“Assessing wartime insurance resilience: Development and application of the insurance market wartime resilience index”

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ASSESSING WARTIME INSURANCE RESILIENCE: DEVELOPMENT AND APPLICATION OF THE INSURANCE MARKET WARTIME RESILIENCE INDEX

Abstract

The functioning of insurance markets during prolonged military conflict remains insufficiently explored in contemporary insurance and risk management literature. The purpose of this study is to develop and apply the Insurance Market Wartime Resilience Index (IMWRI) for assessing insurance market resilience under conditions of military conflict. The empirical calibration combines indicators from both the non-life and life insurance segments; however, the dominant contribution comes from non-life insurance data. Consequently, the resulting IMWRI should be interpreted as a market-wide resilience measure with a stronger sensitivity to developments in the non-life segment. The proposed IMWRI integrates five dimensions of wartime insurance market functioning: premium resilience, claims functionality, reinsurance support, solvency and financial stability, and market structure adaptation. The empirical results demonstrate that the Ukrainian insurance market produces an approximate IMWRI value of 67.9%. The largest contributions are generated by premium resilience (0.2625) and solvency and financial stability (0.2325), followed by market structure and concentration (0.0893) and claims functionality (0.0780). The smallest contribution is provided by reinsurance support (0.0165). This distribution suggests that wartime insurance resilience in Ukraine is driven primarily by internal market capacity and financial stability rather than by external risk-transfer mechanisms. The proposed IMWRI confirms that resilience is generated through a combination of financial stability, premium continuity, institutional adaptation, and selective risk transfer. Therefore, the future development of wartime insurance systems depends not only on strengthening insurers themselves but also on building integrated public-private risk-sharing mechanisms capable of narrowing the gap between market resilience and protection needs.

Keywords insurance market, military risks, war-risk insurance, insurance resilience, bounded insurability, wartime economy, insurance market resilience index, Ukraine

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INTRODUCTION

Insurance markets play a critical role in maintaining financial stability, facilitating risk redistribution, and preserving economic continuity under uncertainty. In modern economies, insurance contributes to investment security, entrepreneurial activity, credit expansion, household protection, and the overall resilience of financial systems. However, under conditions of large-scale armed conflict, the institutional logic of insurance functioning changes substantially. Military conflict generates catastrophic uncertainty, highly correlated losses, territorial fragmentation of exposure, disruption of actuarial predictability, and significant limitations in the insurability of war-related

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risks. As a result, war creates a structural contradiction between the rapidly increasing demand for financial protection and the declining capacity of insurance markets to provide comprehensive and economically sustainable coverage.

The full-scale war in Ukraine provides a unique empirical context for examining insurance resilience under conditions of prolonged military conflict. Although the insurance market has maintained operational continuity, the widespread exclusion of war-related losses raises important questions regarding the measurement of resilience and the capacity of insurance systems to function under extreme uncertainty. These conditions highlight the need for analytical tools capable of assessing insurance market resilience beyond conventional performance indicators.

One of the central scientific problems associated with insurance market functioning under prolonged military conflict is the emergence of a significant protection gap between actual wartime losses and insurers' compensation capacity. Unlike conventional economic crises or localized catastrophic events, war simultaneously affects multiple insurance segments, increases systemic exposure, weakens diversification mechanisms, complicates reinsurance operations, and intensifies pressure on insurer solvency and institutional stability. Under such conditions, traditional indicators of insurance market performance – including premium growth, claims ratios, or profitability – become insufficient for assessing the real resilience and functional sustainability of the insurance system. Consequently, the evaluation of insurance markets under elevated military risks requires broader analytical approaches capable of integrating operational continuity, compensation activity, financial stability, reinsurance support, and institutional adaptation within a unified resilience framework.

Despite increasing interest in catastrophic and conflict-related risks, the measurement of wartime insurance resilience remains underdeveloped. Existing research provides valuable insights into risk management and insurer adaptation, yet offers limited tools for assessing the overall resilience of insurance markets under prolonged military conflict. This gap highlights the need for a dedicated framework capable of evaluating insurance market resilience in wartime environments.

The Ukrainian case is especially important in this context because it provides a unique empirical example of an insurance market operating under prolonged high-intensity military risk while remaining institutionally functional. The Ukrainian insurance sector demonstrates that wartime insurance resilience may coexist with substantial limitations in protection adequacy, selective insurability, and structural market contraction. Therefore, the Ukrainian experience contributes not only to national policy discussions concerning wartime financial protection and reconstruction but also to the broader theoretical understanding of insurance resilience, catastrophic risk governance, and institutional adaptation under extreme uncertainty.

Therefore, the purpose of this study is to develop a theoretical and methodological framework for measuring wartime insurance market resilience and to test the proposed Insurance Market Wartime Resilience Index using the Ukrainian insurance market as an illustrative empirical case.

1. THEORETICAL BASIS

1.1. War risk and bounded insurability

The problem of insurability under catastrophic and systemic risks has long occupied an important place in insurance research. Classical studies on catastrophe insurance show that private insurance markets face structural limitations when risks are low-frequency, high-severity, geographically concentrated, and difficult to diversify. Jaffee and Russell (1997) argue that the failure of private catastrophe insurance markets is closely related to insurers' inability to mobilize sufficient capital for extremely large losses. Similarly, Froot (2001) demonstrates that catastrophe reinsurance mar-

kets may remain limited even when the theoretical demand for protection against extreme events is high. These studies are important for the present research because military risks share several characteristics with catastrophe risks: they are potentially systemic, highly correlated, difficult to model, and capable of generating simultaneous losses across multiple sectors.

However, war risk differs from natural catastrophe risk in several fundamental ways. While natural catastrophes are usually modeled through probabilistic hazard assessment, military risks are politically contingent, strategically driven, territorially unstable, and strongly affected by state behavior. This makes them particularly difficult to price and diversify. OECD studies on catastrophe and terrorism risk insurance emphasize that when catastrophic risks exceed private underwriting capacity, public-private partnerships, government backstops, and special risk-sharing mechanisms become necessary to preserve market functionality (OECD, 2005a, 2021, 2026). This logic is directly relevant to Ukraine, where private insurers cannot independently absorb the dominant share of direct war-related losses.

The literature on terrorism insurance provides a useful bridge between catastrophe insurance and wartime insurance. Additional evidence regarding the limits of insurability under catastrophic conditions is provided by studies of natural disaster insurance systems. Botzen and van den Bergh (2008) demonstrate that catastrophe insurance schemes often require institutional support mechanisms because private insurers face difficulties in covering highly concentrated losses. Similarly, Kousky (2019) argues that disaster insurance performs not only a compensatory function but also contributes to risk reduction, recovery, and economic resilience. These findings are relevant to wartime insurance because military risks generate protection challenges comparable to those observed in large-scale natural catastrophes, although with substantially higher levels of uncertainty and political contingency.

Michel-Kerjan and Pedell (2005) show that after the 9/11 attacks, France, Germany, and the United States developed different public-private mechanisms to maintain terrorism risk coverage, while Cummins (2006) argues that government participation in catastrophe insurance should be carefully designed to avoid crowding out private market solutions. Kunreuther (2015) also emphasizes that insurance for extreme events requires public-private cooperation because private markets alone often underprovide coverage for low-probability, high-consequence risks. These findings support the theoretical assumption that war-risk insurance requires a hybrid institutional architecture rather than reliance on ordinary commercial insurance logic alone.

The importance of public intervention in extreme-risk insurance markets is also emphasized by Moss (2002), who argues that governments often become the ultimate risk managers when private markets cannot efficiently absorb systemic risks. Empirical evidence from terrorism insurance markets further supports this conclusion. Michel-Kerjan and Raschky (2011) show that government-backed terrorism insurance programs significantly influence market participation and coverage availability. These observations reinforce the argument that sustainable war-risk insurance requires hybrid public-private institutional arrangements rather than exclusive reliance on conventional commercial insurance mechanisms.

1.2. Market functionality and protection adequacy

Recent studies on cyber warfare further demonstrate how war exclusions create protection gaps in modern insurance markets. Cremer et al. (2024) analyze cyber war exclusions in the context of the Russia-Ukraine war and show that the boundary between insurable cyber incidents and excluded war-related events remains contested. He et al. (2025) similarly argue that cyberwarfare challenges traditional insurance governance because broad war exclusions may limit coverage precisely when protection is most needed. These works are particularly relevant because they show that war-related exclusions are no longer confined to traditional property, marine, or aviation insurance but increasingly affect technologically advanced risk segments.

Thus, the first stream of literature confirms that military risks should be understood as a special form of catastrophic and politically contingent

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risk. They challenge the core principles of insurability because they combine systemic loss correlation, limited diversification, high uncertainty, and legal exclusions. This provides the theoretical basis for distinguishing between insurance market functionality and comprehensive protection adequacy under wartime conditions.

A second important stream of literature examines how insurance markets respond to geopolitical instability, macro-financial shocks, and crisis conditions. Unlike purely actuarial studies, this literature focuses on market resilience, premium dynamics, solvency, and institutional adaptation. OECD research on the impact of the global financial crisis on insurance markets shows that insurance sectors may remain resilient during systemic shocks, but their performance depends on capital adequacy, prudential regulation, investment stability, and policy responses (OECD, 2005a, 2005b). More recent OECD and IAIS reports also emphasize that insurance market resilience should be evaluated not only through profitability, but also through solvency, claims-paying capacity, and the ability to maintain risk-transfer functions under stress.

Empirical studies on geopolitical risk provide direct evidence that political instability influences insurance behavior and pricing. Olasehinde-Williams and Balcilar (2022) find that geopolitical risk increases insurance premiums, especially in non-life insurance, suggesting that political uncertainty affects both demand for insurance and the cost of coverage. Hemrit and Nakhli (2021) also show that the relationship between geopolitical risk and insurance premiums may be asymmetric and nonlinear. Zhou et al. (2025) find that geopolitical risk increases corporate insurance investment, indicating that firms react to uncertainty by expanding insurance purchases where coverage is available. These findings are highly relevant for Ukraine because wartime conditions simultaneously increase demand for insurance protection and constrain the supply of insurable coverage.

The literature also links insurance resilience to financial stability and solvency. Huang et al. (2023), using a contingent claim approach, examine the impact of war on insurer safety and show that war can affect insurer behavior, guaranteed rates, and stability. Studies of insurance market resilience after large shocks, including the global financial crisis and COVID-19, suggest that insurers' ability to remain functional depends on capital buffers, asset quality, market structure, and adaptive regulation. Nebolsina (2025), for example, analyzes U.S. insurance market resilience during the global financial crisis and COVID-19 using insurer-level data, while Vintilă et al. (2024) examine the resilience of the European insurance industry using indicators such as gross written premiums, claims, assets, liabilities, and the number of insurers. These works support the use of multidimensional indicators in assessing resilience.

The resilience of insurance markets has also been examined through the behavior of reinsurance and capital-market participants following catastrophic events. Ragin and Halek (2016) demonstrate that catastrophe events influence market expectations and the valuation of insurance intermediaries, reflecting investors' perceptions of sectoral resilience and future loss exposure. In the reinsurance industry, Jarzabkowski et al. (2015) show that resilience is supported by continuous risk-trading practices and the dynamic redistribution of extreme risks across global markets. These findings suggest that insurance resilience depends not only on insurers themselves but also on broader risk-transfer networks and market institutions.

1.3. Wartime insurance resilience as selective institutional functionality

Wartime insurance market resilience is defined in this study as the ability of the insurance market to preserve selective institutional functionality, claims-paying capacity, solvency, and risk-transfer operations under elevated military risks, despite bounded insurability and a persistent protection gap. This definition emphasizes that wartime resilience should not be equated with comprehensive protection against all war-related losses. Rather, it refers to the ability of the insurance system to continue operating within those segments, contracts, and institutional arrangements that remain economically and legally insurable.

This interpretation is important because war changes the meaning of insurance market stability. Under ordinary conditions, market resilience is of-

ten assessed through premium dynamics, claims ratios, profitability, solvency, or market growth. Under wartime conditions, however, these indicators may produce an incomplete picture. A market may remain solvent, continue collecting premiums, and pay claims in covered segments, while still leaving a large share of direct military destruction, occupation-related losses, missile damage, and large-scale business interruption outside standard insurance coverage. Therefore, wartime insurance resilience should be understood as selective functionality rather than full protection adequacy.

The existing literature supports this logic, although it rarely integrates it into a unified measurement framework. Studies on catastrophic and geopolitical risks show that insurance market resilience cannot be reduced to a single variable. Premium dynamics, claims activity, solvency, reinsurance, regulatory support, and market structure all influence the ability of insurers to preserve functionality under crisis conditions. This provides the theoretical justification for using a composite index approach to assess wartime insurance resilience.

The literature specifically addressing wartime insurance markets remains more limited and fragmented. International policy reports indicate that the Russian invasion of Ukraine affected global insurance markets through direct war losses, sanctions, marine and aviation risks, political violence coverage, reinsurance constraints, inflation, and financial market volatility (OECD, 2022). These effects show that war influences insurance systems both directly, through losses and exclusions, and indirectly, through macroeconomic instability, financial uncertainty, and institutional stress. For Ukraine, this distinction is essential because insurers continue to operate, but a large share of direct war-related losses remains outside standard insurance compensation.

Ukrainian studies after 2022 provide important evidence of wartime market transformation, but they remain mostly sectoral and descriptive. Dobryk et al. (2024) analyze obstacles and restructuring processes in the Ukrainian insurance market under war conditions. Tkachuk and Kraus (2024) examine the impact of the full-scale invasion on life, health, property, and motor insurance. Bulantsov (2024) focuses on regulatory problems and European integration challenges, while Kholodna (2024) studies the risk-oriented approach to improving the financial condition of insurance companies. Dranus et al. (2025) examine socially responsible marketing and insurer activity during wartime, and Horyslavets and Kozhan (2025) emphasize regulatory, digital, and business model challenges. These studies identify important manifestations of wartime adaptation, but they do not provide an integrated framework for measuring wartime insurance resilience.

Another relevant group of Ukrainian and policy-oriented sources concerns investment protection, reconstruction finance, and institutional war-risk mechanisms. Kryvenko and Yevtushenko (2024) emphasize the role of insurance in investment protection and financial market development under martial law and reconstruction uncertainty. National Bank of Ukraine reports for 2024–2025 provide official evidence on the restructuring of the insurance market after 2022, including a decline in the number of insurers, market concentration, changes in non-life premiums, claims dynamics, reinsurance activity, and prudential indicators. These materials are important for the empirical calibration of the proposed index, as they provide official data for assessing selected dimensions of market functionality.

Thus, the Ukrainian case demonstrates that wartime adaptation occurs through selective rather than comprehensive resilience. Insurers preserve operations in segments that remain legally and economically insurable, while direct war destruction, occupation-related damage, missile strikes, and large-scale business interruption losses are often excluded or only partially covered. In this sense, Ukraine illustrates a broader theoretical problem: an insurance market may be institutionally resilient but substantively incomplete as a protection mechanism. This distinction forms the theoretical basis for the proposed Insurance Market Wartime Resilience Index.

The reviewed literature demonstrates that insurance under catastrophic and conflict-related risks has been examined from multiple perspectives, including risk management, insurer adaptation, regulatory responses, and geopolitical uncertain-

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ty. However, existing studies rarely assess wartime insurance resilience as an integrated phenomenon. Most analyses focus on individual dimensions such as claims performance, solvency, reinsurance, or market adaptation, while their combined contribution to insurance market resilience remains insufficiently explored.

Recent studies further emphasize the growing strategic importance of insurance as a resilience mechanism in periods of systemic crisis. The Geneva Association (2023) argues that insurance contributes to economic stability, investment continuity, and societal resilience by facilitating recovery after major shocks. Similarly, Nobanee et al. (2024) identify insurance entrepreneurship as an important adaptive mechanism during crises, highlighting the role of innovation and institutional flexibility in maintaining market functionality under adverse conditions. These perspectives support the interpretation of wartime insurance resilience as a broader institutional capacity extending beyond traditional claims compensation.

Furthermore, current research lacks a dedicated framework for measuring how insurance markets maintain functionality under prolonged military conflict. This gap is particularly relevant in the Ukrainian context, where the insurance market continues to operate despite elevated military risks and widespread war-related exclusions. To address this gap, it is necessary to develop an integrated approach capable of assessing the resilience of the insurance market during wartime as a multidimensional construct.

2. RESULTS

2.1. Development of the IMWRI framework

The functioning of insurance markets under elevated military risks differs substantially from insurance activity under ordinary economic conditions. Large-scale armed conflict generates catastrophic uncertainty, correlated losses, territorial fragmentation of exposure, disruptions in actuarial predictability, and significant limitations in the insurability of war-related risks. Under such conditions, conventional insurance market indicators – such as premium growth, claims ratios, or profitability – are insufficient for evaluating the real resilience and functional sustainability of the insurance system.

To address this limitation, this study develops the Insurance Market Wartime Resilience Index (IMWRI), an integrated analytical framework designed to assess insurance market resilience under conditions of prolonged military conflict. The proposed framework conceptualizes wartime insurance resilience as the ability of the insurance market to preserve operational continuity, compensation activity, financial stability, and institutional functionality despite elevated military risks and bounded insurability conditions.

The methodological novelty of the proposed approach lies in integrating financial, operational, institutional, and structural dimensions of insurance market functioning within a unified wartime resilience framework. Unlike traditional insurance market assessments that focus on isolated indicators, the IMWRI combines premium continuity, claims functionality, reinsurance support, solvency and financial stability, and market structure transformation into a composite resilience measure applicable to conflict-affected economies.

Accordingly, wartime insurance market functioning is interpreted not as the ability to provide full compensation for all losses, but as the ability of the insurance system to maintain selective risk-transfer functionality under extreme uncertainty.

Based on this theoretical logic, the author's result is the development of the Insurance Market Wartime Resilience Index (IMWRI), which operationalizes wartime insurance resilience through five normalized components: premium resilience, claims functionality, reinsurance support, solvency and financial stability, and market structure adaptation.

The IMWRI is based on three assumptions: first, wartime insurance operates under bounded insurability; second, market resilience depends on both internal market indicators and external institutional support; third, wartime functionality should be interpreted as selective continuity rather than full compensation of war-related losses.

Therefore, the index is not intended as a purely actuarial forecasting tool, but as a composite framework for evaluating the functional resilience of insurance markets under military risk.

The Ukrainian insurance market provides an especially relevant empirical context for applying the proposed model. Since the onset of the full-scale invasion, the market has operated under the following conditions: large-scale physical destruction, geographic fragmentation of insurable space, war exclusions in standard insurance contracts, increased dependence on reinsurance and regulatory coordination, and rising demand for selected forms of insurance protection.

Under these conditions, the proposed model allows us to analyze the Ukrainian insurance market not simply in terms of premium growth or claims ratios, but in terms of its broader resilience architecture. In particular, it helps explain how the market may remain operational even when the majority of direct war-related losses remain outside the scope of ordinary insurance coverage.

Therefore, the model contributes to the study not only by formalizing the insurance market under military risk, but also by providing a basis for future empirical calibration and comparative research on wartime insurance systems.

2.2. Normalization and weighting procedure

The proposed IMWRI is based on heterogeneous indicators that differ in scale, economic meaning, and statistical interpretation. Therefore, the normalization and weighting procedure follows the general logic of composite indicator construction, according to which heterogeneous variables must be made comparable before aggregation (OECD & Joint Research Centre-European Commission, 2008). The normalization procedure is designed not to estimate the full actuarial value of wartime losses, but to make different dimensions of insurance market functionality comparable within a single composite framework.

The normalization logic follows three principles. First, indicators that directly express a ratio to a benchmark are used in their ratio form. This applies, for example, to premium resilience, where the current premium volume is compared with a pre-war or benchmark level. A value equal to 1 indicates preservation of the benchmark level, a value below 1 indicates deterioration, and a value above 1 indicates recovery or expansion relative to the benchmark. Second, indicators naturally expressed as shares of gross premiums or total assets are interpreted within the interval from 0 to 1. This applies to claims functionality, reinsurance support, and the eligible asset component of solvency. Third, indicators that combine positive and negative structural effects are calibrated analytically. This applies to the market structure component, where higher concentration may indicate the survival of stronger insurers, but excessive market contraction may also signal reduced competition and structural narrowing.

The five IMWRI components are normalized as follows. The premium resilience component is calculated as the ratio of current gross premiums to the pre-war or benchmark premium level. The claims functionality component is calculated as the ratio of claims paid to gross premiums and reflects active compensation within covered insurance lines rather than compensation for total wartime losses. The reinsurance support component is measured as the share of premiums ceded to reinsurance and reflects the availability of external risk-sharing capacity. The solvency and financial stability component combines prudential asset quality and sectoral profitability, since wartime resilience depends not only on the formal availability of assets but also on the financial ability of insurers to remain operational. The market structure component combines market concentration and insurer-number dynamics, because wartime consolidation may simultaneously strengthen the role of financially stable insurers and reduce market diversity.

The weighting scheme is expert-analytical and reflects the relative importance of each component for preserving insurance market functionality under wartime conditions. Premium resilience, solvency, and financial stability receive the highest weights, 0.25 each, because premium continuity and prudential viability are necessary conditions for the survival of the insurance market as an institutional mechanism. Claims functional-

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ity receives a weight of 0.20 because claims settlement represents the direct compensatory function of insurance, although under wartime conditions, it remains limited to covered and legally insurable risks. Reinsurance support and market structure adaptation receive weights of 0.15 each. Reinsurance is important as an external stabilization channel, but its capacity to absorb prolonged military risk is limited. Market structure is also important because concentration may indicate institutional consolidation, but it may simultaneously reflect reduced competition and market narrowing.

Thus, the baseline weighting structure is specified as follows:

$$\begin{aligned} w_{PR} &= 0.25, \\ w_{CF} &= 0.20, \\ w_{RS} &= 0.15, \\ w_{SF} &= 0.25, \\ w_{MS} &= 0.15, \end{aligned} \tag{1}$$

where w_{PR} is the weight of premium resilience, w_{CF} is the weight of claims functionality, w_{RS} is the weight of reinsurance support, w_{SF} is the weight of solvency and financial stability, and w_{MS} is the weight of market structure adaptation. The sum of all weights equals one:

$$\sum_{i=1}^{5} w_i = 1. \tag{2}$$

The resulting index is calculated as a weighted additive composite indicator:

$$\begin{aligned} IMWRI = {} & w_{PR}PR + w_{CF}CF \\ & + w_{RS}RS + w_{SF}SF + w_{MS}MS, \end{aligned} \tag{3}$$

where *PR*, *CF*, *RS*, *SF*, and *MS* are the normalized values of the five component indicators.

The additive form is appropriate because the purpose of the index is to assess the combined contribution of several complementary dimensions of wartime insurance market functioning rather than to model a purely actuarial causal mechanism.

Since the IMWRI relies on proxy calibration and expert-analytical weights, its result should be interpreted as an approximate and indicative measure of wartime insurance market resilience. It should not be interpreted as a precise actuarial estimate of war-related losses or as evidence of comprehensive protection adequacy. To reduce the dependence of the findings on one particular weighting structure, the baseline calibration should be supplemented by a sensitivity analysis using alternative weighting scenarios.

2.3. Empirical testing on the Ukrainian case

The proposed IMWRI is tested on the Ukrainian case using a semi-empirical proxy-based calibration based on official data from the National Bank of Ukraine for 2022–2025. This approach is appropriate because a substantial share of direct wartime losses remains outside standard insurance statistics due to war exclusions and bounded insurability conditions.

The Ukrainian case is suitable for illustrative empirical testing because it combines operational continuity with significant wartime protection limitations. Therefore, the calibration focuses not on estimating the full actuarial value of war-related losses, but on assessing selected dimensions of market functionality: premium continuity, claims activity, reinsurance support, prudential resilience, and market structure adaptation.

The functioning of the Ukrainian insurance market under elevated military risks is approximated through the following composite indicator:

$$IMWRI_t = \sum_{i=1}^{5} w_i Z_i, \tag{4}$$

subject to:

$$\sum_{i=1}^{5} w_i = 1, \quad w_i \geq 0, \tag{5}$$

where $IMWRI_t$ – Insurance Market Wartime Resilience Index in period t; Z_i – normalized component indicators; w_i – component weights.

For the Ukrainian case, the index includes five measurable components:

$$IMWRI_t = w_1 P_t^* + w_2 C_t^* + w_3 R_t^* + w_4 S_t^* + w_5 M_t^*, \quad (6)$$

where P_t^* – premium resilience component; C_t^* – claims functionality component; R_t^* – reinsurance support component; S_t^* – solvency and financial stability component; M_t^* – market structure and concentration component.

This specification is preferable for empirical application because all five dimensions can be approximated using official or directly inferable market indicators.

2.4. Operationalization of IMWRI components for Ukraine

2.4.1. Premium resilience component

The premium resilience component is defined as:

$$P_t^* = \frac{P_t}{P_{ref}}, \quad (7)$$

where P_t – current gross premium volume; P_{ref} – benchmark or pre-war reference premium level.

For Ukraine, the NBU reports that in 2024, non-life insurance premiums exceeded the pre-war level, which implies that the premium resilience component is above unity in the non-life segment. This indicates that, despite military disruption, the premium base remained active and, in some segments, even recovered structurally.

2.4.2. Claims functionality component

The claims functionality component is defined as:

$$C_t^* = \frac{C_t}{P_t}, \quad (8)$$

where C_t – claims paid; P_t – gross premiums.

This variable reflects the functional claims-paying capacity of the market rather than the coverage of total wartime losses. In Q1 2025, the annualized claims paid ratio in the non-life segment was approximately 39%, while in key product lines it remained materially active, including approximately 47% in C&C, 44% in MTPL, and 53% in health insurance. These values indicate that the market continues to perform a real compensation function within the boundaries of covered risks.

2.4.3. Reinsurance support component

The reinsurance support component is defined as:

$$R_t^* = \frac{RP_t}{P_t}, \quad (9)$$

where RP_t – premiums ceded to reinsurance; P_t – gross premiums.

In Ukraine, the share of premiums ceded to reinsurance increased to 11% in Q1 2025, compared to 8% previously, while 95% of ceded premiums were transferred to non-resident reinsurers. This confirms that reinsurance remains an important external stabilizing mechanism, even though it does not fully absorb wartime exposure.

2.4.4. Solvency and financial stability component

The solvency component is approximated as a composite of asset quality and profitability:

$$S_t^* = \frac{1}{2}\left(\frac{EA_t}{TA_t} + \frac{\Pi_t}{\Pi_{ref}}\right), \quad (10)$$

where EA_t – eligible assets; TA_t – total assets; Π_t – current sector profit; Π_{ref} – benchmark profit level.

As of 1 January 2025, 86% of insurers' assets (UAH 62.7 billion) qualified as eligible assets for prudential purposes. In addition, non-life insurers' profit reached UAH 2.5 billion in 2024, while life insurers' net profit exceeded UAH 1.4 billion. These values support the conclusion that wartime insurance resilience in Ukraine has a strong prudential and financial basis.

2.4.5. Market structure and concentration component

The market structure component is defined as:

$$M_t^* = \frac{1}{2}\left(\frac{Top10_t}{100} + \frac{N_t}{N_{ref}}\right), \quad (11)$$

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where $Top10_t$ – premium share of the top ten insurers; N_t – current number of insurers; N_{ref} – benchmark number of insurers.

This variable captures two simultaneous wartime effects:

1) rising concentration, which may indicate greater resilience of dominant insurers;

2) market shrinkage, which may indicate loss of diversity and competition.

In Ukraine, by the end of 2024, the top ten non-life insurers accounted for 71% of premiums, while the total number of insurers had fallen to 48 non-life and 10 life insurers, down sharply from pre-war and earlier market levels. Thus, this component reflects resilience through concentration, but also structural narrowing of the market.

The structure of the IMWRI is based on five normalized components: premium resilience, claims functionality, reinsurance support, solvency and financial stability, and market structure adaptation. These components are aggregated through a weighted additive procedure, which makes it possible to convert heterogeneous indicators of wartime insurance market functioning into a single resilience measure.

The baseline weights justified in Section 3.2 are applied to the calibrated Ukrainian component values.

Table 1 presents the semi-empirical calibration of the Insurance Market Wartime Resilience Index (IMWRI) for Ukraine. The interpretation thresholds are based on equal interval partitioning of the normalized [0;1] scale. This approach is commonly applied in composite indicator studies when no universally accepted benchmark values exist, and the objective is comparative assessment rather than actuarial forecasting.

The calibrated values are $PR = 1.05$, $CF = 0.39$, $RS = 0.11$, $SF = 0.93$, and $MS = 0.595$. Substituting these values into the weighted additive model gives:

$$\begin{aligned} IMWRI &= 0.25(1.05) + 0.20(0.39) \\ &+0.15(0.11) + 0.25(0.93) \\ &+0.15(0.595) = 0.6788. \end{aligned} \tag{12}$$

Table 1. Variables and semi-empirical calibration of the IMWRI for Ukraine

Source: Compiled by the authors based on National Bank of Ukraine analytical reports and the author's semi-empirical model calibration.

Component	Formula / proxy	Observed / reference value	Normalized / calibrated value	Weight	Weighted contribution	Interpretation
Premium resilience	$P_t^* = \frac{P_t}{P_{ref}}$	Non-life premiums in 2024 exceeded the pre-war level	1.05	0.25	0.2625	Indicates preserved or slightly improved premium-generating capacity under wartime conditions
Claims functionality	$C_t^* = \frac{C_t}{P_t}$	Annualized non-life claims paid ratio ≈ 39%	0.39	0.20	0.0780	Reflects active claims settlement within covered insurance lines
Reinsurance support	$R_t^* = \frac{RP_t}{P_t}$	Share of premiums ceded to reinsurance = 11%	0.11	0.15	0.0165	Shows selective but meaningful external risk-sharing capacity
Solvency and financial stability	$S_t^* = \frac{1}{2}\left(\frac{EA_t}{TA_t} + \frac{\Pi_t}{\Pi_{ref}}\right)$	Eligible assets = 86% of total assets; profitability benchmark = 1.00	0.93	0.25	0.2325	Indicates relatively strong prudential and financial stability under war
Market structure and concentration	$M_t^* = \frac{1}{2}\left(\frac{Top10_t}{100} + \frac{N_t}{N_{ref}}\right)$	Top-10 non-life insurers = 71% of premiums; N_t = 48, N_{ref} = 100	0.595	0.15	0.0893	Reflects resilience through concentration, but also reduced market diversity
Final index	$IMWRI_t = \sum_{i=1}^{5} w_i Z_i$	–	–	1.00	0.6788	Moderately high wartime resilience

Table 2. IMWRI interpretation scale

Source: Built by the authors.

IMWRI value	Resilience level	Interpretation
0.00-0.20	Very low resilience	The insurance market is severely impaired and unable to maintain core insurance functions
0.21-0.40	Low resilience	The market retains limited operational capacity but experiences significant functional disruption
0.41-0.60	Moderate resilience	Core insurance functions are preserved, although substantial structural vulnerabilities remain
0.61-0.80	Moderately high resilience	The market maintains operational continuity, financial stability, and compensation activity despite elevated military risks
0.81-1.00	High resilience	The market demonstrates strong adaptive capacity and sustained functionality under adverse conditions

Thus, the approximate IMWRI value for Ukraine is 67.9%.

Since the IMWRI is normalized within the interval [0; 1], its values can be interpreted using a five-level resilience scale. The scale is designed to facilitate comparative assessment and policy interpretation of wartime insurance market performance.

According to the classification given in Table 2, the calculated value of IMWRI = 0.679 falls within the range of 0.61-0.80 and therefore corresponds to a moderately high level of wartime insurance resilience.

The resulting value of 67.9% suggests that the Ukrainian insurance market has retained a moderately high level of operational resilience under elevated military risks. The strongest positive contribution is generated by premium continuity and prudential stability, while the weakest contribution is associated with reinsurance support, reflecting the still limited capacity of external risk transfer to compensate for wartime uncertainty. The results also indicate that wartime resilience is achieved not through comprehensive risk coverage, but through selective institutional adaptation within a narrowed insurability space.

2.5. Sensitivity analysis

A sensitivity analysis is required because the IMWRI is a newly developed composite indicator, and its final value may be influenced by the choice of component weights. Since wartime insurance resilience is a multidimensional construct, there is no universally accepted theoretical or empirical basis for assigning definitive weights to its components. Premium resilience, claims functionality, reinsurance support, solvency, and market structure may have different relative importance depending on the perspective of regulators, insurers, policyholders, or international partners. Therefore, testing alternative weighting scenarios is necessary to verify whether the obtained resilience assessment is robust or merely a mechanical result of the baseline weighting scheme.

The purpose of the sensitivity analysis is to evaluate the stability of the IMWRI interpretation under different assumptions about the relative importance of its components. If the index remains within the same or adjacent interpretation ranges across alternative scenarios, this supports the reliability of the proposed framework. If the index changes sharply, it would indicate that the result is highly weight-dependent and should be interpreted with caution. In this study, sensitivity analysis is therefore used as a validation procedure for the proposed IMWRI rather than as an attempt to determine one universally optimal weighting structure.

The sensitivity analysis uses the same calibrated component values as in the baseline model: premium resilience (PR = 1.05), claims functionality (CF = 0.39), reinsurance support (RS = 0.11), solvency and financial stability (SF = 0.93), and market structure adaptation (MS = 0.595). The baseline scenario assigns the highest weights to premium resilience and solvency, reflecting their central role in preserving insurance market viability. Alternative scenarios include equal weights, solvency-priority weights, claims-priority weights, reinsurance-priority weights, and premium-solvency priority weights.

The results of the sensitivity analysis show that the IMWRI value ranges from 0.577 to 0.753, depend-

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Table 3. Sensitivity analysis of IMWRI under alternative weighting scenarios

Source: Calculated by the authors based on the calibrated IMWRI component values.

Scenario	w_{PR}	w_{CF}	w_{RS}	w_{SF}	w_{MS}	IMWRI value	Interpretation (according to the scale in Table 2)
Baseline weighting	0.25	0.20	0.15	0.25	0.15	0.679	Moderately high resilience
Equal weights	0.20	0.20	0.20	0.20	0.20	0.615	Moderately high resilience
Solvency-priority scenario	0.20	0.15	0.10	0.40	0.15	0.741	Moderately high resilience
Claims-priority scenario	0.20	0.35	0.10	0.20	0.15	0.633	Moderately high resilience
Reinsurance-priority scenario	0.20	0.15	0.30	0.20	0.15	0.577	Moderate resilience
Premium-solvency priority scenario	0.30	0.15	0.10	0.30	0.15	0.753	Moderately high resilience

ing on the weighting scenario. The lowest value is observed in the reinsurance-priority scenario, which reflects the relatively weak contribution of reinsurance support to wartime insurance resilience in Ukraine. The highest value is observed in the premium-solvency priority scenario, where greater importance is assigned to premium continuity and prudential stability, the two strongest components of the Ukrainian insurance market under wartime conditions.

Importantly, none of the alternative scenarios changes the general interpretation of the Ukrainian insurance market as functionally resilient but structurally constrained. Even under the most conservative reinsurance-priority scenario, the index remains within the moderate resilience range. Under the baseline, solvency-priority, and premium-solvency priority scenarios, the index indicates a moderately high level of wartime insurance market resilience. This confirms that the study's main conclusion does not depend exclusively on one particular set of expert-analytical weights.

Therefore, the sensitivity analysis supports the robustness of the proposed IMWRI interpretation. The Ukrainian insurance market demonstrates a moderate to moderately high level of wartime resilience, primarily due to premium continuity, solvency, and institutional adaptation. At the same time, the results confirm that this resilience remains bounded by limited reinsurance support, structural market narrowing, and the persistent wartime protection gap.

3. DISCUSSION

The empirical application of the Insurance Market Wartime Resilience Index (IMWRI) produced a value of 0.679, indicating a moderately high level of wartime insurance resilience in Ukraine. This finding is particularly significant because it demonstrates that the insurance market has retained operational continuity despite prolonged military conflict and unprecedented levels of uncertainty. However, the broader importance of this result becomes evident only when interpreted in relation to the existing literature on catastrophic risk, insurance resilience, and conflict-related insurance markets.

The obtained results are broadly consistent with the literature on catastrophe insurance and extreme-risk management. Previous studies have demonstrated that insurance markets rarely collapse completely when exposed to systemic shocks; instead, they adapt through repricing, risk selection, institutional restructuring, and the development of alternative risk-transfer mechanisms (Jaffee & Russell, 1997; Froot, 2001; Cummins, 2006; Kunreuther & Michel-Kerjan, 2009). Similarly, the Ukrainian insurance market has preserved operational continuity despite elevated military risks, primarily through financial adaptation and selective coverage strategies. Rather than experiencing systemic failure, the market has preserved premium generation, claims settlement, and financial stability while simultaneously reducing exposure to risks that are no longer economically insurable.

At the same time, the findings extend the existing literature because most catastrophe-insurance studies focus on natural disasters, climate-related events, or terrorism risks. Military conflict differs fundamentally from these forms of catastrophic exposure. Unlike natural disasters, war generates persistent uncertainty, geographically shifting exposure, highly correlated losses, and prolonged disruptions of economic activity. One of the central findings of this study is the distinction between insurance market resilience and protec-

tion adequacy. This result extends the concept of bounded insurability developed by Berliner (1982) and later discussed in catastrophe-risk literature (Cummins, 2006; Paudel, 2012). The Ukrainian case demonstrates that an insurance market may remain operationally resilient while simultaneously excluding a substantial share of wartime losses from standard coverage. Consequently, resilience should not be interpreted as evidence of comprehensive protection, but rather as the capacity to preserve core insurance functions under severe insurability constraints.

This finding contributes to the literature on bounded insurability originally developed by Berliner (1982) and subsequently expanded in catastrophe-risk research. Previous studies have shown that certain risks become difficult or impossible to insure when uncertainty, loss correlation, and potential severity exceed the capacity of private insurance markets. The Ukrainian experience provides empirical evidence supporting this argument. The market remains resilient partly because many of the most destructive wartime losses – such as direct military damage, occupation-related losses, missile strikes, and large-scale business interruption – are excluded from ordinary insurance contracts. Therefore, resilience is achieved not despite bounded insurability but, to some extent, because of it.

This interpretation is also consistent with studies examining the relationship between insurance and disaster-risk reduction. Surminski et al. (2015) and Surminski and Hudson (2017) argue that insurance should be viewed not only as a compensation mechanism but also as an instrument supporting adaptation and resilience-building. Their findings suggest that the value of insurance during extreme events extends beyond direct indemnification and includes the preservation of economic continuity, incentives for risk management, and support for recovery processes. The Ukrainian case illustrates a similar dynamic, where the resilience of the insurance market derives partly from its continued institutional functioning even when comprehensive compensation remains unattainable.

The findings are also consistent with recent research demonstrating that geopolitical and military risks exert a significant influence on insurance markets. Hemrit and Nakhli (2021) and Olasehinde-Williams and Balcilar (2022) show that geopolitical uncertainty affects insurance pricing and market performance, while Huang et al. (2023) provide evidence that war exposure directly influences insurer safety and financial stability. More recent studies by Zhou et al. (2025) further confirm that geopolitical risk affects insurance-related investment decisions. The Ukrainian case extends this literature by demonstrating how these pressures collectively shape overall insurance market resilience.

The decomposition of the IMWRI also provides important insights into the internal structure of wartime resilience. The strongest contributions to the index are generated by premium resilience and solvency and financial stability. This result suggests that the Ukrainian insurance market currently derives its resilience primarily from internal financial strength and institutional continuity. The finding is consistent with previous studies emphasizing the importance of capitalization, prudential regulation, and financial discipline during periods of systemic crisis. It also reflects the regulatory role of the National Bank of Ukraine, which has maintained supervisory continuity and prudential oversight throughout the wartime period.

The relatively weak contribution of reinsurance support to the IMWRI is consistent with studies emphasizing the limitations of conventional risk-transfer mechanisms under extreme uncertainty. Earlier research by Froot (2001) and Cummins (2008) highlights the importance of alternative risk-transfer instruments and catastrophe-linked securities when traditional reinsurance capacity becomes constrained. Similarly, OECD (2022) stresses that war-related risks often exceed the capacity of ordinary private insurance and reinsurance arrangements. The Ukrainian case confirms that external risk-sharing remains one of the most vulnerable dimensions of wartime insurance resilience.

The findings also support recent OECD analyses emphasizing that catastrophic-risk insurance systems increasingly rely on layered protection structures combining private insurance, reinsurance, capital-market instruments, and public support mechanisms (OECD, 2021; 2026). From this

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perspective, the relatively weak contribution of reinsurance observed in the Ukrainian case should not be interpreted as a market failure, but rather as evidence of the structural limitations of private risk-transfer capacity under prolonged military conflict.

Recent studies examining cyberwarfare and conflict-related insurance risks further support the findings of this article. Cremer et al. (2024) demonstrate that cyberwarfare creates substantial insurability challenges, while He et al. (2025) argue that war exclusions remain one of the central barriers to effective insurance coverage under modern conflict conditions. Although these studies focus on cyber risks, they reinforce the broader conclusion that military conflict systematically expands the domain of risks considered partially or fully uninsurable.

The findings also complement recent studies of the Ukrainian insurance market. Previous research has documented wartime market restructuring, regulatory challenges, financial adaptation, and changes in insurers' business models (Bulantsov, 2024; Dobryk et al., 2024; Tkachuk & Kraus, 2024; Kholodna, 2024). Other studies emphasize the growing role of insurance in investment protection, market development, and stakeholder confidence under crisis conditions (Kryvenko & Yevtushenko, 2024; Horyslavets & Kozhan, 2025). The present study extends these contributions by proposing a quantitative framework that integrates these individual dimensions into a unified measure of wartime insurance resilience. The Ukrainian experience suggests that resilience in the context of a prolonged military conflict cannot be achieved solely through conventional private insurance mechanisms. Instead, effective wartime risk management requires a hybrid institutional architecture combining private insurers, international reinsurers, public support instruments, development-finance institutions, and donor-backed guarantee mechanisms. Such arrangements are increasingly discussed in international policy debates concerning reconstruction finance and war-risk insurance, particularly in conflict-affected economies. The results of this study provide empirical support for these discussions by demonstrating that private-market resilience alone is insufficient to close the wartime protection gap.

CONCLUSIONS

This study aims to develop and apply the Insurance Market Wartime Resilience Index (IMWRI) to assess insurance market resilience under conditions of military conflict. The developed index has been tested using Ukraine as an illustrative empirical case. The results demonstrate that the Ukrainian insurance sector has preserved a moderately high level of wartime resilience despite prolonged military disruption, maintaining premium continuity, claims activity, and prudential stability. The theoretical contribution lies in distinguishing wartime market functionality from protection adequacy, while the methodological contribution lies in operationalizing this distinction through a composite resilience index.

At the same time, the study shows that wartime insurance resilience does not imply comprehensive protection adequacy. The Ukrainian insurance market remains operational primarily within a bounded insurability environment in which a substantial share of direct military losses remains outside standard insurance coverage. Thus, wartime resilience is achieved through selective adaptation, market concentration, institutional continuity, and the preservation of economically sustainable insurance segments.

The proposed IMWRI framework provides an integrated approach for evaluating wartime insurance resilience through a combined assessment of premium continuity, claims functionality, reinsurance support, solvency, and market structure transformation. The sensitivity analysis confirms that the interpretation of Ukraine's insurance market as moderately to moderately highly resilient remains stable under alternative weighting scenarios, although the index should be understood as an approximate and indicative measure rather than a precise actuarial estimate of war-related losses.

From a policy perspective, the findings indicate that the long-term sustainability of wartime insurance systems requires the development of hybrid war-risk insurance mechanisms combining private insurance, international reinsurance, public support instruments, and external guarantee facilities. Strengthening such institutional architecture is essential for reducing the wartime protection gap and supporting economic recovery in conflict-affected economies.

From a methodological perspective, the study contributes by proposing a quantitative framework for assessing wartime insurance resilience as a multidimensional construct. Unlike traditional approaches focusing on individual indicators, the IMWRI integrates premium continuity, claims functionality, reinsurance support, solvency and financial stability, and market structure adaptation into a single analytical measure. The sensitivity analysis further confirms that the interpretation of Ukrainian wartime resilience remains relatively stable across alternative weighting scenarios, supporting the robustness of the proposed framework.

Nevertheless, several limitations should be acknowledged. The empirical calibration relies on a semi-empirical proxy-based approach because a significant proportion of wartime losses is not directly observable through standard insurance statistics. Moreover, the analysis is conducted at the sectoral level and therefore does not fully capture heterogeneity across insurers, regions, or insurance classes. Future research may address these limitations by developing panel-based resilience models, conducting cross-country comparisons, and incorporating dynamic measures of war-risk exposure and reconstruction demand.

Overall, the Ukrainian case demonstrates that insurance markets exposed to prolonged military conflict can remain institutionally resilient even when comprehensive wartime protection is unattainable. The findings suggest that wartime insurance resilience should be understood as a multidimensional capacity to preserve core insurance functions under conditions of extreme uncertainty and bounded insurability. In this sense, resilience represents not a return to normal market equilibrium, but an adaptive form of institutional continuity capable of supporting broader processes of economic recovery and national resilience.

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