The Impact of Risk Management Mandates: Evidence from Variable Annuities*

Cameron M. Ellis† Andrew Ellul‡ Chotibhak Jotikasthira§ Jianren Xu¶

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Abstract

We measure the causal effects of risk management mandates on firms' product choices and systemic risk exposure. Exploiting the staggered roll-out of an industry-wide mandate for enterprise risk management (ERM), a firm-wide approach, in the insurance industry, we find that affected firms reduced their offering of variable annuities with risky-guarantees and increased their offering of index-linked annuities, which provide a natural hedge. ERM also leads insurers to reduce correlated asset holdings, dampening potential fire-sale spillovers. Our findings suggest that ERM mandates materially reshape firms' risk-taking and strengthen financial stability.

Keywords: Enterprise Risk Management · Variable Annuities · Index-Linked Annuities · Risk Management

JEL classifications: G22 · G28 · G32 · G11

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†Tippie College of Business, University of Iowa, cameron-ellis@uiowa.edu

‡Kelley School of Business, Indiana University, anellul@indiana.edu

§Cox School of Business, Southern Methodist University, cjotikasthira@smu.edu

¶G. Brint Ryan College of Business, University of North Texas, jianren.xu@unt.edu

"A comprehensive approach to enterprise risk management is important for several reasons... without a commitment to good governance and risk management, silos can form and the interdependence between risk categories can be overlooked."

–U.S. Securities and Exchange Commission Chairman Mary L. Schapiro March 23, 2011

1 Introduction

Governments frequently impose risk management mandates that dictate how firms handle and oversee their exposures. In the US, the Sarbanes-Oxley Act (SOX), SEC Rule 33-9089 on board risk oversight, and the Dodd-Frank Act all aim to enforce firm-wide risk management controls.[1] However, because these mandates typically take effect across entire sectors (or even countries) at the same time, it is difficult to untangle their true causal impact on corporate risk-taking. Prior studies have attempted various identification strategies. However, since uniform regulatory roll-outs rarely generate clean control groups, they typically rely on either extremely strong assumptions or yield only very "local" evidence.[2]

We tackle this issue by exploiting the staggered roll-out of the Own Risk and Solvency Assessment (ORSA) Model Law, a mandate centered on "enterprise risk management" (ERM), a widely accepted and leading-edge approach to firm-wide risk management, for U.S. insurance companies that was adopted by different states at different times. We find that imposing mandatory ERM prompts life insurers to scale back the risky, long-horizon minimum return guarantees, reallocate product launches toward index-linked annuities which naturally hedge the equity risk, and reduce systemic vulnerabilities in their asset portfolios. Our results demonstrate how risk management mandates materially reshape firm strategies in both product offerings and investment decisions.

ERM mandates require firms to take a holistic view of firm-wide exposures by managing interdependencies across risk classes and anticipating both internal and external threats. A core principle is the "tone from the top", which ensures that leadership sets and enforces a consistent

[1] Other examples of governments mandating firm-wide risk management approaches include: Solvency II for European Insurers, Capital Requirements Directive IV for European Banks, "Gesetz zur Kontrolle und Transparenz im Unternehmensbereich" for publicly listed German companies, the Health Insurance Portability and Accountability Act (HIPPA) for health data collectors, the Energy Policy Act for utilities connected to the electric grid, and the General Data Protection Regulation (GDPR) for general data privacy in Europe.

[2] Identification strategies include: Exemptions for very small companies (e.g., Balasubramanyan et al., 2024; Jiang and Ji, 2024); Cross-country comparisons (e.g., Houston et al., 2012; Ongena et al., 2013; Frame et al., 2020); Assumed variation in treatment intensity (e.g., Aiyar et al., 2014); and the inclusion of fixed effects (e.g., Amiraslani et al., 2024). A large separate literature also examines firms that voluntarily adopt ERM. Within this literature, earlier studies mainly rely on treatment effects models (e.g., Hoyt and Liebenberg, 2011; Eckles et al., 2014; Berry-Stölzle and Xu, 2018), while more recent research often employs difference-in-differences strategies with endogenous treatment, typically in matched samples (e.g., Eastman et al., 2024; Li et al., 2024; Neel and Xu, 2025).

risk appetite across business lines. By highlighting potential natural hedges—where losses in one product or asset can be offset by gains in another—ERM avoids "silo" management and promotes strategic resource allocation. Integrating into this broader framework, ORSA compels U.S. insurers to conduct comprehensive self-assessments of current and future risks, especially under stress scenarios, and to submit summary reports that allow regulators to monitor firm-level solvency and risk mitigation.

We use traditional variable annuities (TVAs) as a natural testing ground. TVAs are a key liability category for life insurers, with approximately $1.5 trillion in assets (about 35% of total U.S. life insurer liabilities) in 2015 (Koijen and Yogo, 2015). While these contracts appeal to policyholders by offering equity market participation, the embedded guarantees can expose insurers to sizable market and longevity risks. Periods of financial distress magnify these exposures, making TVAs a prime laboratory for studying how risk management mandates alter product decisions (Koijen and Yogo, 2015). ERM also requires firms to incorporate the behavior of other firms into their risk models, and TVAs represent the only source of systemic risk in the insurance industry (Hufeld et al., 2017).

States adopt ORSA in a staggered manner. To avoid using early-treated firms in states that adopt ORSA earlier as controls for later-treated firms—and to estimate causal effects for various benefit/contract offerings jointly and asset allocations—we implement an imputation difference-in-differences (DiD) design (Borusyak et al., 2024). This approach first fits a model on untreated state-year data, then predicts counterfactual outcomes for treated state-years, and computes treatment effects as the difference between predicted and actual outcomes. We find that firms newly subject to ORSA are less likely to offer the most generous guarantees on their existing TVA contracts, a pattern consistent with the mandate's emphasis on holistic risk oversight. These results suggest that once insurers account for the true portfolio cost of market-exposed benefits, they respond by shedding products that increase volatility and capital strain.

Next, we exam firm offerings of registered index-linked annuities (RILAs), which continue to offer equity-based returns but place part of the downside risk back on policyholders. In 2023, RILA sales surpassed TVA sales for the first time (Almazora, 2024). Because some of the equity risk is transferred back to the policyholder, RILAs act as a natural hedge for the risk in the embedded guarantees of TVAs (Barbu and Sen, 2024). We find that insurers exposed to ORSA disproportionately increase their RILA offerings while not adjusting their offering of "fixed" annuities, which have no similar hedging benefit. This shift reflects how "tone from the top" directives under ERM encourage product portfolios that offset, rather than concentrate, equity-market exposures. Finally, we show a corresponding effect on insurers' asset portfolios. ORSA leads firms to reduce holdings that are highly correlated with those of their peers, lowering the risk of industry-wide

fire sales in times of stress. By emphasizing external risk assessment along with internal controls, ORSA prompts insurers to diversify away from common asset concentrations, thereby mitigating potential feedback loops in adverse market conditions.

Our study contributes to the literature on general financial regulation and its economic impacts. While prior research has examined how regulatory changes affect market outcomes (Barbu et al., 2024; Koijen and Yogo, 2016), identifying causal effects is challenging due to the tendency for broad-based reforms that influence all firms simultaneously and for treated and untreated firms to face overlapping regulatory environments (Houston et al., 2012; Ongena et al., 2013; Aiyar et al., 2014; Frame et al., 2020). By leveraging the staggered adoption of ORSA, we exploit within-industry variation that allows cleaner identification of regulatory effects. This approach enables us to isolate how enhanced risk management specifically shapes insurers' strategic decisions, rather than capturing only economy-wide shifts in market structure. We thereby extend the literature by demonstrating compelling causal impacts of regulation on financial institutions, with a particular focus on annuity product offerings and insurer asset allocation. In doing so, we shed light on the mechanisms through which risk management mandates can foster both firm-level discipline and broader financial stability.

In the ERM-specific literature, our findings provide causal evidence on how mandatory, firm-wide risk control influences business decisions. While prior studies examine the benefits of ERM adoption (Hoyt and Liebenberg, 2011; Eckles et al., 2014; Berry-Stölzle and Xu, 2018; Li et al., 2024; Eastman et al., 2024) and variations in ERM quality (Ellul and Yerramilli, 2013; Chen et al., 2020; Beasley et al., 2023; Amiraslani et al., 2024), they rely on firms' voluntary ERM implementation, which introduces endogeneity concerns, despite efforts to address them through research designs. Existing regulatory studies, such as those on the Dodd-Frank Act, also face identification challenges due to confounding regulatory changes and limitations in both sample size and the locality of estimated average treatment effects.[3] In contrast, ORSA offers a cleaner setting for causal inference. Further, Dodd-Frank does not require comprehensive reporting to regulators that ORSA mandates, limiting its regulatory effectiveness (Balasubramanyan et al., 2024). The detailed ORSA reports enforce a more rigorous and strengthened ERM framework, thereby elevating ERM to a higher standard (Krupa, 2024). As such, our work evaluates this advanced, mandatory, and regulatory-driven approach to ERM.

Finally, we also contribute to the extensive literature on TVAs, where numerous studies examine their risk-taking, guarantee structures, and capital implications (e.g., Ellul et al., 2022; Koijen and Yogo, 2015; Hufeld et al., 2017; Koijen and Yogo, 2022; Li, 2024; Barbu, 2023; Rogers and

[3]The Dodd-Frank Act, enacted in 2010 in response to the financial crisis, has a broad scope with various provisions, making it susceptible to confounding regulatory changes for a DiD analysis. Additionally, the regression discontinuity approach based on two bank size thresholds under Dodd-Frank relies on small local samples: one threshold includes only about 200 banks with assets around $10 billion, while the other, at the $50 billion threshold, has too few banks for meaningful analysis (Balasubramanyan et al., 2024).

Tonetti, 2023). Our findings highlight how regulatory requirements can reshape product portfolios, adding a new dimension to the analysis of TVA pricing, market dynamics, and insurer risk management. In addition, we complement an emerging literature on TVAsannuities (e.g., Friedberg and Webb, 2021; Barbu et al., 2024; Mezger, 2024; Moenig and Xu, 2023; Ellis et al., 2023) by showing that insurers respond to enterprise-wide oversight not simply by retreating from risky contracts but by adopting products like RILAs that permit strategic risk sharing with policyholders.

Our findings have important implications for policymakers and regulators. We show that risk management mandates can help temper excessive risk-taking while reducing the likelihood of systemic spillovers. Regulators intent on bolstering financial stability can use ERM requirements to foster safer product structures and discourage highly correlated investment behavior. As such, we show that ERM contributes to a stable financial marketplace and health economy, supporting the SEC's initiative. Given our evidence that ERM mandates for insurers, along with prior findings that voluntary ERM adoption in other industries (Neel and Xu, 2025), help limit contagion risk, our study advocates for extending targeted ERM regulatory frameworks to the broader economy.

2 Institutional Mechanics

2.1 Variable Annuities

Traditional Variable annuities (TVAs) are hybrid financial instruments that combine investment products, typically mutual funds, with insurance features designed to provide a degree of income stability and downside protection. Sold primarily by life insurance companies, these products often offer an assortment of guaranteed benefits (many of which can be combined) in exchange for fees, with each benefit type shifting varying degrees of risk to the insurer. These benefits include:

1. **Guaranteed Minimum Accumulation Benefit (GMAB):** Ensures that the contract's account value will not fall below a specified amount at the end of a set holding period. While it provides a floor on the contract value, it exposes the insurer to market risk if the underlying investments perform poorly.

2. **Guaranteed Minimum Income Benefit (GMIB):** Allows the policyholder to annuitize at a guaranteed rate, effectively locking in a minimum lifetime income. Because it combines longevity risk with market risk, GMIB can be more complex and costly for insurers to hedge.

3. **Guaranteed Minimum Withdrawal Benefit (GMWB):** Guarantees a minimum level of withdrawals over a defined period, regardless of market fluctuations. The insurer bears the risk that the underlying account value may deplete faster than expected, particularly during market downturns.

4. **Guaranteed Lifetime Withdrawal Benefit (GLWB):** Extends GMWB to a lifetime horizon, thereby adding significant longevity risk on top of equity market risk. As a result, GLWB is often considered one of the most challenging guarantee types to hedge cost-effectively.

5. **Guaranteed Minimum Death Benefit (GMDB):** Provides a minimum benefit to a beneficiary upon the policyholder's death. While it introduces some market risk, it is typically triggered only at death, so its risk exposure can be lower compared to lifetime guarantees like GLWB or GMIB.

Among these, the living benefits that continue throughout the policyholder's lifetime (notably GMIB and GLWB) tend to be the most complex and risky for insurers, since they must account for both uncertain market returns and uncertain lifespans.[4] Although, in theory, insurers could hedge this risk through derivatives or reinsurance, practical and regulatory barriers often render such hedging strategies costly or incomplete. In the wake of the Great Financial Crisis and the COVID-19 Pandemic, many insurers faced severe financial distress on their TVA exposures, leading to higher prices, renegotiation of contract terms, and even exits from the market (Koijen and Yogo, 2022; Barbu, 2023).

TVAsAnnuities (RILAs) are a new form of variable annuity. RILAs have drastically gained in popularity in recent years, with annual sales exceeding $40 billion in 2022, after being virtually non-existent a decade earlier (Ellis et al., 2023). A RILA entails an investment into a separate account managed by an insurance company. The account evolution is linked to the performance of a popular market index—such as the S&P 500—over a crediting term of usually one year (but potentially up to six years). At the end of the year, the insurer credits the investor's account with the index return, subject to downside protection in the form of a Floor or Buffer. For instance, with a 10% Floor the investor can lose at most 10% of her funds over the crediting term, and with a 10% Buffer the loss of the index would be reduced by up to 10%. In exchange, the investor accepts an upside limit, usually in the form of a Cap, that the credited return cannot exceed. When equipped with a target-date-style glide path that gradually decreases the investor's risk exposure over time, the proposed TD-RILAs create a passive investment vehicle that is well-suited for QRPs.

RILAs exhibit notable advantages for insurers. RILA carriers can hedge the embedded equity risk almost perfectly and at a low cost by trading European options on popular equity indices. This approach stands in stark contrast to the more complex ex ante hedging and frequent re-

[4] By contrast, GMDBs, although still risky, generally have more predictable triggers and shorter time horizons.

balancing required for TVA guarantees. Moreover, carriers are not tied to a long-term contract because they can adjust the Cap rate at the end of each crediting term to reflect current market conditions, such as changes in option prices. As Moenig (2022) shows, carriers took advantage of this flexibility in mid-2020 when option prices surged—though investors did not suffer as a result. Third, while TVAs are notorious for their high fees, RILAs are generally priced very attractively (Moenig, 2022; Moenig and Samuelson, 2024). This reflects the efficiency of their risk management design and their regulatory framework: because there is no direct investment into the reference index, carriers invest RILA premiums at their discretion (typically in corporate bonds) and earn a credit spread, which helps keep overall costs low. As Moenig (2022) illustrates, these attributes allow providers to offer RILAs at relatively low cost while still earning consistent profits.

RILAs can also serve as a natural hedge to these TVA guarantees because they effectively let insurers sell downside risk back to investors (i.e., household savers) (**?**). In TVAs, insurers provide downside protection to policyholders, whereas in RILAs, the policyholders accept some downside risk in exchange for enhanced upside potential, thereby "selling" a long-term put option to the insurer. This offsetting exposure allows carriers to hedge large realizations of equity (and interest rate) risk within their product portfolio, a process sometimes termed hedging through product design. Notably, unlike short maturity options traded in financial markets – which require collateral posting and frequent rolling – RILAs involve cash deposits that the insurer can invest in safe bonds. Consequently, the collateral is already on the insurer's balance sheet, eliminating both counter-party and liquidity risks. Because these flows occur within tax-advantaged retirement accounts, insurers are further positioned to act as natural intermediaries of aggregate market risk, matching the guarantee needs of some households with the appetite for partial downside exposure of others (**?**).

By tapping into heterogeneous investor preferences – older and more risk-averse households often prefer TVA-style guarantees, whereas younger or more risk-tolerant households might opt for RILAs – insurers cross-sectionally share the same aggregate market risk. The result is lower capital volatility and a reduced need for external hedging. Furthermore, because RILA designs do not involve outright equity purchases, insurers earn credit spreads on their underlying bond investments while transferring part of the equity risk directly back to policyholders. This synergy often produces lower overall costs for investors, increased stability for insurers, and a more balanced allocation of equity market risk across households with different risk profiles.

2.2 Enterprise Risk Management

Enterprise Risk Management (ERM) is a holistic and integrated approach to risk management that addresses the limitations of traditional "silo"-based methods, where risks are managed independently within individual business units. By shifting to an enterprise-wide perspective, ERM coor-

dinates and aligns risk management activities across all business units, fostering a cohesive framework that enhances organizational resilience, efficiency, and strategic decision-making (COSO, 2004; SEC, 2007).

Risk Interdependencies and Natural Hedges: An important feature of ERM is its emphasis on a "tone from the top" framework, where the board of directors plays a key role in guiding enterprise-wide risk management practices (Braumann et al., 2020; Neel and Xu, 2025). This leadership ensures that risk management strategies are consistent across the organization and aligned with the firm's mission, vision, and core values (COSO, 2017; Li et al., 2024). By fostering a culture of accountability and strategic alignment, the "tone from the top" approach empowers decision-makers at all levels to prioritize the firm's long-term objectives over narrow, project-specific goals. Through this big-picture perspective, ERM ensures that risk management decisions reflect the broader interests of the organization, enabling sustainable growth and profitability.

This strategic, high-level view also enables ERM to identify interdependencies across risks or projects and recognize how they interact and influence one another. Such an integrated understanding allows firms to exploit natural hedges—instances where the dynamics of one risk or project offset the effects of another. By leveraging these interdependencies, ERM mitigates redundant risk management efforts, enhances operational efficiency, and optimizes resource allocation.

The importance of ERM's comprehensive approach was highlighted in a 2011 speech by the U.S. Securities and Exchange Commission (SEC) Chairman Mary L. Schapiro, who emphasized that a commitment to ERM is essential to prevent the formation of silos and the overlooking of interdependencies between risk categories. She further outlined the need for ERM to be embedded in key business processes, with senior managers ensuring effective oversight at both the product and asset class levels.

Corporate examples illustrate the challenges of silo-based approaches and the advantages ERM provides in addressing them. In 1984, Lufthansa, Germany's largest airline, signed a 3 billion U.S. dollar contract to purchase aircraft from Boeing and entered into a 1.5 billion U.S. dollar forward contract to hedge exchange rate risk, fearing continued appreciation of the U.S. dollar. However, a significant portion of Lufthansa's cash flow was U.S. dollar-denominated, naturally offsetting the exchange rate exposure. By overlooking this natural hedge and managing the risk in isolation, Lufthansa incurred a major and unnecessary foreign exchange loss when the U.S. dollar depreciated against the mark in 1985 (The Economist, February 10, 1996, p. 16-17).

Similarly, Statoil, one of the world's largest oil and gas producers based in Norway, implemented ERM to centralize derivative hedging decisions, replacing its prior unit-specific approach. Before adopting ERM, individual business units managed their own hedging strategies, driven by unit-specific profitability and incentive structures. ERM centralized these decisions, aligning them with the firm's overall strategic goals and improving coordination across the enterprise

(Alviniussen and Jankensgård, 2015). Moreover, in a study of Swedish-listed firms, Jankensgård (2015) find that firms managing their foreign exchange derivative positions in an integrated fashion achieved higher valuations, as measured by Tobin's Q, than firms that did not adopt such an approach.

External Risk Environment and Systemic Risk: An ERM program improves firms' ability to assess and manage uncertainties in their external risk environment, in addition to internal risk environment. Unlike silo-based frameworks that focus solely on the firm's own risks, ERM prompts firms to consider how their business interacts with others in their industry and broader economy. This comprehensive perspective enables firms to anticipate and mitigate industry-wide and market-wide vulnerabilities when adverse macroeconomic conditions arise. By exploring opportunities to engage in businesses less correlated with those of peers, ERM helps firms to better insulate from systemic risks that might impact the entire industry or broader economy, ensuring greater resilience and adaptability.

ERM systematically gathers and analyzes external risk factors using frameworks like PESTLE (political, economic, sociological, technological, legal, and environmental factors) to evaluate events such as elections, regulatory changes, economic trends, and climate risks (COSO, 2017; Elliot, 2018). Facilitated workshops with stakeholders often employ tools like SWOT analysis and spider diagrams to map risks, define risk appetites, and align them with strategic objectives (Arena et al., 2017; Quail, 2010; Fraser and Simkins, 2016). Moreover, ERM equips firms with advanced tools for quantifying risks and their potential impacts. Techniques like Monte Carlo simulations, extreme value theory, and neural networks allow firms to incorporate external risks into decision-making (Deloitte, 2013, 2015; Mikes and Kaplan, 2015; Elliot, 2018).

Empirical research supports this view. Li et al. (2024) show that ERM is particularly effective in firms operating under higher external uncertainty, as measured by industry-level earnings volatility and political risk. Similarly, Liu and Xu (2024) find that banks with ERM are better equipped to manage macroeconomic risks, such as unemployment fluctuations or housing price declines, by incorporating these conditions into decisions on mortgage loan sales. Further, these banks maintain higher loan loss provisions during economic upturns, reducing credit market procyclicality.

Risk Portfolio and Long-term Resilience: ERM aligns a firm's risk appetite with its strategic objectives, setting an optimal risk level rather than simply minimizing all risks in silos, as some risks present opportunities (Hayne and Free, 2014; Arena et al., 2017). Taking a holistic risk-portfolio approach, ERM may strategically increase certain risks to achieve broader goals, such as resilience to systemic shocks, while keeping overall risk within acceptable limits.

Consistent with this view, Xu and Xie (2018) find that firms with ERM make greater R&D investments and generate more innovation, measured by patent count, citation-weighted patents, and market-based patent value. The results suggest that ERM enables firms to strategically take risks that enhance competitiveness and sustainability while achieving overall long-term risk resilience.

In summary, ERM is an integrated approach to risk management that aligns risk strategies with a firm's overall objectives and promotes leadership from the top. By identifying interdependencies between risks, ERM optimizes resource allocation and facilitates natural hedges. ERM also considers both internal and external risks, enabling firms to better anticipate and manage macroeconomic vulnerabilities and systemic risks. In addition, ERM seeks to set an optimal risk level, balancing potential opportunities with the firm's risk appetite to achieve strategic goals and long-term resilience.

Own Risk and Solvency Assessment (ORSA) Requirements: The Own Risk and Solvency Assessment (ORSA) is a U.S. regulatory framework designed to enhance the financial stability of the insurance industry by strengthening the role of ERM and improving solvency positions. ORSA was introduced by the National Association of Insurance Commissioners (NAIC), following the 2008 financial crisis, to address the vulnerabilities exposed during that period, particularly the systemic risks within large insurance groups. The financial crisis highlighted the need for a more forward-looking and comprehensive regulatory tool to evaluate not only insurers' financial condition but also their capacity to manage a broad range of interconnected risks.

ORSA requires insurers to conduct a thorough self-assessment of their current and future risks under various stress scenarios. This assessment includes a wide array of potential risks, helping insurers understand their ability to meet policyholder obligations, anticipate future capital needs, and effectively evaluate and manage risks. Unlike traditional solvency assessments, which are primarily regulatory in nature, ORSA is a proactive, forward-looking procedure that integrates into an insurer's ERM framework. It is intended to be an ongoing, iterative process rather than a one-time event. Each insurer has flexibility in how they conduct their assessments, allowing for tailored approaches that align with their unique risk profiles and business models. However, the overarching goals of ORSA remain consistent across all insurers.

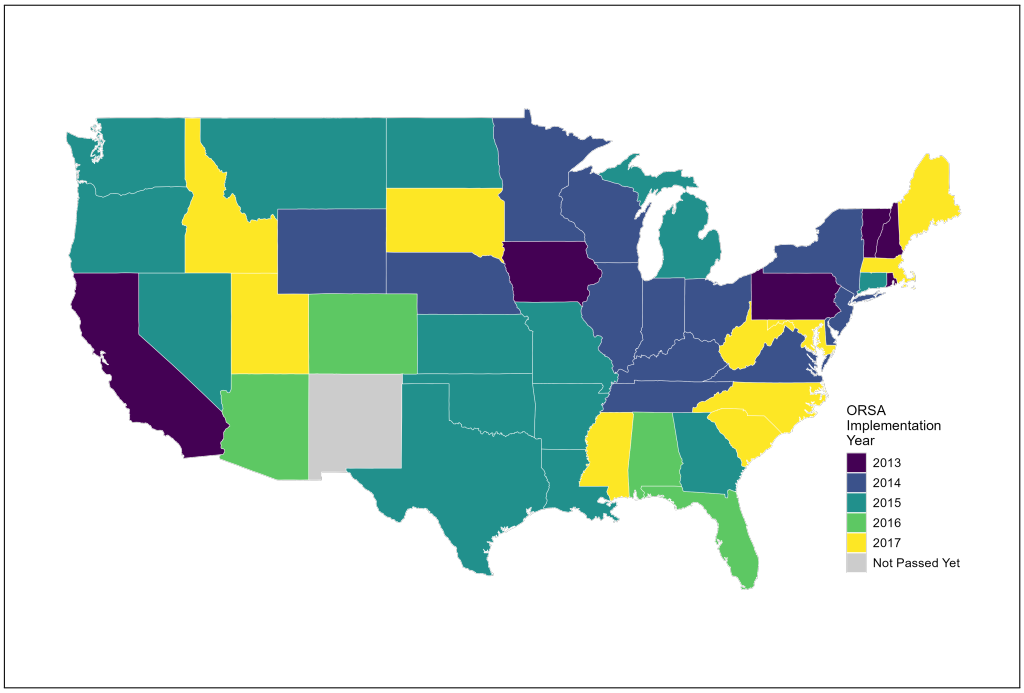
The ORSA's primary goals are twofold: (1) to ensure that insurers have an effective level of ERM in place for identifying, assessing, and reporting on key risks, and (2) to provide a group-level view of risks and capital, supplementing the traditional legal entity perspective. ORSA is mandatory for U.S. insurers writing more than $500 million in annual direct written and assumed premiums and/or for insurance groups writing over $1 billion. These insurers are required to conduct and document an ORSA regularly. The results are summarized in an ORSA Summary

Report, which is submitted to the lead state commissioner and, if applicable, the domiciliary state regulator. This report serves as a tool for regulators to gain a comprehensive understanding of an insurer's risk profile and financial resilience, while maintaining confidentiality.

The ORSA reporting requirement is outlined in the NAIC's Risk Management and Own Risk and Solvency Assessment Model Act (#505). U.S. states and jurisdictions adopted the Model Act between 2013 and 2017 in a staggered manner, as represented in Figure 1. As of 2024, 53 out of 56 U.S. jurisdictions have formally enacted the Model Act. Since its introduction, ORSA has become a cornerstone of the NAIC's regulatory framework, fostering an effective level of ERM across insurers and contributing to the stability and resilience of the insurance industry.

Eastman and Xu (2021) examine the market reactions of insurers with and without voluntary ERM adoption on key dates leading up to the passage of ORSA. Krupa (2024) finds that, due to ORSA's integrated approach in considering all firm-wide risks, insurers' managers are required to assess both tax and non-tax risks when making tax strategies. This leads to increased awareness of previously underestimated non-tax risks and a significant reduction in tax aggressiveness. The study also shows that this effect holds regardless of whether insurers had voluntarily adopted ERM prior to ORSA, suggesting that ORSA elevates ERM practices to a higher level, likely due to its mandatory nature and the detailed self-assessment reports required by regulators.

Figure 1: Map of ORSA Roll-out



Note: Figure shows which the roll-out of ORSA regulations for insurer lead states.

3 Data

3.1 Data Sources

Our data come from two main sources. The first source is Morningstar Annuity Intelligence, where we obtain annuity contract characteristics including benefit riders and annuity sales. The second source is the insurers' annual filings from the National Association of Insurance Commissioners (NAIC), obtained through S&P Global Market Intelligence, where we obtain insurer characteristics such as net total assets, direct and net premiums, asset allocations, etc. Importantly, the NAIC data also include account values and gross reserves associated with annuities with guarantees (from the General Interrogatories (2003-2016) and from the Variable Annuities Supplement, Parts 1 and 2, in subsequent years).

3.2 Sample Construction

We start with Morningstar Annuity Intelligence contract-level data, and merge the NAIC firm-level data to it by firm name and year. Our sample thus includes only firms that offer at least one annuity contract during the period between 1996 and 2023.[5] The data frequency is annual (although the annuity contract sales data are quarterly), and the units of observation are benefit-year, contract-year, or firm-year, depending on the analysis. Our identification relies on the staggered implementations of ORSA during the period from 2013-2017, and therefore, the relevant variation ends when all firms become subject to ORSA in 2018. Our sample includes 154 unique firms, 4,530 unique annuity contracts (of which 3,827 are TVA contracts), and 30,729 unique benefit riders (of which 23,968 are offered within TVA contracts).

3.3 Variable Construction

Our firm-level variables, including assets, surplus, premiums, and RBC ratios, are taken directly from the NAIC data and are standard. To investigate whether a firm's portfolio is similar to those of its peers, we use the cosine similarity measure proposed by Girardi et al. (2021) and calculate, for each firm, the weighted average similarity across all peers in a given year. We ignore cash and Treasuries because they are liquid and unlikely to generate fire-sale feedback loops, and use S&P Global's broad grouping of the remaining assets into: real estates, common stocks, preferred stocks, foreign government bonds, agency bonds, municipal bonds, industrial corporate bonds, utility corporate bonds, bank loans, credit tenant bonds, etc. because fire sales in individual assets

[5] The NAIC data begins in 1996, although Morningstar Annuity Intelligence begins earlier.

are unlikely to generate significant fire-sale losses to insurers.[6] We weight the similarity with each peer by either the peer's asset size, as forced asset sales by larger peers are likely to trigger larger price impacts, or the peer's asset size divided by RBC ratio, as forced asset sales are unlikely among peers that are well capitalized.

We use Morningstar's classifications of contracts into fixed annuities, fixed-index and index-linked annuities, which we group together as RILAs, and TVAs. We create a dummy for each classification. We track whether each contract is being offered in a given year using its inception and close dates. Other variables, including mortality and expense risk fee, sales, assets, and flows, are taken directly from Morningstar and are standard. Contract sales, assets, and flows are, however, available only for a subset of TVA contracts.

We examine the benefits riders offered within TVA contracts. We focus on TVA contracts only because the same benefits work differently and are not equally risky for other annuity types. About 50% of the TVA contracts in our sample do not offer benefit riders. For those that do, we classify the benefits broadly into guarantees and non-guarantees using its benefit type, as specified by Morningstar. Specifically, the types that contain the following words– GMWB, GMAB, and GMIB – are considered guarantees. Finally, we track whether each benefit rider is active in a given year using its inception and close dates.

3.4 Summary Statistics

We report the summary statistics in Table 1. Panel A shows that our sample life insurers have the average (pooled across years) net total assets of $31,804 million, average surplus of $1,614 million, and average premiums of $2,971 million.[7] By and large, the insurers are profitable and well capitalized as evidenced by their net income and RBC ratios. The asset portfolios of the insurers highly overlap with each other, with the average peer (cosine) similarity of 0.92[8], slightly higher than what Girardi et al. (2021) report for their sample of large insurers[9] Importantly, there is significant variation in peer similarity both in the cross section and the time series; firm fixed effects and year fixed effects explain 39% and 14% of the variation, respectively.

Panel B shows that in the full sample, most annuity contracts being offered, 89% to be precise, are TVA. Fixed annuities and RILAs are about 6% and 4% of the sample, respectively. However, if we split the sample into the years before and after ORSA implementations, we find that the

[6] Unlike other firm-level variables which begin in 1996, S&P Global only reports the broad asset allocations beginning in 2001.

[7] Annuity writing insurers tend to be large compared to the average insurer. The average net total assets, surplus, and premiums in 2018 are $50,675 million, $2,623 million, and $3,525 million, respectively.

[8] If two insurers have the exact same asset allocations, then the similarity will be 1. If their asset allocations do not overlap at all, then the similarity will be 0.

[9] The sample in Girardi et al. (2021) includes both life and P&C insurers.

shares of TVAs, fixed annuities, and RILAs change from 94-4-2% to 11-13-76%, consistent with the idea that ERM guides firms towards less risky product offerings. On average, the contracts in our sample are offered for about 12 years (ignoring the right truncation), with significant cross-sectional variation. For the sample of TVA contracts, the average mortality and expense risk fee is 0.83%. The average number of benefits offered within a TVA contract is about 2, although, as discussed, about half of the contracts do not offer any benefit riders. About 30% of TVA contracts (or, 60% of those that offer at least one benefit) offer at least one benefit rider that is a guarantee.

Panel C shows that across all benefit-year observations, 44% of active benefits are guarantees. On average, the benefits are active for about 9 years (ignoring the right truncation). Non-guarantee benefits appear less likely to be closed, with the average active period of almost 14 years.

Table 1: Summary Statistics

Panel A: Firm-level variables

	Obs.	Average	Std. Dev.	P10	P50	P90
Net total assets ($ mil.)	3,371	31,804	61,562	219	7,442	99,941
Total surplus ($ mil.)	3,371	1,614	3,150	37	460	4,741
Premiums ($ mil.)	3,371	2,971	5,772	10	724	9,728
Net income ($ mil.)	3,371	148	496	-33	26	535
RBC ratio	3,364	20.48	85.49	5.22	8.77	19.62
Assets-weighted peer similarity	2,614	0.92	0.11	0.85	0.95	0.97
Assets-to-RBC ratio-weighted peer similarity	2,614	0.92	0.11	0.85	0.95	0.97

Panel B: Contract-level variables

	Obs.	Average	Std. Dev.	P10	P50	P90
Dummy(Fixed annuity)	38,890	0.06	0.24	0.00	0.00	0.00
Dummy(RILA)	38,890	0.04	0.21	0.00	0.00	0.00
Dummy(TVA)	38,890	0.89	0.31	0.00	1.00	1.00
Time being offered (years)	4,530	12.43	9.90	3.00	10.00	25.00
Variables below are for TVA contracts only						
Mortality and expense risk fee (%)	34,797	0.83	0.54	0.00	0.90	1.45
Number of benefits	34,806	2.14	4.20	0.00	0.00	8.00
Dummy(One of the benefits is a guarantee)	34,806	0.30	0.46	0.00	0.00	1.00
New sales ($ mil.)	8,735	250	823	1	33	567
Total sales ($ mil.)	8,834	252	825	1	34	577
Net total assets ($ mil.)	9,773	6,957	59,298	14	602	10,106
Estimated net flows ($ mil.)	10,323	84	2,506	-83	3	318

Panel C: Benefit-level variables (TVA contracts only)

	Obs.	Average	Std. Dev.	P10	P50	P90
Dummy(Guarantee)	155,555	0.44	0.50	0.00	0.00	1.00
Time being active (years)	23,968	8.98	7.45	2.00	7.00	20.00
Non-guarantee	8,973	13.82	7.99	4.00	13.00	24.00
Guarantee	14,995	6.08	5.31	2.00	4.00	14.00

Notes: This table presents summary statistics of firm-level (Panel A), annuity-level (Panel B), and benefit-level (Panel C) variables. The data are based on the NAIC annual regulatory filing, obtained through S&P Global, and Morningstar Annuity Intelligence. The sample period is from 1996 to 2018, and the observation frequencies are firm-year, contract-year, and benefit-year, respectively. The sample includes only life insurers that write annuities.

4 Methods

We exploit the staggered adoption of ORSA regulations across states to investigate the impact of ERM on annuity companies using a DiD approach. Specifically, we examine whether the roll-out of ORSA caused insurers to (1) offer fewer of the riskiest types of benefits; (2) offer fewer TVAs and more index-linked annuities; and (3) reduce their investment in systemically risky assets.

Our key assumption is that in the absence of the introduction of ORSA, the treatment and control groups would have had parallel trends over time. Any deviation in trends between the two groups after the policy change is then attributed as the causal effect of the policy. However, if states adopt ORSA at different times, the traditional two-way fixed effects DiD approach can be biased because it compares insurers in states that adopt ORSA that year to states that have already adopted it in earlier years.[10] Essentially, once a state adopts ORSA, it's insurers are no longer a valid control for insurers in states that adopt ORSA later. Recent developments in the literature have established methods to address this limitation.[11]

All of these new methods exclude the problematic comparisons between insurers in states that implement ORSA and those in states that have already expanded. Because we are interested in jointly estimating treatment effects for different benefit/contract types, we use the imputation approach of Borusyak et al. (2024), which involves first fitting a model using data from insurers in the untreated state-years and then using that model to predict counterfactual outcomes for insurers in the treated state-years. We then compute treatment effects by comparing these predicted counterfactuals to actual outcomes. We cluster all regressions by the insurance company's lead state, which is our unit of treatment assignment (Abadie et al., 2023).

Benefit Offerings: We first examine the offering of different types of benefits for TVAs. We transform our benefit-contract-level panel data, which only contains TVAs, into a "long"-balanced format and add a binary variable for if the benefit is offered in year t. We then estimated a linear probability model on this transformed data, which approximates a hazard function.

For annuity contract k and benefit i, (potentially) offered by insurance company j in year t, we estimate the following model using the imputation approach:

$$P(y^0_{ikjt} = 1) = \theta_j + \tau_t \times Benefit_Type_i + \epsilon_{ikjt} \tag{1}$$

$$P(y^1_{ikjt} = 1) - \widehat{y^0_{ikjt}} = \beta \times ORSA_{jt} \times Benefit_Type_i + \nu_{ikjt} \tag{2}$$

[10] See Goodman-Bacon (2021) for discussions of the drawbacks of two-way fixed effects with differential timing.

[11] For example, Callaway and Sant'Anna (2020), Athey et al. (2021), Borusyak et al. (2024), Gardner (2021), and Jakiela (2021).

where y_{ikjt} is a binary indicator for if the benefit is offered on contract k in year t; θ_j are firm fixed effects; τ_t are year fixed effects which, in the first stage, are interacted with $Benefit_Type_i$, which is an indicator for if the benefit is one of the more risky "guarantees'"; and $ORSA_{jt}$ is a binary indicator for insurance firm j being exposed to ORSA regulation in year t. Equation (1) uses untreated benefit-years to predict potential counterfactual outcomes for the treated benefit-years, which are then used in Equation (2) to estimate the impact of ORSA adoption on different types of benefits by comparing actual outcomes to predicted untreated outcomes.

Contract Offerings: We next examine the opening and closing of individual contracts. We use a similar functional form to the above benefit-level analysis, but with a contract-level panel instead.

Formally, for annuity contract k, (potentially) offered by insurance company j in year t, we estimate the following model using the imputation approach:

$$P(y^0_{kjt} = 1) = \theta_j + \tau_t \times Annuity_Type_k + \epsilon_{kjt}$$
$$P(y^1_{kjt} = 1) - \widehat{y^0_{kjt}} = \beta \times ORSA_{jt} \times Annuity_Type_k + \nu_{kjt}$$

where y_{kjt} is a binary indicator for if annuity contract k is offered in year t; $Annuity_Type_{kj}$ is an indicator for if the annuity is a Traditional Variable Annuity, A Fixed Annuity, or an Index-Linked Annuity; and all other variables are the same as Equations (1) and (2).

Asset Similarity: Finally, we examine if ERM adoption leads firms to change their asset portfolios in a way that reduces herding behavior. For this analysis, we use our insurer-year panel.

Formally, for insurer j in year t, we estimate the following model again using the imputation approach:

$$AS^0_{jt} = \theta_j + \tau_t + \epsilon_{jt}$$
$$AS^1_{jt} - \widehat{AS^0_{jt}} = \beta \times ORSA_{jt} + \nu_{jt}$$

where AS_{jt} is the cosine-similarity between insurer j's assets and all other insurers in year t.

Discussion of Assumptions: We rely on two primary assumptions for our analysis. The first is that, in the absence of ORSA, both the treated and control insurers would have had parallel post-trends in each of the dependent variables above. While we cannot directly check post-trends, we do check for parallel pre-trends using a staggered event study analysis. The second primary assumption is known as the "stable unit treatment value" assumption (or SUTVA). This assumption requires that the response of a particular insurer depends only on the treatment value of that insurer, and not on the treatment value of other insurers. For our benefit and contract level analysis, this assumption likely holds. However, for our asset similarity analysis it mechanically does not. This is because when one insurer changes their own assets to be dissimilar from another, it

changes the cosine similarity of both insurers. For our analysis, this means that the control group is also partially treated, which biases our estimates towards zero and thus makes them a lower bound.

5 Results

Table 2: Impact of ORSA on Annuity Contract Offering

	P(Benefit Active)	P(Contract Offered)
Dependent Variables:		
ORSA x Guarantee Rider	-0.216^{***}	
	(0.036)	
ORSA x Account Value Rider	0.133^{***}	
	(0.037)	
ORSA x Traditional Variable Annuity		-0.368^{***}
		(0.026)
ORSA x Fixed Annuity		0.012
		(0.041)
ORSA x Index-Linked Annuity		0.184^{***}
		(0.031)
Pre-ORSA Mean: Guarantee Rider	0.580	
Pre-ORSA Mean: Account Value Rider	0.317	
Pre-ORSA Mean: Traditional VA		0.380
Pre-ORSA Mean: Fixed Annuity		0.634
Pre-ORSA Mean: Index-Linked Annuity		0.152
Benefit Type x Year FE	Yes	
Annuity Type x Year FE		Yes
Firm FE	Yes	Yes
Observations	488,124	89,658

Notes: * p < 0.1, ** p < 0.05, *** p < 0.01. This table reports regression results of the impact of ORSA implementation on the benefit and contract offerings of variable annuity companies. The first column is at the benefit-contract level and only features traditional variable annuity contracts. The second column is at the contract and features all contracts ever offered on Morningstar. Standard errors are clustered at the Lead State level. The Pre-ORSA means are the means of the dependent variable in the year prior to ORSA adoption.

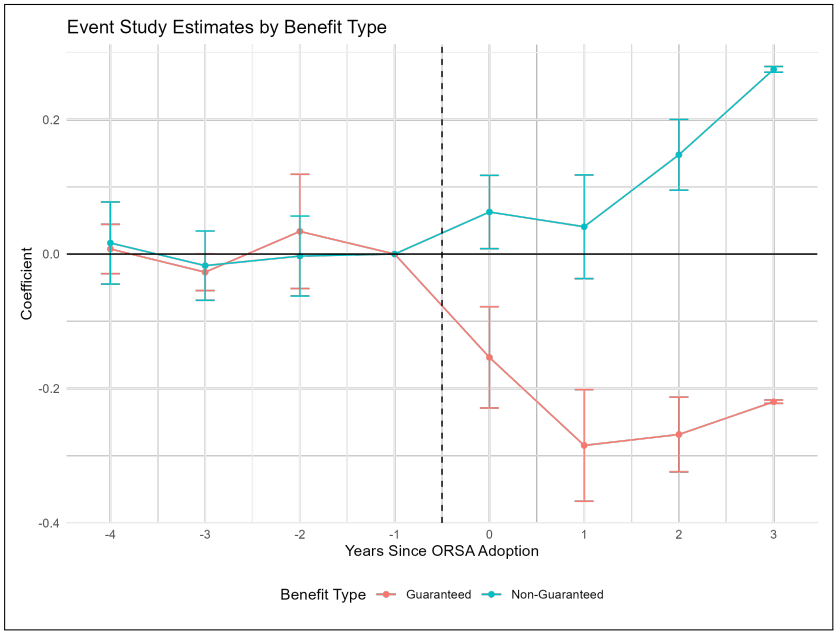
To begin, we study how insurers adjust features in the TVAs they already offer. Table 2 column (1) reports estimates on the likelihood of continuing to offer each benefit type. The coefficient for guarantee-based riders (such as GMWB, GMAB, or GMIB) is -0.216, implying that an ORSA-exposed insurer is about 21.6 percentage points less likely to keep providing such guarantees,

a drop of roughly 37% from the pre-ORSA average. Meanwhile, simpler riders without equity or longevity guarantees become about 13.3 percentage points more likely to remain active, suggesting that managers respond to ERM mandates by paring back the riskiest embedded benefits. Figure 2 (top panel) plots event-study estimates for these guarantee features. The absence of differential pre-trends reinforces that this shift coincides closely with ORSA implementation.

Next, we examine whether insurers discontinue or continue offering entire annuity contracts. Table 2 (columns 3–5) indicates a pronounced shift away from TVAs toward RILAs once ORSA is in effect. Specifically, insurers reduce TVAs by 36.8 percentage points and expand RILAs by 18.4 percentage points, representing near-complete substitution for many carriers that maintain annuity business. The event-study visualization in the middle panel of Figure 3 again shows a common pre-trend and a notable divergence after ORSA takes hold. Interestingly, insurers do not meaningfully alter their fixed annuity offerings, suggesting that the main ERM-driven substitution is from TVAs to RILAs. This pattern is consistent with the idea that an enterprise view helps firms exploit cross-product hedges, since RILAs help offset exposure embedded in TVAs (Barbu and Sen, 2024).

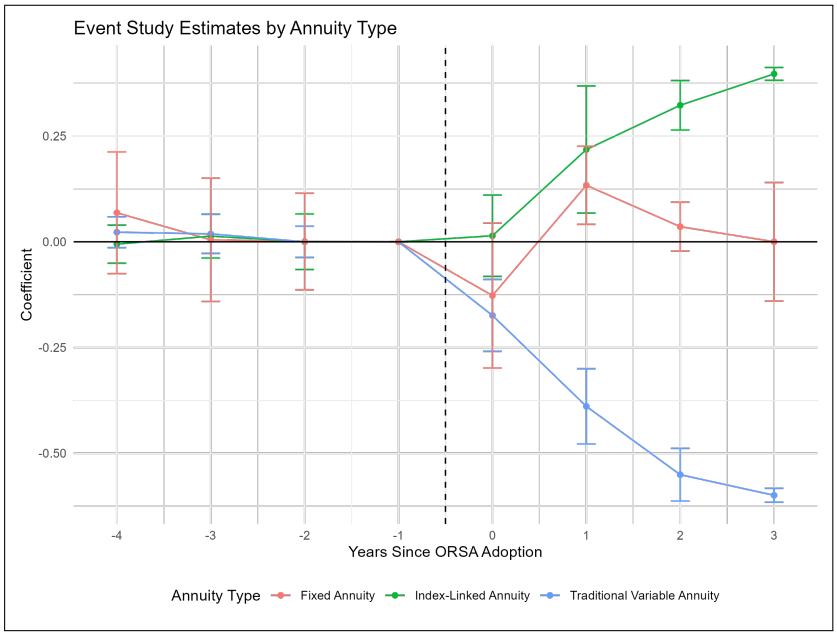
Finally, in Table 3, we present evidence that ORSA reduces insurers' tendency to hold portfolios that look like their peers. The coefficient is -0.025, implying a 2.7% fall in average cosine similarity. Although modest in size, this drop is large enough to limit correlated positions that might otherwise amplify fire sales during stress events. As depicted in the bottom panel of Figure 4, there is no sign of distinct trends prior to ORSA, but a systematic divergence afterward, reinforcing the view that ERM's external risk emphasis encourages firms to adopt more idiosyncratic asset allocations.

Figure 2: Event Study Estimates: Benefit Type



Note: This figure shows the event study coefficients for column (1) in Table 2. 90% confidence intervals are shown from standard errors clustered at the Lead State level.

Figure 3: Event Study Estimates: Contract Type



Note: This figure shows the event study coefficients for column (2) in Table 2. 90% confidence intervals are shown from standard errors clustered at the Lead State level.

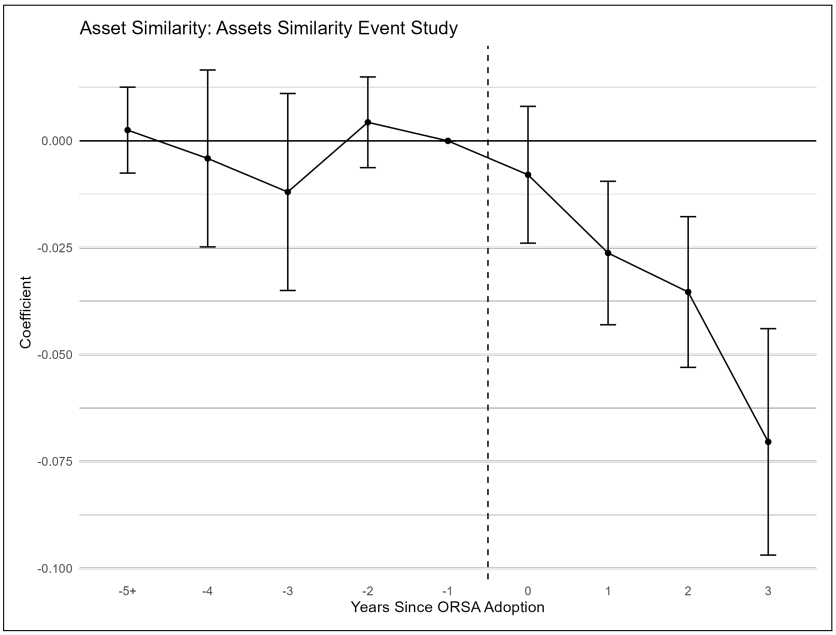
Table 3: Impact of ORSA on Asset Similarity

	Assets/RBC	Assets
Dependent variable: Asset Portfolio Similarity Measures		
ORSA	-0.025^{***}	-0.025^{***}
	(0.010)	(0.010)
Insurer Fixed Effects?	Yes	Yes
Year Fixed Effects?	Yes	Yes
Observations	1,635	1,635

Notes: * p < 0.1, ** p < 0.05, *** p < 0.01. This table reports regression results of the impact of ORSA implementation on the similarity of insurer's asset holdings. The first column weights the similarity measure by RBC-adjusted assets while the second column weights by total assets. Standard errors are clustered at the Lead State level.

Taken together, these results show that introducing an enterprise risk management lens nudges insurers to adjust product structures, re-optimize their annuity offerings, and diversify asset holdings away from their peers. Insurers appear to internalize solvency risk across all business lines, rather than narrowly assessing each line in isolation. This holistic approach translates into fewer high-risk guarantees, more reliance on naturally hedged annuities such as RILAs, and less portfolio herding. As such, mandatory ERM emerges as an effective policy lever for aligning firm-level incentives with broader financial stability objectives.

Figure 4: Event Study Estimates: Asset Similarity



Note: This figure shows the event study estimates for column (1) of Table 3. 90% confidence intervals are shown from standard errors clustered at the Lead State level.

6 Conclusions

We exploit the staggered roll-out of ORSA requirements for insurers across U.S. states to study how ERM mandates affect firms' product strategies and systemic exposures. Using an imputation DiD design, we document changes in annuity guarantee offerings and asset allocations at the insurer level.

We show that ORSA leads to a sizable reduction in the riskiest guarantee features of TVAs, coupled with increased adoption of RILAs, which naturally hedge equity-market risks by shifting part of the downside to policyholders. In addition, asset portfolios become less correlated across insurers, suggesting a decline in industry-wide herding that could otherwise exacerbate fire-sale spillovers. These results underscore how ERM-focused regulations can meaningfully reshape financial institutions' risk exposures. By prompting insurers to consider risk interdependencies, ORSA enhances the resilience of product lines and asset portfolios. In turn, this reduces vulnerabilities to market volatility and strengthens the insurance sector's capacity to weather external shocks.

Despite the uniquely clean design of the ORSA intervention, our study does have limitations. First, our results only speak to the impact of ERM mandates on firms' risk-taking and do not estimate the cost to firms of adopting the measure. Measuring the full equilibrium impacts on con-

sumer welfare would require demand and supply-side modeling that extends beyond the scope of our analysis. Additionally, even though variable annuities are important in their own right, our focus on a specific industry may limit the extension of results to other markets. The variable annuities industry cleanly isolates many of the general problems that ERM programs seek to solve but insurers are, by definition, experts in managing risk and thus we cannot perfectly speak to if other markets would see the same level of impact.

Despite these caveats, the consistent evidence of product re-balancing and reduced portfolio similarity highlights that ERM mandates can indeed alter both strategic and systemic outcomes. The pattern emerges robustly across multiple measures of annuity guarantees and asset holdings, reinforcing the credibility of our inferences. From a regulatory perspective, strengthening ERM through mandates like ORSA appears to mitigate excessive risk-taking and systemic contagion. Policymakers seeking to promote financial stability can therefore view well-designed ERM rules as a lever to encourage healthier product design and curtail correlated asset holdings. These insights may prove valuable not only for U.S. life insurers but also for global regulators considering parallel reforms to manage systemic risk in insurance and broader financial sectors.

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