ISSN: 2755-0214

Journal of Economics & Management Research

SCIENTIFIC Research and Community

Review Article

Open Access

Does Prudential Regulation Improve Solvency? A Structural Break Analysis of Pension Fund Dynamics

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ABSTRACT

This paper examines whether the 2019 prudential regulatory event improved pension-fund solvency dynamics. The analysis relies exclusively on previously estimated results reported in the thesis archive and combines ARIMA intervention models, polynomial time-trend regressions, Chow structural-break tests, and time-series decompositions. ARIMA results show no statistically significant intervention effect for the solvency-related index in either group (Control: xreg = 0.0024, p = 0.7423; Treatment: xreg = 0.0190, p = 0.3090). Time-trend regressions likewise show no differential post-event effect, although the treatment coefficient is negative and significant (-0.0491; p = 0.002). Chow tests, however, detect significant structural breaks in 2019 for both groups, with stronger evidence in treatment (Control: F = 1.710325, p = 0.0114; Treatment: F = 1.985284, p = 0.0015). Decomposition results show mild deterioration in the control trajectory and continued upward trend in treatment. The evidence therefore points to structural adjustment and heterogeneous resilience rather than a clean causal solvency gain attributable to the intervention regressor alone.

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Received: May 15, 2026; **Accepted:** May 21, 2026; **Published:** May 29, 2026

Keywords: Solvency, Pension Funds, Prudential Regulation, Structural Break, Intervention Analysis, Resilience

JEL Classification: G23, G28, K23, C22

Introduction

Solvency lies at the heart of pension-fund regulation because prudential rules are intended to preserve the ability of funds to honor long-horizon commitments under uncertainty. Yet the empirical question is not whether regulation matters in the abstract, but whether intensified oversight can be shown to improve solvency-related outcomes in a measurable way. The broader pension literature suggests caution. Regulatory and accounting rules can alter long-term investment behavior, risk tolerance, and funding management, but the effect may appear through gradual institutional adaptation rather than an immediate discrete performance jump [1,2].

This paper addresses that issue through the solvency-related series reported in the thesis archive as is. The aim is deliberately narrow: to assess whether the 2019 event is associated with identifiable changes in the trajectory of this indicator. The contribution of the paper is therefore empirical organization rather than re-estimation. It turns a dispersed set of reported results into a focused econometric article on solvency.

The methodological framing follows intervention analysis and structural-break reasoning. Box and Tiao showed that in time series with dependent errors, intervention effects must be interpreted jointly with the underlying stochastic structure [3]. Chow provided the canonical framework for testing whether the relationship itself changes across subperiods [4]. More recent work on time-series causal attribution, including Menchetti, Cipollini and Mealli, reinforces the point that causal language must be disciplined by model structure and counterfactual plausibility [5]. This is particularly important in regulatory settings, where policy change often interacts with pre-existing institutional trends.

Methodology

No new estimation is performed. The article is built entirely from the outputs already reported in the thesis results archive. Four empirical components are used.

First, ARIMA intervention models assess whether the 2019 event is associated with a statistically significant within-group change in the level of the solvency-related series. This is the classic box-Tiao intervention framework, in which the intervention coefficient is evaluated after accounting for autoregressive and moving-average dependence.

Second, polynomial time-trend regressions add a different identification angle by separating baseline treatment differences, the average event effect, and the event-treatment interaction. Because the reported specification includes quadratic and cubic time terms, the regressions are able to accommodate non-linear movement rather than forcing a purely linear trend.

Third, Chow structural-break tests evaluate whether the parameterization of the series changes around 2019. This is especially useful in regulatory applications because a rule change may modify the process generating the data even when a direct level effect is not statistically clean.

Fourth, decomposition of trend and noise provides descriptive support for interpretation. In the present case, decomposition is useful because solvency may evolve through changes in trajectory smoothness, deviations from projected path, or short-run instability rather than through one large permanent jump.

The source archive also reports diagnostic caveats for some model classes, including violations of normality and mixed evidence on residual assumptions. Those caveats are retained here as part of the empirical context. They do not invalidate the descriptive and inferential value of the results, but they reinforce the need for cautious interpretation, which is consistent with the broader intervention-analysis literature [6,7].

Results

ARIMA Intervention Evidence

Table 1 presents the ARIMA intervention coefficients for the solvency-related series in both groups and serves as the starting point for evaluating whether the 2019 event generated a direct level effect.

Table 1: ARIMA Intervention Coefficients for the Solvency-Related Series in the Control and Treatment Groups

Group	Key parameter	Estimate	p-value	Reading
Control	is xreg	0.0024	0.7423	No direct intervention effect.
Treatment	is xreg	0.0190	0.3090	No direct intervention effect.

The lack of significance does not mean the series is featureless. In control, AR1 = 0.7347 ($p < 0.0001$), MA1 = 0.1878 ($p = 0.0100$), MA4 = 0.1572 ($p = 0.0017$), and the intercept = 1.0152 ($p < 0.0001$) are all significant. In treatment, AR1 = 0.7954 ($p < 0.0001$), MA1 = -0.2504 ($p = 0.0375$), and the intercept = 0.9683 ($p = 0.0000$) are significant. Thus, the solvency-related series has clear temporal structure in both groups, but the intervention term itself does not isolate a robust post-2019 level shift.

Time-Trend Regression Evidence

Table 2 then reports the polynomial time-trend regression coefficients, allowing a separate reading of event, treatment, and event-treatment interaction effects for the solvency-related indicator.

Table 2: Polynomial Time-Trend Regression Coefficients for the solvency-Related Indicator, Including Event, Treatment and Interaction Terms

Parameter	Estimate	p-value	Interpretation
event	-0.0003	0.989	No average post-2019 shift in the solvency-related indicator.
treatment	-0.0491	0.002	Treated units begin from a lower baseline level in this specification.
event: treatment	0.0164	0.482	No differential treated-group effect after 2019.

These coefficients sharpen the interpretation. The regulatory event is not estimated to improve the treated-control differential directly, but the treated group is systematically distinct in level terms. This is consistent with the idea that pension regulation interacts with heterogeneous institutional conditions rather than operating on identical initial states [2].

Structural-Break Evidence

Finally, Table 3 summarizes the structural-break evidence and shows whether the behavior of the solvency-related series changes significantly around 2019.

Table 3: Chow Structural-Break Test Results for The Solvency-Related Series Around 2019.

Group	Break year	F-statistic	p-value	Inference
Control	2019	1.710325	0.0114	Significant structural break.
Treatment	2019	1.985284	0.0015	More pronounced structural break.

The Chow evidence is stronger than the ARIMA and regression interaction terms. This indicates that 2019 matters, but not as a simple mean shift. The process generating the solvency-related series changes, especially in treatment, even though the reported direct intervention coefficients remain statistically weak.

Decomposition of Trend and Noise

Decomposition provides the most intuitive view of the asymmetry across groups. In the control group, trend stays around 0.99 before 2019 and then declines mildly afterward. Noise becomes more negative after the event, reaching -0.0412 in 2020 and -0.0490 in 2021, although 2019 itself shows a temporary positive deviation of 0.0020. The archive interprets this as mild deterioration with increased short-run instability.

In treatment, the long-run pattern is more favorable. Trend rises from 0.890 in 2014 to 1.127 in 2019 and 1.138 in 2022. Noise remains relatively contained, moving from -0.125 in 2014 to 0.027 in 2019 and 0.042 in 2022. In substantive terms, treatment displays continued trend growth and more controlled deviations from projected path than the control group.

That combination helps reconcile the earlier results. If the regulatory event changed the institutional environment, it may have done so by affecting resilience and structural adaptation rather than by generating a sharp average treatment gain in a single post-event coefficient.

Discussion

The results support a restrained interpretation of prudential effectiveness. There is evidence of meaningful post-2019 reorganization in the solvency-related series, but not evidence of a robust direct intervention effect in the narrow regression sense. This distinction is important. In regulatory environments, solvency improvements may be mediated by gradual adaptation, portfolio repositioning, or governance learning rather than by an immediate jump in the indicator.

The literature helps frame that result. Vittas emphasizes that pension regulation influences governance and market behavior through institutional channels that are often indirect [1]. The OECD similarly argues that solvency rules and accounting standards can reshape long-term investing behavior without necessarily yielding immediate simple gains in headline outcomes [2]. The present evidence is compatible with that perspective: the treated group appears more structurally resilient after 2019, but the gain is visible mainly in the trend-and-noise configuration and in the stronger break dynamics, not in the direct intervention coefficient.

From an econometric standpoint, the findings also reinforce the value of multi-method reading. Box and Tiao show why intervention effects in dependent series cannot be understood apart from the stochastic structure, while Menchetti, Cipollini and Mealli caution that causal attribution in time series requires disciplined assumptions [3,5]. Here, the safest conclusion is that prudential intensification coincides with structural adjustment in solvency dynamics and stronger treatment-group resilience, but not with an unequivocal causal solvency improvement estimated by a single reduced-form interaction term.

Conclusion

Using only the reported thesis outputs, this paper finds that the 2019 event is associated with significant structural change in the solvency-related series and with a more favorable post-event trajectory in treatment relative to control. At the same time, ARIMA and polynomial regressions do not identify a robust direct intervention coefficient. The evidence therefore supports a conclusion of structural adjustment and heterogeneous resilience rather than a simple, discrete, regulation-induced solvency gain.

A literature-anchored econometric article built from the pre-existing thesis outputs, with emphasis on solvency-related dynamics, structural breaks, and institutional resilience after the 2019 regulatory event.

Empirical focus: solvency-related index reported as is.	**Policy shock:** 2019 regulatory event.	**Reported tools:** ARIMA, polynomial regressions, Chow test, decomposition.

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