Humanities & Social Sciences Communications

ARTICLE

https://doi.org/10.1057/s41599-023-02191-y

OPEN

The impact of war on insurer safety: a contingent claim model analysis

Fu-Wei Huang[1], Panpan Lin[2], Jyh-Horng Lin[3]✉ & Ching-Hui Chang[4]

Determining the optimal guaranteed rate of life insurance policies can effectively promote sustainable societies and disaster-resilient communities in times of war. Nevertheless, such strategic coverage remains uncommon in many countries. This article presents a capped-down-and-out call option model to assess life insurers' safety during conflicts. Wars may lead to reduced life insurance businesses due to lower guaranteed rates set by insurers, yet they can also improve insurer safety within an imperfectly competitive insurance market. By increasing the surrender rate of the policy associated with reducing the optimal guarantee rate, the insurer's security is improved, thereby contributing to the stability of the overall insurance. Our findings suggest setting guaranteed rates is critical to asset-liability matching management, especially in wartime, to maintain insurance stability.

[1] Department of Banking and Finance, CTBC Business School, Tainan, Taiwan. [2] School of Economics, Southwestern University of Finance and Economics, Chengdu 611130, China. [3] Department of International Business, Tamkang University, New Taipei City, Taiwan. [4] Department of Accounting, Ming Chuan University, Taipei, Taiwan. ✉email: lin9015@mail.tku.edu.tw

Introduction

Artificial hazards can devastate communities, creating significant challenges regarding insurance policy decisions. Among these hazards, war is a leading cause of worldwide disaster losses. The Russia-Ukraine war in February 2022 had far-reaching consequences for various sectors within the life insurance industry. Life insurance is crucial in mitigating risks by providing coverage and financial protection to policyholders. Additionally, policy surrender options allow policyholders to terminate their policies before maturity and receive the promised surrender payments from the insurer (Cheng and Li 2018). Ensuring the safety of insurers becomes paramount in safeguarding policyholders' interests and maintaining the stability of the insurance market. This article aims to develop a contingent claim model that assesses the impact of war on insurer safety, considering the policy surrender aspect.

There are several compelling reasons for focusing on insurer safety during times of war. Firstly, the probability of insurer insolvency and the level of policyholder protection, encapsulated by insurer safety, significantly influence strategic decisions made by insurers and are of utmost concern to regulators striving to uphold insurance stability (e.g., Xu et al. 2017, in financial investment; Xue et al. 2019, in derivatives trading; Chi and Liu 2021, in reinsurance and external finance; Gizzi et al. 2020, in earthquake under insurance). Secondly, insurers often evaluate their performance relative to their peers based on safety considerations (Gatzert 2008). Lastly, insurer safety provides critical information for rating agencies, regulators, investors, and other stakeholders involved in the insurance industry (e.g., Brachetta and Ceci 2020, in reinsurance under partial information; Peng et al. 2021, in inside information; Pan et al. 2023, in online insurance marketing).

Our insurance model incorporates several essential features. We consider an imperfectly competitive insurance market where the large-scale insurer acts as a guaranteed rate-setter (Hong and Seog 2018). Furthermore, we explicitly account for the capped inclusion of borrowing-firm credit risks into the insurer's investment risks (Dermine and Lajeri 2001). Policy surrender is modeled as a form of disintermediation, and we also incorporate the presence of a premature default risk structure (Cheng and Li 2018), often referred to as the barrier (Brockman and Turtle 2003) in asset-liability matching management. Research by (Luo and Choi 2021) suggests that a structural break may occur during times of war. Therefore, we incorporate a linear reduction in returns and a quadratic increase in volatility to capture such structural breaks. Building upon previous works, this article develops a capped barrier model to evaluate insurer safety during a war.

The findings of our analysis reveal that war can enhance the profitability and safety of insurers,[1] subsequently influencing insurance stability. Increasing the surrender rate contributes to improved insurer safety. These results consider more realistic market and cost conditions and a more appropriate approach to guaranteed rate-setting behavior. Our findings complement existing literature on the microeconomic impact of war on insurance activities. As Neumann and Shenhav (1977) demonstrated, the 1973 war did not adversely affect the overall profitability of the insurance industry. Contrary to theoretical expectations, 1973 and 1974 were the best years in Israel's insurance industry history. By developing a barrier-capped call option model that considers policy surrender and other pertinent factors, we aim to enhance our comprehension of how war impacts insurers and the overall stability of the insurance industry. Overall, the research's contribution lies in providing insights into the complexities of insurer safety and the potential consequences of war, ultimately assisting policymakers and industry stakeholders in making informed decisions to safeguard policyholders' interests and ensure the stability of the insurance market.

The remainder of this article unfolds as follows: Section 2 reviews pertinent literature, laying the groundwork for the study. In Section 3, we devise a framework for managing life insurance during wartime. Section 4 carries out a numerical analysis to explore the framework's implications. Finally, the article concludes by summarizing the work presented.

Literature review

The impact of war on the insurance industry and insurer safety has been a subject of interest for researchers examining the interplay between geopolitical events and financial markets. Several studies have contributed to our understanding of this topic by investigating various aspects of insurer safety and the macroeconomic implications of the war on insurance activities. This literature review provides a comprehensive overview of relevant studies that have informed the current research.

Caplan (2003) explores the importance of war and terrorism insurance in the context of global security and economic stability. The challenges the insurance industry faces in pricing and managing risk are examined. The research sets out strategies for long-term international stability and affordability of the war and terrorism insurance sector, emphasizing the need for public-private partnerships, regulatory frameworks, and risk-sharing mechanisms. Nyampong (2013) investigates how different insurance markets provided and excluded coverage for aviation war and terrorism risks and other closely related risks before and after the significant September 11, 2001 event. Hemrit (2022) investigates the potential impact of geopolitical risks and corporate governance on Saudi Arabian insurers. An empirical finding reveals the negative impact of geopolitical risk on insurance demand. The evidence also suggests that corporate governance significantly impacts insurance demand in the long run.

In the specific context of war, limited research directly examines the impact of conflict on insurer security and the evaluation of insurer performance in wartime. Webel (2022) reports that estimates of insurance and the war in Ukraine for the eventual insured damage of the war are highly uncertain. Still, the amount of insurance affected is not unexpected. Many aviation claims have been made, and the damage could be $10 billion. Marine insurance is also expected to be severely affected, as are other specialty insurance. However, Huynh et al. (2013) argue that although war can result in millions of deaths, life insurance companies may include a war exemption clause in the policy contract that relieves policyholders from paying claims if they die due to a war-related event.

This study seeks to enhance the existing literature by creating a contingent claim model that considers policy surrender and assesses the influence of war on insurer safety. By incorporating these factors into our analysis, we gain insights into how insurers adapt to the challenges brought on by war and enhance their stability during such periods.

Model

We lay the conceptual framework before building our model. A life insurer provides funds to a borrowing firm during a war, considering the credit risk with structural breaks. The insurer finances investments by issuing profit-sharing life insurance policies in an imperfectly competitive market, featuring a surrender clause. Using a capped barrier option, we assess the insurer's market-value equity and explore the war's effect on its

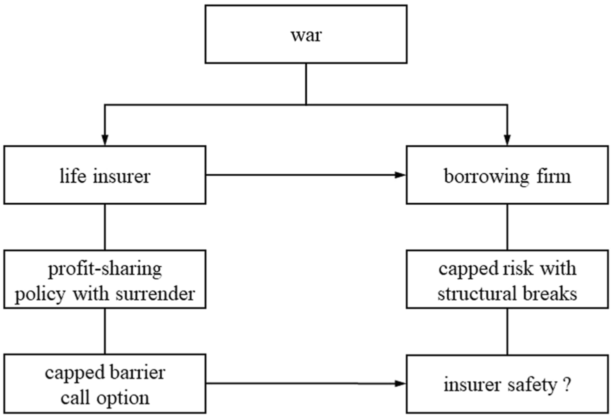

Fig. 1 The conceptual framework of insurer safety.

safety. The outlined conceptual framework is illustrated as follows: (Fig. 1).

Consider a one-year (360-day) horizon $t \in [1,\ 360]$ for an insurer-borrowing firm situation. The balance sheets of the borrowing firm and the insurer at $t = 1$ are, respectively:

$$A_B = (L + B - \phi L_C) + K_B \tag{1}$$

$$(L + B - \phi L_C) = (1 - \phi)L_C + K_C = \alpha(L + B - \phi L_C) + (1 - \alpha)(L + B - \phi L_C) \tag{2}$$

The borrowing firm funds its investment (A_B) with an insurer's asset portfolio (i.e., consisting of risky assets (L) and liquid assets (B) deducting life insurance policy surrender (ϕL_C)) and its capital (K_B) where $0 < \phi < 1$ is the surrender rate and L_C is the amount life insurance policies. The insurer funds its asset portfolio with life insurance policies and capital (K_C). Eq. (2) also expresses the insurer's liabilities ($(1 - \phi)L_C = \alpha(L + B - \phi L_C)$) and capital ($K_C = (1 - \alpha)(L + B - \phi L_C)$). The ratio $0 < \alpha < 1$ is the leverage.

The underlying asset value of the borrowing firm follows a geometric Brownian motion:

$$dA = (\mu - w)Adt + (\sigma + w + w^2/2)Ad\Omega \tag{3}$$

The term $A = (1 + R_A)A_B$, where R_A is the investment-market interest rate, is the expected repayments, with a structural break ($-w$) in instantaneous drift ($\mu - w$) and a structural break ($w + w^2/2$) in instantaneous volatility ($\sigma + w + w^2/2$). Ω is a standard Wiener process.

The life insurance policy includes a guaranteed interest rate R and surplus participation δ. The lending function of the insurer models the insurer's equity as a barrier-capped call option. The insurer's equity value π is the option on the assets:

$$\pi = BCC(V,\ Z) - \delta BCC(\alpha V,\ Z) \tag{4}$$

where

$$V = (1 + R_L)L + (1 + (x/360)R_L)\phi L_C - (1 + ((360 - x)/360)R_C)\phi L_C$$

$$Z = \alpha(Le^{R_L} + Be^{R_B} + \phi L_C e^{(x/360)R} - \phi L_C e^{((360-x)/360)R_C}) - (1 + R_B)B$$

In Eq. (4), the underlying assets (V) include: the first one is the repayment from the risky-asset investment with the market rate of return R_L, the second one is the repayment from the risky-asset investment funded by the policy surrender that does not occur until the date on x (i.e., the rate of return remains as R_L), and the last one is the reduced repayment from the policy surrender, which costs policyholders at a market rate (R_C). The strike price (Z) is the net liabilities, consisting of the guaranteed payoffs to the policyholders and the repayments from the liquid-asset investment.

The first term ($BCC(V, Z)$) is the barrier-capped call:

$$BCC(V,\ Z) = SC(V,\ Z) - DIC(V,\ Z) \tag{5}$$

where

$$SC(V,\ Z) = AN(d_1) - Ze^{-(R_L - R_C)}N(d_2) - AN(d_3) + Ve^{-(R_L - R_C)}N(d_4)$$

$$DIC(V,\ Z) = A\left(\tfrac{H}{A}\right)^{2\eta}N(d_5) - Ze^{-(R_L - R_C)}\left(\tfrac{H}{A}\right)^{2\eta-2}N(d_6) - A\left(\tfrac{H}{A}\right)^{2\eta}N(d_7) + Ve^{-(R_L - R_C)}\left(\tfrac{H}{A}\right)^{2\eta-2}N(d_8)$$

$$H = hZ,\ \eta = \frac{R_L - R_C}{\sigma_w^2} + \frac{1}{2}$$

and where H is the barrier value of the insurer's assets that triggers bankruptcy, h is the barrier ratio (Brockman and Turtle, 2003), ($R_L - R_C$) is the compounded rate of return and $N(\cdot)$ is the standard normal cumulative distribution function. In Eq. (5), the term $SC(V,\ Z)$ is the standard capped call. The value is the call on the borrowing-firm investment return at the strike price Z, net of a call given to the borrowing firm on the same investment return at the strike price V. The last two terms are the loss resulting from the cap. The term $DIC(V,\ Z)$ is the capped down-and-in call activated only if the barrier breaches.

The second term in Eq. (4) is the policyholder entitled to a share δ of the net equity capital gains. Analogously, we can write:

$$BCC(\alpha V,\ Z) = SC(\alpha V,\ Z) - DIC(\alpha V,\ Z) \tag{6}$$

where

$$SC(\alpha V,\ Z) = AN(d_1) - Ze^{-(R_L - R_C)}N(d_2) - AN(c_3) + \alpha Ve^{-(R_L - R_C)}N(c_4)$$

$$DIC(\alpha V, Z) = A\left(\tfrac{H}{A}\right)^{2\eta}N(d_5) - Ze^{-(R_L - R_C)}\left(\tfrac{H}{A}\right)^{2\eta-2}N(d_6) - A\left(\tfrac{H}{A}\right)^{2\eta}N(c_7) + \alpha Ve^{-(R_L - R_C)}\left(\tfrac{H}{A}\right)^{2\eta-2}N(c_8)$$

Eq. (6) is the barrier-capped call. The same pattern as previously applies.

The default-value-to-liability ratio is an insurer's safety measure (Gatzert 2008). We specify the safety ratio as the default value divided by the liabilities:

$$q = \frac{P_{def}\pi}{Lia} \tag{7}$$

where P_{def} is the default probability in the insurer's equity returns, the numerator ($P_{def}\pi$) is the expected default value, and the denominator (Lia) is the insurer's liabilities. Given information about Eq. (4), we apply Brockman and Turtle (2003) that the default probability is as follows:

$$P_{def} = P_V + \delta P_{\alpha V} \tag{8}$$

where

$$P_V = N(b_1) + e^{b_2}(1 - N(b_3))$$

$$P_{\alpha V} = N(a_1) + e^{a_2}(1 - N(a_3))$$

Next, the insurer's liability value is a barrier-capped put on the investment return from the borrowing firm (Dermine and Lajeri 2001), that is:

$$Lia = BCP(V,\ Z) + \delta BCC(\alpha V,\ Z) \tag{9}$$

Table 1 Effect of the war on the insurer's guaranteed rate at various levels of barrier*.

	h						
w	**0.64**	**0.66**	**0.68**	**0.70**	**0.72**	**0.74**	**0.76**
	$\partial R/\partial w$						
0.16 → 0.18	−3.9985	−3.9993	−4.0012	−4.0053	−4.0138	−4.0303	−4.0601
0.18 → 0.20	−4.0485	−4.0522	−4.0500	−4.0747	−4.1014	−4.1472	−4.2219
0.20 → 0.22	−4.2451	−4.2567	−4.2775	−4.3135	−4.3725	−4.4650	−4.6042
0.22 → 0.24	−4.2037	−4.2353	−4.2874	−4.3696	−4.4940	−4.6755	−4.9322
0.24 → 0.26	−4.1210	−4.1931	−4.3033	−4.4654	−4.6961	−5.0163	−5.4518
0.26 → 0.28	−4.0274	−4.1701	−4.3753	−4.6620	−5.0544	−5.5842	−7.3632

*Parameter values, unless stated otherwise, see the baseline (from (i) to (vi)). The optimal guaranteed rate in the cases (w : 0.16 → 0.20 and h : from 0.64 to 0.74) is 4.00%. The optimal rate in the cases (w : 0.20 → 0.26 and h : from 0.64 to 0.74) is 3.75%. The optimal rate in the case (w : 0.26 → 0.28 and h : from 0.76) is 3.75%) is 3.50%.

where

$$BCP(V,\ Z) = PUT(V,\ Z) + DIP(V,\ Z)$$

$$PUT(V,\ Z) = Ze^{-(R_L - R_C)}[1 - N(d_2)] - A[1 - N(d_1)]$$

$$DIP(V,\ Z) = Ze^{-(R_L - R_C)}\left(\frac{H}{A}\right)^{2\eta-2}[1 - N(d_6)] - A\left(\frac{H}{A}\right)^{2\eta}[1 - N(d_5)]$$

The valuation of the insurer's liabilities is similar to the put option in the literature, except that the underlying asset is the borrowing firm's assets, not the insurer's assets.

Partially differentiating Eq. (4), the first-order condition is:

$$\begin{aligned}\frac{\partial\pi}{\partial R} &= \frac{\partial BCC(V,Z)}{\partial R} - \delta\frac{\partial BCC(\alpha V,Z)}{\partial R}\\ &= \left[\frac{\partial SC(V,Z)}{\partial R} - \frac{\partial DIC(V,Z)}{\partial R}\right] - \delta\left[\frac{\partial SC(\alpha V,Z)}{\partial R} - \frac{\partial DIC(\alpha V,Z)}{\partial R}\right] = 0\end{aligned} \quad (10)$$

where the second-order condition (i.e., $\partial^2\pi/\partial R^2<0$) is required for equity maximization. The optimal guaranteed rate can be determined using Eq. (10). It involves comparing the marginal equity represented by the gross capped-barrier option, without factoring in the participation payments, with the marginal profit-sharing participation payments made to policyholders in the form of the capped-barrier option. Thus, the optimal guaranteed rate corresponds to the rate at which the profit-sharing policyholders pay the life insurer, accounting for their savings with interest repayments net of risk payments.

Differentiation of Eq. (10) concerning i ($=w$ and ϕ) evaluated at the optimal guaranteed rate yields:

$$\frac{dq}{di} = \frac{\partial q}{\partial i} + \frac{\partial q}{\partial R}\frac{\partial R}{\partial i} \quad (11)$$

where

$$\frac{\partial R}{\partial i} = -\frac{\partial^2\pi}{\partial R\partial i}\Big/\frac{\partial^2\pi}{\partial R^2}$$

The subsequent analysis provides the intuition for the comparative statics.

Results and discussion

One advantage of the numerical analysis method is its ability to provide precise and quantitative results. Numerical analysis employs mathematical algorithms and computational techniques to solve complex problems, allowing researchers to obtain accurate numerical solutions. This precision enhances the findings' reliability and helps make informed decisions based on data-driven outcomes.[2] In this section, we establish a baseline for numerical analysis using the developed model. Through this analysis, the paper elucidates the impact of war on the insurer's guaranteed interest rate (thus the insurer's interest rate margin) and safety. Additionally, it examines the influence of the surrender effect (and the disintermediation effect) on insurer security. The effects presented in this paper sufficiently explore the impact of war on financial stability, thereby contributing to the existing body of literature.

We start by defining the baseline as follows:

(i) Holsboer (2000) indicates that insurers offer a 3.25% guaranteed rate of life insurance policies. Let ($R(\%)$, L_C) illustrate the policy locus, increasing from (2.75, 307), (3.00, 323), (3.25, 334), (3.50, 341), (3.75, 345), (4.00, 347), to (4.25, 348).

(ii) We follow Briys and de Varenne (1994): the participation rate $\delta = 0.80$ and leverage $\alpha = 0.90$. For every $100,000 of cash value life insurance, approximately $460 is received in surrender benefit (Russell et al. 2013). We assume the policy surrender rate $\phi = 0.46\%$ initially.

(iii) We assume insurer capital $K_C = 35$ and borrowing-firm capital $K_B = 55$.

(iv) The borrowing-firm investment return rate (R_A) equals 5.79% (Trinks et al. 2020). The insurer's investment return rate is $R_L = 5.00\%$ (Tan et al. 2020). We follow Brockman and Turtle (2003) and assume $R_B = 4.50\%$. The surrender cost for policyholders is supposed to be $R_C = 1.50\%$. The liquid assets are $B = 70$.

(v) The average barrier is 69.20%, and the mean value of asset volatility equals 29.04%, with a standard deviation of 22.86% (Brockman and Turtle, 2003). We assume $h = 69.20\%$. We assume $\sigma = 10.00\%$ (Briys and de Varenne, 1994). The average withdrawal date (x) of policy surrender is 180.

(vi) The structural break in volatility is $w = 0.20$ (Kholodilin and Yao 2006).

Assuming the given parameter values, we initially provide a comparative static numerical analysis of the impact of war on the optimal guaranteed rate for insurers under different barrier levels. By considering various premature states, we also demonstrate the robustness test of the numerical results.

The findings presented in Table 1 are also visually depicted in Fig. 2.

Amidst the war backdrop, insurers may hesitate to provide new life insurance policies at reduced guaranteed rates, as illustrated in Table 1. Reduced guaranteed rates translate to an augmented interest margin for the insurer. This observation concurs with the research conducted by Neumann and Shenhav (1977). Additionally, the negative impact is exacerbated when the barrier, representing the likelihood of bankruptcy, increases. The heightened probability of bankruptcy amplifies the impact of war, ultimately benefiting life insurers. The study's findings hold crucial target policy implications and recommendations for the insurance industry. Policymakers should encourage insurers to maintain competitive life insurance coverage during periods of war, addressing consumer reluctance due to high premiums. Additionally, regulatory bodies must closely monitor insurers' financial stability and enforce robust risk management frameworks to mitigate the risk of insolvency. Transparency and disclosure in the industry should be promoted, providing stakeholders with accurate information about insurers' financial strength and exposure to war-related risks, thereby fostering market confidence and stability.

The findings presented in Table 2 reveal that war significantly impacts insurer safety. The positive direct effect indicates that the insurer's safety is positively influenced by the consequences of war while keeping the optimal guaranteed rate constant. However, an increase in the war's impact leads to a decrease in the guaranteed rate, subsequently diminishing the insurer's safety. This result

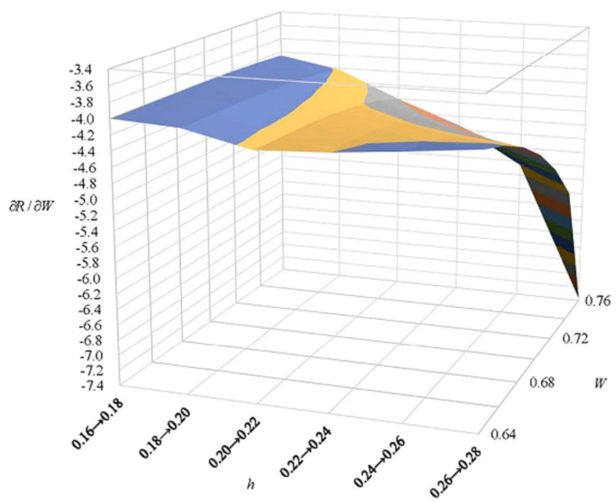

Fig. 2 War effect on the guaranteed rate at different barriers.

demonstrates a negative indirect effect through the optimal guaranteed rate adjustments. Overall, the total impact demonstrates that war ultimately increases the insurer's safety due to increased profits and reduced liabilities, thereby enhancing insurer stability. Our findings closely align with those of Neumann and Shenhav (1977), primarily because we incorporated a war exclusion clause in the policy contract. This clause exempts the insurers from paying out claims in the event of a policyholder's death resulting from w ar-related events but not from non-war-related injuries.

The study offers key policy recommendations for regulators and policymakers. They should recognize the positive impact of war on insurer security in imperfectly competitive markets. Encouraging insurers to adapt risk management strategies to counter declining guaranteed rates is essential. Promoting transparency in rate-setting and fostering a well-capitalized insurance sector can enhance resilience during war. Developing contingency plans to support insurers and ensuring market stability are crucial. These considerations will bolster the insurance industry's overall stability in the face of war-related challenges.

Table 3 illustrates that increasing the policy surrender rate contributes to insurer safety. The surrender option plays a significant role in the cash intermediation of policies, affecting both liabilities and the risk of premature default on assets relative to liabilities in asset-liability matching management. When policy surrender leads to disintermediation, it may not necessarily harm insurer safety if the insurer's asset-liability matching management through the optimal guaranteed rate adjustments is efficient. Therefore, life insurers have increasingly relied on strategic guaranteed rate-setting behavior during wartime, as concerns about insurer safety have grown among politicians, stakeholders, and regulators. Our findings support the conclusions drawn by Chen et al. (2023): surrender does not pose a critical threat to insurer solvency. Based on Table 3 findings, policy recommendations encourage surrender option awareness and retention incentives, implement stricter regulations for disintermediation risks, and

Table 2 Impact of the war on the insurer's safety*.

	(R(%), L_C)						
w	**(2.75, 307)**	**(3.00, 323)**	**(3.25, 334)**	**(3.50, 341)**	**(3.75, 345)**	**(4.00, 347)**	**(4.25, 348)**
	dq/dw						
0.16 → 0.18	-	0.0355	0.0356	0.0357	0.0357	**0.0357**	-
0.18 → 0.20	-	0.0505	0.0506	0.0507	0.0508	**0.0508**	-
0.20 → 0.22		0.0654	0.0656	0.0657	**0.0658**	0.0658	-
0.22 → 0.24	-	0.0789	0.0791	0.0792	**0.0793**	0.0794	-
0.24 → 0.26	-	0.0899	0.0901	0.0902	**0.0903**	0.0904	-
0.26 → 0.28	-	0.0978	0.0980	**0.0982**	0.0982	0.0983	-

*See Table 1. The bold values represent the value evaluated at the optimal guaranteed rate. The negative indirect effect is insufficient to offset the positive direct impact.

Table 3 Impact of the surrender rate on the insurer's safety*.

	(R(%), L_C)						
ϕ(%)	**(2.75, 307)**	**(3.00, 323)**	**(3.25, 334)**	**(3.50, 341)**	**(3.75, 345)**	**(4.00, 347)**	**(4.25, 348)**
	$dq/d\phi$ $(10)^{-4}$						
0.46 → 1.00	-	2.8631	2.8608	2.8652	**2.8732**	2.8793	-
1.00 → 1.50	-	2.9428	2.9559	2.9714	**2.9867**	2.9965	-
1.50 → 2.00	-	3.0153	3.0452	3.0731	**3.0967**	3.1104	-
2.00 → 2.50	-	3.0835	3.1322	3.1741	**3.2070**	3.2254	-
2.50 → 3.00	-	3.1465	3.2161	3.2738	**3.3174**	3.3409	-
3.00 → 3.50	-	3.2031	3.2957	3.3714	**3.4272**	3.4566	-

*See Table 3. The bold values represents the value evaluated at the optimal guaranteed rate.

promote transparent rate-setting practices during war or economic uncertainty for enhanced insurer safety and industry stability.

Conclusions

The research shows that war significantly impacts life insurance activities, reducing overall activity levels. However, this leads to increased profits and improved insurer safety. Insurers can strategically manage asset-liability matching with a guaranteed rate-setting strategy to maintain stability during the war. Allowing policy surrender and considering borrowing-firm risks are essential for insurers to adapt and make informed pricing decisions during conflicts. These findings contribute to insurers' profitability, safety, and overall stability in wartime, and the study suggests exploring reinsurance contracts for risk-sharing behavior.

Data availability

Data sharing does not apply to this article as no datasets were generated or analyzed during the current study.

Received: 3 May 2023; Accepted: 25 September 2023;
Published online: 06 October 2023

Notes

1 See a statistical report on June 20, 2022: "How the Ukraine war is benefiting Russian insurers – and pushing up insurance premiums everywhere" at https://theconversation.com/how-the-ukraine-war-is-benefiting-russian-insurers-and-pushing-up-insurance-premiums-everywhere-184965.

2 Alternative methods to numerical analysis include qualitative analysis, experimental studies, statistical analysis, case studies, mixed-methods approach, meta-analysis, and analytical models. Each approach offers unique strengths and is chosen based on the research question and available data.

References

Brachetta M, Ceci C (2020) A BSDE-based approach for the optimal reinsurance problem under partial information. Insur Math Econ 95:1–16. https://doi.org/10.1016/j.insmatheco.2020.07.009

Briys E, de Varenne F (1994) Life insurance in a contingent claim framework: pricing and regulatory implications. Geneva Risk Insur Rev 19(1):53–72. https://doi.org/10.1007/BF01112014

Brockman P, Turtle HJ (2003) A barrier option framework for corporate security valuation. J Financ Econ 67(3):511–529. https://doi.org/10.1016/S0304-405X(02)00260-X

Caplan H (2003) War and terrorism insurance: plans for long-term international stability and affordability. Geneva Pap Risk Insur Issues Pract 28(3):426–447. https://www.jstor.org/stable/41952704

Chen C, Hilpert C, Lavasani AM, Schaefer M (2023) Surrender contagion in life insurance. Eur J Oper Res 305(3):1465–1479. https://doi.org/10.1016/j.ejor.2022.07.009

Cheng C, Li J (2018) Early default risk and surrender risk: Impacts on participating life insurance policies. Insur Math Econ 78:30–43. https://doi.org/10.1016/j.insmatheco.2017.11.001

Chi Y, Liu F (2021) Enhancing an insurer's expected value by reinsurance and external financing. Insur Math Econ 101(Part B):466–484. https://doi.org/10.1016/j.insmatheco.2021.08.010

Dermine J, Lajeri F (2001) Credit risk and the deposit insurance premium: a note. J Bus Econ 53(5):497–508. https://doi.org/10.1016/S0148-6195(01)00045-5

Gatzert N (2008) Asset management and surplus distribution strategies in life insurance: an examination with respect to risk pricing and risk measurement. Insur Math Econ 42(2):839–849. https://doi.org/10.1016/j.insmatheco.2007.09.001

Gizzi FT, Kam J, Porrini D (2020) Time windows of opportunities to fight earthquake under-insurance: evidence from Google trends. Humanit Soc Sci 7 (61). https://doi.org/10.1057/s41599-020-0532-2

Hemrit W (2022) Does insurance demand react to economic policy uncertainty and geopolitical risk? Evidence from Saudi Arabia. Geneva Pap Risk Insur Issues Pract 47:460–492. https://doi.org/10.1057/s41288-021-00229-3

Holsboer JH (2000) The impact of low interest rates on insurers. Geneva Pap Risk Insur Issues Pract 25(1):38–58. https://www.jstor.org/stable/41952510

Hong J, Seog SH (2018) Life insurance settlement and the monopolistic insurance market. Insur Math Econ 81 36–50. https://doi.org/10.1016/j.insmatheco.2017.12.003

Huynh A, Bruhn A, Browne B (2013) A review of catastrophic risks for life insurers. Risk Manag Insur Rev 16(2):233–266. https://doi.org/10.1111/rmir.12011

Kholodilin KA, Yao VW (2006) Modelling the structural break in volatility. Appl Econ Lett 13(7):417–422. https://doi.org/10.1080/13504850500398542

Luo S, Choi SW (2021) Economic development, population, and civil war: a Bayesian changepoint model. J Int Trade Law Policy 5(1):2–18. https://doi.org/10.1108/ITPD-11-2020-0084

Neumann S, Shenhav Y (1977) Short-term impact of war economy on the insurance industry in Israel. J Risk Insur 44(1):87–102. https://doi.org/10.2307/251859

Nyampong YOM (2013) The insurance of aviation war and terrorism risks by specialist war insurance markets. Insuring the air transport industry against aviation war and terrorism risks and allied perils: issues and options in a Post-September 11, 2001 Environment, 71–114

Pan G, Liu M, Tseng LM, Geng Z (2023) Cultural intelligence and sales performance in online insurance marketing: evidence from a Chinese insurance firm. Humanit Soc Sci 10 (124). https://doi.org/10.1057/s41599-023-01623-z

Peng X, Chen F, Wang W (2021) Robust optimal investment and reinsurance for an insurer with inside information. Insur Math Econ 96:15–30. https://doi.org/10.1016/j.insmatheco.2020.10.004

Russell DT, Fier SG, Carson JM, Dumm RE (2013) An empirical analysis of life insurance policy surrender activity. J Insur Issues 36(1):35–57. https://www.jstor.org/stable/41946336

Tan X, Sirichand K, Vivian A, Wang X (2020) How connected is the carbon market to energy and financial markets? A systematic analysis of spillovers and dynamics. Energy Econ 90(2020):104870. https://doi.org/10.1016/j.eneco.2020.104870

Trinks A, Mulder M, Scholtens B (2020) An efficiency perspective on carbon emissions and financial performance. Ecol. Econ. 175(2020):106632. https://doi.org/10.1016/j.ecolecon.2020.106632

Webel B (2022) Insurance, cyberattacks, and war in Ukraine. Congressional Research Service. https://crsreports.congress.gov/product/pdf/IN/IN11914/2. Accessed May 13 2023

Xu L, Zhang L, Yao D (2017) Optimal investment and reinsurance for an insurer under the Markov-modulated financial market. Insur Math Econ 74:7–19. https://doi.org/10.1016/j.insmatheco.2017.02.005

Xue X, Wei P, Weng C (2019) Derivatives trading for insurers. Insur Math Econ 84:40–50. https://doi.org/10.1016/j.insmatheco.2018.11.001

Author contributions

These authors jointly supervised this work.

Competing interests

The authors declare no competing interests.

Ethical approval

This article does not contain any studies with human participants performed by any of the authors.

Informed consent

This article does not contain any studies with human participants performed by any of the authors.

Additional information

Correspondence and requests for materials should be addressed to Jyh-Horng Lin.