African Journal of Strategy, Defence and Security Studies (AJSDSS)
E-ISSN 2978-3364 (Online); ISSN 2978-3356 (Print)

Indexed by SABINET and EBSCO

Volume 2, Number 1, April 2026

Pp 95-115

The Risks of an Unconstrained Iranian Nuclear Program Approach: Implications for Global Peace and Security

DOI: https://doi.org/10.31920/2978-3364/2026/v2n1a5

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Abstract

This study examines the security implications of an unconstrained Iranian nuclear program within the context of the Second Nuclear Age, following the United States (U.S.) withdrawal from the Joint Comprehensive Plan of Action (JCPOA). Guided by Deterrence theory and supported by insights from Offensive and Defensive Realism, this study conceptualises current Middle Eastern Proliferation dynamics. Through an exploratory research design and thematic analysis of secondary data, the study investigates Iran's post-2018 nuclear advancements, the impact of U.S. maximum pressure sanctions, and the strategic responses of Israel, Saudi Arabia, Turkey, and the Gulf States. The analysis demonstrates that Iranian nuclear hedging and proxy operations accelerate proliferation risks, shorten breakout timelines, and erode the Nuclear Non-Proliferation Treaty (NPT). Findings reveal that Israeli shadow operations and U.S. military encirclement reinforce the Iranian perception that nuclear

capabilities are essential for regime survival. To reduce arms-race incentives and prevent miscalculation, this study recommends integrating coercive diplomacy into a renewed multilateral framework. The study argues that a regional security architecture that connects rigorous verification mechanisms to credible security assurances must be established.

Keywords: *Iran, JCPOA, Middle East, Nuclear Proliferation, Regional arms race, Security*

Introduction

Nuclear weapons have reshaped global security dynamics, altering both regional and international stability. Although nuclear deterrence can prevent extensive wars, the spread of weapons among more states increases the risk of miscalculation and catastrophic outcomes (Krepon & Gagné, 2001; Talmadge et al., 2023).

During the Cold War, the United States and the Soviet Union maintained nuclear stability through a structured bipolar balance, establishing what scholars term the First Nuclear Age. Both superpowers relied on the doctrine of Mutually Assured Destruction (MAD), which made any offensive action invite devastating retaliation (Futter, 2021; Kroenig, 2020).

The post-Cold War era ushered in the Second Nuclear Age, marked by vertical proliferation of arsenals and the rise of new states and non-state actors pursuing distinct nuclear agendas. This shift complicated traditional nuclear diplomacy and deterrence networks.

Emerging nuclear powers, particularly in the Middle East, have altered the regional balance and introduced unprecedented security risks. These emerging powers lack the institutional mechanisms and communication channels that Cold War adversaries developed, increasing the likelihood that misunderstandings and miscalculations could easily trigger unintended escalations (Ahrari, 2014; Futter, 2021; Osimen et al., 2024a).

Iran's nuclear ambitions have generated specific concerns among neighbouring states and major powers. Saudi Arabia and Israel view a nuclear-capable Iran as a direct threat to regional stability; Saudi officials hinted at developing independent nuclear capabilities to establish a necessary counterbalance (Cordesman, 2022a; Fitzpatrick, 2020).

Regional Rivalries and external military encirclement create a security dilemma. Iran's defensive measures often appear offensive to its neighbours, while their countermeasures, such as Saudi interventionism and Israeli preemptive strikes, appear existential to Iran and thus reinforce its reliance on nuclear deterrence (Jan 2025).

If Iran becomes a nuclear power, Saudi Arabia and other regional actors may pursue nuclear programs, potentially triggering a broader arms race that would undermine the global non-proliferation regime and regional stability (Adami & Bakhshi, 2020; Olu-Owolabi et al., 2024; Chidozie et al., 2024).

The intersection of nuclear proliferation and non-state actor networks compounds these risks. Iran's support for groups such as Hezbollah and Hamas raises concern that these organisations might eventually access nuclear materials, creating security threats that extend beyond traditional diplomatic conflict (American Jewish Committee, 2024).

Geographical rivalries among regional and major powers have also reshaped Middle Eastern nuclear dynamics. The United States' withdrawal from the Joint Comprehensive Plan of Action (JCPOA) in 2018 illustrates how major-power decisions can destabilise arms control efforts and incentivise proliferation (Nephew, 2018). That withdrawal created significant uncertainty about Iran's nuclear trajectory and its implications for regional and global security.

Existing studies leave two critical gaps. First, scholars have not fully examined how the JCPOA's collapse and the reinstatement of U.S. sanctions altered Iran's strategic decision-making, specifically how external pressure empowered hardline factions, shifted governance dynamics, and pushed Iran towards nuclear hedging. Second, studies have underexamined structural drivers of Middle Eastern proliferation beyond Iran's actions, including U.S. strategic inconsistency, Israel's undeclared arsenal and covert operations against Iranian facilities, and Saudi Arabia's shift towards more offensive regional policies.

This study addresses these gaps by examining how interactions among regional and major powers create security dilemmas that drive proliferation. Rather than attributing instability solely to Iranian choices, it analyses the systemic factors that compel multiple actors towards nuclear weapons development. Therefore, the objectives of this study are to: Examine the regional security implications of Iran's nuclear program following the U.S. withdrawal from the JCPOA, and to analyse the structural drivers of nuclear proliferation dynamics in the Middle East.

Materials and Methods

This study employs an exploratory qualitative research design to examine the regional security implications of Iran's unconstrained nuclear program following the U.S. withdrawal from the JCPOA. This approach was selected to capture the complex geopolitical dimensions of nuclear proliferation, regional power dynamics, and multilateral non-proliferation mechanisms.

Data collection relies on secondary sources dated 2013-2025 to cover the pre-JCPOA period, the agreement's lifecycle, and subsequent Iranian nuclear escalation. The study prioritised secondary sources from established institutions, peer-reviewed journals, policy papers, conferences, and verified online sources to ensure reliability.

The inclusion criteria for sources were direct relevance to Iran's nuclear program, JCPOA implementation or collapse, regional security dynamics, or non-proliferation networks. The study also excludes unverified opinion pieces lacking empirical support and focuses instead on credible empirical data to rigorously assess source quality.

Thematic analysis was selected as the analytical technique to identify patterns, themes, and relationships that are not apparent through quantitative methods. The analysis interpreted these themes through deterrence theory, utilising offensive realism and defensive realism as supportive frameworks. This theoretical triangulation supports a balanced and objective assessment of regional nuclear dynamics.

Deterrence Theory in the Second Nuclear Age: The Offensive and Defensive Realism in the Context of Iranian Nuclear Proliferation

Deterrence theory emerged as a strategic framework to address the unprecedented challenges posed by nuclear proliferation. Bernard Brodie pioneered the concept in 1946, arguing that nuclear weapons shifted warfare's purpose from winning conflicts to preventing them (Brodie & Dunn, 1946). Thomas Schelling later expanded this framework by emphasising credible threats and rational state behaviour as central components of deterrence (Brodie, 1959; Schelling, 1980).

Traditional deterrence theory, tested during the Cold War between the United States and the Soviet Union, assumes that states act rationally to avoid the catastrophic outcomes of nuclear war (Freedman & Michaels, 2019). The theory holds that credible threats of retaliation dissuade aggression when confrontation risks catastrophic damage; this

stability depends on a mutual understanding that survival outweighs territorial or ideological gains. Applying deterrence theory to Iran's nuclear ambitions reveals limitations, particularly for regional stability and the risk of proliferation to non-state actors. Geller (2022) argues that the extreme risks of nuclear conflict can deter aggressive action and thus promote stability. However, this claim rests on the assumption that state decision-making remains uniformly rational.

Contemporary nuclear politics complicate that assumption; unstable regimes, ideological commitments, and persistent regional conflicts disrupt predictable state behaviour and weaken the rational foundations of traditional deterrence (Talmadge et al., 2023).

Offensive Realism, as articulated by Mearsheimer (2001), explains nuclear pursuits as efforts by states to maximise power and secure themselves against rivals. This perspective aligns with the behaviour of states that seek dominance and protection from perceived threats.

However, offensive realism does not fully account for the specific drivers of Iran's nuclear ambitions. Iran's motivations appear to combine ideological goals, particularly anti-Western sentiment, with regional hegemonic aspirations and acute security concerns. These motives suggest that Iran's nuclear trajectory could destabilise the region rather than stabilise it (Bahgat & Ehteshami, 2021).

Defensive Realism, grounded in Kenneth Waltz's work, offers a contrasting interpretation by emphasising security maximisation (Waltz, 1979). From this vantage, Iran's nuclear program functions as a hedge that guarantees regime survival against superior forces.

Defensive realists interpret Iran's support for proxy groups and its forward defence posture, deploying allies like Hezbollah and Hamas on its borders, as rational responses to structural vulnerabilities and conventional military inferiority (Oguejiofor, 2025). Both frameworks illuminate different aspects of the same observable behaviour, producing interpretive uncertainty. Offensive realism reads Iran's nuclear advancement as a hegemonic threat, defensive realism reads it as prudent security-seeking. This ambiguity undermines deterrence because relationships require a shared understanding of strategic intentions. When rival states interpret identical actions in opposing ways, mutual incomprehension can transform deterrence from a stabilising mechanism into a driver of further proliferation.

Iran's ideological commitments, evident in its support for proxy organisations and its rejection of Western alliances, complicate deterrence models that assume predictable, self-preserving state

behaviour (Barzegar, 2008). These ideological elements raise the prospect that Iran might employ nuclear capabilities for objectives beyond narrow self-defence, thereby increasing regional insecurity. Neighbouring states may respond to Iran's nuclear advances by seeking their own capabilities, which could ignite a regional arms race and erode the non-proliferation regime (Gause, 2014). The risk that nuclear materials could reach non-state actors further exposes deterrence theory's limits. Iran's ties to proxies raise concerns about diversion of nuclear assets and the consequent threat of nuclear terrorism, a danger that traditional state-centric deterrence frameworks do not adequately address (Segan & Narang, 2023).

Deterrence theory, therefore, retains analytical value but requires recalibration for the contemporary, multipolar environment. Offensive and Defensive Realism illuminate competing motives behind proliferation; however, neither fully explains the ideological drivers or the risk posed by weak institutional separation between states and non-state actors.

Iran's Nuclear Program

Iran frames its pursuit of nuclear capabilities as essential to national sovereignty and self-defence against external threats. These ambitions, however, have intensified regional tensions and prompted neighbouring states to bolster their military capabilities, producing a security dilemma in which Iranian measures and regional countermeasures mutually reinforce one another.

Tehran extends its influence through proxy networks, and when combined with potential nuclear capabilities, these networks raise the prospect of rapid escalation. Proxy violence originating beyond direct state control complicates traditional deterrence, since hostile acts may emanate from actors outside established command-and-control structures (Adami & Bakhshi, 2020). The possibility that non-state actors could obtain nuclear materials via Iranian channels constitutes a grave global security concern. Plitsas (2025) warns that proliferation to militant groups would exceed the assumptions of traditional deterrence theory, producing unpredictable threats that operate beyond state control and outside established IAEA safeguards, posing a global danger.

These risks unfold within the context of the Second Nuclear Age. The nuclear acquisitions of India, Pakistan, and North Korea have exposed weaknesses in Cold War deterrence assumptions and demonstrated how new nuclear states operate under distinct regional

pressures and honour-based logics (Sagan & Narang, 2023). Their decisions reflect regional conflict dynamics, rather than the bipolar stability that characterised the Cold War.

Rising instability across the Middle East, South Asia, and East Asia indicates that proliferation can increase the frequency of crises and the likelihood of miscalculation (Saalman & Topychkanov, 2021). In the Middle East, Iran's nuclear trajectory intersects with proxy conflicts, sectarian tensions, and great power competition, producing novel challenges for crisis management and escalation control.

Iran's nuclear potential, together with its substantial regional influence, has led neighbouring states to contemplate defensive nuclear options. Scholars argue that this combination of factors creates destabilising regional dynamics that demand a comprehensive international response (Geller, 2017; Takeyh, 2019).

Role of the IAEA in Nuclear Non-Proliferation and Efforts to Combat Iranian Proliferation

The International Atomic Energy Agency (IAEA) plays a central role in monitoring and verifying compliance with global non-proliferation norms, including oversight of Iran's nuclear program. As a specialised agency of the United Nations (UN), the IAEA implements safeguards under the Treaty on the Non-Proliferation of Nuclear Weapons, which require non-nuclear states to ensure that declared nuclear material does not divert to weapons development (Henderson & Heinonen, 2015).

To assess Iran's compliance, the IAEA employs a suite of verification measures, which include routine and ad hoc inspections, remote surveillance, environmental sampling, and analysis of Iran's nuclear material accountancy reports. These measures aim to confirm that declared facilities support peaceful activities, such as electricity generation and research (IAEA, n.d.).

IAEA operations in Iran face persistent challenges. Periodic restrictions on inspectors' access, delays in visa approvals, and unresolved questions about possible undeclared sites have raised doubts about Iran's full adherence to its safeguards obligations (IAEA, 2020). These frictions reflect tensions between Iran's assertions of sovereign control over sensitive facilities and the international community's demand for transparency regarding activities that could enable weapons development.

Despite these obstacles, the IAEA characterises its inspections in Iran as extensive (IAEA, 2020). Inspectors conduct scheduled and short-

notice visits, verify nuclear inventories, and review surveillance data from key installations. Verification remains complicated by the dual-use nature of nuclear technology; uranium enrichment, reactor operation, and fuel-cycle research can support either peaceful or military applications, depending on scale, configuration, and intent.

Since 2019, IAEA reports have documented that Iran exceeded enrichment levels and stockpile limits established by the JCPOA, thereby shortening estimated breakout timelines and heightening proliferation concerns (IAEA, 2021). These developments underscore the need for renewed diplomacy and strengthened verification arrangements.

Scholars recommend that future non-proliferation efforts reconcile states' rights to peaceful nuclear energy with stricter monitoring provisions, expanded access to suspect sites, and regional confidence-building measures (Khan et al., 2023; Bandarra & Martuscelli, 2024; Sakina et al., 2025).

Einhorn and Nephew (2019) propose a tailored verification regime that emphasises enhanced inspection rights and sustained monitoring. Implementing such measures, however, would require a broad international consensus, which geopolitical divisions and the contentious politics surrounding Iran's nuclear ambitions currently impede.

The JCPOA and Safeguards Against Iranian Proliferation

The Joint Comprehensive Plan of Action (JCPOA), concluded in 2015 between Iran and the P5+1 (the United States, United Kingdom, France, Russia, China, and Germany), represented a landmark arms-control agreement that constrained Iran's nuclear program in exchange for sanctions relief. This agreement capped uranium enrichment at 3.67% U-235, reduced installed centrifuges, and imposed strict verification measures through the IAEA (Pillar et al., 2013).

The agreement sought to extend Iran's estimated breakout time, the period required to produce sufficient fissile material for one device, by restricting enrichment levels, limiting stockpile size, and centrifuge types (Samore et al., 2015). Iran accepted the IAEA Additional Protocol, granting inspectors access to declared facilities and potential undeclared sites and thereby strengthening verification and reinforcing confidence in compliance.

Critics emphasised the JCPOA's sunset clauses, which phased out key restrictions after 10-25 years. They argued that these provisions could legally enable Iran to expand its nuclear capacity over time and shorten breakout timelines (Davenport, 2020; Osimen et al., 2024b). The

United States' withdrawal in May 2018 and the subsequent reimposition of sanctions destabilised the agreement, prompting Iran to exceed enrichment limits, install advanced centrifuges, and expand its stockpiles (IAEA, 2021). Although the IAEA continued monitoring under reduced arrangements, Iran curtailed some transparency measures by turning off certain surveillance equipment and restricting inspector access, which complicated verification (IAEA, 2025).

Nevertheless, when fully implemented, the JCPOA delivered concrete non-proliferation gains, Tehran dismantled the Arak heavy-water reactor, shipped out excess enriched uranium (no more than 300kg), and accepted continuous monitoring at key sites like Natanz and Fordow (European External Action Service, n.d.).

Implications of America's Exit from the JCPOA

The United States' 2018 withdrawal transformed efforts to constrain Iran's nuclear ambitions by removing the core exchange of sanctions relief for verifiable nuclear limits (Maloney, 2023). This rupture reversed the JCPOA's balance of incentives and immediately complicated multilateral enforcement and verification mechanisms.

Reimposed U.S. sanctions strained relations among European signatories and reduced their collective leverage over Tehran (Smith, 2019). European attempts to preserve limited economic channels failed to compensate for U.S. pressure, eroding Iranian trust and reinforcing perceptions of Western unreliability across successive U.S. administrations (Vaez & Sadjadpour, 2019; Cordesman, 2022b). The withdrawal undermined the credibility of multilateral non-proliferation diplomacy. Experts caution that abandoning a functioning arms-control agreement discourages future concessions when states doubt enforcement or political continuity. This raised substantive questions about the NPT and the IAEA when principal guarantors reverse course (United Nations, 2023; Cohen, 2025; Arms Control Association, 2025).

Regionally, the U.S. exit heightened threat perceptions in Israel and Saudi Arabia, prompting consideration of unilateral and bilateral measures to contain Iran, including deeper security cooperation and independent deterrent options. This shift away from a unified multilateral framework contributed to a more competitive and unstable Middle Eastern security environment.

In the aftermath, Iran expanded its nuclear activities, authorities deployed advanced centrifuges (IR-6, IR-8, IR-9), and increased enriched-uranium stockpiles beyond the JCPOA cap. Independent

analyses verify enrichment to 20% and 60% U-235 levels, which exceed the original 3.67% threshold (Kelley, 2021; Gadd et al., 2022; Liechtenstein, 2023; Iran Watch, 2025).

Tehran suspended the Additional Protocol in 2021, reducing inspector access and creating verification gaps (Mills, 2024). Messmer (2025) notes that restrictions and disabled surveillance equipment have complicated IAEA verification and increased uncertainty about undeclared facilities. These technical and transparency setbacks shortened estimated breakout timelines and left diplomatic revival efforts fragile (Robinson, 2023; Mills, 2024).

The Iranian Nuclear Program on Global Peace and Security

Regional Destabilisation and Proxy Warfare

Iran's involvement in the Israel-Gaza conflict illustrates how it leverages instability to expand influence while advancing its nuclear program. Following Hama's October 7, 2023, attack on Israel, Tehran voiced strong support for resistance groups, framed the assault within its Axis of Resistance strategy, and warned against Israeli retaliation, signaling its stake in the confrontation (Carl, 2023).

Iran's backing of Hamas, Hezbollah, and other militias increases the likelihood of direct confrontation with Israel. Exchanges of fire across the Lebanese-Israeli border and attacks on shipping and U.S. assets in Iraq, Syria, and the Red Sea demonstrate how proxy warfare can escalate rapidly.

Analysts observe that heightened conflict diverts international scrutiny, enabling Iran to advance enrichment and centrifuge deployment under diminished pressure while maintaining claims of peaceful intent (Aziz, 2024; Nashed, 2025; von Hein, 2025). The Gaza war has strained normalisation efforts under the Abraham Accords. Public outrage over civilian casualties has placed normalisation "off the table", prompting some Arab governments to distance themselves from U.S. and Israeli policies, thereby creating diplomatic space for Iran to strengthen ties and court new partners (Jamal, 2023; Harutyunyan, 2025).

This dynamic reinforces Tehran's deterrence posture, which has already hardened since the U.S. withdrawal from the JCPOA and the subsequent expansion of enrichment beyond agreed limits (Loft & Mills, 2025).

Iran's proxy network, including Hezbollah, Hamas, Iraqi militias, and the Houthis, provides funding, training, missiles, and drones that

threaten Israel, Gulf States, and maritime routes (Plitsas, 2025). Proxies operate with independent agendas, complicating deterrence and increasing the risk of miscalculation. A perceived Iranian nuclear shield may embolden militias to adopt riskier tactics, such as larger missile barrages or attacks on infrastructure (Cordesman & Hwang, 2021).

These dynamics highlight the need for renewed multilateral diplomacy that links nuclear restrictions to regional security guarantees. Analysts advocate a dual-track strategy combining arms-control measures, enhanced verification, targeted sanctions, and defensive cooperation to reduce the utility of Iran's nuclear leverage and stabilise the regional order (Asghedom et al., 2024).

Structural Drivers of Instability: The Role of Regional Competitors and External Powers

Iran's nuclear program remains a central source of instability in the Middle East, but it interacts with offensive postures of other regional powers and external actors. Since 2015, Saudi Arabia has shifted from a defensive posture to an aggressive interventionist stance under Crown Prince Mohammed bin Salman (Einhorn & Nephew, 2016). This strategic turn reinforces a self-perpetuating security dilemma in which states interpret their own actions as defensive and rivals' actions as aggressive, thereby deepening mistrust and militarisation.

Saudi Arabia's military intervention in Yemen, launched in March 2015 as Operation Decisive Storm, exemplifies this offensive trajectory. Riyadh framed the campaign as a response to Houthi expansion and alleged Iranian influence, yet the intervention hardened Houthi resistance, entrenched Yemen's division, and generated a humanitarian catastrophe (Darwich, 2018; Ranjan, 2023; Abdullah et al., 2024; Jody, 2024).

Similarly, the Saudi-UAE blockade of Qatar from 2017 to 2021 damaged Gulf Cooperation Council (GCC) cohesion and pushed Qatar towards closer engagement with Iran and Turkey, thereby expanding Tehran's diplomatic and economic space (Harsono & Ceria, 2024; Papageorgiou & Jamali, 2025).

Saudi policy also reflects ideological competition. The promotion of Wahhabi interpretations of Islam has shaped sectarian dynamics and contributed to radicalisation in Iraq and Syria, mirroring Iran's own ideological outreach (Mirza et al., 2021; Moosavin et al., 2022).

Israel's posture forms another structural driver of Iranian threat perceptions. Israel maintains deliberate ambiguity regarding its nuclear

arsenal, widely assessed as the region's only, and has conducted preventive strikes against adversaries' nuclear and missile infrastructure. These actions encourage neighbours to consider asymmetric or nuclear responses, reinforcing Iran's argument that deterrence requires nuclear hedging.

Israel pursues a sustained preemptive campaign against Iran's nuclear program, combining covert operations, targeted assassinations, and cyberattacks such as the Stuxnet virus, which damaged centrifuges at Natanz (Aanonsen, 2025; Livermore, 2025; Gulf News, 2025). While these measures delayed Iran's progress, they strengthened Tehran's conviction that nuclear weapons are vital for regime survival. Iran also perceives strategic encirclement by U.S. forces stationed across the Middle East, including bases in Bahrain, Qatar, Kuwait, Saudi Arabia, the UAE, Iraq, and Turkey (Tabatabai et al., 2021; Sichani & Jalalirad, 2025). This conventional asymmetry drives reliance on asymmetric tools, such as ballistic missiles, drones, proxies, and nuclear hedging as cost-effective deterrents.

The U.S. maximum pressure sanctions after 2018 further weakened pragmatic factions and empowered hardliners who argue that only nuclear deterrence can shield Iran from coercion (Overhaus, 2020; Connelly, 2025). Regional instability thus arises from overlapping revisionist agendas. Saudi Arabia seeks to limit Iranian influence, Israel aims to preserve its military edge, Turkey seeks to gain influence in Syria and Iraq, and the United States strives to retain primacy despite retrenchment (Bahgat, 2020; Abadi et al., 2024). Structural realism explains how defensive moves appear offensive, reinforcing arms races.

Durable stability requires an inclusive security architecture that addresses the survival concerns of Iran, Saudi Arabia, Israel, Turkey, and the Gulf. Without such arrangements, unilateral sanctions and covert campaigns risk accelerating rather than constraining proliferation incentives (Bahgat, 2020; Alakel & Arab, 2025).

Conclusion

An unconstrained Iranian nuclear program threatens regional and global security by intensifying proliferation risks and crisis instability. Advanced nuclear capabilities combined with proxy networks weaken deterrence assumptions and expose the limits of viewing Iran solely through offensive realism. The U.S. withdrawal from the JCPOA in 2018 eroded multilateral trust, empowered hardliners, and encouraged non-compliance, which shortened breakout timelines. Reduced transparency

and unresolved safeguards issues constrain the IAEA's verification capacity, amplifying uncertainty. Regional actors adopt hedging strategies that reinforce a dangerous security dilemma, escalating tensions and heightening the risk of a broader arms race. Durable stability requires restored restrictions, strengthened verification, and credible security assurances through structured dialogue.

Areas for Further Study

The following refinements are essential for strengthening global security models and rebuilding confidence in non-proliferation norms:

1. Further research should compare Iran's nuclear trajectory with North Korea and the India-Pakistan conflict to test deterrence theory globally. Such analysis would reveal whether the fragility observed in the Middle East reflects a broader pattern of multipolar instability.
2. Scholars must design diplomatic frameworks resilient to leadership changes in major powers and agreements that combine credible security guarantees with robust verification mechanisms.
3. Evaluating enhanced monitoring technologies remains central for improving IAEA access in contested areas.
4. Traditional Deterrence models require supplementation with approaches that account for ideological commitments, regime instability, proxy networks, and heightened misperception risks in multipolar orders.

Acknowledgements:

The authors are profoundly grateful to the Covenant University Centre for Research, Innovation, and Discovery (CUCRID) for funding this publication.

Declaration of Conflict of Interest:

The authors declare no conflict of interest.

Data Availability Statement:

The authors affirm that the data sets generated during this study are available from the findings and conclusions of the article.

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