000000                     |
| Common-moderate initialization — Strong audit                                    | 0.009000       | 0.000000                | 0.000000                     | 0.000000                      | 0.000000                     |
| Common-moderate initialization — Reduced governance delay                        | 0.009000       | 0.000000                | 0.000000                     | 0.000000                      | 0.000000                     |
| Common-moderate initialization — Moderate baseline                               | 0.009000       | 0.000000                | 0.000000                     | 0.000000                      | 0.000000                     |
| Common-moderate initialization — Audit upgrade with weak regulatory penalty      | 0.009000       | 0.000000                | 0.000000                     | 0.000000                      | 0.000000                     |
| Common-moderate initialization — Weak governance                                 | 0.009000       | 0.106000                | 0.010000                     | 0.004857                      | 0.000000                     |
| Fixed-midpoint initialization — High-transparency coordination                   | 0.000000       | 0.000000                | 0.000000                     | 0.000000                      | 0.000000                     |
| Fixed-midpoint initialization — Strong regulation                                | 0.000000       | 0.000000                | 0.000000                     | 0.000000                      | 0.000000                     |
| Fixed-midpoint initialization — Strong audit                                     | 0.000000       | 0.000000                | 0.000000                     | 0.000000                      | 0.000000                     |

| Initialization regime and scenario                                         | Event at $S_0$ | New event after $t = 0$ | Mean event rate, windows 1–4 | Mean event rate, windows 5–32 | Persistence through window 4 |
|----------------------------------------------------------------------------|----------------|-------------------------|------------------------------|-------------------------------|------------------------------|
| Fixed-midpoint initialization — Reduced governance delay                   | 0.000000       | 0.000000                | 0.000000                     | 0.000000                      | 0.000000                     |
| Fixed-midpoint initialization — Moderate baseline                          | 0.000000       | 0.000000                | 0.000000                     | 0.000000                      | 0.000000                     |
| Fixed-midpoint initialization — Audit upgrade with weak regulatory penalty | 0.000000       | 0.000000                | 0.000000                     | 0.000000                      | 0.000000                     |
| Fixed-midpoint initialization — Weak governance                            | 0.000000       | 0.075000                | 0.000000                     | 0.004179                      | 0.000000                     |

Panel B. ASI and terminal governance outcomes.

| Initialization regime and scenario                                               | Mean ASI, windows 1-32 | Terminal GQ | Terminal OOG |
|----------------------------------------------------------------------------------|------------------------|-------------|--------------|
| Scenario-conditioned initialization — High-transparency coordination             | 0.069556               | 0.873129    | 0.937877     |
| Scenario-conditioned initialization — Strong regulation                          | 0.228840               | 0.681917    | 0.773065     |
| Scenario-conditioned initialization — Strong audit                               | 0.236878               | 0.510812    | 0.761060     |
| Scenario-conditioned initialization — Reduced governance delay                   | 0.332351               | 0.502998    | 0.655584     |
| Scenario-conditioned initialization — Moderate baseline                          | 0.336574               | 0.459743    | 0.651358     |
| Scenario-conditioned initialization — Audit upgrade with weak regulatory penalty | 0.277781               | 0.455273    | 0.717142     |
| Scenario-conditioned initialization — Weak governance                            | 0.585777               | 0.101574    | 0.367086     |
| Common-moderate initialization — High-transparency coordination                  | 0.077081               | 0.873127    | 0.937873     |
| Common-moderate initialization — Strong regulation                               | 0.231318               | 0.681909    | 0.773052     |
| Common-moderate initialization — Strong audit                                    | 0.239427               | 0.510806    | 0.761050     |
| Common-moderate initialization — Reduced governance delay                        | 0.332351               | 0.502998    | 0.655584     |
| Common-moderate initialization — Moderate baseline                               | 0.336574               | 0.459743    | 0.651358     |
| Common-moderate initialization — Audit upgrade with weak regulatory penalty      | 0.279066               | 0.455271    | 0.717139     |
| Common-moderate initialization — Weak governance                                 | 0.578147               | 0.101608    | 0.367140     |
| Fixed-midpoint initialization — High-transparency coordination                   | 0.072974               | 0.873128    | 0.937875     |
| Fixed-midpoint initialization — Strong regulation                                | 0.226490               | 0.681920    | 0.773069     |
| Fixed-midpoint initialization — Strong audit                                     | 0.234354               | 0.510822    | 0.761076     |
| Fixed-midpoint initialization — Reduced governance delay                         | 0.327483               | 0.503011    | 0.655604     |

| Initialization regime and scenario                                         | Mean ASI, windows 1-32 | Terminal GQ | Terminal OOG |
|----------------------------------------------------------------------------|------------------------|-------------|--------------|
| Fixed-midpoint initialization — Moderate baseline                          | 0.331478               | 0.459759    | 0.651384     |
| Fixed-midpoint initialization — Audit upgrade with weak regulatory penalty | 0.273932               | 0.455289    | 0.717168     |
| Fixed-midpoint initialization — Weak governance                            | 0.572889               | 0.101629    | 0.367175     |

Note: Event variables are diagnostic joint-event measures. ASI is the adverse-state index; GQ and OOG are the embedded governance quality and outcome-only governance indices, respectively, reported as terminal values.

Table S3 reports all 40 additive-interaction contrasts across the two mechanism grids and two initialization regimes examined in Table 10.

**Table S3.** Additive-interaction contrasts across mechanism grids and initialization regimes.

*Panel A. Audit quality  $\times$  regulatory intensity—common-moderate initialization.*

| Outcome | Contrast             | Estimate  | 95% paired interval    | Standardized cross-difference | Share of corner change |
|---------|----------------------|-----------|------------------------|-------------------------------|------------------------|
| GQ      | Extreme $2 \times 2$ | -0.001490 | [-0.001493, -0.001487] | -0.006341                     | -0.792%                |
| GQ      | Adjacent 00          | -0.000218 | [-0.000219, -0.000217] | -0.006411                     | -0.293%                |
| GQ      | Adjacent 01          | -0.000336 | [-0.000336, -0.000335] | -0.006581                     | -0.322%                |
| GQ      | Adjacent 10          | -0.000388 | [-0.000389, -0.000387] | -0.006464                     | -0.459%                |
| GQ      | Adjacent 11          | -0.000549 | [-0.000550, -0.000548] | -0.006097                     | -0.482%                |
| OOG     | Extreme $2 \times 2$ | -0.001938 | [-0.001942, -0.001934] | -0.008246                     | -1.492%                |
| OOG     | Adjacent 00          | -0.000283 | [-0.000285, -0.000282] | -0.008335                     | -0.563%                |
| OOG     | Adjacent 01          | -0.000436 | [-0.000437, -0.000436] | -0.008558                     | -0.687%                |
| OOG     | Adjacent 10          | -0.000504 | [-0.000506, -0.000503] | -0.008405                     | -0.756%                |
| OOG     | Adjacent 11          | -0.000714 | [-0.000715, -0.000712] | -0.007930                     | -0.898%                |

*Panel B. Audit quality  $\times$  regulatory intensity—fixed-midpoint initialization.*

| Outcome | Contrast             | Estimate  | 95% paired interval    | Standardized cross-difference | Share of corner change |
|---------|----------------------|-----------|------------------------|-------------------------------|------------------------|
| GQ      | Extreme $2 \times 2$ | -0.001490 | [-0.001493, -0.001487] | -0.006341                     | -0.792%                |
| GQ      | Adjacent 00          | -0.000218 | [-0.000219, -0.000217] | -0.006414                     | -0.293%                |
| GQ      | Adjacent 01          | -0.000336 | [-0.000336, -0.000335] | -0.006580                     | -0.322%                |
| GQ      | Adjacent 10          | -0.000388 | [-0.000389, -0.000387] | -0.006464                     | -0.459%                |
| GQ      | Adjacent 11          | -0.000549 | [-0.000550, -0.000547] | -0.006096                     | -0.482%                |
| OOG     | Extreme $2 \times 2$ | -0.001938 | [-0.001942, -0.001934] | -0.008246                     | -1.492%                |
| OOG     | Adjacent 00          | -0.000284 | [-0.000285, -0.000282] | -0.008340                     | -0.563%                |
| OOG     | Adjacent 01          | -0.000436 | [-0.000437, -0.000436] | -0.008557                     | -0.687%                |
| OOG     | Adjacent 10          | -0.000504 | [-0.000506, -0.000503] | -0.008406                     | -0.756%                |
| OOG     | Adjacent 11          | -0.000713 | [-0.000715, -0.000712] | -0.007927                     | -0.898%                |

*Panel C. Regulatory intensity  $\times$  information transparency—common-moderate initialization.*

| Outcome | Contrast             | Estimate  | 95% paired interval    | Standardized cross-difference | Share of corner change |
|---------|----------------------|-----------|------------------------|-------------------------------|------------------------|
| GQ      | Extreme $2 \times 2$ | -0.001635 | [-0.001639, -0.001631] | -0.006539                     | -0.464%                |

| Outcome | Contrast      | Estimate  | 95% paired interval    | Standardized cross-difference | Share of corner change |
|---------|---------------|-----------|------------------------|-------------------------------|------------------------|
| GQ      | Adjacent 00   | -0.000181 | [-0.000183, -0.000178] | -0.006021                     | -0.147%                |
| GQ      | Adjacent 01   | -0.000470 | [-0.000471, -0.000468] | -0.006709                     | -0.234%                |
| GQ      | Adjacent 10   | -0.000306 | [-0.000307, -0.000305] | -0.006805                     | -0.200%                |
| GQ      | Adjacent 11   | -0.000678 | [-0.000679, -0.000677] | -0.006460                     | -0.296%                |
| OOG     | Extreme 2 × 2 | -0.002122 | [-0.002127, -0.002117] | -0.008488                     | -0.969%                |
| OOG     | Adjacent 00   | -0.000234 | [-0.000237, -0.000232] | -0.007813                     | -0.316%                |
| OOG     | Adjacent 01   | -0.000610 | [-0.000611, -0.000608] | -0.008708                     | -0.461%                |
| OOG     | Adjacent 10   | -0.000397 | [-0.000398, -0.000396] | -0.008833                     | -0.455%                |
| OOG     | Adjacent 11   | -0.000881 | [-0.000882, -0.000879] | -0.008386                     | -0.608%                |

*Panel D. Regulatory intensity × information transparency—fixed-midpoint initialization.*

| Outcome | Contrast      | Estimate  | 95% paired interval    | Standardized cross-difference | Share of corner change |
|---------|---------------|-----------|------------------------|-------------------------------|------------------------|
| GQ      | Extreme 2 × 2 | -0.001635 | [-0.001639, -0.001631] | -0.006539                     | -0.464%                |
| GQ      | Adjacent 00   | -0.000181 | [-0.000183, -0.000179] | -0.006026                     | -0.147%                |
| GQ      | Adjacent 01   | -0.000470 | [-0.000471, -0.000468] | -0.006710                     | -0.235%                |
| GQ      | Adjacent 10   | -0.000306 | [-0.000307, -0.000305] | -0.006804                     | -0.200%                |
| GQ      | Adjacent 11   | -0.000678 | [-0.000679, -0.000677] | -0.006458                     | -0.295%                |
| OOG     | Extreme 2 × 2 | -0.002122 | [-0.002127, -0.002117] | -0.008488                     | -0.969%                |
| OOG     | Adjacent 00   | -0.000235 | [-0.000237, -0.000232] | -0.007820                     | -0.316%                |
| OOG     | Adjacent 01   | -0.000610 | [-0.000611, -0.000608] | -0.008709                     | -0.461%                |
| OOG     | Adjacent 10   | -0.000397 | [-0.000398, -0.000396] | -0.008832                     | -0.455%                |
| OOG     | Adjacent 11   | -0.000880 | [-0.000882, -0.000879] | -0.008383                     | -0.608%                |

Table S4 reports the complete Shapley decompositions under the two initialization regimes examined in Table 11, together with coalition-marginal ranges and computational checks.

**Table S4.** Complete Shapley decomposition and computational checks across initialization regimes.

*Panel A. Exact Shapley contributions under common-moderate initialization.*

| Outcome | Mechanism block                                | Shapley contribution | 95% paired interval  | Coalition marginal range | First-rank frequency |
|---------|------------------------------------------------|----------------------|----------------------|--------------------------|----------------------|
| GQ      | Transparency                                   | 0.129033             | [0.128945, 0.129120] | 0.111518/0.141025        | 100.0%               |
| GQ      | Audit                                          | 0.034641             | [0.034464, 0.034815] | 0.006903/0.055862        | 0.0%                 |
| GQ      | Regulation and delay                           | 0.115065             | [0.114999, 0.115131] | 0.100296/0.125096        | 0.0%                 |
| GQ      | Internal monitoring and CFO reporting prudence | 0.116163             | [0.116017, 0.116307] | 0.091324/0.132712        | 0.0%                 |
| GQ      | Market feedback and management pressure        | 0.018282             | [0.018197, 0.018366] | 0.002515/0.028596        | 0.0%                 |
| OOG     | Transparency                                   | 0.087905             | [0.087778, 0.088031] | 0.061382/0.106373        | 38.0%                |
| OOG     | Audit                                          | 0.056426             | [0.056125, 0.056718] | 0.012269/0.091055        | 0.0%                 |
| OOG     | Regulation and delay                           | 0.026987             | [0.026893, 0.027080] | 0.005334/0.041915        | 0.0%                 |
| OOG     | Internal monitoring and CFO reporting prudence | 0.088282             | [0.088064, 0.088499] | 0.049980/0.114353        | 62.0%                |
| OOG     | Market feedback and management pressure        | 0.026633             | [0.026512, 0.026753] | 0.003386/0.042210        | 0.0%                 |

*Panel B. Exact Shapley contributions under fixed-midpoint initialization.*

| Outcome | Mechanism block                                | Shapley contribution | 95% paired interval  | Coalition marginal range | First-rank frequency |
|---------|------------------------------------------------|----------------------|----------------------|--------------------------|----------------------|
| GQ      | Transparency                                   | 0.129030             | [0.128942, 0.129117] | 0.111517/0.141023        | 100.0%               |
| GQ      | Audit                                          | 0.034639             | [0.034461, 0.034813] | 0.006902/0.055862        | 0.0%                 |
| GQ      | Regulation and delay                           | 0.115060             | [0.114994, 0.115126] | 0.100295/0.125091        | 0.0%                 |
| GQ      | Internal monitoring and CFO reporting prudence | 0.116160             | [0.116015, 0.116304] | 0.091322/0.132713        | 0.0%                 |
| GQ      | Market feedback and management pressure        | 0.018280             | [0.018195, 0.018364] | 0.002514/0.028596        | 0.0%                 |
| OOG     | Transparency                                   | 0.087901             | [0.087773, 0.088027] | 0.061380/0.106370        | 38.0%                |
| OOG     | Audit                                          | 0.056421             | [0.056120, 0.056714] | 0.012267/0.091055        | 0.0%                 |
| OOG     | Regulation and delay                           | 0.026979             | [0.026885, 0.027072] | 0.005332/0.041907        | 0.0%                 |
| OOG     | Internal monitoring and CFO reporting prudence | 0.088277             | [0.088060, 0.088494] | 0.049976/0.114354        | 62.0%                |

| Outcome | Mechanism block                         | Shapley contribution | 95% paired interval  | Coalition marginal range | First-rank frequency |
|---------|-----------------------------------------|----------------------|----------------------|--------------------------|----------------------|
| OOG     | Market feedback and management pressure | 0.026630             | [0.026509, 0.026750] | 0.003384/0.042210        | 0.0%                 |

*Panel C. Efficiency check.*

| Initialization                 | Outcome | Full-minus-baseline change | Sum of five Shapley values | Efficiency residual |
|--------------------------------|---------|----------------------------|----------------------------|---------------------|
| Common-moderate initialization | GQ      | 0.413184                   | 0.413184                   | 1.110e-16           |
| Common-moderate initialization | OOG     | 0.286232                   | 0.286232                   | 1.110e-16           |
| Fixed-midpoint initialization  | GQ      | 0.413169                   | 0.413169                   | 1.110e-16           |
| Fixed-midpoint initialization  | OOG     | 0.286207                   | 0.286207                   | 1.110e-16           |

*Panel D. Reconstruction, symmetry, and dummy checks.*

| Initialization                 | Outcome | Maximum subset/permutation difference | Symmetry and dummy checks |
|--------------------------------|---------|---------------------------------------|---------------------------|
| Common-moderate initialization | GQ      | 2.914e-16                             | Passed                    |
| Common-moderate initialization | OOG     | 2.914e-16                             | Passed                    |
| Fixed-midpoint initialization  | GQ      | 2.914e-16                             | Passed                    |
| Fixed-midpoint initialization  | OOG     | 2.914e-16                             | Passed                    |

Note: Blocks: information transparency (IT); audit detection and audit quality (AD + AQ); regulatory intensity and governance delay (RG +  $\tau$ ); board oversight and CFO reporting prudence (BO + CP); market feedback and management pressure (MF + MP).

Table S5 reports the  $3 \times 3$  response-shape diagnostic formed by centers 0.25, 0.35, and 0.45 and slopes 2, 4, and 8. Each scenario–setting combination uses 1,000 paired replications.

**Table S5.** Regulatory-intervention response-shape diagnostic.

*Panel A. Regulatory intervention and governance outcomes.*

| Center | Slope | Scenario                                   | Terminal RI | Terminal GQ | Terminal OOG |
|--------|-------|--------------------------------------------|-------------|-------------|--------------|
| 0.25   | 2     | High-transparency coordination             | 0.248695    | 0.875704    | 0.940920     |
| 0.25   | 2     | Strong regulation                          | 0.308507    | 0.685382    | 0.777660     |
| 0.25   | 2     | Strong audit                               | 0.131508    | 0.512674    | 0.763516     |
| 0.25   | 2     | Reduced governance delay                   | 0.262799    | 0.504409    | 0.657510     |
| 0.25   | 2     | Moderate baseline                          | 0.210251    | 0.461104    | 0.653215     |
| 0.25   | 2     | Audit upgrade with weak regulatory penalty | 0.124337    | 0.456754    | 0.719157     |
| 0.25   | 2     | Weak governance                            | 0.158139    | 0.101117    | 0.366583     |
| 0.25   | 4     | High-transparency coordination             | 0.204800    | 0.874208    | 0.939206     |
| 0.25   | 4     | Strong regulation                          | 0.289326    | 0.684301    | 0.776258     |
| 0.25   | 4     | Strong audit                               | 0.115451    | 0.511806    | 0.762416     |
| 0.25   | 4     | Reduced governance delay                   | 0.265906    | 0.504633    | 0.657803     |
| 0.25   | 4     | Moderate baseline                          | 0.213751    | 0.461352    | 0.653539     |
| 0.25   | 4     | Audit upgrade with weak regulatory penalty | 0.114037    | 0.456189    | 0.718427     |
| 0.25   | 4     | Weak governance                            | 0.174440    | 0.102094    | 0.367853     |
| 0.25   | 8     | High-transparency coordination             | 0.141801    | 0.872024    | 0.936702     |
| 0.25   | 8     | Strong regulation                          | 0.254757    | 0.682338    | 0.773712     |
| 0.25   | 8     | Strong audit                               | 0.088858    | 0.510349    | 0.760569     |
| 0.25   | 8     | Reduced governance delay                   | 0.271786    | 0.505055    | 0.658354     |
| 0.25   | 8     | Moderate baseline                          | 0.220374    | 0.461820    | 0.654150     |
| 0.25   | 8     | Audit upgrade with weak regulatory penalty | 0.095958    | 0.455181    | 0.717124     |
| 0.25   | 8     | Weak governance                            | 0.192997    | 0.103204    | 0.369295     |
| 0.35   | 2     | High-transparency coordination             | 0.228971    | 0.875036    | 0.940154     |
| 0.35   | 2     | Strong regulation                          | 0.286987    | 0.684092    | 0.775982     |

| Center | Slope | Scenario                                   | Terminal RI | Terminal GQ | Terminal OOG |
|--------|-------|--------------------------------------------|-------------|-------------|--------------|
| 0.35   | 2     | Strong audit                               | 0.121138    | 0.512087    | 0.762771     |
| 0.35   | 2     | Reduced governance delay                   | 0.248708    | 0.503565    | 0.656413     |
| 0.35   | 2     | Moderate baseline                          | 0.196158    | 0.460259    | 0.652117     |
| 0.35   | 2     | Audit upgrade with weak regulatory penalty | 0.115586    | 0.456235    | 0.718486     |
| 0.35   | 2     | Weak governance                            | 0.152174    | 0.100760    | 0.366119     |
| 0.35   | 4     | High-transparency coordination             | 0.173310    | 0.873121    | 0.937959     |
| 0.35   | 4     | Strong regulation                          | 0.249223    | 0.681887    | 0.773119     |
| 0.35   | 4     | Strong audit                               | 0.097252    | 0.510766    | 0.761097     |
| 0.35   | 4     | Reduced governance delay                   | 0.238155    | 0.502969    | 0.655641     |
| 0.35   | 4     | Moderate baseline                          | 0.185985    | 0.459688    | 0.651376     |
| 0.35   | 4     | Audit upgrade with weak regulatory penalty | 0.098067    | 0.455232    | 0.717189     |
| 0.35   | 4     | Weak governance                            | 0.164756    | 0.101515    | 0.367100     |
| 0.35   | 8     | High-transparency coordination             | 0.112057    | 0.870984    | 0.935509     |
| 0.35   | 8     | Strong regulation                          | 0.190636    | 0.678430    | 0.768629     |
| 0.35   | 8     | Strong audit                               | 0.065428    | 0.508974    | 0.758823     |
| 0.35   | 8     | Reduced governance delay                   | 0.218701    | 0.501866    | 0.654209     |
| 0.35   | 8     | Moderate baseline                          | 0.167177    | 0.458626    | 0.649999     |
| 0.35   | 8     | Audit upgrade with weak regulatory penalty | 0.072487    | 0.453737    | 0.715255     |
| 0.35   | 8     | Weak governance                            | 0.183170    | 0.102619    | 0.368534     |
| 0.45   | 2     | High-transparency coordination             | 0.210468    | 0.874403    | 0.939429     |
| 0.45   | 2     | Strong regulation                          | 0.266237    | 0.682846    | 0.774363     |
| 0.45   | 2     | Strong audit                               | 0.111272    | 0.511527    | 0.762061     |
| 0.45   | 2     | Reduced governance delay                   | 0.234827    | 0.502733    | 0.655331     |
| 0.45   | 2     | Moderate baseline                          | 0.182268    | 0.459427    | 0.651035     |
| 0.45   | 2     | Audit upgrade with weak regulatory penalty | 0.107200    | 0.455736    | 0.717840     |
| 0.45   | 2     | Weak governance                            | 0.145947    | 0.100388    | 0.365635     |

| Center | Slope | Scenario                                   | Terminal RI | Terminal GQ | Terminal OOG |
|--------|-------|--------------------------------------------|-------------|-------------|--------------|
| 0.45   | 4     | High-transparency coordination             | 0.148291    | 0.872251    | 0.936961     |
| 0.45   | 4     | Strong regulation                          | 0.214174    | 0.679769    | 0.770366     |
| 0.45   | 4     | Strong audit                               | 0.082111    | 0.509896    | 0.759993     |
| 0.45   | 4     | Reduced governance delay                   | 0.211954    | 0.501394    | 0.653592     |
| 0.45   | 4     | Moderate baseline                          | 0.159713    | 0.458108    | 0.649323     |
| 0.45   | 4     | Audit upgrade with weak regulatory penalty | 0.084439    | 0.454410    | 0.716125     |
| 0.45   | 4     | Weak governance                            | 0.153390    | 0.100836    | 0.366217     |
| 0.45   | 8     | High-transparency coordination             | 0.097029    | 0.870456    | 0.934905     |
| 0.45   | 8     | Strong regulation                          | 0.149561    | 0.675899    | 0.765337     |
| 0.45   | 8     | Strong audit                               | 0.052519    | 0.508205    | 0.757846     |
| 0.45   | 8     | Reduced governance delay                   | 0.175375    | 0.499234    | 0.650787     |
| 0.45   | 8     | Moderate baseline                          | 0.123449    | 0.455970    | 0.646545     |
| 0.45   | 8     | Audit upgrade with weak regulatory penalty | 0.058605    | 0.452868    | 0.714129     |
| 0.45   | 8     | Weak governance                            | 0.166533    | 0.101626    | 0.367245     |

*Panel B. Adverse-state, joint-event, and ranking diagnostics.*

| Center | Slope | Scenario                                   | Mean ASI | Any-event incidence | GQ/OOG rank change |
|--------|-------|--------------------------------------------|----------|---------------------|--------------------|
| 0.25   | 2     | High-transparency coordination             | 0.067205 | 0.000               | No change          |
| 0.25   | 2     | Strong regulation                          | 0.225996 | 0.000               | No change          |
| 0.25   | 2     | Strong audit                               | 0.235276 | 0.000               | No change          |
| 0.25   | 2     | Reduced governance delay                   | 0.331363 | 0.000               | No change          |
| 0.25   | 2     | Moderate baseline                          | 0.335607 | 0.000               | No change          |
| 0.25   | 2     | Audit upgrade with weak regulatory penalty | 0.276584 | 0.000               | No change          |
| 0.25   | 2     | Weak governance                            | 0.586398 | 0.338               | No change          |
| 0.25   | 4     | High-transparency coordination             | 0.068375 | 0.000               | No change          |
| 0.25   | 4     | Strong regulation                          | 0.226447 | 0.000               | No change          |
| 0.25   | 4     | Strong audit                               | 0.235905 | 0.000               | No change          |

| Center | Slope | Scenario                                   | Mean ASI | Any-event incidence | GQ/OOG rank change |
|--------|-------|--------------------------------------------|----------|---------------------|--------------------|
| 0.25   | 4     | Reduced governance delay                   | 0.330824 | 0.000               | No change          |
| 0.25   | 4     | Moderate baseline                          | 0.335044 | 0.000               | No change          |
| 0.25   | 4     | Audit upgrade with weak regulatory penalty | 0.276937 | 0.000               | No change          |
| 0.25   | 4     | Weak governance                            | 0.585365 | 0.335               | No change          |
| 0.25   | 8     | High-transparency coordination             | 0.070106 | 0.000               | No change          |
| 0.25   | 8     | Strong regulation                          | 0.227337 | 0.000               | No change          |
| 0.25   | 8     | Strong audit                               | 0.236980 | 0.000               | No change          |
| 0.25   | 8     | Reduced governance delay                   | 0.329892 | 0.000               | No change          |
| 0.25   | 8     | Moderate baseline                          | 0.334068 | 0.000               | No change          |
| 0.25   | 8     | Audit upgrade with weak regulatory penalty | 0.277581 | 0.000               | No change          |
| 0.25   | 8     | Weak governance                            | 0.584200 | 0.329               | No change          |
| 0.35   | 2     | High-transparency coordination             | 0.067856 | 0.000               | No change          |
| 0.35   | 2     | Strong regulation                          | 0.227368 | 0.000               | No change          |
| 0.35   | 2     | Strong audit                               | 0.235908 | 0.000               | No change          |
| 0.35   | 2     | Reduced governance delay                   | 0.332252 | 0.000               | No change          |
| 0.35   | 2     | Moderate baseline                          | 0.336494 | 0.000               | No change          |
| 0.35   | 2     | Audit upgrade with weak regulatory penalty | 0.277136 | 0.000               | No change          |
| 0.35   | 2     | Weak governance                            | 0.586773 | 0.339               | No change          |
| 0.35   | 4     | High-transparency coordination             | 0.069476 | 0.000               | No change          |
| 0.35   | 4     | Strong regulation                          | 0.229055 | 0.000               | No change          |
| 0.35   | 4     | Strong audit                               | 0.237060 | 0.000               | No change          |
| 0.35   | 4     | Reduced governance delay                   | 0.332565 | 0.000               | No change          |
| 0.35   | 4     | Moderate baseline                          | 0.336781 | 0.000               | No change          |
| 0.35   | 4     | Audit upgrade with weak regulatory penalty | 0.277977 | 0.000               | No change          |
| 0.35   | 4     | Weak governance                            | 0.585972 | 0.337               | No change          |

| Center | Slope | Scenario                                   | Mean ASI | Any-event incidence | GQ/OOG rank change |
|--------|-------|--------------------------------------------|----------|---------------------|--------------------|
| 0.35   | 8     | High-transparency coordination             | 0.071378 | 0.000               | No change          |
| 0.35   | 8     | Strong regulation                          | 0.231773 | 0.000               | No change          |
| 0.35   | 8     | Strong audit                               | 0.238698 | 0.000               | No change          |
| 0.35   | 8     | Reduced governance delay                   | 0.333161 | 0.000               | No change          |
| 0.35   | 8     | Moderate baseline                          | 0.337329 | 0.000               | No change          |
| 0.35   | 8     | Audit upgrade with weak regulatory penalty | 0.279273 | 0.000               | No change          |
| 0.35   | 8     | Weak governance                            | 0.584808 | 0.334               | No change          |
| 0.45   | 2     | High-transparency coordination             | 0.068476 | 0.000               | No change          |
| 0.45   | 2     | Strong regulation                          | 0.228706 | 0.000               | No change          |
| 0.45   | 2     | Strong audit                               | 0.236517 | 0.000               | No change          |
| 0.45   | 2     | Reduced governance delay                   | 0.333135 | 0.000               | No change          |
| 0.45   | 2     | Moderate baseline                          | 0.337375 | 0.000               | No change          |
| 0.45   | 2     | Audit upgrade with weak regulatory penalty | 0.277672 | 0.000               | No change          |
| 0.45   | 2     | Weak governance                            | 0.587165 | 0.340               | No change          |
| 0.45   | 4     | High-transparency coordination             | 0.070388 | 0.000               | No change          |
| 0.45   | 4     | Strong regulation                          | 0.231432 | 0.000               | No change          |
| 0.45   | 4     | Strong audit                               | 0.238064 | 0.000               | No change          |
| 0.45   | 4     | Reduced governance delay                   | 0.334260 | 0.000               | No change          |
| 0.45   | 4     | Moderate baseline                          | 0.338475 | 0.000               | No change          |
| 0.45   | 4     | Audit upgrade with weak regulatory penalty | 0.278902 | 0.000               | No change          |
| 0.45   | 4     | Weak governance                            | 0.586686 | 0.339               | No change          |
| 0.45   | 8     | High-transparency coordination             | 0.072142 | 0.000               | No change          |
| 0.45   | 8     | Strong regulation                          | 0.235091 | 0.000               | No change          |
| 0.45   | 8     | Strong audit                               | 0.239824 | 0.000               | No change          |
| 0.45   | 8     | Reduced governance delay                   | 0.336123 | 0.000               | No change          |

| Center | Slope | Scenario                                   | Mean ASI | Any-event incidence | GQ/OOG rank change |
|--------|-------|--------------------------------------------|----------|---------------------|--------------------|
| 0.45   | 8     | Moderate baseline                          | 0.340308 | 0.000               | No change          |
| 0.45   | 8     | Audit upgrade with weak regulatory penalty | 0.280445 | 0.000               | No change          |
| 0.45   | 8     | Weak governance                            | 0.585843 | 0.336               | No change          |

Note: RI and ASI denote regulatory intervention and the adverse-state index, respectively. Rank changes use the maintained response rule as reference.

Table S6 compares the maintained reporting-window pattern with flat weights, half contrast, and amplified contrast, separating governance outcomes from adverse-state diagnostics.

**Table S6.** Reporting-window pattern diagnostic.

*Panel A. Governance outcomes and ranking stability.*

| Weight pattern     | Scenario                                   | Terminal GQ | Terminal OOG | GQ/OOG rank change |
|--------------------|--------------------------------------------|-------------|--------------|--------------------|
| Maintained         | High-transparency coordination             | 0.873121    | 0.937959     | No change          |
| Maintained         | Strong regulation                          | 0.681887    | 0.773119     | No change          |
| Maintained         | Strong audit                               | 0.510766    | 0.761097     | No change          |
| Maintained         | Reduced governance delay                   | 0.502969    | 0.655641     | No change          |
| Maintained         | Moderate baseline                          | 0.459688    | 0.651376     | No change          |
| Maintained         | Audit upgrade with weak regulatory penalty | 0.455232    | 0.717189     | No change          |
| Maintained         | Weak governance                            | 0.101515    | 0.367100     | No change          |
| Flat               | High-transparency coordination             | 0.825546    | 0.934381     | No change          |
| Flat               | Strong regulation                          | 0.634491    | 0.765702     | No change          |
| Flat               | Strong audit                               | 0.479780    | 0.758218     | No change          |
| Flat               | Reduced governance delay                   | 0.467487    | 0.649528     | No change          |
| Flat               | Moderate baseline                          | 0.424166    | 0.645209     | GQ +1; OOG +0      |
| Flat               | Audit upgrade with weak regulatory penalty | 0.424980    | 0.710808     | GQ -1; OOG +0      |
| Flat               | Weak governance                            | 0.082612    | 0.363767     | No change          |
| Half contrast      | High-transparency coordination             | 0.852646    | 0.937115     | No change          |
| Half contrast      | Strong regulation                          | 0.657927    | 0.768980     | No change          |
| Half contrast      | Strong audit                               | 0.495680    | 0.760563     | No change          |
| Half contrast      | Reduced governance delay                   | 0.484984    | 0.652185     | No change          |
| Half contrast      | Moderate baseline                          | 0.441683    | 0.647893     | No change          |
| Half contrast      | Audit upgrade with weak regulatory penalty | 0.439595    | 0.713181     | No change          |
| Half contrast      | Weak governance                            | 0.091991    | 0.365315     | No change          |
| Amplified contrast | High-transparency coordination             | 0.881126    | 0.934847     | No change          |

| Weight pattern     | Scenario                                   | Terminal GQ | Terminal OOG | GQ/OOG rank change |
|--------------------|--------------------------------------------|-------------|--------------|--------------------|
| Amplified contrast | Strong regulation                          | 0.695259    | 0.775974     | No change          |
| Amplified contrast | Strong audit                               | 0.522970    | 0.757009     | No change          |
| Amplified contrast | Reduced governance delay                   | 0.521442    | 0.659895     | No change          |
| Amplified contrast | Moderate baseline                          | 0.478181    | 0.655659     | No change          |
| Amplified contrast | Audit upgrade with weak regulatory penalty | 0.468532    | 0.717077     | No change          |
| Amplified contrast | Weak governance                            | 0.111185    | 0.369123     | No change          |

*Panel B. Adverse-state and joint-event diagnostics.*

| Weight pattern | Scenario                                   | Mean ASI | Maximum ASI | Any-event incidence |
|----------------|--------------------------------------------|----------|-------------|---------------------|
| Maintained     | High-transparency coordination             | 0.069476 | 0.352185    | 0.000               |
| Maintained     | Strong regulation                          | 0.229055 | 0.455024    | 0.000               |
| Maintained     | Strong audit                               | 0.237060 | 0.445429    | 0.000               |
| Maintained     | Reduced governance delay                   | 0.332565 | 0.491029    | 0.000               |
| Maintained     | Moderate baseline                          | 0.336781 | 0.491032    | 0.000               |
| Maintained     | Audit upgrade with weak regulatory penalty | 0.277977 | 0.462738    | 0.000               |
| Maintained     | Weak governance                            | 0.585972 | 0.629575    | 0.337               |
| Flat           | High-transparency coordination             | 0.067198 | 0.337992    | 0.000               |
| Flat           | Strong regulation                          | 0.225858 | 0.444512    | 0.000               |
| Flat           | Strong audit                               | 0.226709 | 0.429505    | 0.000               |
| Flat           | Reduced governance delay                   | 0.329629 | 0.482166    | 0.000               |
| Flat           | Moderate baseline                          | 0.333819 | 0.482172    | 0.000               |
| Flat           | Audit upgrade with weak regulatory penalty | 0.269762 | 0.447691    | 0.000               |
| Flat           | Weak governance                            | 0.585387 | 0.628437    | 0.304               |
| Half contrast  | High-transparency coordination             | 0.067525 | 0.343451    | 0.000               |
| Half contrast  | Strong regulation                          | 0.227819 | 0.449879    | 0.000               |
| Half contrast  | Strong audit                               | 0.231868 | 0.437715    | 0.000               |
| Half contrast  | Reduced governance delay                   | 0.331434 | 0.486694    | 0.000               |

| Weight pattern     | Scenario                                   | Mean ASI | Maximum ASI | Any-event incidence |
|--------------------|--------------------------------------------|----------|-------------|---------------------|
| Half contrast      | Moderate baseline                          | 0.335636 | 0.486698    | 0.000               |
| Half contrast      | Audit upgrade with weak regulatory penalty | 0.274617 | 0.455450    | 0.000               |
| Half contrast      | Weak governance                            | 0.585779 | 0.628985    | 0.319               |
| Amplified contrast | High-transparency coordination             | 0.074840 | 0.360658    | 0.000               |
| Amplified contrast | Strong regulation                          | 0.231134 | 0.459946    | 0.000               |
| Amplified contrast | Strong audit                               | 0.245232 | 0.452646    | 0.000               |
| Amplified contrast | Reduced governance delay                   | 0.333025 | 0.495162    | 0.000               |
| Amplified contrast | Moderate baseline                          | 0.337254 | 0.495166    | 0.000               |
| Amplified contrast | Audit upgrade with weak regulatory penalty | 0.283136 | 0.469555    | 0.000               |
| Amplified contrast | Weak governance                            | 0.585967 | 0.630224    | 0.348               |

Note: Rank changes use the maintained pattern as reference; any-event incidence is the share of replications with at least one diagnostic joint event.

Table S7 applies all 125 threshold triples to the same fixed trajectories. This common-trajectory design holds environmental shocks constant across threshold comparisons and reports the corresponding ASI summaries.

**Table S7.** Threshold-grid event incidence and adverse-state index summaries.

*Panel A. Threshold-grid event incidence.*

| Initialization regime               | Scenario                                        | Any-event incidence<br>(minimum/main-<br>tained/maximum) | Threshold triples<br>with at least one<br>event |
|-------------------------------------|-------------------------------------------------|----------------------------------------------------------|-------------------------------------------------|
| Scenario-conditioned initialization | High-transparency coordination                  | 0.000/0.000/0.000                                        | 0                                               |
| Scenario-conditioned initialization | Strong regulation                               | 0.000/0.000/0.000                                        | 0                                               |
| Scenario-conditioned initialization | Strong audit                                    | 0.000/0.000/0.000                                        | 0                                               |
| Scenario-conditioned initialization | Reduced governance delay                        | 0.000/0.000/0.003                                        | 12                                              |
| Scenario-conditioned initialization | Moderate baseline                               | 0.000/0.000/0.003                                        | 12                                              |
| Scenario-conditioned initialization | Audit upgrade with weak regula-<br>tory penalty | 0.000/0.000/0.001                                        | 1                                               |
| Scenario-conditioned initialization | Weak governance                                 | 0.041/0.325/0.893                                        | 125                                             |
| Common-moderate initialization      | High-transparency coordination                  | 0.000/0.000/0.000                                        | 0                                               |
| Common-moderate initialization      | Strong regulation                               | 0.000/0.000/0.000                                        | 0                                               |
| Common-moderate initialization      | Strong audit                                    | 0.000/0.000/0.000                                        | 0                                               |
| Common-moderate initialization      | Reduced governance delay                        | 0.000/0.000/0.003                                        | 12                                              |
| Common-moderate initialization      | Moderate baseline                               | 0.000/0.000/0.003                                        | 12                                              |
| Common-moderate initialization      | Audit upgrade with weak regula-<br>tory penalty | 0.000/0.000/0.001                                        | 4                                               |
| Common-moderate initialization      | Weak governance                                 | 0.000/0.111/0.704                                        | 120                                             |
| Fixed-midpoint initialization       | High-transparency coordination                  | 0.000/0.000/0.000                                        | 0                                               |
| Fixed-midpoint initialization       | Strong regulation                               | 0.000/0.000/0.000                                        | 0                                               |
| Fixed-midpoint initialization       | Strong audit                                    | 0.000/0.000/0.000                                        | 0                                               |
| Fixed-midpoint initialization       | Reduced governance delay                        | 0.000/0.000/0.000                                        | 0                                               |
| Fixed-midpoint initialization       | Moderate baseline                               | 0.000/0.000/0.000                                        | 0                                               |
| Fixed-midpoint initialization       | Audit upgrade with weak regula-<br>tory penalty | 0.000/0.000/0.000                                        | 0                                               |
| Fixed-midpoint initialization       | Weak governance                                 | 0.000/0.075/0.615                                        | 100                                             |

Panel B. Adverse-state index summaries.

| Initialization regime               | Scenario                                   | Mean ASI,<br>windows 1–4 | Mean ASI,<br>windows 1–32 | Mean<br>maximum ASI | Mean<br>terminal ASI |
|-------------------------------------|--------------------------------------------|--------------------------|---------------------------|---------------------|----------------------|
| Scenario-conditioned initialization | High-transparency co-ordination            | 0.242818                 | 0.069556                  | 0.354172            | 0.034425             |
| Scenario-conditioned initialization | Strong regulation                          | 0.379691                 | 0.228840                  | 0.457016            | 0.183229             |
| Scenario-conditioned initialization | Strong audit                               | 0.373857                 | 0.236878                  | 0.447424            | 0.189928             |
| Scenario-conditioned initialization | Reduced governance delay                   | 0.438155                 | 0.332351                  | 0.493065            | 0.298833             |
| Scenario-conditioned initialization | Moderate baseline                          | 0.439587                 | 0.336574                  | 0.493067            | 0.303007             |
| Scenario-conditioned initialization | Audit upgrade with weak regulatory penalty | 0.399765                 | 0.277781                  | 0.464745            | 0.233069             |
| Scenario-conditioned initialization | Weak governance                            | 0.589901                 | 0.585777                  | 0.629690            | 0.582138             |
| Common-moderate initialization      | High-transparency co-ordination            | 0.288276                 | 0.077081                  | 0.420496            | 0.034426             |
| Common-moderate initialization      | Strong regulation                          | 0.391640                 | 0.231318                  | 0.472494            | 0.183238             |
| Common-moderate initialization      | Strong audit                               | 0.388406                 | 0.239427                  | 0.469915            | 0.189935             |
| Common-moderate initialization      | Reduced governance delay                   | 0.438155                 | 0.332351                  | 0.493065            | 0.298833             |
| Common-moderate initialization      | Moderate baseline                          | 0.439587                 | 0.336574                  | 0.493067            | 0.303007             |
| Common-moderate initialization      | Audit upgrade with weak regulatory penalty | 0.408106                 | 0.279066                  | 0.478928            | 0.233071             |
| Common-moderate initialization      | Weak governance                            | 0.552699                 | 0.578147                  | 0.623919            | 0.582098             |
| Fixed-midpoint initialization       | High-transparency co-ordination            | 0.265372                 | 0.072974                  | 0.391469            | 0.034425             |
| Fixed-midpoint initialization       | Strong regulation                          | 0.367938                 | 0.226490                  | 0.443473            | 0.183226             |
| Fixed-midpoint initialization       | Strong audit                               | 0.364483                 | 0.234354                  | 0.440894            | 0.189916             |
| Fixed-midpoint initialization       | Reduced governance delay                   | 0.414435                 | 0.327483                  | 0.464033            | 0.298819             |
| Fixed-midpoint initialization       | Moderate baseline                          | 0.415662                 | 0.331478                  | 0.464038            | 0.302988             |

| Initialization regime         | Scenario                                      | Mean ASI,<br>windows 1–4 | Mean ASI,<br>windows 1–32 | Mean<br>maximum ASI | Mean<br>terminal ASI |
|-------------------------------|-----------------------------------------------|--------------------------|---------------------------|---------------------|----------------------|
| Fixed-midpoint initialization | Audit upgrade with<br>weak regulatory penalty | 0.384160                 | 0.273932                  | 0.449906            | 0.233051             |
| Fixed-midpoint initialization | Weak governance                               | 0.528737                 | 0.572889                  | 0.622298            | 0.582073             |

Note: ASI is a continuous diagnostic without a cutoff.

Table S8 reports GQ and OOG values and GQ ranks for three benchmark scenarios under common mechanism-weight multipliers.

**Table S8.** Governance-index results under common mechanism-weight multipliers.

| Weight multiplier | Scenario                       | GQ     | OOG    | GQ rank |
|-------------------|--------------------------------|--------|--------|---------|
| 1.00              | High-transparency coordination | 0.8731 | 0.9385 | 1       |
| 1.00              | Strong regulation              | 0.6824 | 0.7737 | 2       |
| 1.00              | Weak governance                | 0.1020 | 0.3673 | 7       |
| 0.90              | High-transparency coordination | 0.7610 | 0.9000 | 1       |
| 0.90              | Strong regulation              | 0.5866 | 0.7295 | 2       |
| 0.90              | Weak governance                | 0.1132 | 0.4050 | 7       |
| 1.10              | High-transparency coordination | 0.9822 | 0.9683 | 1       |
| 1.10              | Strong regulation              | 0.7929 | 0.8302 | 2       |
| 1.10              | Weak governance                | 0.0847 | 0.3270 | 7       |

Note: GQ ranks use all seven scenarios.

Table S9 reports GQ and OOG values and GQ ranks for three benchmark scenarios under four simulation-noise multipliers.

**Table S9.** Governance-index results under simulation-noise multipliers.

| Noise multiplier | Scenario                       | GQ     | OOG    | GQ rank |
|------------------|--------------------------------|--------|--------|---------|
| 0.50             | High-transparency coordination | 0.8776 | 0.9452 | 1       |
| 0.50             | Strong regulation              | 0.6811 | 0.7719 | 2       |
| 0.50             | Weak governance                | 0.1013 | 0.3668 | 7       |
| 1.00             | High-transparency coordination | 0.8733 | 0.9390 | 1       |
| 1.00             | Strong regulation              | 0.6807 | 0.7711 | 2       |
| 1.00             | Weak governance                | 0.1014 | 0.3668 | 7       |
| 1.50             | High-transparency coordination | 0.8684 | 0.9322 | 1       |
| 1.50             | Strong regulation              | 0.6800 | 0.7701 | 2       |
| 1.50             | Weak governance                | 0.1016 | 0.3669 | 7       |
| 2.00             | High-transparency coordination | 0.8629 | 0.9246 | 1       |
| 2.00             | Strong regulation              | 0.6787 | 0.7680 | 2       |
| 2.00             | Weak governance                | 0.1017 | 0.3670 | 7       |

Note: GQ ranks use all seven scenarios.

Table S10 reports GQ and OOG values and core-order positions for three benchmark scenarios at four Monte Carlo run sizes.

**Table S10.** Governance-index results by Monte Carlo run size.

| Runs | Scenario                       | GQ     | OOG    | Core-order position |
|------|--------------------------------|--------|--------|---------------------|
| 100  | High-transparency coordination | 0.8740 | 0.9393 | 1                   |
| 100  | Strong regulation              | 0.6826 | 0.7737 | 2                   |
| 100  | Weak governance                | 0.1008 | 0.3656 | 7                   |
| 200  | High-transparency coordination | 0.8732 | 0.9385 | 1                   |
| 200  | Strong regulation              | 0.6822 | 0.7734 | 2                   |
| 200  | Weak governance                | 0.1025 | 0.3682 | 7                   |
| 500  | High-transparency coordination | 0.8726 | 0.9376 | 1                   |
| 500  | Strong regulation              | 0.6822 | 0.7733 | 2                   |
| 500  | Weak governance                | 0.1014 | 0.3667 | 7                   |
| 1000 | High-transparency coordination | 0.8728 | 0.9377 | 1                   |
| 1000 | Strong regulation              | 0.6824 | 0.7737 | 2                   |
| 1000 | Weak governance                | 0.1013 | 0.3666 | 7                   |

Note: Core-order positions use all seven scenarios.

Table S11 reports scenario–state pairs with nonzero state-clipping contact.

**Table S11.** Scenario-specific state-clipping contacts.

| Scenario                       | State variable           | Lower-boundary contact | Upper-boundary contact | Minimum | Maximum |
|--------------------------------|--------------------------|------------------------|------------------------|---------|---------|
| Strong audit                   | Audit risk (AR)          | 0.2%                   | 0.0%                   | 0.0     | 0.4913  |
| High-transparency coordination | Earnings management (EM) | 25.3%                  | 0.0%                   | 0.0     | 0.4731  |
| High-transparency coordination | Disclosure quality (DQ)  | 0.0%                   | 0.4%                   | 0.5564  | 1.0     |
| High-transparency coordination | Audit risk (AR)          | 26.6%                  | 0.0%                   | 0.0     | 0.4442  |

Note: Boundary-contact rates are calculated within each scenario.

### S3. LHS/PRCC Global Sensitivity Analysis

Table S12 defines 28 common factors and their uncertainty ranges.

**Table S12.** Common-factor LHS design: factor families and uncertainty ranges.

| Factor family                                   | Number of factors | Uncertainty range                                        |
|-------------------------------------------------|-------------------|----------------------------------------------------------|
| Scenario parameters, including governance delay | 9                 | Multipliers 0.85–1.15; governance-delay shift -1 to +1   |
| Equation and adjustment blocks                  | 11                | Mostly 0.85–1.15; intercepts 0.90–1.10                   |
| Noise scale                                     | 1                 | 0.75–1.50                                                |
| Reporting-window channels                       | 4                 | Channel multipliers 0.90–1.10                            |
| Tail-risk thresholds                            | 3                 | EM 0.58–0.66; AR 0.52–0.58; DQ 0.42–0.48                 |
| <b>Total</b>                                    | <b>28</b>         | 4,000 LHS samples; four replications per sample–scenario |

Note: Each sample–scenario combination uses four common-random-number replications.

Table S13 assesses convergence against the 4,000-sample reference.

**Table S13.** PRCC convergence by LHS sample size.

| LHS samples | Valid comparisons | Mean Spearman $\rho$ | Mean $ \Delta\text{PRCC} $ | Mean top-five overlap | Max $ \Delta\text{PRCC} $ |
|-------------|-------------------|----------------------|----------------------------|-----------------------|---------------------------|
| 500         | 48/48             | 0.8365               | 0.0483                     | 0.7536                | 0.1654                    |
| 1,000       | 44/44             | 0.9675               | 0.0240                     | 0.7750                | 0.1039                    |
| 2,000       | 44/48             | 0.9822               | 0.0195                     | 0.7750                | 0.0790                    |
| 4,000       | 44/44             | 1.0000               | 0.0000                     | 1.0000                | 0.0000                    |

Note: The 56 comparisons span seven scenarios  $\times$  eight outputs (GQ, OOG, EM, DQ, AR, MT, reporting-window tail-risk observation rate, and trajectory-level any-event rate). Active factors satisfy  $|\text{PRCC}| \geq 0.10$  in the 4,000-sample reference. The “Valid comparisons” column lists rank-correlation/absolute-change counts; these require at least two/one active factors, respectively.

Table S14 lists the five largest absolute scenario-specific PRCCs for GQ and OOG in each scenario.

**Table S14.** Leading scenario-specific PRCCs for GQ and OOG.

| Scenario and output    | Rank | Factor | PRCC   |
|------------------------|------|--------|--------|
| Moderate baseline, GQ  | 1    | EICS   | 0.922  |
| Moderate baseline, GQ  | 2    | OCS    | -0.804 |
| Moderate baseline, GQ  | 3    | IT     | 0.728  |
| Moderate baseline, GQ  | 4    | MP     | -0.652 |
| Moderate baseline, GQ  | 5    | RG     | 0.640  |
| Moderate baseline, OOG | 1    | OCS    | -0.892 |
| Moderate baseline, OOG | 2    | MP     | -0.778 |
| Moderate baseline, OOG | 3    | IPCS   | 0.648  |
| Moderate baseline, OOG | 4    | IT     | 0.597  |
| Moderate baseline, OOG | 5    | EqIS   | 0.492  |
| Weak governance, GQ    | 1    | OCS    | -0.907 |
| Weak governance, GQ    | 2    | MP     | -0.779 |
| Weak governance, GQ    | 3    | IT     | 0.597  |
| Weak governance, GQ    | 4    | EICS   | 0.549  |
| Weak governance, GQ    | 5    | EqIS   | 0.499  |
| Weak governance, OOG   | 1    | OCS    | -0.941 |
| Weak governance, OOG   | 2    | MP     | -0.844 |
| Weak governance, OOG   | 3    | EqIS   | 0.542  |
| Weak governance, OOG   | 4    | ARCS   | -0.506 |
| Weak governance, OOG   | 5    | IT     | 0.435  |
| Strong audit, GQ       | 1    | EICS   | 0.932  |
| Strong audit, GQ       | 2    | OCS    | -0.756 |
| Strong audit, GQ       | 3    | IT     | 0.712  |
| Strong audit, GQ       | 4    | MP     | -0.610 |
| Strong audit, GQ       | 5    | BO     | 0.606  |
| Strong audit, OOG      | 1    | OCS    | -0.864 |
| Strong audit, OOG      | 2    | MP     | -0.765 |
| Strong audit, OOG      | 3    | IPCS   | 0.702  |

| Scenario and output                 | Rank | Factor | PRCC   |
|-------------------------------------|------|--------|--------|
| Strong audit, OOG                   | 4    | IT     | 0.605  |
| Strong audit, OOG                   | 5    | RW-AWS | 0.596  |
| Strong regulation, GQ               | 1    | EICS   | 0.957  |
| Strong regulation, GQ               | 2    | IT     | 0.736  |
| Strong regulation, GQ               | 3    | OCS    | -0.717 |
| Strong regulation, GQ               | 4    | BO     | 0.665  |
| Strong regulation, GQ               | 5    | RG     | 0.607  |
| Strong regulation, OOG              | 1    | OCS    | -0.851 |
| Strong regulation, OOG              | 2    | MP     | -0.747 |
| Strong regulation, OOG              | 3    | IPCS   | 0.708  |
| Strong regulation, OOG              | 4    | IT     | 0.627  |
| Strong regulation, OOG              | 5    | DRCS   | 0.625  |
| High-transparency coordination, GQ  | 1    | EICS   | 0.983  |
| High-transparency coordination, GQ  | 2    | BO     | 0.743  |
| High-transparency coordination, GQ  | 3    | DRCS   | 0.666  |
| High-transparency coordination, GQ  | 4    | RG     | 0.633  |
| High-transparency coordination, GQ  | 5    | IT     | 0.626  |
| High-transparency coordination, OOG | 1    | DRCS   | 0.807  |
| High-transparency coordination, OOG | 2    | MTCS   | 0.758  |
| High-transparency coordination, OOG | 3    | EqIS   | 0.643  |
| High-transparency coordination, OOG | 4    | IT     | 0.589  |
| High-transparency coordination, OOG | 5    | RW-DWS | 0.441  |
| Reduced governance delay, GQ        | 1    | EICS   | 0.936  |
| Reduced governance delay, GQ        | 2    | OCS    | -0.811 |
| Reduced governance delay, GQ        | 3    | IT     | 0.727  |
| Reduced governance delay, GQ        | 4    | MP     | -0.690 |
| Reduced governance delay, GQ        | 5    | RG     | 0.652  |
| Reduced governance delay, OOG       | 1    | OCS    | -0.896 |
| Reduced governance delay, OOG       | 2    | MP     | -0.796 |

| Scenario and output                             | Rank | Factor | PRCC   |
|-------------------------------------------------|------|--------|--------|
| Reduced governance delay, OOG                   | 3    | IPCS   | 0.655  |
| Reduced governance delay, OOG                   | 4    | IT     | 0.594  |
| Reduced governance delay, OOG                   | 5    | EqIS   | 0.528  |
| Audit upgrade with weak regulatory penalty, GQ  | 1    | EICS   | 0.925  |
| Audit upgrade with weak regulatory penalty, GQ  | 2    | OCS    | -0.803 |
| Audit upgrade with weak regulatory penalty, GQ  | 3    | IT     | 0.725  |
| Audit upgrade with weak regulatory penalty, GQ  | 4    | MP     | -0.675 |
| Audit upgrade with weak regulatory penalty, GQ  | 5    | GDS    | -0.647 |
| Audit upgrade with weak regulatory penalty, OOG | 1    | OCS    | -0.881 |
| Audit upgrade with weak regulatory penalty, OOG | 2    | MP     | -0.773 |
| Audit upgrade with weak regulatory penalty, OOG | 3    | IPCS   | 0.686  |
| Audit upgrade with weak regulatory penalty, OOG | 4    | RW-AWS | 0.635  |
| Audit upgrade with weak regulatory penalty, OOG | 5    | IT     | 0.573  |

Note: Factors are ranked by absolute PRCC; signed values are shown. Each PRCC controls for all other factors in that scenario. Abbreviations: EICS, embedded-index coefficient scale; OCS, opportunism coefficient scale; IT, information transparency; MP, management pressure; RG, regulatory intensity; IPCS, institutional-pressure coefficient scale; EqIS, equation-intercept scale; ARCS, audit-risk coefficient scale; BO, board oversight; RW-AWS, reporting-window audit-weight scale; DRCS, disclosure-response coefficient scale; MTCS, market-trust coefficient scale; RW-DWS, reporting-window disclosure-weight scale; GDS, governance-delay shift.

## S4. Limited Heterogeneity Stress Test across Firm, Audit, and Regulatory Conditions

Table S15 reports factor-level means and 95% intervals from the balanced  $3 \times 2 \times 2$  limited heterogeneity design.

**Table S15.** Factor-level means in the balanced  $3 \times 2 \times 2$  heterogeneity design.

*Panel A. Governance and reporting outcomes, mean [95% interval].*

| Dimension and level            | GQ                         | OOG                        | EM                         | DQ                         |
|--------------------------------|----------------------------|----------------------------|----------------------------|----------------------------|
| Firm: weak                     | 0.2703<br>[0.2692, 0.2715] | 0.4846<br>[0.4829, 0.4863] | 0.4000<br>[0.3977, 0.4023] | 0.4061<br>[0.4038, 0.4083] |
| Firm: baseline                 | 0.4903<br>[0.4892, 0.4914] | 0.6817<br>[0.6801, 0.6833] | 0.2225<br>[0.2201, 0.2250] | 0.6283<br>[0.6262, 0.6304] |
| Firm: strong                   | 0.7620<br>[0.7610, 0.7629] | 0.8966<br>[0.8953, 0.8979] | 0.0550<br>[0.0531, 0.0570] | 0.9123<br>[0.9101, 0.9145] |
| Audit: low                     | 0.4720<br>[0.4711, 0.4729] | 0.6294<br>[0.6281, 0.6307] | 0.2771<br>[0.2752, 0.2790] | 0.6334<br>[0.6316, 0.6352] |
| Audit: high                    | 0.5431<br>[0.5422, 0.5439] | 0.7459<br>[0.7447, 0.7471] | 0.1746<br>[0.1728, 0.1764] | 0.6644<br>[0.6626, 0.6662] |
| Regulation: weak/long delay    | 0.3878<br>[0.3868, 0.3887] | 0.6498<br>[0.6485, 0.6511] | 0.2799<br>[0.2780, 0.2818] | 0.6162<br>[0.6144, 0.6180] |
| Regulation: strong/short delay | 0.6273<br>[0.6265, 0.6281] | 0.7255<br>[0.7243, 0.7267] | 0.1718<br>[0.1701, 0.1736] | 0.6816<br>[0.6798, 0.6834] |

*Panel B. Audit risk, market trust, and tail-risk incidence, mean or rate [95% interval].*

| Dimension and level            | AR                         | MT                         | Any-tail-risk rate         |
|--------------------------------|----------------------------|----------------------------|----------------------------|
| Firm: weak                     | 0.3810<br>[0.3784, 0.3835] | 0.3133<br>[0.3108, 0.3157] | 0.0988<br>[0.0800, 0.1214] |
| Firm: baseline                 | 0.2200<br>[0.2176, 0.2223] | 0.5410<br>[0.5387, 0.5433] | 0.0000<br>[0.0000, 0.0048] |
| Firm: strong                   | 0.0865<br>[0.0847, 0.0884] | 0.8158<br>[0.8136, 0.8179] | 0.0000<br>[0.0000, 0.0048] |
| Audit: low                     | 0.3464<br>[0.3444, 0.3483] | 0.5077<br>[0.5057, 0.5095] | 0.0658<br>[0.0531, 0.0813] |
| Audit: high                    | 0.1120<br>[0.1102, 0.1137] | 0.6057<br>[0.6038, 0.6076] | 0.0000<br>[0.0000, 0.0032] |
| Regulation: weak/long delay    | 0.2612<br>[0.2593, 0.2631] | 0.5240<br>[0.5221, 0.5260] | 0.0583<br>[0.0464, 0.0731] |
| Regulation: strong/short delay | 0.1971<br>[0.1952, 0.1989] | 0.5894<br>[0.5876, 0.5912] | 0.0075<br>[0.0040, 0.0142] |

Note: Any-tail-risk rate is the share of replications with at least one diagnostic joint event.

## S5. Firm–Auditor–Regulator Learning Extension

### S5.1 Learning Model Specification

Each role maps three binary pre-decision signals to one of eight observation states. The firm observes high EM, high RI, and low MT; the auditor observes low DQ, high AR, and annual-report status; and the regulator observes high delayed EM, high delayed AR, and low current DQ. Cutoffs are 0.50 for EM, DQ, and MT, 0.45 for AR, and 0.35 for RI; delayed signals use the same EM and AR cutoffs.

For the current window, the firm chooses aggressive reporting ( $a_F = 0$ ) or integrity-oriented reporting ( $a_F = 1$ ), the auditor chooses low audit effort ( $a_A = 0$ ) or high audit effort ( $a_A = 1$ ), and the regulator chooses low enforcement intensity ( $a_R = 0$ ) or high enforcement intensity ( $a_R = 1$ ). The current-window mappings are:

$$CP_t = C(CP + \delta m_F(2a_F - 1)), \quad (S1)$$

$$AD_t = C(AD + \delta m_A(2a_A - 1)), \quad (S2)$$

$$RG_t = C(RG + \delta m_R(2a_R - 1)). \quad (S3)$$

$C(\cdot)$  clips each input to the standardized 0–1 range, and  $\delta = 0.10$  is the baseline action amplitude. For each replication,  $m_i$  and  $c_i$  are drawn independently for every role  $i \in \{F, A, R\}$  from Uniform(0.90, 1.10) and fixed across training and evaluation. The three actions are applied simultaneously before the recursive state update.

Each role has an independent zero-initialized  $8 \times 2$  action-value table  $Q$ . For transition  $(o_t, a_t, r_t, o_{t+1})$ , the update is:

$$Q(o_t, a_t) \leftarrow Q(o_t, a_t) + \alpha [r_t + \gamma \max_a Q(o_{t+1}, a) - Q(o_t, a_t)]. \quad (S4)$$

At the final window, the target is  $r_t$  without the next-state term. The baseline sets  $\alpha = 0.15$  for every role and  $\gamma = 0.90$ ;  $\varepsilon$  decreases linearly from 0.25 to 0.02 over 200 episodes of 32 windows. Held-out evaluation freezes all  $Q$  tables and sets  $\varepsilon = 0$ .

For role  $i$ ,  $\omega_Z^i$  is the signed weight on outcome  $Z$ , and  $\lambda$  is the common higher-action effort-cost coefficient. Rewards are computed from the post-update state:

$$r_t^F = \omega_{EM}^F EM_t + \omega_{MT}^F MT_t + \omega_{RI}^F RI_t + \omega_{AR}^F AR_t - \lambda c_F e_{F,t}^2, \quad (S5)$$

$$r_t^A = \omega_{AR}^A (1 - AR_t) + \omega_{DQ}^A DQ_t - \lambda c_A e_{A,t}^2, \quad (S6)$$

$$r_t^R = \omega_{OOG}^R OOG_t + \omega_{Tail}^R Tail_t - \lambda c_R e_{R,t}^2. \quad (S7)$$

Here,  $e_{i,t} = a_{i,t}$ ; value 1 denotes integrity-oriented reporting, high audit effort, or high enforcement intensity, and value 0 denotes the lower-cost action.  $Tail_t$  is the diagnostic joint-event indicator. Table S1 Panel C gives the reward weights and effort-cost coefficient.

### S5.2 Learning Experiment Design

The experiment compares fixed-baseline, random, and learned-greedy policies in all 12 cells of the balanced  $3 \times 2 \times 2$  design. Each cell uses 200 paired replications of 32 windows; evaluation policies share initial states and environmental shocks, and training precedes held-out frozen-policy evaluation.

The 500-sample LHS varies 17 learning factors across four prespecified design-corner cells. A separate training-horizon check covers all 12 cells; each of the 100-, 200-, and 400-episode settings uses 20 replications per cell. Table S16 lists the factor groups and ranges.

**Table S16.** Learning-factor families and uncertainty ranges.

| Factor family                                         | Number of factors | Uncertainty range                                                          |
|-------------------------------------------------------|-------------------|----------------------------------------------------------------------------|
| Role-specific learning rates and discount factor      | 4                 | Role-specific $\alpha$ : 0.05–0.30; $\gamma$ : 0.70–0.99                   |
| Exploration schedule                                  | 2                 | Initial $\varepsilon$ : 0.10–0.40; final $\varepsilon$ : 0.00–0.08         |
| Action amplitude, effort cost, and stable-trait width | 3                 | Action effect 0.05–0.15; effort cost 0.02–0.08; trait half-width 0.05–0.15 |
| Firm, auditor, and regulator reward weights           | 8                 | Eight role-reward weights over their uncertainty ranges (-0.70 to 1.20)    |
| <b>Total</b>                                          | <b>17</b>         | 500 LHS samples; held-out frozen-policy evaluation                         |

Note: Policy evaluation follows the held-out frozen-policy design.

Table S17 reports held-out policy outcomes, paired contrasts, action shares, and sensitivity diagnostics.

**Table S17.** Held-out learning-policy outcomes and sensitivity diagnostics.

*Panel A. Held-out policy outcomes.*

| Evaluation policy     | Outcome            | Mean   | 95% interval     |
|-----------------------|--------------------|--------|------------------|
| Fixed baseline        | GQ                 | 0.5075 | [0.4980, 0.5170] |
| Fixed baseline        | OOG                | 0.6876 | [0.6803, 0.6950] |
| Fixed baseline        | EM                 | 0.2258 | [0.2192, 0.2324] |
| Fixed baseline        | DQ                 | 0.6489 | [0.6404, 0.6574] |
| Fixed baseline        | AR                 | 0.2292 | [0.2220, 0.2363] |
| Fixed baseline        | MT                 | 0.5567 | [0.5480, 0.5654] |
| Fixed baseline        | Any-tail-risk rate | 0.0329 | [0.0258, 0.0401] |
| Random policy         | GQ                 | 0.5021 | [0.4927, 0.5116] |
| Random policy         | OOG                | 0.6858 | [0.6784, 0.6932] |
| Random policy         | EM                 | 0.2286 | [0.2220, 0.2352] |
| Random policy         | DQ                 | 0.6479 | [0.6393, 0.6564] |
| Random policy         | AR                 | 0.2315 | [0.2244, 0.2386] |
| Random policy         | MT                 | 0.5553 | [0.5466, 0.5640] |
| Random policy         | Any-tail-risk rate | 0.0329 | [0.0258, 0.0401] |
| Learned greedy policy | GQ                 | 0.4750 | [0.4655, 0.4845] |
| Learned greedy policy | OOG                | 0.6585 | [0.6509, 0.6660] |
| Learned greedy policy | EM                 | 0.2551 | [0.2483, 0.2619] |
| Learned greedy policy | DQ                 | 0.6167 | [0.6080, 0.6253] |
| Learned greedy policy | AR                 | 0.2569 | [0.2495, 0.2643] |
| Learned greedy policy | MT                 | 0.5292 | [0.5204, 0.5381] |
| Learned greedy policy | Any-tail-risk rate | 0.0508 | [0.0420, 0.0596] |

*Panel B. Paired policy contrasts.*

| Policy contrast                     | Outcome | Mean difference | 95% interval       |
|-------------------------------------|---------|-----------------|--------------------|
| Learned greedy minus fixed baseline | GQ      | -0.0326         | [-0.0335, -0.0316] |
| Learned greedy minus fixed baseline | OOG     | -0.0292         | [-0.0299, -0.0284] |
| Learned greedy minus fixed baseline | EM      | +0.0293         | [+0.0284, +0.0301] |
| Learned greedy minus fixed baseline | DQ      | -0.0322         | [-0.0330, -0.0315] |

| Policy contrast                     | Outcome            | Mean difference | 95% interval       |
|-------------------------------------|--------------------|-----------------|--------------------|
| Learned greedy minus fixed baseline | AR                 | +0.0277         | [+0.0269, +0.0286] |
| Learned greedy minus fixed baseline | MT                 | -0.0275         | [-0.0281, -0.0268] |
| Learned greedy minus fixed baseline | Any-tail-risk rate | +0.0179         | [+0.0119, +0.0239] |
| Learned greedy minus random policy  | GQ                 | -0.0271         | [-0.0284, -0.0259] |
| Learned greedy minus random policy  | OOG                | -0.0273         | [-0.0281, -0.0265] |
| Learned greedy minus random policy  | EM                 | +0.0265         | [+0.0256, +0.0275] |
| Learned greedy minus random policy  | DQ                 | -0.0312         | [-0.0321, -0.0303] |
| Learned greedy minus random policy  | AR                 | +0.0254         | [+0.0245, +0.0264] |
| Learned greedy minus random policy  | MT                 | -0.0261         | [-0.0268, -0.0254] |
| Learned greedy minus random policy  | Any-tail-risk rate | +0.0179         | [+0.0117, +0.0241] |

Panel C. Action shares and learning sensitivity.

| Diagnostic                       | Firm integrity          | Auditor high effort     | Regulator high enforcement | Result stability                                       |
|----------------------------------|-------------------------|-------------------------|----------------------------|--------------------------------------------------------|
| Random-policy action share       | 0.498                   | 0.504                   | 0.499                      | Near-equal random action shares                        |
| Learned-greedy action share      | 0.096                   | 0.209                   | 0.268                      | Held-out learned policy                                |
| 500-sample learning LHS          | 0.135<br>[0.000, 0.484] | 0.219<br>[0.008, 0.555] | 0.332<br>[0.008, 0.719]    | GQ/OOG sign retention<br>96.4%/96.8%                   |
| Training episodes<br>100/200/400 | 0.122/0.088/0.105       | 0.227/0.220/0.189       | 0.324/0.280/0.270          | GQ/OOG signs retained at<br>all three training lengths |

Panel D. Outcome sensitivity.

| Diagnostic                    | GQ contrast                                                        | OOG contrast                                                       | Tail-risk contrast                                                                                        |
|-------------------------------|--------------------------------------------------------------------|--------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|
| 500-sample learning LHS       | Sign retention 96.4%;<br>5th–95th percentile<br>[-0.0503, -0.0025] | Sign retention 96.8%;<br>5th–95th percentile<br>[-0.0420, -0.0039] | Observation-rate contrast: zero<br>61.2%, negative 2.6%; any-event<br>contrast: zero 77.2%, negative 2.0% |
| Training episodes 100/200/400 | -0.0292/-0.0324/-0.0318                                            | -0.0268/-0.0288/-0.0285                                            | —                                                                                                         |