# Supervisory Technology and Capital-Relief Contracting: Evidence from Reinsurance

Mario Cerrato[a], Paolo Coccorese[b], and Xuan Zhang[c]

[a] Adam Smith Business School, University of Glasgow, 2 Discovery Place, Glasgow G11 6EY, United Kingdom. Email: Mario.Cerrato@glasgow.ac.uk.

[b] Department of Economics and Statistics, University of Salerno, Via Giovanni Paolo II 132, 84084 Fisciano (SA), Italy. Email: coccorese@unisa.it.

[c] College of Economics and Management, Nanjing University of Aeronautics and Astronautics, 29 Jiangjun Avenue, Nanjing 211106, China. Email: xuanzhang@nuaa.edu.cn.

**Abstract**

How does supervisory technology affect financial contracts that provide both risk transfer and regulatory capital relief? We study the United Kingdom's 2005 shift from formula-based to substance-sensitive insurance supervision. High-default-risk insurers reduce reinsurance cession by 6–13 percentage points relative to safer firms after the reform. The estimates remain economically large under insurer-specific trends, pre-consultation treatment rankings, and alternative timing designs. The contraction is weaker among insurers with larger capital cushions, while aggregate cession shifts toward safer firms. Supervisory technology therefore changes not only compliance, but also the use and cross-sectional allocation of capital-relief contracts.

**Keywords:** Financial contracting; supervisory technology; capital regulation; reinsurance; regulatory arbitrage

**JEL Codes:** G22, G28, G32

# 1 Introduction

Financial regulation often grants capital credit to contracts that combine economic risk transfer with regulatory relief. Securitizations, guarantees, derivatives, and reinsurance can reduce risk, but they can also improve reported capital positions. When recognition depends primarily on contractual form, regulated institutions may obtain capital relief without a commensurate transfer of economic risk. The central question is therefore not only how capital rules are written, but whether supervisors can distinguish substantive risk transfer from transactions whose private value derives mainly from regulatory recognition.

This distinction makes supervisory technology a determinant of financial contracting. Capital-relief contracts are especially valuable when external capital is costly. Under balance-sheet constraints, a transaction that releases regulatory capital can relax financing pressure without an equity issue. Debt-overhang logic therefore predicts a high shadow value of capital relief at fragile intermediaries (Myers, 1977). In banking, funding-value adjustments similarly show how intermediary balance-sheet constraints enter the private value of financial transactions (Andersen et al., 2019). More substance-sensitive supervision should compress this value most sharply for fragile institutions, changing both contract use and its allocation across firms.

Insurance provides an unusually informative setting for studying this broader prudential problem because the relevant contracting margin is observed directly in regulatory returns. Reinsurance transfers underwriting risk and generates regulatory capital credit. The instrument is specific to insurance; the economic problem is not. In banking, analogous contracting margins are often difficult to isolate because regulatory reforms coincide with recapitalizations, liquidity interventions, and macro-financial shocks. UK non-life insurance offers a cleaner setting in which a common supervisory reform changed the assessment of capital adequacy while leaving the underlying contract available.

We study the United Kingdom's 2005 transition to Individual Capital Adequacy Standards (ICAS). Before ICAS, non-life insurers operated under a formulaic Solvency I framework in which reinsurance credit depended largely on contract recognition and accounting treatment. ICAS introduced insurer-specific capital assessment, forward-looking stress analysis, and greater supervisory scrutiny of reinsurance-based capital relief (Financial Services Authority, 2002, 2003, 2004). The reform shifted supervision from standardized formulae toward a substance-sensitive assessment of capital-credit claims without prohibiting reinsurance. Figure 1 summarizes the institutional timeline.

*[Insert Figure 1 about here]*

Our empirical design asks whether this change in supervisory assessment reduced reinsurance cession differentially among insurers with high ex-ante fragility. Treatment status is defined using model-implied default probabilities from the published competing-risk model for UK general insurers in Caporale et al. (2017). The model uses realized insolvency events, competing non-default exits, and lagged insurer information to generate forward default probabilities. We use the pre-ICAS ordinal ranking rather than the exact probability levels: insurers in the top tercile form the high-fragility group and insurers in the bottom tercile form the comparison group. The difference-in-differences design compares their changes in cession around ICAS using insurer and year fixed effects, insurer characteristics, and insurer-specific trends.

The institutional timing provides several demanding tests of the design. A nested specification separates the 2005 ICAS transition from the 2001 collapse of Independent Insurance. Treatment rankings constructed using information only through 2000, 2001, or 2002 establish that the result does not depend on consultation-period observations. Catastrophe-year, attrition, and restructuring tests address the principal insurance-market alternatives, while modern DID estimators and a 1995–2000 pre-consultation slope diagnostic assess specification and timing sensitivity.

High-fragility insurers reduce reinsurance cession substantially after ICAS. The baseline differential decline is approximately 13 percentage points, and the estimate is about 8 percentage points after absorbing insurer-specific linear trends. Relative to the treated-group pre-ICAS mean, the trend-adjusted estimate represents a decline of roughly 17 percent. The result is stable across tercile, median, and continuous treatment definitions, alternative DID estimators, catastrophe-year exclusions, and attrition-sensitive samples. More stringently, treatment rankings frozen using information only through 2000 or 2001 produce post-ICAS contractions of 14–15 percentage points when the 2002–2004 consultation period is omitted.

The cross-sectional allocation is central to the economic interpretation. Insurers with larger pre-ICAS capital cushions contract less, as predicted when the shadow value of capital relief is lower. Aggregate cession shifts away from high-PD insurers and toward safer firms. ICAS therefore changes more than the total use of reinsurance: it reallocates capital-relief contracting across intermediaries according to their exposure to capital pressure.

The paper makes three contributions. First, it distinguishes supervisory technology from formal rule design. Existing work shows how institutions respond to capital rules through securitization, asset substitution, and transaction structure (Acharya et al., 2013;

Ellul et al., 2011; Becker and Ivashina, 2015). We show that the supervisor's capacity to assess economic substance changes contracting even when formal eligibility and the contractual instrument remain in place. Second, the paper links intermediary balance-sheet frictions to the cross-sectional allocation of capital-relief contracts. The stronger response among fragile and weakly capitalized insurers identifies the shadow value of regulatory capital as the key economic margin. Third, the paper contributes to research on reinsurance, insurance capital management, and shadow insurance (Froot et al., 1993; Mayers and Smith, 1990; Garven and Lamm-Tennant, 2003; Cole and McCullough, 2006; Powell and Sommer, 2007; Upreti and Adams, 2015; Koijen and Yogo, 2015, 2016, 2023; Kirti and Sarin, 2024) by studying observable third-party non-life cession around a common, clearly dated supervisory reform.

The rest of the paper is organized as follows. Section 2 describes the ICAS reform, the pre-reform regulatory environment, and the empirical predictions. Section 3 presents the data and variable construction. Section 4 outlines the identification strategy. Section 5 reports the main estimates, timing evidence, robustness tests, and allocation results. Section 6 concludes.

# 2 Institutional Background, Theoretical Framework, and Empirical Predictions

## 2.1 The pre-ICAS regulatory environment

Before 2005, UK non-life insurance supervision operated under a formulaic capital framework rooted in EU Solvency I Directives. Under this regime, required capital was determined by standardized ratios applied to premiums and claims, with limited adjustment for individual insurer risk profiles. The Financial Services Authority (FSA, established in 2001 as the successor to the Department of Trade and Industry's insurance supervisory role) relied primarily on ex-post monitoring of balance-sheet solvency ratios, with capital requirements following predetermined formulae that mapped premium volume and claims experience to minimum solvency margins.

Within this framework, reinsurance cession received standardized capital credit. The critical regulatory feature for our analysis is that the credit an insurer received for ceding risk to a reinsurer depended primarily on the contractual form of the arrangement—whether it met the formal requirements for recognition—rather than on a supervisory assessment of the economic substance of risk transfer. This created a direct margin for regulatory arbitrage: insurers could structure cession arrangements that satisfied formal recognition criteria while transferring relatively little actual risk, thereby improving reported solvency metrics with minimal change in economic exposure.

The incentive to exploit this margin was strongest for insurers under capital pressure. When an insurer's solvency ratio approached regulatory thresholds, the shadow value of capital relief from reinsurance credit was high. Form-compliant cession provided an immediately available mechanism for improving reported solvency without the costs associated with genuine risk transfer (which requires payment of a risk-appropriate premium to the reinsurer) or with raising fresh capital (which may require dilutive equity issuance or acceptance of unfavorable debt terms). This incentive reflects a recurring pattern in financial regulation: when capital constraints bind, regulated entities can restructure transactions to satisfy rule text rather than regulatory intent (Acharya et al., 2013; Ellul et al., 2011).

## 2.2 The ICAS reform: supervisory technology change

The transition to ICAS represented a fundamental change in supervisory technology, phased in through a multi-year consultation process. The FSA initiated the reform with Consultation Paper 136 in 2002 (Financial Services Authority, 2002), which proposed replacing formulaic solvency requirements with individualized capital assessments. Consultation Paper 190 in 2003 (Financial Services Authority, 2003) extended the framework to non-life insurers with enhanced capital requirements and individual capital assessments. Policy Statement 04/16 in 2004 (Financial Services Authority, 2004) finalized the Integrated Prudential Sourcebook, consolidating the new supervisory framework effective from 2005.

The ICAS framework combined individualized capital assessment with forward-looking stress analysis. Insurers were required to assess capital needs in light of their own risk profiles, business mix, and adverse scenarios, replacing a uniform formulaic approach with a more insurer-specific supervisory review.

The element most relevant for reinsurance was the treatment of capital-credit claims. Under ICAS, the FSA could challenge reinsurance arrangements that appeared to provide limited economic risk transfer relative to the capital relief claimed. Supervisors could require additional capital buffers, demand documentation of transfer substance, or apply discounts to claimed relief. In effect, reinsurance credit moved from a binary recognition test—does the arrangement satisfy formal requirements?—toward a graduated assessment of transfer quality.

## 2.3 The 2001 Independent Insurance collapse

Any analysis of UK insurance regulation in the early 2000s must contend with the collapse of Independent Insurance in June 2001. Independent Insurance was a prominent UK non-life insurer whose failure—triggered by the discovery of significant under-reserving—represented the largest insurance insolvency in the UK at that time. The failure generated market-wide disruption, increased regulatory scrutiny of reserving practices, and may have independently affected reinsurance behavior by raising counterparty-risk awareness.

The Independent Insurance collapse is a first-order identification concern because it creates a plausible alternative narrative: the post-2005 reduction in cession among high-fragility insurers might reflect delayed market adjustment to the 2001 failure rather than a response to ICAS. We address this concern directly in our empirical design through a nested difference-in-differences framework that separately identifies the 2001 and 2005 effects (Section 4.3).

## 2.4 Theoretical framework and empirical predictions

### 2.4.1 Supervisory precision and the value of cession

We model ICAS as an increase in the precision with which supervisors assess the economic substance of capital-credit claims. Total cession can be written conceptually as

$$C_{it} = C_{it}^{T} + C_{it}^{A}, \tag{1}$$

where $C_{it}^T$ provides economically substantive risk transfer and $C_{it}^A$ derives a larger share of its private value from regulatory capital relief. The two components are not observed separately; the decomposition organizes the empirical predictions.

Let $\chi_t$ denote supervisory precision and $\lambda_{it}$ the insurer's shadow value of regulatory capital. The marginal private value of capital-relief-sensitive cession can be summarized as

$$V_{it}^A = \lambda_{it}\, \Phi_A(C_{it}^A; \chi_t) - \mathcal{I}_{it}(C_{it}^A; \chi_t), \tag{2}$$

where $\Phi_A$ is the capital credit attached to such cession and $\mathcal{I}$ is the expected cost of supervisory challenge and documentation. Substance-sensitive review implies

$$\frac{\partial^2 \Phi_A}{\partial C^A \partial \chi} < 0, \qquad \frac{\partial^2 \mathcal{I}}{\partial C^A \partial \chi} > 0.$$

An increase in $\chi_t$ therefore lowers the marginal value of $C^A$, especially when $\lambda_{it}$ was high before reform. Substantive transfer remains valuable because it also reduces underwriting and liability risk, so its demand need not move one-for-one with capital-credit-sensitive cession.

#### 2.4.2 Primary prediction and cross-sectional implications

The primary empirical prediction is that insurers with greater pre-ICAS fragility—and therefore a higher shadow value of capital relief—reduce cession more after ICAS:

$$\beta_{DID} \equiv \frac{\partial Y_{it}}{\partial (HighPD_i \times Post_t)} < 0. \tag{3}$$

*H1: Arbitrage-Curbing Hypothesis.* Following ICAS, high-fragility insurers reduce reinsurance cession more than low-fragility insurers.

The framework also guides the heterogeneity analysis. The contraction should be weaker among insurers with stronger pre-ICAS capital positions because they had less need to obtain capital relief through cession. Organizational form may alter reporting incentives, and liability-side risk may preserve substantive transfer demand even when capital-credit-sensitive cession becomes less attractive (Lamm-Tennant and Starks, 1993; Cummins et al., 1999; Fama and Jensen, 1983). These are cross-sectional implications rather than separate identifying assumptions.

#### 2.4.3 Identification threats

Two alternative explanations present natural identification challenges.

The *panic hypothesis* posits that the post-2005 cession contraction reflects delayed deleveraging following the 2001 Independent Insurance collapse rather than a regulatory response to ICAS. If high-fragility insurers reduced cession after 2001 due to heightened counterparty-risk awareness or market-wide reinsurance supply contraction, and this adjustment persisted through the mid-2000s, it could masquerade as an ICAS effect in a simple post-2005 DID design.

The *weather hypothesis* posits that catastrophe years—such as the 1987 Great Storm, the 1990 Burns' Day Storm, or the 2007 UK floods—jointly drive measured fragility and reinsurance demand, generating a spurious cross-sectional correlation. If catastrophe shocks differentially increase both default risk and cession among affected insurers, the treatment-control differential could reflect weather-driven selection rather than regulatory response.

We address both threats through dedicated identification tests described in Section 4.

# 3 Data, Sample Construction, and Variable Definitions

## 3.1 Data source

The empirical base is a harmonized insurer-year panel of UK statutory regulatory returns spanning successive supervisory regimes from 1985 to 2014. The data source is the SynThesys Non-Life database, which compiles annual return information for UK-authorized non-life insurance firms. For this study, the relevant fields are ceded reinsurance premiums, total premiums, capital resources, regulatory capital requirements, solvency measures, claims, technical provisions, and business-line concentration.

This database has previously been used by Caporale et al. (2017) to study insolvency risk determinants in UK general insurance. Our panel construction follows the variable definitions and construction approach used in these companion studies.

## 3.2 Dependent variable: reinsurance cession ratio

The primary dependent variable is the reinsurance cession ratio, defined as:

$$rein_{it} = \frac{\text{Ceded reinsurance premiums}_{it}}{\text{Total premiums}_{it}}, \tag{4}$$

where the numerator is the premium volume ceded to reinsurers and the denominator is the total premium base. Both numerator and denominator are constructed using a time-invariant definition that is held fixed across specifications. This pre-commitment to a common outcome definition is important: revising the cession measure while adding controls could mechanically alter coefficients and obscure identification.

The cession ratio is a standard measure of reinsurance intensity in the empirical insurance literature (Cole and McCullough, 2006; Upreti and Adams, 2015; Shiu, 2011). It captures the share of underwritten risk that is transferred to third-party reinsurers and is directly relevant to capital-credit calculations under both formulaic and risk-based supervisory regimes.

### 3.3 Treatment variable: pre-ICAS fragility

Treatment is based on model-implied default probabilities developed and validated for UK general insurers by Caporale et al. (2017), using the forward-intensity approach of Duffie et al. (2007) and Duan et al. (2012). The model is estimated from realized insurer insolvencies, explicitly treats merger and business transfer as competing non-default exits, and maps lagged insurer solvency, balance-sheet, and common macroeconomic information into forward default probabilities. The measure therefore summarizes multiple dimensions of insurer fragility in a single ex-ante ranking that is available for both listed and unlisted firms. Appendix C summarizes the probability model and its competing-risk structure.

For each insurer, $PD_i^{pre}$ is the average model-implied default probability through 2004, and the resulting rank is frozen before implementation. The top tercile forms the high-fragility group ($HighPD_i = 1$); the bottom tercile forms the comparison group ($HighPD_i = 0$). The middle tercile is omitted from the binary design, limiting classification noise near the center of the distribution. The design uses the ordinal content of the published risk measure rather than requiring exact calibration of its probability levels. Median-split and continuous specifications are reported alongside the tercile design, and additional tests reconstruct the ranking using information only through 2000, 2001, or 2002.

### 3.4 Sample construction and coverage

The core-control sample contains 3,297 firm-years for 208 insurers over 1986–2014. Appendix Tables A1 and A2 report coverage under alternative control requirements and reconcile the main estimation sample with the stricter sample used for attrition diagnostics.

### 3.5 Control variables

The headline specification conditions on a parsimonious set of insurer characteristics that are standard in reinsurance-demand and insurance-capital studies. The controls capture capital slack, balance-sheet liquidity, insurer size, premium growth, business-line concentration, organizational form, and derivative use. This set absorbs differences in solvency capacity, operating scale, underwriting growth, portfolio diversification, ownership structure, and risk-management activity that could otherwise correlate with both ex-ante fragility and reinsurance demand. Insurer fixed effects absorb all time-invariant components of these characteristics; organizational-form indicators therefore matter primarily when they vary within insurer over time or enter heterogeneity tests. Appendix Table A8 reports the economic definitions and database labels used to construct these variables.

### 3.6 Summary statistics

The summary statistics by fragility group and period show a sharp pre-reform contrast (Table 1). Treated (high-PD) firms enter the sample with substantially higher cession ratios (0.46 vs. 0.18 for controls), higher leverage (0.85 vs. 0.51), and higher technical-provision density (0.67 vs. 0.45). These cross-sectional differences are consistent with the theoretical prediction that high-fragility firms face stronger capital-relief incentives and therefore rely more heavily on cession. The raw difference-in-differences for the cession ratio is −0.077, presaging the regression result.

*[Insert Table 1 about here]*

In raw group means, leverage falls by 0.246 and technical-provision density by 0.103. These comparisons are descriptive; the subsequent balance-sheet regressions examine the same outcomes.

## 4 Empirical Strategy

### 4.1 Baseline specification

The core empirical model is a standard difference-in-differences specification with insurer and year fixed effects:

$$Y_{it} = \beta\, did_{it} + \Gamma' X_{it} + \alpha_i + \delta_t + \varepsilon_{it}, \tag{5}$$

where $Y_{it}$ is the reinsurance cession ratio, $did_{it} = HighPD_i \times Post_t$ is the treatment interaction, $\alpha_i$ are insurer fixed effects absorbing all time-invariant insurer characteristics, $\delta_t$ are year fixed effects absorbing common macroeconomic shocks and market-wide trends, and $X_{it}$ is the control vector. Under conditional parallel trends, the coefficient $\beta$ identifies the average differential change in cession for high-fragility insurers after ICAS, relative to low-fragility insurers, conditional on common time effects and insurer-level controls.

The benchmark specification adds insurer-specific linear trends:

$$Y_{it} = \beta^T \, did_{it} + \Gamma' X_{it} + \alpha_i + \delta_t + \kappa_i \, t + \varepsilon_{it}, \tag{6}$$

where $\kappa_i \, t$ absorbs insurer-specific secular drift. This specification is the main trend-adjusted benchmark because, in a long panel spanning a 30-year regulatory transition, treatment assignment can correlate with low-frequency firm-specific trajectories. The trade-off is that trend absorption can attenuate genuine policy effects if the treatment itself unfolds gradually. We therefore report both specifications and interpret them jointly: the baseline captures the full differential shift under standard TWFE assumptions, while the trend-augmented model nets out pre-existing insurer-specific drift.

Standard errors are clustered at the insurer level in all models, reflecting the panel structure and the potential for serial correlation in residuals within firm (Bertrand et al., 2004).

## 4.2 Dynamic event-study specification

To assess the timing of the treatment effect and test for pre-trends, we estimate an event-time specification:

$$Y_{it} = \sum_{k \neq -1} \delta_k \left( HighPD_i \times \mathbf{1}\{t - t_0 = k\} \right) + \Gamma' X_{it} + \alpha_i + \delta_t + \varepsilon_{it}, \tag{7}$$

where $t_0 = 2005$ is the reform date and $k = -1$ (calendar year 2004) is the omitted reference period. The event path locates the onset and persistence of the differential response, while a joint $F$-test evaluates the pre-implementation coefficients. Following Roth (2022), we use the event study together with the trend-augmented DID and the institutional timing tests rather than treating any single pre-trend statistic as dispositive.

An anticipation test specifically targets the 2003–2004 consultation window:

$$Y_{it} = \beta \, did_{it} + \eta \left( HighPD_i \times \mathbf{1}\{t \in [2003, 2004]\} \right) + \Gamma' X_{it} + \alpha_i + \delta_t + \varepsilon_{it}. \tag{8}$$

A significant $\eta$ is consistent with phased policy transmission, as insurers began adjusting during the consultation period. Post-policy estimates remain negative after dropping 2003–2004 entirely from the sample, which helps distinguish anticipation from a mechanical pre-trend artifact.

## 4.3 Nested DID: separating the 2001 and 2005 effects

To address the panic hypothesis, we estimate a nested specification that simultaneously includes post-2001 and post-2005 treatment interactions:

$$Y_{it} = \beta_{01}\,(HighPD_i \times Post2001_t) + \beta_{05}\,(HighPD_i \times Post2005_t) + \Gamma' X_{it} + \alpha_i + \delta_t + \kappa_i\, t + \varepsilon_{it}. \tag{9}$$

In this parameterization, $\beta_{01}$ captures the differential shift following the 2001 Independent Insurance collapse, while $\beta_{05}$ captures the *incremental* differential shift following ICAS implementation, conditional on any post-2001 adjustment. If the main post-ICAS estimate is driven by 2001 panic, $\beta_{01}$ should be negative and $\beta_{05}$ should be attenuated toward zero.

## 4.4 Catastrophe-year robustness

To address the weather hypothesis, we conduct three tests. First, we exclude catastrophe years (1987, 1990, and 2007) and re-estimate the trend-augmented specification. Second, we add a market-wide loss-ratio control to absorb common environmental stress. Third, we interact the treatment variable with a catastrophe-year indicator:

$$Y_{it} = \beta\, did_{it} + \gamma\,(CatYear_t \times HighPD_i) + \Gamma' X_{it} + \alpha_i + \delta_t + \kappa_i\, t + \varepsilon_{it}. \tag{10}$$

A significant $\gamma$ would indicate that catastrophe years differentially drive cession changes among high-fragility firms—the specific confound the weather hypothesis requires. An imprecisely estimated $\gamma$ provides no evidence for that channel, but does not by itself prove its absence.

### 4.5 Placebo timing and multiplicity correction

Placebo tests move the reform date to 2000, 2001, 2002, 2003, and 2004. We adjust the resulting five $p$-values using both the Holm procedure, which controls the family-wise error rate, and the Benjamini–Hochberg procedure, which controls the false-discovery rate:

$$p_{(j)}^{Holm} = \max_{m \le j}\big[(K - m + 1)\, p_{(m)}\big], \qquad p_{(j)}^{BH} = \min_{m \ge j}\left[\frac{K}{m}\, p_{(m)}\right], \tag{11}$$

where $K = 5$ and $p_{(j)}$ denotes ordered $p$-values.

### 4.6 Wild-cluster bootstrap inference

To address potential finite-cluster over-rejection—a concern in insurer panels where residuals may be serially correlated within firms—we use wild-cluster bootstrap inference as an auxiliary check for specifications in which the procedure is applicable to the fixed-effect structure (Cameron et al., 2008). For the most conservative trend-augmented specifications, which absorb insurer-specific linear trends through firm-by-time interactions, the standard wild-cluster bootstrap procedure is not applicable to this absorbed fixed-effect structure. We therefore rely on firm-clustered standard errors and conventional clustered $p$-values for the trend-augmented estimates, and report wild-bootstrap checks only for compatible baseline specifications.

### 4.7 Modern DID estimators and treatment-effect heterogeneity

de Chaisemartin and d'Haultfoeuille (2020) and Goodman-Bacon (2021) show that TWFE estimates can be distorted when treatment effects are heterogeneous and comparison weights are nontransparent; Callaway and Sant'Anna (2021) and Sun and Abraham (2021) provide alternative estimators for multi-period settings. Our design avoids the main staggered-timing problem because treatment begins in the same calendar year for all treated units and treatment status is fixed from pre-ICAS fragility. We nevertheless report a set of alternative DID estimators as an additional robustness check. In addition to baseline TWFE and trend-augmented DID, we implement a quadratic-trend extension, the Callaway and Sant'Anna (2021) estimator for binary treatment definitions, the cohort-weighted event-study aggregation of Sun and Abraham (2021), and synthetic difference-in-differences following Arkhangelsky et al. (2021). These estimators are not separate natural experiments; rather, they probe whether the headline result is an artifact of a particular weighting or trend specification.

## 5 Results

### 5.1 Baseline difference-in-differences estimates

Table 2 shows a negative post-ICAS differential under each treatment definition. In the tercile design, the baseline TWFE coefficient is $-0.130$ ($p = 0.001$), the insurer-trend estimate is $-0.080$ ($p = 0.071$), the quadratic-trend estimate is $-0.080$ ($p = 0.082$), and the Callaway–Sant'Anna estimate is $-0.065$ ($p = 0.077$). Median and continuous definitions produce the same sign. The reduction in magnitude after trend absorption indicates that low-frequency insurer trajectories matter, but the estimated contraction remains economically material.

Relative to the high-PD pre-ICAS mean of 0.46 in Table 1, the insurer-trend estimate corresponds to a decline of about 17 percent. Firm-clustered inference is used for the trend specification; wild-bootstrap checks are reported only for compatible baseline models. Appendix Table A4 shows that the coefficient remains negative across alternative control families.

*[Insert Table 2 about here]*

## 5.2 Event-study and timing evidence

Figure 2 and Panel A of Table 3 locate the decline around the ICAS transition. The joint pre-period test yields $p = 0.087$, while a separate 1995–2000 diagnostic produces a positive and statistically insignificant differential slope with core controls. The early data therefore show no tendency for high-PD insurers to contract cession faster before the consultation process.

The 2003–2004 coefficient is $-0.102$ ($p = 0.018$), placing the first adjustment inside the formal consultation and rule-finalization period. This timing is consistent with phased policy transmission. Excluding 2003–2004 leaves estimates of $-0.139$ in the baseline model and $-0.128$ with insurer trends. Appendix Table A5 imposes a still stricter timing discipline: using treatment rankings formed only from PD observations through 2000 or 2001 and omitting the consultation years produces post-ICAS estimates of $-0.140$ and $-0.150$, respectively, both statistically significant at the 5 percent level. The post-ICAS contraction therefore does not depend on consultation-period information entering the fragility ranking.

*[Insert Figure 2 about here]*

*[Insert Table 3 about here]*

### 5.3 Alternative timing and shock explanations

Panel B of Table 3 separates the 2001 Independent Insurance failure from the 2005 reform. The post-2001 interaction is near zero (0.005, $p = 0.892$), whereas the incremental post-2005 term is $-0.081$ ($p = 0.066$). These estimates do not support the view that the headline post-ICAS differential is simply delayed adjustment to the 2001 failure.

The placebo and catastrophe results provide complementary evidence. Placebo dates in 2000 and 2001 yield small estimates, while dates during the consultation window are more negative; after multiplicity adjustment, 2003 remains significant. Excluding the major catastrophe years leaves the insurer-trend estimate at $-0.070$, and the catastrophe interaction is small and statistically imprecise ($p = 0.745$). The data therefore provide no evidence that differential catastrophe exposure generates the main post-ICAS pattern. Full placebo and catastrophe specifications are reported in Appendix Tables A6 and A7.

### 5.4 Attrition and balance-sheet adjustment

Appendix Table A3 shows that most sample loss in richer specifications reflects missing controls rather than merger, transfer, run-off, or insolvency events. The insurer-trend estimate is $-0.0799$ in the full core-control sample and $-0.0819$ after excluding run-off, transfer, and liquidation firm-years. Estimates remain negative under the other sample definitions.

Table 4 examines possible substitute margins. Log assets decline in the baseline model, but the coefficient becomes small after insurer trends are included. Leverage, capital resources, and excess capital show no precise post-ICAS response. The evidence does not identify a dominant recapitalization or deleveraging margin accompanying the cession change.

*[Insert Table 4 about here]*

## 5.5 Capital pressure and other heterogeneity

The moderator specification interacts the treatment indicator with pre-ICAS characteristics $Z_i$. Table 5 shows the most precise gradient for capital strength. The $HighEquity$ interaction is 0.190 ($p = 0.040$) with insurer trends, implying weaker contraction among insurers with larger pre-ICAS capital cushions. This pattern links the response to capital pressure: economically substantive transfer demand should depend primarily on underwriting exposure, whereas the private value of capital-relief-sensitive cession rises as regulatory capital becomes scarce.

The remaining moderators are less precise. Short-tail exposure attenuates the contraction in the baseline model but not after trend absorption; mutual status, technical-provision density, and liability-heavy exposure are statistically weak. These estimates are best read as heterogeneity patterns rather than direct evidence on treaty substance. Appendix Table A10 reports the full moderator regressions and subsample information.

*[Insert Table 5 about here]*

## 5.6 Aggregate allocation and economic magnitude

Table 6 shows that reinsurance use is reallocated across fragility groups. The gross-premium-weighted cession ratio for high-PD insurers falls from 0.409 before ICAS to 0.265 after ICAS, while the low-PD ratio rises from 0.209 to 0.257. The top–bottom sample aggregate declines by 4.0 percentage points and the full-market aggregate by 1.5 percentage points. Thus, the firm-level response is partly offset by increased cession among safer insurers rather than reflecting a uniform market-wide withdrawal.

Applying the insurer-trend estimate to pre-ICAS gross premiums written implies an average annual reduction of approximately £184 million for the high-PD segment, or 9.4 percent of pre-ICAS industry annual cession. These translations are illustrative rather than structural welfare calculations. Their economic relevance is likely concentrated among firms close to supervisory capital constraints, consistent with the capital-strength gradient.

*[Insert Table 6 about here]*

# 6 Conclusion

The UK ICAS transition shows that supervisory technology changes the use and allocation of contracts that generate regulatory capital relief. High-PD non-life insurers reduce cession by 6–13 percentage points relative to safer firms after ICAS, with a trend-adjusted estimate of about 8 percentage points. The response is weaker among insurers with larger capital cushions, and aggregate cession shifts toward low-PD firms. These patterns are exactly what a balance-sheet-friction mechanism predicts: more precise supervisory assessment reduces the private value of capital relief most where regulatory capital is most scarce.

The broader implication extends beyond insurance. Banking and insurance supervisors both evaluate transactions that qualify for capital recognition while potentially transferring less risk than their legal form suggests. The UK's Prudential Regulation Authority maintains sector-specific approaches to banking and insurance supervision, but the underlying economic task is common: capital recognition must track substantive risk transfer rather than contractual form alone (Bank of England, 2023). ICAS provides a clean empirical example of how improvements in this supervisory technology reshape financial contracting without banning the contract itself.

This mechanism matters for modern risk-based capital regimes. Pillar 2 and ORSA-style review must evaluate transfer quality, counterparty resilience, concentration, and performance under stress rather than treating aggregate cession as a sufficient statistic (Grochola and Schlütter, 2025; Aigner et al., 2025). IFRS 17 improves the visibility of insurance liabilities and reinsurance held, but accounting transparency and prudential assessment perform different functions (IASB, 2017). The evidence therefore points to a general principle of financial regulation: the allocation of capital-relief contracts depends not only on the rules that confer recognition, but also on the technology supervisors use to verify economic substance.

# References

Acharya, Viral V. and Schnabl, Philipp and Suarez, Gustavo (2013). Securitization without Risk Transfer. Journal of Financial Economics, 107(3), 515–536.

Aigner, Philipp and He, M. and Schlütter, Sebastian and Zwiesler, D. (2025). Identifying scenarios for the own risk and solvency assessment of insurance companies. Insurance: Mathematics and Economics, 122, 30–43.

Andersen, Leif, Darrell Duffie, and Yang Song (2019). Funding Value Adjustments. Journal of Finance, 74(1), 145–192.

Arkhangelsky, Dmitry and Athey, Susan and Hirshberg, David A. and Imbens, Guido W. and Wager, Stefan (2021). Synthetic Difference-in-Differences. American Economic Review, 111(12), 4088–4118.

Bank of England (2023). The PRA's Approach to Supervision of the Banking and Insurance Sectors. Prudential Regulation Authority, London.

Becker, Bo and Ivashina, Victoria (2015). Reaching for Yield in the Bond Market. Journal of Finance, 70(5), 1863–1902.

Bertrand, Marianne and Duflo, Esther and Mullainathan, Sendhil (2004). How much should we trust differences-in-differences estimates?. Quarterly Journal of Economics, 119(1), 249–275.

Callaway, Brantly and Sant'Anna, Pedro H. C. (2021). Difference-in-Differences with multiple time periods. Journal of Econometrics, 225(2), 200–230.

Cameron, A. Colin and Gelbach, Jonah B. and Miller, Douglas L. (2008). Bootstrap-based improvements for inference with clustered errors. Review of Economics and Statistics, 90(3), 414–427.

Caporale, Guglielmo Maria and Cerrato, Mario and Zhang, Xuan (2017). Analysing the determinants of insolvency risk for general insurance firms in the UK. Journal of Banking & Finance, 84, 107–122.

de Chaisemartin, Clément and d'Haultfoeuille, Xavier (2020). Two-Way Fixed Effects Estimators with Heterogeneous Treatment Effects. American Economic Review, 110(9), 2964–2996.

Cole, Cassandra R. and McCullough, Kathleen A. (2006). A Reexamination of the Corporate Demand for Reinsurance. Journal of Risk and Insurance, 73(1), 169–192.

Cummins, J. David and Weiss, Mary A. and Zi, Hongmin (1999). Organizational Form and Efficiency: The Coexistence of Stock and Mutual Property-Liability Insurers. Management Science, 45(9), 1254–1269.

Duan, Jin-Chuan and Sun, Jun and Wang, Tao (2012). Default Probability Estimation via Pairwise Comparisons. Journal of Econometrics, 170(1), 160–171.

Duffie, Darrell and Saita, Leandro and Wang, Ke (2007). Multi-period corporate default prediction with stochastic covariates. Journal of Financial Economics, 83(3), 635–665.

Ellul, Andrew and Jotikasthira, Chotibhak and Lundblad, Christian T. (2011). Regulatory Pressure and Fire Sales in the Corporate Bond Market. Journal of Financial Economics, 101(3), 596–620.

Fama, Eugene F. and Jensen, Michael C. (1983). Separation of Ownership and Control. Journal of Law and Economics, 26(2), 301–325.

Financial Services Authority (2002). Individual Capital Adequacy Standards. Consultation Paper 136, London.

Financial Services Authority (2003). Enhanced Capital Requirements and Individual Capital Assessments for Non-life Insurers. Consultation Paper 190, London.

Financial Services Authority (2004). Integrated Prudential Sourcebook for Insurers. Policy Statement 04/16, London.

Froot, Kenneth A. and Scharfstein, David S. and Stein, Jeremy C. (1993). Risk Management: Coordinating Corporate Investment and Financing Policies. Journal of Finance, 48(5), 1629–1658.

Garven, James R. and Lamm-Tennant, Joan (2003). The Demand for Reinsurance: Theory and Empirical Tests. Insurance and Risk Management, 71(2), 217–237.

Goodman-Bacon, Andrew (2021). Difference-in-Differences with Variation in Treatment Timing. Journal of Econometrics, 225(2), 254–277.

Grochola, Nicolaus and Schlütter, Sebastian (2025). Discretionary decisions in capital requirements under Solvency II. The Geneva Papers on Risk and Insurance – Issues and Practice, 50(2), 405–443.

International Accounting Standards Board (2017). IFRS 17 Insurance Contracts. Effective for annual reporting periods beginning on or after 1 January 2023.

Kirti, Divya and Sarin, Natasha (2024). What Private Equity Does Differently: Evidence from Life Insurance. Review of Financial Studies, 37(1), 201–230.

Koijen, Ralph S. J. and Yogo, Motohiro (2015). The Cost of Financial Frictions for Life Insurers. American Economic Review, 105(1), 445–475.

Koijen, Ralph S. J. and Yogo, Motohiro (2016). Shadow Insurance. Econometrica, 84(3), 1265–1287.

Koijen, Ralph S. J. and Yogo, Motohiro (2023). The Economics of Insurance. Princeton University Press.

Lamm-Tennant, Joan and Starks, Laura T. (1993). Stock versus Mutual Ownership Structures: The Risk Implications. Journal of Business, 66(1), 29–46.

Mayers, David and Smith, Clifford W., Jr. (1990). On the Corporate Demand for Insurance: Evidence from the Reinsurance Market. Journal of Business, 63(1), 19–40.

Myers, Stewart C. (1977). Determinants of Corporate Borrowing. Journal of Financial Economics, 5(2), 147–175.

Powell, Lawrence S. and Sommer, David W. (2007). Internal versus External Capital Markets in the Insurance Industry: The Role of Reinsurance. Journal of Financial Services Research, 31(2-3), 173–188.

Roth, Jonathan (2022). Pretest with Caution: Event-Study Estimates after Testing for Parallel Trends. American Economic Review: Insights, 4(3), 305–322.

Shiu, Yung-Ming (2011). Reinsurance and Capital Structure: Evidence from the United Kingdom Non-Life Insurance Industry. Journal of Risk and Insurance, 78(2), 475–494.

Sun, Liyang and Abraham, Sarah (2021). Estimating dynamic treatment effects in event studies with heterogeneous treatment effects. Journal of Econometrics, 225(2), 175–199.

Upreti, Vineet and Adams, Mike (2015). The Strategic Role of Reinsurance in the United Kingdom's Non-Life Insurance Market. Journal of Banking & Finance, 61, 206–219.

# Tables and Figures

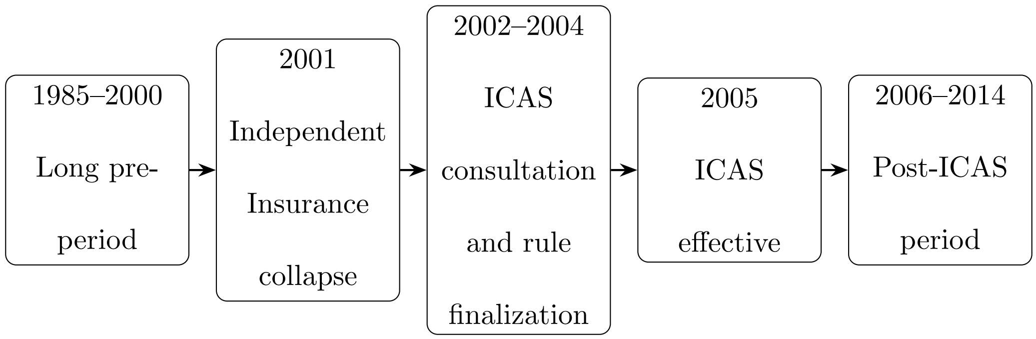


**Figure 1:** Schematic timeline of the ICAS transition and the empirical identification windows. Consultation documents were CP 136 (2002), CP 190 (2003), and PS 04/16 (2004).

**Table 1:** Summary Statistics by Fragility Group and Period

| Variable | High-PD pre | Low-PD pre | High-PD post | Low-PD post | Raw $\Delta\Delta$ |
|---|---|---|---|---|---|
| Cession ratio | 0.460 | 0.184 | 0.419 | 0.221 | −0.077 |
| Technical provisions / assets | 0.672 | 0.446 | 0.548 | 0.424 | −0.103 |
| $\ln(Assets)$ | 11.634 | 11.039 | 11.127 | 11.496 | −0.963 |
| Leverage | 0.852 | 0.508 | 0.567 | 0.469 | −0.246 |
| Premium growth | −0.005 | 0.069 | −0.101 | −0.032 | 0.005 |

*Notes.* Pre-ICAS is 1986–2004 and post-ICAS is 2005–2014. High- and low-PD groups are the top and bottom terciles of the frozen pre-ICAS default-risk ranking. The final column is the unadjusted difference-in-differences in group means.

**Table 2:** Main Difference-in-Differences Estimates

| Treatment definition | TWFE | Linear trends | Quadratic trends | C&S |
|---|---|---|---|---|
| Tercile | $-0.130^{***}$ (0.001) | $-0.080^{*}$ (0.071) | $-0.080^{*}$ (0.082) | $-0.065^{*}$ (0.077) |
| Median | $-0.095^{***}$ (0.002) | $-0.040$ (0.212) | $-0.039$ (0.230) | $-0.043^{*}$ (0.100) |
| Continuous | $-5.752^{***}$ (0.001) | $-4.157^{**}$ (0.050) | $-4.140^{*}$ (0.058) | — |

*Notes.* Entries are treatment coefficients; parentheses contain $p$-values. All models include insurer and year fixed effects and the core controls. Linear and quadratic columns add insurer-specific trends. C&S denotes the Callaway and Sant'Anna (2021) estimator for binary treatments. Sun–Abraham average post effects are $-0.131$ (tercile) and $-0.096$ (median); synthetic DID estimates are $-0.118$ and $-0.078$. Significance: $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

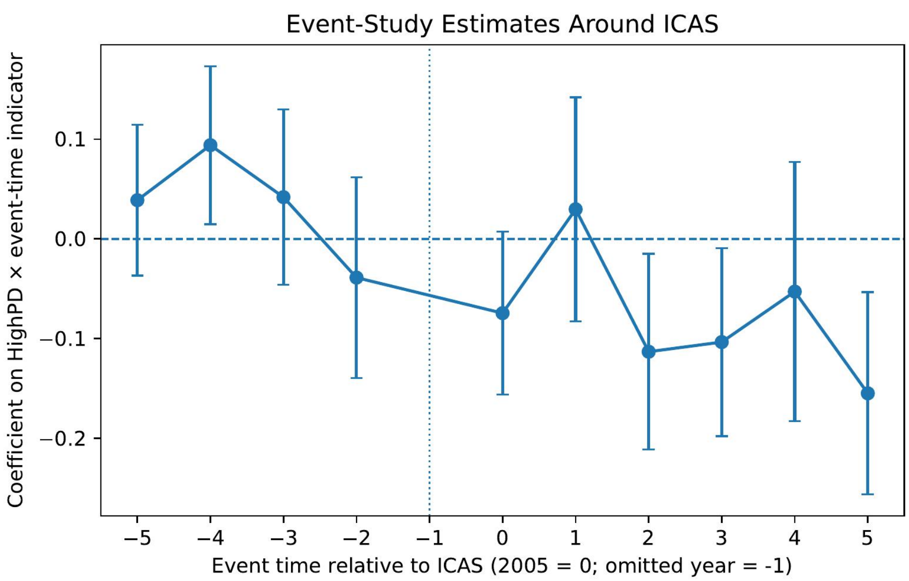


**Figure 2:** Event-study coefficients around ICAS implementation. The figure reports $\delta_k$ for $k \in \{-5, -4, -3, -2, 0, 1, 2, 3, 4, 5\}$, omitting $k = -1$ (calendar year 2004) as the baseline. Vertical bars denote 95% confidence intervals with standard errors clustered at the insurer level.

**Table 3:** Timing and Identification Diagnostics

| Diagnostic | Estimate | Inference |
|---|---|---|
| *Panel A. Event timing and pre-ICAS slopes* | | |
| Pre-period joint test | — | $p = 0.087$ |
| Consultation window, 2003–2004 | $-0.1022$ | $p = 0.018$ |
| Drop 2003–2004, TWFE | $-0.1391$ | $p = 0.001$ |
| Drop 2003–2004, insurer trends | $-0.1277$ | $p = 0.014$ |
| High-PD trend, 1995–2000, core controls | 0.0105 | $p = 0.157$ |
| *Panel B. Nested 2001/2005 design* | | |
| $HighPD \times Post2001$ | 0.0052 | $p = 0.892$ |
| $HighPD \times Post2005$ | $-0.0807$ | $p = 0.066$ |
| *Panel C. Placebo and catastrophe diagnostics* | | |
| Placebo 2000 | 0.0157 | $p = 0.630$ |
| Placebo 2001 | $-0.0053$ | $p = 0.892$ |
| Placebo 2003 | $-0.1155$ | $p = 0.005$ |
| Insurer trends, excluding catastrophe years | $-0.0702$ | SE = 0.0442 |
| Catastrophe year $\times HighPD$ | 0.0056 | $p = 0.745$ |

*Notes.* The final column reports the relevant inference statistic: two-sided $p$-values except where the clustered standard error is shown explicitly. Core controls and insurer-clustered inference are used where applicable. The 2003 placebo has Holm-adjusted $p = 0.027$; it falls within the formal consultation period and is not interpreted as a clean pre-ICAS placebo. Catastrophe years are 1987, 1990, and 2007. Full placebo, catastrophe, and early-slope results appear in the Appendix.

**Table 4:** Balance-Sheet Adjustment Beyond Reinsurance

| Outcome | TWFE | Insurer trends |
|---|---|---|
| ln($Assets$) | −0.7210*** (0.2285) | −0.0281 (0.1768) |
| Leverage | −0.0238 (0.0325) | −0.0322 (0.0266) |
| Premium growth | 0.0932*** (0.0346) | 0.0299 (0.0483) |
| Capital resources | 83,632 (162,266) | 80,409 (95,917) |
| Excess capital over requirement | −7,273 (59,731) | −11,747 (33,817) |
| *Excluding run-off, transfer, and liquidation firm-years* | | |
| ln($Assets$) | −0.7227*** (0.2290) | −0.0330 (0.1773) |
| Leverage | −0.0240 (0.0325) | −0.0330 (0.0266) |

*Notes.* Entries are coefficients on $HighPD \times Post$ under the core-control specification; firm-clustered standard errors are in parentheses. The leverage proxy is constructed from reported liabilities and capital resources. Significance: $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

**Table 5:** Heterogeneity in the Post-ICAS Cession Response

| Pre-ICAS moderator | TWFE interaction | Insurer-trend interaction |
|---|---|---|
| Capital strength ($HighEquity$) | −0.017 (0.854) | 0.190** (0.040) |
| Mutual ownership | −0.045 (0.452) | 0.050 (0.613) |
| Technical-provision density | 0.029 (0.690) | −0.048 (0.571) |
| Liability-heavy exposure | 0.075 (0.307) | 0.117 (0.141) |
| Short-tail share | 0.166** (0.039) | 0.077 (0.518) |

*Notes.* Entries are coefficients on $HighPD \times Post \times Z_i$; parentheses contain $p$-values. All models use the core controls, insurer fixed effects, and year fixed effects. The second column adds insurer-specific linear trends. Significance: $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

**Table 6:** Aggregate Reinsurance Allocation and Economic Magnitude

*Panel A. GPW-weighted aggregate cession ratios*

| Group | Pre-ICAS | Post-ICAS | Change |
|---|---|---|---|
| High-PD insurers | 0.409 | 0.265 | −0.144 |
| Low-PD insurers | 0.209 | 0.257 | 0.047 |
| Top–bottom sample total | 0.297 | 0.256 | −0.040 |
| Full market | 0.315 | 0.301 | −0.015 |

*Panel B. Selected magnitude translations*

| Metric | Estimate | Unit |
|---|---|---|
| Mean annual cession reduction, high-PD segment | 183.6 | GBP million |
| Share of pre-ICAS industry annual cession | 9.4 | percent |
| Additional capital | 22.0 | GBP million |
| Median per-firm capital impact | 0.5 | GBP million |

*Notes.* Panel A reports gross-premium-weighted cession ratios; pre-ICAS is 1986–2004 and post-ICAS is 2005–2014. Panel B applies the benchmark tercile insurer-trend estimate to pre-ICAS gross premiums written and assumes a 12% required-capital ratio. The capital translations are illustrative and are not structural welfare estimates.

# A Sample and Control-Set Robustness

**Table A1:** Sample Coverage by Specification

| Sample | Observations | Firms | Years | Treated share |
|---|---|---|---|---|
| No controls | 3,825 | 209 | 1985–2014 | 0.466 |
| Core controls | 3,297 | 208 | 1986–2014 | 0.440 |
| Extended controls I | 2,070 | 149 | 1986–2014 | 0.314 |
| Extended controls II | 2,020 | 154 | 1986–2014 | 0.319 |

*Notes.* Changes in coverage reflect non-missing requirements for additional controls.

**Table A2:** Core-Control Sample Reconciliation

| Sample definition | Observations | Firms | Use case |
|---|---|---|---|
| Main core-control estimation sample | 3,297 | 208 | Main DID estimates |
| Strict top–bottom flow-accounting sample | 2,876 | 209 | Attrition and sample-flow analysis |

*Notes.* The two core-control samples refer to different analytical objects. The 3,297-observation sample is the regression estimation sample used in the headline DID tables. The 2,876-observation sample applies stricter top–bottom-only and complete-flow filters for attrition accounting and is not used as the denominator for headline DID estimates.

**Table A3:** Attrition Decomposition and Alternative-Sample Stability

*Panel A. Reasons for attrition in richer-control specifications*

| Reason | Count | Share |
|---|---|---|
| Missing controls only | 258 | 0.7167 |
| Merger, acquisition, transfer, or Part VII | 56 | 0.1556 |
| Year-end change or reporting gap | 19 | 0.0528 |
| Liquidation or insolvency | 15 | 0.0417 |
| Run-off | 12 | 0.0333 |

*Panel B. Main DID under alternative sample definitions*

| Sample and model | DID estimate (standard error) |
|---|---|
| Full sample, TWFE | $-0.1298^{***}$ (0.0411) |
| Full sample, insurer trends | $-0.0799^{*}$ (0.0457) |
| Balanced panel, TWFE | $-0.0913^{*}$ (0.0480) |
| Balanced panel, insurer trends | $-0.0662$ (0.0610) |
| Survivor-only, TWFE | $-0.1192^{**}$ (0.0479) |
| Survivor-only, insurer trends | $-0.0824$ (0.0522) |
| Exclude run-off, transfer, and liquidation, TWFE | $-0.1295^{***}$ (0.0409) |
| Exclude run-off, transfer, and liquidation, insurer trends | $-0.0819^{*}$ (0.0457) |

*Notes.* Panel B reports coefficients on $HighPD \times Post$ from core-control regressions. Standard errors are clustered at insurer level. Significance: $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

**Table A4:** Control-Set Robustness Across Alternative Control Families

*Panel A. Baseline TWFE*

| | No controls | Core controls | Extended I | Extended II |
|---|---|---|---|---|
| $HighPD \times Post$ | $-0.1240^{***}$ | $-0.1298^{***}$ | $-0.1484^{***}$ | $-0.1267^{**}$ |
| Standard error | 0.0421 | 0.0397 | 0.0366 | 0.0560 |
| Observations | 3,825 | 3,297 | 2,070 | 2,020 |
| Firms | 209 | 208 | 149 | 154 |
| Wild-bootstrap $p$ | 0.010 | 0.003 | 0.000 | 0.068 |

*Panel B. Insurer-specific linear trends*

| | No controls | Core controls | Extended I | Extended II |
|---|---|---|---|---|
| $HighPD \times Post$ | $-0.1042^{**}$ | $-0.0799^{*}$ | $-0.1142^{**}$ | $-0.1060^{**}$ |
| Standard error | 0.0438 | 0.0441 | 0.0561 | 0.0536 |
| Observations | 3,825 | 3,297 | 2,070 | 2,020 |
| Firms | 209 | 208 | 149 | 154 |

*Notes.* All specifications include insurer and year fixed effects. Wild-bootstrap $p$-values are reported only for bootstrap-compatible baseline models. Significance: $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

**Table A5:** Early Fragility Rankings and Consultation-Window Tests

| PD cutoff | Baseline TWFE | Insurer trends | Exclude 2002–2004 | Separate anticipation period |
|---|---|---|---|---|
| Through 2000 | $-0.139^{***}$ (0.0417) | $-0.073$ (0.0448) | $-0.140^{**}$ (0.0588) | $-0.127^{**}$ (0.0571) |
| Through 2001 | $-0.141^{***}$ (0.0424) | $-0.065$ (0.0456) | $-0.150^{**}$ (0.0600) | $-0.133^{**}$ (0.0581) |
| Through 2002 | $-0.133^{***}$ (0.0415) | $-0.063$ (0.0450) | — | — |
| Through 2004 | $-0.124^{***}$ (0.0408) | $-0.077^{*}$ (0.0448) | — | — |

*Notes.* Each row reconstructs the top- and bottom-tercile treatment groups using insurer-level mean model-implied PD observed only through the indicated year. The final two columns use insurer-specific linear trends; "Exclude 2002–2004" omits the consultation period, while "Separate anticipation period" includes a distinct HighPD interaction for those years. Standard errors clustered at insurer level are in parentheses. Significance: $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

**Table A6:** Placebo Reform-Year Tests with Multiplicity Adjustments

| Placebo year | DID coef. | Raw $p$ | Holm adj. $p$ | BH adj. $p$ |
|---|---|---|---|---|
| 2000 | 0.0157 | 0.630 | 1.000 | 0.788 |
| 2001 | $-0.0053$ | 0.892 | 1.000 | 0.892 |
| 2002 | $-0.0791$ | 0.040 | 0.121 | 0.067 |
| 2003 | $-0.1155$ | 0.005 | 0.027 | 0.027 |
| 2004 | $-0.0953$ | 0.021 | 0.082 | 0.051 |

*Notes.* Each row reassigns the reform date and re-estimates the baseline core-control DID. Holm and Benjamini–Hochberg corrections applied over the five-element $p$-value family. After correction, one placebo (2003) remains significant at 5%, consistent with the FSA consultation timeline.

**Table A7:** Catastrophe-Year Sensitivity (Core Controls, Insurer Trends)

| | (1) Baseline | (2) Exclude cat. years | (3) Add loss control | (4) Cat. interaction |
|---|---|---|---|---|
| $HighPD \times Post$ | $-0.0799^{*}$ | $-0.0702$ | $-0.0799^{*}$ | $-0.0818^{*}$ |
| | (0.0441) | (0.0442) | (0.0441) | (0.0429) |
| $CatYear \times HighPD$ | — | — | — | 0.0056 |
| | | | | (0.0171) |
| Observations | 3,297 | 2,928 | 3,297 | 3,297 |
| $p$: $CatYear \times HighPD$ | — | — | — | 0.745 |

*Notes.* Catastrophe years are 1987, 1990, and 2007. All specifications include the core controls, insurer FE, year FE, and insurer-specific trends. Standard errors clustered at insurer level.

# B Variable Dictionary

**Table A8:** Variable Definitions

| Variable | Type | Definition |
|---|---|---|
| $rein_{it}$ | Outcome | Reinsurance cession ratio: ceded premiums divided by total premiums. |
| $HighPD_i$ | Treatment | $= 1$ for the top tercile of the frozen pre-ICAS ranking from the published model-implied default probability; $= 0$ for the bottom tercile; middle excluded. |
| $Post_t$ | Timing | $= \mathbf{1}\{year_t \geq 2005\}$. |

*Table A8 continued*

| Variable | Type | Definition |
|---|---|---|
| $did_{it}$ | Regressor | $HighPD_i \times Post_t$. |
| $excess_{it}$ | Control | Capital slack / excess-capital measure capturing the distance between available capital resources and regulatory capital needs. |
| $liq_{it}$ | Control | Balance-sheet liquidity measure capturing the availability of liquid assets relative to insurer obligations. |
| $size_{it}$ | Control | Insurer size, measured by the logarithm of total assets. |
| $growth_{it}$ | Control | Premium-growth control capturing changes in business volume. |
| $H\_index_{it}$ | Control | Herfindahl-type business concentration index. |
| $MutualDummy_i$ | Control / moderator | Indicator for mutual organizational form. |
| $derivativeDummy_{it}$ | Control | Indicator for derivative use, where available. |
| $Mutual_i$ | Moderator | Indicator for mutual organizational form in heterogeneity tests. |

*Table A8 continued*

| Variable | Type | Definition |
|---|---|---|
| $HighEquity_i$ | Moderator | Upper-tail indicator of pre-ICAS equity / capital-cushion strength. |
| $HighTechTA_i$ | Moderator | Above-median pre-ICAS technical-provision density (Technical Provisions/Total Assets). |
| $LiabilityHeavy_i$ | Moderator | High pre-ICAS long-tail liability mix from the remapped business-line exercise. |
| $ShortTailShare_i$ | Moderator | Pre-ICAS short-tail business share from the remapped business-line exercise. |

*Notes.* The headline core-control specification consists of capital slack, liquidity, size, premium growth, business concentration, mutual organizational form, and derivative-use indicators. Database labels are reported here only to make the mapping from regulatory-return fields to economic variables transparent.

# C Technical Identification Notes

**Default-probability ranking.** The treatment ranking uses the forward-intensity framework described in Duffie et al. (2007) and Duan et al. (2012). In a competing-risk formulation, the probability of default over horizon $\tau$ is

$$q(X_{it}, \tau) = \mathbb{E}_t\left[\int_t^{t+\tau} \exp\left(-\int_t^z [\lambda_i(u) + \phi_i(u)]du\right) \lambda_i(z)dz \mid X_{it}\right],$$

where $X_{it}$ contains insurer and common state variables, $\lambda_i$ is default intensity, and $\phi_i$ captures non-default exits. The empirical design uses each insurer's average model-implied probability through 2004 and freezes the resulting ordinal rank before ICAS implementation. Because the consultation process began in 2002, Appendix Table A5 also reconstructs treatment using PD observations only through 2000, 2001, or 2002. The post-ICAS differential is stable across these rankings and becomes larger when the 2002–2004 consultation years are omitted.

The main specifications use firm and year fixed effects, with trend-augmented variants adding insurer-specific linear time components. Wild-cluster bootstrap $p$-values (Cameron et al., 2008) are used only for bootstrap-compatible baseline specifications; trend-augmented specifications rely on firm-clustered inference.

**Timing and trend diagnostics.** The event study places the differential adjustment around the ICAS consultation and implementation period. The 1995–2000 pre-consultation slope diagnostic shows no prior contraction among high-PD insurers, and the headline result remains economically large after insurer-specific trends, early treatment-ranking cutoffs, consultation-window exclusions, nested timing tests, catastrophe-year interactions, attrition checks, and alternative DID estimators.

Economic significance is computed as $ES = \hat{\beta}/\bar{Y}_T^{pre}$, where $\bar{Y}_T^{pre}$ is the treated-group pre-ICAS mean outcome.

**Additional pretrend diagnostic.** Table A9 reports the pre-consultation slope diagnostic used in the discussion of timing.

**Table A9:** Pre-Consultation Cession-Slope Diagnostic

| Specification | $HighPD \times$ trend | $p$-value | Observations | Firms |
|---|---|---|---|---|
| No additional controls | 0.0126 | 0.058 | 881 | 181 |
| Core controls | 0.0105 | 0.157 | 781 | 167 |

*Notes.* Estimates use 1995–2000, insurer and year fixed effects, and firm-clustered standard errors. Over the 1995–2000 window, mean cession rises from 0.455 to 0.481 for high-PD insurers and is unchanged at 0.192 for low-PD insurers.

# D Extended Mechanism Results

**Table A10:** Full Moderator Regressions

| Moderator | Interaction TWFE | Interaction trends | DID TWFE | DID trends |
|---|---|---|---|---|
| Mutual | −0.045 (0.452) | 0.050 (0.613) | −0.116** (0.012) | −0.090* (0.078) |
| Technical-provision density | 0.029 (0.690) | −0.048 (0.571) | −0.150** (0.017) | −0.047 (0.497) |
| Liability-heavy exposure | 0.075 (0.307) | 0.117 (0.141) | −0.137** (0.043) | −0.078 (0.225) |
| Capital strength | −0.017 (0.854) | 0.190** (0.040) | −0.106* (0.099) | −0.167** (0.012) |
| Short-tail share | 0.166** (0.039) | 0.077 (0.518) | −0.193*** (0.000) | −0.107* (0.090) |

*Notes.* Interaction columns report $HighPD \times Post \times Z_i$; DID columns report the unconditional treatment effect in the same moderator sample. Parentheses contain $p$-values. Significance: $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.