The Impact of the Russia-Ukraine Conflict on the Cloud Computing Risk Landscape

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***Abstract*—The Russian invasion of Ukraine has fundamentally altered the information technology (IT) risk landscape, particularly in cloud computing environments. This paper examines how this geopolitical conflict has accelerated data sovereignty concerns, transformed cybersecurity paradigms, and reshaped cloud infrastructure strategies worldwide. Through an analysis of documented cyber operations, regulatory responses, and organizational adaptations between 2022 and early 2025, this research demonstrates how the conflict has served as a catalyst for a broader reassessment of IT risk. The research reveals that while traditional IT risk frameworks offer foundational guidance, their standard application may inadequately address the nuances of state-sponsored threats, conflicting data governance regimes, and the weaponization of digital dependencies without specific geopolitical augmentation. The contribution of this paper lies in its focused synthesis and strategic adaptation of existing best practices into a multi-layered approach. This approach uniquely synergizes resilient cloud architectures (including sovereign and hybrid models), enhanced data-centric security strategies (such as advanced encryption and privacy-enhancing technologies), and geopolitically-informed governance to build digital resilience. The interplay between these layers, emphasizing how geopolitical insights directly shape architectural and security choices beyond standard best practices—particularly by integrating the human element, including personnel vulnerabilities and expertise, as a core consideration in technical design and operational management—offers a more robust defense against the specific, multifaceted risks arising from geopolitical conflict in increasingly fractured digital territories.**

Keywords—Cybersecurity, data sovereignty, geopolitical risk, IT risk, Russia-Ukraine conflict

I. Introduction

The global cloud computing landscape has undergone a profound transformation since Russia's full-scale invasion of Ukraine in February 2022. What began as a conventional military conflict quickly expanded into cyberspace, presenting unprecedented challenges for organizations, Cloud Service Providers (CSPs), and policymakers worldwide. The conflict has become a critical inflection point in the evolution of information technology (IT) risk, particularly concerning data sovereignty, infrastructure resilience, and cybersecurity governance. Geopolitical tensions are increasingly expressed and contested within the digital sphere, with technology, data, and artificial intelligence (AI) becoming central arenas for great power competition [1].

Cloud computing, once primarily evaluated through technical and operational risk lenses, now faces scrutiny through geopolitical frameworks. Traditional IT risk management focused predominantly on technical vulnerabilities, human errors, and localized cyber threats [2]. However, the contemporary global landscape has witnessed a significant transformation where macro-level geopolitical factors increasingly dictate the contours of IT risk. These factors transcend organizational boundaries, introducing systemic risks that challenge conventional risk management approaches. Cybersecurity threats, often state-sponsored, are aligning more closely with geopolitical objectives, creating a new paradigm of *digital geopolitical risk*.

The Russia–Ukraine conflict provides a compelling case study of how geopolitical tensions directly impact cloud computing security, availability, and compliance. This paper examines how the conflict has accelerated existing trends toward data sovereignty, catalyzed new approaches to infrastructure resilience, and fundamentally altered risk calculations for organizations dependent on cloud services. The novelty of this research lies not in proposing entirely new individual defense mechanisms, but rather in synthesizing and strategically adapting recognized best practices into a cohesive, multi-layered framework. This framework is specifically tailored to address the complex, multifaceted risks at the nexus of cloud technology and international conflict. It achieves this by detailing the crucial, dynamic interplay and prioritization of its constituent layers—architecture, data security, and governance—when confronting such threats. A central argument is that geopolitical insights derived from the governance layer must actively inform and shape architectural decisions, which, in turn, dictate specific data security controls, going beyond standard applications of these practices. Furthermore, the framework deeply embeds the human element—encompassing expertise, awareness, and vulnerability to geopolitical pressures—as a critical factor throughout each layer, recognizing that technology and policy are ultimately implemented and managed by people. This synthesized approach aims to fill a crucial gap by providing a holistic strategy for navigating a digital world where IT risk is inextricably linked with geopolitical instability.

A. Research Objectives and Methodology

This research aims to analyze the direct and indirect impacts of the Russia–Ukraine conflict on cloud computing infrastructure, operations, and governance. It seeks to assess how the conflict has transformed data sovereignty approaches, evaluate how existing IT risk management frameworks can be augmented to address geopolitical realities, and propose strategies for building resilient cloud architectures in an era of heightened geopolitical uncertainty.

The study employs a qualitative synthesis methodology, primarily involving a comprehensive review and analysis of existing information. This includes an in-depth review of technical reports and threat intelligence from cybersecurity firms, an examination of regulatory developments and policy documents from key jurisdictions, an assessment of documented cloud service disruptions and cyber operations, and a comparative analysis of risk management approaches discussed in literature published before and after the full-scale invasion. For instance, the documented shift in Ukraine's data hosting policies post-invasion [3]—moving government data to international cloud facilities—compared to pre-conflict

norms illustrates a direct adaptation influenced by geopolitical duress. Data sources include cybersecurity threat reports [4], [5], [6], [7], [8], [9], regulatory filings [10], [11], [12], [13], technical documentation, academic papers, and expert analyses published before and up to May 2025. Given the recency of some 2025 data, particularly from Quarter 1 (Q1) and Quarter 2 (Q2), it is acknowledged that certain findings based on this very current information may be subject to further refinement as more comprehensive annual analyses become available, though sources are cited based on their publication status. The core methodological contribution lies in the structured analysis and synthesis of these diverse qualitative data sources to provide a comprehensive overview of the evolving risk landscape and to develop the proposed multi-layered framework.

B. Defining Key Concepts

Understanding the evolving IT risk landscape requires clarity on several core concepts:

- *Data Sovereignty* refers to the fundamental ability of an entity—be it an individual, organization, or nation—to exercise control over its own digital destiny. This control extends to the data, hardware, and software upon which it relies and creates [14]. Crucially, data are subject to the laws and governance structures of the country in which they are collected or stored, meaning data sovereignty inherently involves legal jurisdiction over data.
- *Data Localization* describes regulatory requirements mandating that data are to be stored and/or processed domestically, within the geographical borders of a specific country [15].
- *Sovereign Cloud* describes cloud computing infrastructure and services specifically designed to comply with the geographic and legal requirements of a particular nation. The primary aim is to ensure data residency and adherence to local regulations, often explicitly offering protection against foreign data access demands [16]. The motivations include ensuring data privacy, regulatory compliance, bolstering national security, and reducing strategic dependence on foreign CSPs [17].
- *Geopolitical IT Risk* is used to synthesize a concept encompassing IT-related risks—such as data breaches, service disruptions, compliance failures, and loss of intellectual property—that are directly or indirectly caused or significantly exacerbated by international political tensions, unilateral state actions, conflicts over digital resources, or divergent approaches to digital governance. This understanding is informed by works like [18], which underscore the connection between geopolitical risk and significant cybersecurity implications, and the broader concept of "digital geopolitical risk" where data governance laws become instruments of national strategy and cybersecurity threats align with geopolitical objectives.

II. The Nexus of Geopolitics, Data, and Cloud Computing

A. Data as a Geopolitical Asset

In the contemporary global arena, data have transcended their role as a mere economic resource to become a strategic geopolitical asset. Control over data, its access, and its utilization are now central to national interest, underpinning national security, economic competitiveness, and international influence [19]. Nations actively seek to govern data flows and storage to empower law enforcement, stimulate domestic economic growth, and safeguard the rights and privacy of their citizens. The U.S. National Security Strategy emphasizes outmaneuvering geopolitical competitors, linking technological leadership to national power [1]. The capacity to collect, analyze, and control vast datasets is particularly crucial for advancements in transformative technologies like AI, further amplifying data's geopolitical significance, as AI is seen as a foundational element of the innovation economy and a source of national power [20]. Technology, particularly data and AI, has become a central arena for great power competition.

B. The Rise of Digital Sovereignty

The global pursuit of digital sovereignty is driven by a confluence of factors, including concerns over foreign surveillance, the desire for local economic development in the digital sector, the protection of citizen privacy, and the assertion of national control in the digital sphere. This global trend manifests in diverse regulatory and strategic approaches across jurisdictions, leading to a "fracturing digital world" characterized by regulatory divergence.

The European Union (EU) has been at the forefront of asserting digital sovereignty. The General Data Protection Regulation (GDPR) stands as a prime example, establishing a unified framework for data protection across member states [10]. Its significant extraterritorial reach, applying to entities outside the EU if they process data of EU individuals [21], has led to “The Brussels Effect,” where EU standards shape global business practices [22]. The EU's Data Governance Act (DGA) further aims to facilitate data sharing within a "single market for data" [23]. Initiatives like Gaia-X seek to build a federated and secure data infrastructure for Europe, promoting data sharing under European rules.

The United States (US) has adopted a different stance, characterized by laws enabling government access to data and strategic use of technology controls. The Clarifying Lawful Overseas Use of Data (CLOUD) Act permits U.S. law enforcement agencies to compel U.S.-based technology companies to provide data stored on their servers, irrespective of the data's physical location [11], establishing a novel form of "international lawmaking via domestic regulation" [24]. This extraterritorial reach directly conflicts with privacy regimes like the GDPR. The U.S. also employs export controls on advanced technologies as a national security tool [25].

China has implemented a robust state-centric model of digital sovereignty. The Personal Information Protection Law (PIPL) and the Cybersecurity Law mandate strict data localization for critical information infrastructure operators and grant the government broad access to data stored within its jurisdiction [12]. PIPL also has extraterritorial scope, applying to the processing of personal information of individuals in China by entities outside the country. These measures align with China's broader strategy of technological self-reliance [26]. Through its Digital Silk Road initiative, China is also actively extending its technological influence and standards internationally.

Russia has progressively implemented stringent measures for state control over its digital space, exemplified by the

"RuNet Sovereignty Act" (Federal Law No. 90-FZ) [27], designed to centralize control over internet traffic and enable operational independence of the Russian internet segment. Strict data localization laws further solidify this control.

A growing number of countries, particularly emerging economies, are enacting their own data localization laws and data protection frameworks. This reflects a broader global trend of "regulatory emulation", where countries adopt and adapt models from others, contributing to a more multipolar and fragmented global digital governance landscape [28]. As of early 2023, nearly 100 distinct data localization measures were in effect across approximately 40 countries [29].

C. Cloud Computing as a Geopolitical Battleground

Cloud computing infrastructure and services have become indispensable for modern economies, but their provision and governance are now deeply enmeshed in geopolitical competition. A significant concentration of market power resides with a few U.S.-based hyperscale CSPs, namely Amazon Web Services (AWS), Microsoft Azure, and Google Cloud Platform (GCP) [30]. This dominance creates substantial dependencies for many nations and organizations worldwide, particularly in regions like Europe, which exhibit a heavy reliance on these U.S. providers for critical digital infrastructure.

This concentration of control is a key factor fueling digital sovereignty movements globally. Nations perceive this reliance on a handful of foreign providers as a strategic vulnerability. The ability of the U.S. government, through mechanisms like the CLOUD Act, to potentially access data held by these providers globally amplifies these concerns [31].

Such dependencies render cloud services inherently vulnerable to unilateral state actions. These actions can range from the imposition of tariffs on IT components [32] to more direct interventions like sanctions that restrict access to cloud services, or compelled data disclosure under national security mandates. Consequently, the physical location of data centers, the nationality of the CSP, and the legal jurisdictions under which they operate have transformed from technical considerations into critical geopolitical variables. For instance, a sudden geopolitical shift could lead a nation to mandate that all cloud services used by domestic companies be provided by entities not subject to the laws of an adversarial nation, directly impacting cloud provider selection and data migration strategies for any organization operating within that nation. The digital domain is emerging as a key battleground for shaping global norms and power balances.

III. The Russia–Ukraine Conflict as a Catalyst for IT Risk Evolution

The full-scale invasion of Ukraine by Russia, commencing in February 2022, has not only caused immense human suffering and geopolitical upheaval but has also served as a stark illustration of how geopolitical conflict can catalyze and reshape IT risks. This conflict has become a live laboratory for observing the interplay between cyber operations, data sovereignty concerns, and the resilience of digital infrastructure, including cloud services, under extreme duress.

A. Pre-Conflict Digital Landscape and Tensions

Prior to the 2022 invasion, Ukraine was actively pursuing a path of digital transformation. A notable achievement was the launch and expansion of the Diia platform, a mobile application and web portal designed to provide citizens with digital identification and access to a wide range of public services [33], often leveraging cloud backends for scalability and service delivery. Ukraine demonstrated remarkable digital resilience during the conflict, adapting Diia for wartime needs and leveraging global technology partnerships (Starlink, AWS, Microsoft Azure) [34].

Russia had already established a significant legal and technical framework aimed at asserting greater state control over its domestic internet segment. This included the "RuNet Sovereignty Act" (Federal Law No. 90-FZ) [27], designed to enable the Russian internet (RuNet) to function independently of the global internet if necessary, the Yarovaya laws mandating data retention and enabling surveillance, and ongoing efforts towards stricter data localization for Russian citizens' data. These measures reflected an underlying strategic objective to enhance state control over information flows and digital infrastructure, partly driven by concerns about foreign influence and domestic dissent, and significantly impacting how both domestic and international cloud services could operate within Russia.

B. Cyber Operations as an Integral Part of Modern Warfare

The Russia–Ukraine conflict has unequivocally demonstrated that cyber operations are no longer an adjunct to conventional warfare but an integral component, utilized for espionage, disruption, destruction, and influence. Technology, data, and cyber capabilities are increasingly employed as instruments of power.

The conflict has witnessed a marked escalation in both the volume and sophistication of cyberattacks. The Computer Emergency Response Team of Ukraine (CERT-UA) reported a substantial 48% increase in the number of cyber incidents in the second half of 2024 compared to the first half [35]. Microsoft observed that Russian, Iranian, and Chinese actors intensified cyber operations in conjunction with geopolitical conflicts, including targeting critical infrastructure and leveraging AI for influence operations [5].

Intelligence from various cybersecurity firms corroborates this trend. ESET Research documented intensified malicious cyber activity by Russian-aligned Advanced Persistent Threat (APT) groups such as Sednit (Fancy Bear/APT28), Gamaredon, and Sandworm (APT44) [4]. These groups were observed exploiting vulnerabilities, including zero-days (e.g., CVE-2024-11182 by APT28), and deploying new data-wiping malware, such as ZEROLOT by Sandworm against Ukrainian entities [4]. These actions highlight a core aspect of modern conflict: the weaponization of digital dependencies. Nations and organizations relying on interconnected digital infrastructure, including cloud services that may have components, management planes, or support structures in various geopolitical locations, find these dependencies transformed into attack vectors. For example, attacks could target vulnerabilities in the Application Programming Interfaces (APIs) of cloud services, the management consoles used by customers, or the underlying virtualization technology, aiming to disrupt services for a wide range of users or gain access to customer data hosted in the cloud.

Mandiant (now part of Google Cloud) has highlighted Russia's strategy of drawing on cybercriminal capabilities to augment its state-sponsored operations. For instance, APT44 (Sandworm), a unit of Russia's Main Intelligence Directorate

(GRU), has been observed employing malware readily available in cybercrime communities [6]. This malware, while perhaps not originally designed for cloud environments, can be adapted to compromise cloud-hosted virtual machines or storage, particularly if customer configurations are weak or unpatched. Exploits remained the most common initial infection vector in Mandiant's 2024 investigations (33%) [6]. Microsoft has also reported that nation-state actors, including Russia, are increasingly incorporating AI-generated or enhanced content, often produced using cloud-based AI services, into their influence operations to improve productivity and engagement [5], [9].

A consistent feature of Russian cyber operations in the conflict has been the persistent targeting of Ukraine's critical infrastructure, including energy, transport, and telecommunications sectors, as well as government and military systems [34]. The updated Rapid Damage and Needs Assessment (RDNA4) released in February 2025 by the Government of Ukraine and international partners found that direct damage to Ukraine's assets had reached $176 billion by December 31, 2024, with reconstruction costs estimated at $524 billion. There was a staggering 70% increase in damaged or destroyed energy sector assets since the previous assessment [36]. While physical attacks are prominent, cyberattacks often serve as precursors or complementary efforts, targeting the industrial control systems (ICS) or enterprise IT systems managing this infrastructure, which are increasingly connected to or monitored via cloud platforms.

The cyber threat extends beyond Ukraine's borders. A joint cybersecurity advisory issued by the Cybersecurity and Infrastructure Security Agency (CISA) and partner agencies in May 2025 detailed an ongoing campaign by GRU unit 26165 (widely known as APT28 or Fancy Bear) targeting Western logistics entities and technology companies involved in the coordination, transport, and delivery of foreign assistance to Ukraine [7]. These actors also targeted Internet-connected IP cameras at Ukrainian border crossings to monitor and track aid shipments, data from which might be aggregated or processed using cloud storage and analytics. This focus on the logistical supply chain underscores a critical vulnerability: the dependence of physical aid and military support on digital systems, including cloud-based logistics platforms, making the cyber domain a key enabler or disrupter of conventional warfare support operations. The war highlighted acute vulnerabilities of logistics networks and humanitarian aid organizations.

Alongside disruptive and espionage-focused cyberattacks, Russia has waged extensive influence operations aimed at shaping narratives, undermining support for Ukraine, and sowing discord in Western societies. Google's Threat Analysis Group (TAG) reported on numerous Russian coordinated influence operations, involving actors such as Portal Kombat and Doppelganger, which utilized fake news websites and impersonated legitimate media [8]. These campaigns disseminated content in multiple languages across various platforms, many of which are cloud-hosted social media or content delivery networks, supporting Russian narratives and criticizing Ukraine and its allies.

C. Impact on Data Sovereignty and Localization

The war has had a profound impact on how both Ukraine and Russia approach data sovereignty and localization, with significant implications for cloud adoption and governance.

Facing relentless physical and cyberattacks on its infrastructure, Ukraine demonstrated remarkable digital resilience. A key element of this resilience was the strategic leverage of cloud-based solutions, a decision undoubtedly involving skilled personnel capable of rapid assessment and implementation under duress. The Ukrainian government amended its data protection laws (Resolution No. 263) to enable the storage of government data and critical databases in international cloud facilities [3], [34]. This move was crucial for ensuring the continuity of governance, maintaining access to essential public services, and protecting vital information from destruction or compromise. Specifically, capabilities such as scalable cloud storage for critical datasets (e.g., citizen registries, land titles), geographically distributed disaster recovery options offered by global CSPs, and secure communication platforms provided by international CSPs proved invaluable. The Diia platform, for instance, not only continued to function but also expanded its services to support citizens during the crisis, facilitating access to aid, information, and communication channels, all heavily reliant on resilient cloud architectures managed by individuals working under extreme geopolitical stress [34].

In parallel, Russia has significantly tightened its control over its domestic digital space. Amendments to Russia's Federal Law "On Personal Data" (FZ-23), set to take effect on July 1, 2025, will impose even stricter data localization requirements. These changes extend localization obligations to "processors" of data (not just operators) and explicitly prohibit the use of foreign databases for the initial collection of Russian citizens' personal data, compelling all stages of data handling to occur on Russian territory [13]. This legislative tightening signals a clear intent to consolidate state control over data and limit external access or influence, effectively compelling any entity, including cloud service users and providers, to ensure specific data remain within Russia's digital borders. This also implies increased scrutiny and potential pressure on personnel managing such localized data infrastructures.

This move towards stricter data control is accompanied by intensified wartime censorship and suppression of dissent. The Russian government has blocked access to numerous independent media outlets and social media platforms, restricted the use of Virtual Private Networks (VPNs) (which could be used to access international cloud services), and aggressively prosecuted individuals for disseminating "fakes" about the Russian military or criticizing the war, as detailed by OVD-Info [37]. These actions illustrate the dual-use nature of data sovereignty policies in authoritarian contexts, especially during wartime. While ostensibly framed in terms of national security and data protection, these measures also serve as powerful tools for consolidating state control over information, shaping public narratives, and suppressing opposition, with direct consequences for the use and accessibility of global cloud platforms and for the individuals who might seek to use them to bypass state controls.

D. Consequences for Cloud Service Providers and Users

The conflict has precipitated significant consequences for CSPs and their users, both within the immediate region and globally. The direct targeting of digital infrastructure and the imposition of sanctions (e.g., EU Council Regulation (EU) 2022/263 [38]) have created heightened operational risks. CSPs with infrastructure or significant customer bases in the conflict zone or in Russia faced immediate challenges related

to service continuity, data protection, and compliance with rapidly changing legal and political landscapes. Many international technology companies, including major CSPs like AWS, Microsoft Azure, and Google Cloud, suspended or significantly curtailed their operations in Russia, impacting Russian businesses reliant on these global cloud services. This also affected personnel of these CSPs and their customers in the region, who faced operational and personal uncertainties.

Globally, the conflict has served as a stark reminder of the vulnerabilities associated with storing data in geopolitically unstable regions or with providers subject to the jurisdiction of potentially adversarial states. This has accelerated the demand for sovereign cloud solutions and hybrid cloud architectures as organizations seek to mitigate these newly illuminated risks. There is a growing awareness among businesses and governments of the need to carefully assess the geopolitical exposure of their data and digital assets, leading to a re-evaluation of cloud strategies and a greater emphasis on data residency, jurisdictional control, and provider nationality. For instance, a multinational corporation might now reassess hosting its European customer data with a provider whose primary nationality could become a geopolitical liability, or it might reconsider the concentration of its cloud resources in regions perceived as potential flashpoints. These decisions involve complex assessments by human experts weighing technical, legal, and geopolitical variables.

IV. Global Ripple Effects: Transformation of Cloud Computing Landscapes

The dynamics observed in the Russia–Ukraine conflict are not isolated; they reflect broader global trends where data jurisdiction and geopolitical considerations are increasingly shaping IT risk. Several key manifestations illustrate this complex interplay on a worldwide scale. It is also worth noting that while a "hot" conflict like the one in Ukraine presents immediate and visceral IT risks, a "cold" geopolitical rivalry, such as that between the U.S. and China, fosters a different, yet equally significant, set of chronic IT risks. In the latter, the nature of IT risk might manifest less as sudden, destructive cyberattacks and more as sustained espionage targeting cloud-hosted intellectual property (as noted by the National Security Commission on Artificial Intelligence (NSCAI) regarding China's cyber activities [20]), technology decoupling pressures impacting cloud supply chains, regulatory divergences complicating global cloud deployments, and long-term supply chain insecurities for critical cloud hardware, though the intensity and imminence of these risks can escalate rapidly with political shifts. These chronic risks often require a different kind of vigilance and strategic planning, heavily reliant on human intelligence analysis and foresight.

A. The U.S.–China Tech Rivalry

The technological competition between the United States and China has evolved into a defining geopolitical contest of the 21st century. This rivalry spans critical domains including AI, quantum computing, advanced manufacturing, 5G telecommunications, and dominance in global supply chains—many of which are heavily reliant on cloud computing power and infrastructure. The Special Competitive Studies Project (SCSP) identified the People's Republic of China (PRC) as the US's "chief ideological opponent" and "technology peer", aiming to harness the "next tech wave" [26]. China has been reported as outpacing the U.S. in certain critical technology areas, driven by a coordinated state-led approach.

A central battleground in this rivalry is the semiconductor industry, which is foundational to all cloud infrastructure. The U.S. has implemented stringent export controls, such as those under the Export Control Reform Act (ECRA) and the Foreign Direct Product Rule (FDPR), aimed at restricting China's access to advanced semiconductor manufacturing equipment and high-performance chips, citing national security concerns [25]. These measures are intended to slow China's progress in AI and other strategic technologies that rely on advanced computing capabilities, directly affecting the ability of Chinese CSPs to build out next-generation cloud infrastructure and potentially impacting global supply chains for cloud hardware.

This intense rivalry has profound implications for the IT risk landscape, particularly for cloud computing. For Multinational Corporations (MNCs), this rivalry translates into concrete cloud risks such as:

- MNCs may face pressure to align with either U.S. or Chinese technology stacks, potentially limiting their choice of CSPs or forcing costly migrations if geopolitical alignments shift. For example, restrictions on using specific CSPs (e.g., a Chinese CSP for a U.S. government contractor, or a U.S. CSP for certain state-owned enterprises in China) can emerge, complicating global IT strategies. A company might find its preferred global CSP unwelcome in a key market due to these pressures, decisions often influenced by nuanced human interpretation of geopolitical risk signals.
- MNCs using U.S. CSPs may face scrutiny in China (and vice versa), with concerns about data access by foreign governments (e.g., via CLOUD Act or similar Chinese measures like PIPL [12]). This can lead to demands for data localization within specific blocs, complicating global data management strategies and potentially requiring separate cloud environments for different regions, increasing costs and complexity. Navigating these conflicts requires astute legal and technical expertise.
- Cloud services, or the underlying infrastructure they depend on (like advanced semiconductors), could become targets of broader sanctions or export controls. An MNC might find its cloud services degraded or inaccessible in a particular region if its provider is impacted by sanctions related to the U.S.–China rivalry, even if the MNC itself is not directly targeted. For instance, if a U.S. CSP is barred from using specific Chinese-sourced components essential for a particular service, that service's availability or performance could be affected globally.
- Cloud platforms, being repositories of vast amounts of data, become prime targets for state-sponsored espionage. The U.S.–China rivalry heightens the risk of sophisticated APTs (e.g., Chinese groups like Mustang Panda targeting government and maritime sectors [4], or Volt Typhoon targeting U.S. critical infrastructure [39]) attempting to infiltrate cloud environments hosted by providers perceived as aligned

with the opposing side, or targeting corporate tenants on those clouds to steal intellectual property or strategic plans. The security models of global CSPs are thus uniquely stress-tested by the need to defend against well-resourced state actors from multiple, competing geopolitical blocs, relying heavily on the skill and vigilance of their cybersecurity personnel.

The risk of a bifurcated global technology ecosystem, or a "digital cold war", is palpable, where countries and companies may be forced to align with either U.S. or Chinese technology stacks and standards [40]. This directly impacts multi-cloud strategies, as using providers from both "blocs" could become operationally untenable or legally risky. This exemplifies "techno-nationalism", where technological capabilities are inseparable from national power.

B. Conflicting Legal Frameworks

A major source of geopolitical IT risk stems from the proliferation of national data governance laws with extraterritorial reach, often leading to direct legal conflicts for multinational organizations using global cloud services. The EU's GDPR [10], the U.S. CLOUD Act [11], and China's PIPL [12] are prime examples, creating a "compliance trilemma". These conflicting frameworks, detailed in Table I, place MNCs in challenging positions where adherence to one jurisdiction's law may necessitate violating another's.

TABLE I. COMPARATIVE ANALYSIS OF KEY GLOBAL DATA GOVERNANCE REGULATIONS

Feature	GDPR (EU)	CLOUD Act (US)	PIPL (China)	Russian Data Localization Laws (e.g., FZ-152, FZ-23)
Primary Goal	Data Protection/Privacy Rights of Individuals [10]	Law Enforcement Access to Data for Investigations [11]	Personal Information Protection, Regulate Data Handling, Promote Rational Use [12]	State Control, National Security, Data Sovereignty [13], [27]
Territorial Scope	Extraterritorial: Applies if processing data of EU individuals, regardless of controller/processor location [21]	Extraterritorial: U.S. providers must disclose data in their control, regardless of storage location [11]	Extraterritorial: Applies to processing activities outside China if for providing products/ services to, or analyzing, individuals in China [12]	Primarily National: Focus on data of Russian citizens and operations within Russia [13]
Key Data Transfer/ Localization	Strict conditions for non-EU/EEA transfers; adequacy decisions, SCCs [a], BCRs [b] required [10]	Facilitates international data access agreements; asserts U.S. jurisdiction globally for U.S. providers [41]	Security assessment/ certification/standard contract for cross-border transfer; domestic storage for CII [c] operators and large handlers [12]	Mandatory domestic storage and processing for personal data of Russian citizens; prohibition on use of foreign databases for collection [13]
Enforcement/ Penalties	Fines up to €20 million or 4% of global annual turnover [10]	Contempt of court, legal sanctions for non-compliance with U.S. legal process [11]	Fines up to 50 million RMB or 5% of annual revenue; service suspension; personal liability for responsible individuals [12]	Fines, blocking of resources, service suspension; potential criminal liability [13], [27]
Key Implications for Businesses	High compliance burden; need for DPOs [d], DPIAs [e], robust consent mechanisms; data mapping essential	Potential conflicts of law with other jurisdictions; need to respond to U.S. warrants globally	Need for local representation, consent mechanisms, data transfer impact assessments; navigating state security reviews	Significant operational adjustments for data localization; restrictions on using global cloud services; increased scrutiny from Roskomnadzor

[a] SCCs: Standard Contractual Clauses [b] BCRs: Binding Corporate Rules [c] CII: Critical Information Infrastructure [d] DPOs: Data Protection Officers [e] DPIAs: Data Protection Impact Assessments

This comparison highlights the diverse motivations and mechanisms of data governance, ranging from individual rights protection in the EU to state control and law enforcement access priorities in other regions. The extraterritorial reach of these laws, particularly the U.S. CLOUD Act and China's PIPL, creates significant challenges for organizations attempting to maintain global operations while adhering to data sovereignty requirements. For instance, a U.S.-based CSP hosting an EU company's data within an EU data center could be caught between a U.S. warrant for data and GDPR's prohibition on transferring it.

These conflicting legal frameworks place MNCs in "no-win" compliance scenarios, where adhering to one jurisdiction's law may necessitate violating another's, exposing them to significant legal (fines up to 4-5% of global annual turnover under GDPR/PIPL), financial, and reputational risks [29]. This erosion of trust in the predictability and coherence of international legal frameworks for data is pushing organizations towards costly and often inefficient data siloing—such as establishing separate cloud tenants or even entirely separate CSPs for different regions—as a perceived "safer", albeit sub-optimal, strategy to avoid being caught in these legal crossfires. Effectively navigating this requires more than just technical fixes; it demands sophisticated governance involving human expertise in international law and risk management, and strategic architectural choices, as explored later in this paper.

C. Data Localization Trends

Driven by motivations of data sovereignty, national security, and economic protectionism, data localization mandates are becoming increasingly common worldwide. By early 2023, nearly 100 distinct data localization measures were reportedly in place across approximately 40 countries [29], [42]. These laws typically require that data generated within a country are stored and/or processed on servers physically located within that country's borders (e.g., Russia's FZ-23 mandating domestic storage for Russian citizens' data [13]), directly impacting cloud deployment models.

While proponents argue that localization enhances national security, protects citizen privacy, and can stimulate local digital economies—and indeed, some governments may point to increased control over critical national data or a perceived boost in citizen trust within their jurisdiction as specific benefits—numerous studies and reports, including those from the Organisation for Economic Co-operation and Development (OECD) and Khasru [29], point to significant negative economic consequences on a broader scale. Data localization can increase data management costs for businesses by up to 55% [29], particularly when requiring separate cloud instances or dedicated local infrastructure. These costs disproportionately affect Small and Medium-sized Enterprises (SMEs), which may lack the resources, including specialized personnel, to establish local data infrastructure or afford premium-priced local cloud zones in

multiple jurisdictions. Beyond direct costs, data localization can hinder innovation, particularly in data-driven sectors like AI and cloud computing, which often benefit from the ability to aggregate and analyze large, diverse datasets across borders. It can distort market competition by favoring domestic firms or large MNCs that can afford compliance, and may even reduce cybersecurity resilience if local data storage standards are weaker than global best practices or if it limits international threat intelligence cooperation available through global CSPs [29]. Furthermore, data localization can paradoxically introduce or exacerbate cybersecurity risks by proliferating data centers (broadening attack surfaces), making consistent cybersecurity policy application harder, and restricting access to global CSPs with advanced security capabilities. An aggressive pursuit of data sovereignty can contribute to the balkanization of the internet or "splinternet", hindering global scientific collaboration, stifling the free flow of information essential for innovation, and in some contexts, enabling increased state surveillance and censorship that curtail human rights, as observed with Russia's wartime measures [37].

D. Third-Party and Supply Chain Risks

The increasing reliance of organizations on a global ecosystem of third-party vendors, including CSPs, software suppliers, and managed service providers, significantly expands the potential attack surface for cyber threats [43]. Geopolitical tensions directly exacerbate these third-party and supply chain risks, particularly in the context of cloud services which often rely on complex global supply chains for hardware, software, and operational support. The security and integrity of these supply chains often depend on the diligence and trustworthiness of personnel at multiple stages. Nation-states exhibit greater aggression in the cyber domain, with Russian, Iranian, and Chinese actors intensifying operations [5].

Vendors located in regions experiencing conflict or under significant political strain can become attractive targets for state-sponsored cyberattacks (e.g., Russian APT activity against Ukraine and NATO [4]), hacktivist campaigns, or espionage efforts. Hostile governments might compel local vendors (or local employees of global CSPs) to share sensitive data or provide access to their systems, thereby exposing their international clients to surveillance, data breaches, or intellectual property theft. The risk is not just the CSP itself, but also the myriad of smaller software vendors whose tools are used to manage or secure cloud environments, and the individuals within these organizations who may be susceptible to coercion or possess exploitable loyalties. The education and research sector has become the second-most targeted by nation-states, often serving as a reconnaissance ground [5].

Furthermore, geopolitical events such as the imposition of sanctions (e.g., on Russia [38]) or trade restrictions (e.g., U.S. export controls on China [25]) can abruptly sever vendor relationships, leading to operational disruptions, loss of access to critical cloud services or data, and potential security gaps. For example, if a country imposes sanctions on a specific CSP or on technology originating from a certain nation, customers may rapidly need to migrate services, a complex and risky undertaking that places immense pressure on IT staff. Tariffs and trade policies may force businesses to switch suppliers, potentially leading them to alternative vendors with weaker security protocols that require extensive vetting by skilled personnel [32].

The complexity of modern supply chains, often involving multiple tiers of subcontractors (fourth-party risks and beyond), makes comprehensive oversight and verification of security practices exceedingly difficult, especially across different jurisdictions with varying cybersecurity standards and regulatory environments. Cybercriminals and state actors are adept at exploiting these complexities, often infiltrating a less secure third-party vendor providing services to a cloud customer to establish a foothold from which to launch attacks against more lucrative primary targets hosted in the cloud. Supply chain attacks are a growing threat vector.

V. Analyzing and Mitigating Geopolitically Driven IT Risks

The emergence of geopolitics as a primary driver of IT risk necessitates a critical re-evaluation of existing risk management frameworks and the adoption of new, more adaptive mitigation strategies. Traditional approaches, while valuable for general cybersecurity, often fall short in addressing the unique complexities of state-driven threats and fragmented data governance landscapes unless specifically augmented. This research advocates for a cohesive, multi-layered strategic response. The unique effectiveness of this approach stems from the synergistic interplay between its three critical dimensions: (1) resilient cloud architectures, (2) robust data-centric security measures, and (3) geopolitically-informed governance.

This synergy is not merely additive; the layers actively inform and reinforce one another in response to geopolitical stimuli. For instance, Layer 3, "Geopolitically-Informed Governance", through continuous intelligence gathering and analysis by skilled personnel, might identify a heightened risk of state-compelled data access or politically motivated service disruption in a specific jurisdiction where a CSP operates. This insight directly shapes choices within Layer 1, "Resilient Architectures". Instead of a standard best-practice focus on redundancy primarily for uptime, the geopolitical insight might dictate the use of a sovereign cloud for specific data categories despite higher costs, or a hybrid model that keeps sensitive processing on-premises under direct organizational control, or ensuring robust contractual clauses with the CSP for data portability and service transition under such duress. Consequently, Layer 2, "Data-Centric Security", adapts dynamically. If the governance layer (Layer 3) highlights a risk of imminent data seizure in Country A, and the architectural response (Layer 1) involves maintaining some data there due to operational needs but with enhanced safeguards, then data-centric security (Layer 2) would implement specific encryption key management protocols (e.g., customer-held keys managed by vetted personnel located outside the high-risk jurisdiction of Country A), a nuance driven by geopolitics rather than standard cryptographic practice alone. This dynamic feedback loop—where governance intelligence drives architectural design, which in turn dictates specific, context-aware security configurations, all under the lens of geopolitical threat and with continuous consideration of the human element—distinguishes this approach from merely combining separate best practices. The human element, involving skilled personnel with geopolitical awareness, robust vetting, and continuous training, is crucial for interpreting intelligence, making these nuanced architectural and security decisions, and managing the ongoing operational complexities.

A. Limitations of Traditional IT Risk Management Frameworks

Widely adopted IT risk management frameworks such as the National Institute of Standards and Technology (NIST) Cybersecurity Framework (CSF) 2.0 [44], International Organization for Standardization (ISO) 27001 [45] and ISO 27005 [46], COBIT (Control Objectives for Information and Related Technologies) [47], [48], and FAIR (Factor Analysis of Information Risk) [49], [50], provide robust and structured approaches for identifying, assessing, and managing a broad range of cybersecurity risks. They offer valuable guidance on establishing security controls, ensuring compliance, and improving overall security posture. These frameworks are often designed with inherent flexibility, allowing for adaptation to various threat landscapes. An overview of several leading frameworks—including the NIST Risk Management Framework (RMF) [51], methodologies for Information Security Management Systems (ISMS) as exemplified by ISO/IEC 27001 [45], the Committee of Sponsoring Organizations of the Treadway Commission's Enterprise Risk Management (COSO ERM) framework [52], and the NIST AI Risk Management Framework (AI RMF) [53]—and their potential relevance to geopolitical risk is presented in Table II.

TABLE II. OVERVIEW OF LEADING IT AND CYBERSECURITY RISK MANAGEMENT FRAMEWORKS

Framework	Issuing Body/ Origin	Primary Focus	Key Components/ Functions	Primary Use Cases/ Benefits	Relevance to Geopolitical Risk
NIST RMF [51]	NIST (U.S.)	Comprehensive security & privacy risk management for federal systems, adaptable for private sector.	Prepare, Categorize, Select, Implement, Assess, Authorize, Monitor.	Federal compliance, structured security program development, lifecycle risk management.	Threat identification (Prepare/ Categorize) must include state-sponsored threats & geopolitical instability. Supply chain risk (Select/ Implement) needs geopolitical lens. Continuous Monitoring must adapt to shifting intelligence.
NIST CSF 2.0 [44]	NIST (U.S.)	Cybersecurity risk management for critical infrastructure and other organizations.	'Govern', 'Identify', 'Protect', 'Detect', 'Respond', 'Recover'.	Improving cybersecurity posture, risk communication, flexible and adaptable.	'Govern' should establish geopolitical risk tolerance. 'Identify' must include assets exposed to geopolitical threats. 'Respond' and 'Recover' plans should consider state-level attacks.
ISO/IEC 27001:2022 [45] & ISO 27005 [46]	ISO/IEC	ISMS implementation (27001); Information security risk management guidance (27005).	Risk assessment & treatment (Annex A controls for 27001), ISMS lifecycle.	International standard for ISMS, certification, managing sensitive data.	Risk assessment (6.1.2) must consider nation-state threats. Control selection (Annex A) should address data localization pressures or supply chain attacks influenced by geopolitics.
COSO ERM [52]	COSO (U.S. private sector initiative)	Enterprise-wide risk management, integrating with strategy and performance.	Governance & Culture, Strategy & Objective-Setting, Performance, Review & Revision, Info/Comm.	Strategic alignment of risk management, board-level risk visibility, managing broad business risks.	Strategy & Objective-Setting and Performance components must analyze how geopolitical shifts impact strategic goals and create new enterprise risks (e.g., market access, supply chain disruption).
FAIR [49], [50]	FAIR Institute / Open Group	Quantitative analysis of information risk in financial terms.	Threat Event Frequency, Vulnerability, Loss Magnitude.	Justifying security investments, communicating cyber risk in monetary terms, prioritizing mitigation.	Can quantify financial impact of state-sponsored attacks, data breaches due to geopolitical events, or costs of complying with conflicting data regulations.
NIST AI RMF [53]	NIST (U.S.)	Managing risks associated with Artificial Intelligence systems.	'Govern', 'Map', 'Measure', 'Manage'.	Responsible AI development and deployment, addressing bias, security, transparency, reliability.	Crucial as AI is a key area of tech competition. 'Map' should consider how AI systems could be exploited or influenced by geopolitical actors (e.g., AI-driven disinformation, AI supply chain vulnerabilities).

A general reference for popular risk management frameworks can also be found in [54]. Despite the comprehensive nature of these frameworks, their standard application may not inherently lead organizations to sufficiently prioritize or model the unique characteristics of geopolitically driven IT risks. While a robust risk assessment process under any framework should be capable of incorporating new threat actor tactics, techniques, and procedures (TTPs), including state-sponsored ones, the challenge with geopolitical risks lies in their often low-probability, high-impact nature, driven by sovereign state decisions rather than purely technical or economically motivated actors. Traditional risk assessments might focus more on historically prevalent threats or quantifiable vulnerabilities. McKinsey argues that existing IT policies and risk models are often ill-equipped for the range and pace of geopolitical risks, requiring a broader perspective on failure modes beyond availability to include data theft, malicious code insertion, and information manipulation [55].

Consider a scenario: A multinational corporation uses a global CSP, with data for its Southeast Asian operations hosted in a data center in Country X. Country X has historically been stable, and the CSP meets all ISO 27001 controls. A standard risk assessment might identify general cyber threats (malware, phishing) and operational risks (hardware failure). Suddenly, due to escalating regional tensions, Country X's government, under pressure from a larger allied state, enacts an emergency law compelling all entities, including foreign CSPs operating locally, to provide access to any data deemed relevant to national security, with minimal oversight. Simultaneously, intelligence reports indicate state-sponsored actors from an adversarial nation are preparing cyberattacks against companies operating in Country X.

A traditional framework application, without specific geopolitical augmentation, might struggle here. A NIST CSF [44] approach might identify the threat but could lack the necessary preemptive strategic foresight. For example, it might not have prompted an organization to diversify data hosting or establish "geofenced" architectures purely on geopolitical grounds prior to a crisis, particularly if previous technical risk assessments indicated that the current setup was secure and cost-effective. The ISO 27001 framework [45], for example, while comprehensive, does not explicitly prescribe controls for sudden, politically motivated changes in law that negate contractual data protection clauses, nor does it offer specific guidance on how to weigh the risk of state-compelled data access versus the cost of immediate data migration. This highlights a gap where standard best practices, focused on technical and general operational resilience, may not adequately prepare for politically driven disruptions.

The multi-layered approach proposed in this paper, with its emphasis on geopolitically-informed governance (Layer 3), would have proactively integrated intelligence about regional instability and potential legal shifts into the risk model. This human-driven analytical process would have informed different a priori architectural decisions (Layer 1)—perhaps pre-emptively establishing a secondary hosting location in a more stable jurisdiction for critical data, or designing the application for rapid data portability. Data-centric security (Layer 2) might have involved pre-implementing client-side encryption with keys held by trusted personnel outside Country X for the most sensitive data, anticipating such coercion. The response is thus not just reactive, but strategically pre-emptive based on geopolitical foresight, leading to a concretely different and superior outcome in terms of resilience and data protection compared to standard best practices.

Current IT policies and risk models are generally not up to the task of addressing the sheer range and pace of geopolitical risk without such tailored augmentation [55]. The traditional, often functional, view of tech risk—focusing on objectives like availability, delivery, and uptime—is insufficient to encompass the multifaceted threats posed by geopolitical forces.

Furthermore, the "human element" in geopolitical IT risk is a dimension traditional frameworks, while acknowledging human error, may not fully integrate into the core risk calculus concerning state influence. This includes not only the growing skills gap in cybersecurity professionals capable of understanding and navigating complex geopolitical factors (European Union Agency for Cybersecurity (ENISA) highlights an acute shortage [56]) but also the heightened potential for insider threats exacerbated by national loyalties or state-sponsored coercion of CSP or customer personnel. It also involves the challenge of enhancing citizen and employee digital literacy to discern sophisticated influence operations that leverage cloud platforms and social engineering. Traditional risk assessments might identify "human error" as a category but often lack the granularity to model the motivations and pressures introduced by state actors. Addressing these human factors—requiring specialized expertise, continuous awareness training, robust vetting processes (particularly for personnel with privileged access to cloud environments or sensitive data), and clear ethical guidelines—is critical for comprehensive risk mitigation and must be woven into each layer of the proposed strategy. For example, the selection of a cloud region (Layer 1) might be influenced not just by latency or cost, but by an assessment of the geopolitical pressures that could be applied to local CSP staff (a human element risk), directly impacting technical design towards minimizing human dependency in sensitive operations within that region.

B. Adapting Risk Management for Data Sovereignty (Layer 3: Geopolitically-Informed Governance)

To effectively navigate this new terrain, organizations must adapt their risk management practices to explicitly account for data sovereignty requirements and geopolitical complexities. This forms the governance layer of the proposed approach and directly addresses the human element through expertise, awareness, and decision-making processes.

Given the reliance on global supply chains and third-party vendors, particularly CSPs, it is crucial to integrate geopolitical risk assessment into vendor due diligence and ongoing monitoring processes. This involves evaluating country-specific risks such as sanctions, political instability, sudden regulatory changes, and the potential for government interference (including coercion of vendor personnel) in the jurisdictions where vendors operate or store data [57]. Third-Party Risk Management (TPRM) must evolve beyond traditional checks for contractual compliance and financial stability to address broader concerns, including cybersecurity threats linked to a vendor's geographic location or national affiliation, and the trustworthiness and potential vulnerabilities of their personnel in sensitive roles. This necessitates a workforce equipped with geopolitical awareness and the analytical tools to perform such nuanced assessments.

Addressing geopolitical IT risk effectively requires a strategic, top-down approach. Chief Information Officers (CIOs) and Chief Information Security Officers (CISOs) need to be actively involved in business leadership discussions concerning geopolitical risk, contributing insights not only on the implications for the technology estate but also on how technology-related risks can impact broader business strategy and objectives [55]. This requires these leaders, and their teams, to develop and maintain geopolitical literacy—a distinctly human capability. Corporate boards also have a critical role to play; however, research indicates that less than half of corporate boards currently prioritize geopolitical risk on their agendas, despite its pervasive nature. McKinsey suggests incorporating geopolitical scenario planning considering "black swans", "gray rhinos", and "silver linings" [58]. Leadership must champion continuous training programs to enhance employee awareness of social engineering tactics linked to geopolitical events (e.g., phishing campaigns referencing ongoing conflicts) and establish clear protocols for decision-making when geopolitical crises emerge, including criteria for activating data migration or service failover plans. These protocols must account for the human cognitive load and potential biases that arise during high-stress crisis situations.

Organizations should adopt a global perspective when formulating mitigation strategies, rather than relying on country-specific or region-specific plans that might inadvertently shift risks to other geographies or create unmanageable operational complexity [55]. Any decisions regarding the rebalancing of operations—such as reshoring data centers, duplicating critical functions in different cloud

regions, or localizing global operations—must be grounded in a clear and thorough cost-benefit analysis that explicitly incorporates the financial and operational cost of potential geopolitical risks (e.g., fines for non-compliance with new data laws, losses from service disruption due to sanctions) and the expenses associated with mitigation efforts. Such governance is key to navigating conflicting legal frameworks (Section IV.B), as it ensures that architectural and data security choices are made with full awareness of the legal tightropes involved, aiming to minimize the risk of being caught in "no-win" compliance scenarios by proactively assessing jurisdictional exposure and the associated human risks (e.g., coercion of local staff) operating in those jurisdictions.

C. Technical Mitigation Strategies

Alongside adapted governance, specific technical strategies are essential for mitigating IT risks driven by geopolitical factors and data sovereignty concerns. These represent the architectural and data-centric security layers, which are dynamically informed by the geopolitical insights from Layer 3 and implemented and managed by skilled personnel whose trustworthiness, geopolitical awareness, and training are integral to the strategy's success.

1) Layer 1: Resilient Cloud Architectures

Sovereign cloud offerings have emerged as a direct response to data sovereignty concerns, aiming to provide cloud environments where data are stored, processed, and managed in compliance with specific national or regional laws, often with explicit protections against foreign jurisdictional access [16], [17]. Architecturally, these solutions often leverage private cloud infrastructure located entirely within sovereign borders for highly sensitive or regulated data, such as Oracle's EU Sovereign Cloud [16] or solutions based on Atos's four pillars of sovereignty (territorial, data, operational, technology) [59]. For less sensitive workloads, they might integrate with public clouds, potentially using encryption and anonymization techniques if data need to be processed by global hyperscalers. Key features typically include robust jurisdictional data control, demonstrable regulatory compliance, enhanced security measures (including workload protection and security control auditing), and high resilience. Oracle Alloy, for example, enables partners to become cloud providers themselves [16].

However, "sovereign cloud" is not a universal panacea but rather a complex trade-off, subject to geopolitical risks across various dimensions as detailed in Table III. This table breaks down the different facets of sovereignty that organizations and nations strive for, alongside the geopolitical risks inherent in each and crucial considerations for users evaluating such solutions.

TABLE III. GEOPOLITICAL RISK DIMENSIONS IN SOVEREIGN CLOUD ADOPTION

Sovereignty Dimension	Definition	Associated Geopolitical Risks	Key Mitigation Considerations for Users
Data Sovereignty	Control over data in accordance with the laws of the jurisdiction where the data are located.	Extraterritorial legal access (e.g., U.S. CLOUD Act compelling access to data held by a U.S. provider in an EU sovereign cloud); Foreign intelligence surveillance.	Vetting of operational personnel (citizenship, clearances [17]); Contractual commitments regarding location and nationality of support staff; Auditable logs for all administrative access; Restricted administrative privileges. E.g., [17], [59], [31]
Operational Sovereignty	Assurance that cloud operations (administration, maintenance, support) are conducted by personnel subject to local jurisdiction and control.	Compelled action by foreign personnel (e.g., administrators who are citizens of a foreign state being ordered to access/disrupt data); Insider threats influenced by foreign entities.	Choice of data center location and ownership; Redundancy across politically stable and distinct regions (if feasible within sovereignty constraints); Assessment of supply chain for critical hardware components; Diversification of network providers.
Technology Sovereignty	Independence from foreign control over the core technologies (hardware, software, intellectual property) used to deliver cloud services.	Export controls or sanctions on critical hardware (e.g., CPUs, GPUs) or software (e.g., virtualization, OS) [25]; Vendor lock-in with proprietary technologies; Forced technology transfer requirements; Impact of tariffs on technology costs and availability [32].	Preference for open standards and open-source components where feasible to enhance portability; Multi-cloud or hybrid strategies to avoid single-vendor dependence; Due diligence on provider's technology stack and supply chain resilience; Exploring options for local technology development or partnerships.

While it can address specific data residency and jurisdictional control requirements, it can also introduce new challenges. These include potentially higher costs compared to global public clouds, technical complexity in implementation and management, and potentially limited availability of the full range of cutting-edge services and innovations offered by global hyperscalers (though providers like Google Cloud [60] and Alibaba Cloud [61] are also developing sovereign solutions), which can impact a business's competitive agility [62]. Geopolitical pressures might also compel premature adoption if not carefully weighed. Managing complex sovereign cloud architectures under geopolitical stress requires highly specialized personnel, not just with technical skills but also with an understanding of the shifting geopolitical landscape influencing those architectural choices. A critical, often overlooked, human element risk here is the potential for skilled local staff operating the sovereign cloud to be subject to national pressures or coercion; this risk must be factored into the overall security posture and governance oversight (e.g., Oracle staffing sovereign regions with local personnel meeting specific citizenship/clearance [17]). Evaluating their true contribution requires evolving metrics beyond simple Return On Investment (ROI), to encompass the nuanced valuation of mitigated geopolitical risks and enhanced resilience, which is a complex undertaking [63]. Moreover, there's a potential risk that sovereign cloud initiatives, if not carefully structured with independent oversight and strong contractual safeguards regarding personnel vetting and access controls, could be co-opted for enhanced state surveillance or create vendor lock-in within a national context, substituting reliance on global providers with reliance on state-influenced domestic ones [31]. For many nations, true technological sovereignty may be elusive due to dependencies on global ecosystems for foundational technologies like semiconductors [25]. From a nation-state's perspective, however, if the

paramount goal is the absolute protection of its most critical data (e.g., core government functions, national security intelligence), the higher costs, potential innovation lag, and even increased risks of domestic surveillance under state control might be considered acceptable trade-offs. Therefore, adopting a sovereign cloud solution should be a carefully considered tactical component within a broader, diversified risk management strategy, rather than being viewed as a definitive standalone solution. The EU's reliance on non-EU providers for a significant portion of cryptographic products (70% according to ENISA [64]) underscores existing technological dependencies.

Adopting multi-cloud (using services from multiple public CSPs) and hybrid cloud (integrating public cloud services with private cloud or on-premises infrastructure) strategies can significantly enhance resilience against geopolitical risks [65]. By distributing operations, applications, and data across multiple platforms, providers, and geographic regions, organizations can reduce their dependence on any single point of failure, whether it be a specific vendor, a data center location, or a particular jurisdiction. If geopolitical intelligence from Layer 3 indicates rising instability in a region hosting a primary CSP, Layer 1 architectural plans might prioritize workload portability to a secondary provider in a more stable region. Geographic diversification allows for business continuity even if one region becomes politically unstable or access to services from a provider in that region is disrupted due to sanctions or politically motivated service degradation. For instance, if a primary CSP in Jurisdiction A faces CLOUD Act requests for data belonging to an entity in Jurisdiction B (which prohibits such disclosure), a multi-cloud strategy, informed by Layer 3 governance, might allow for that specific dataset to be primarily processed and stored with a CSP in Jurisdiction B or C, whose legal framework is more aligned, thus mitigating the direct conflict. Hybrid architectures enable organizations to store highly sensitive or regulated data in on-premises private clouds that comply with local sovereignty requirements (and where physical and personnel access is under tighter organizational control), while leveraging the scalability, cost-efficiency, and advanced services of public clouds for less sensitive workloads. These architectures can be instrumental in navigating conflicting legal frameworks; for instance, an organization might use an EU-based cloud for GDPR-sensitive data while leveraging a U.S. provider for other data, with careful consideration of data transfer mechanisms and protections. The specific geopolitical advantage lies in the ability to selectively place workloads and data based on an assessment of jurisdictional risk and legal compatibility, reducing the blast radius of a geopolitical event affecting a single provider or region. The European Multi-Cloud blog emphasizes data portability and interoperability as key to digital sovereignty [65]. However, while enhancing resilience, multi-cloud and hybrid strategies introduce significant operational complexity in terms of management, security orchestration, and cost control. Successfully managing these diverse environments, particularly when buffeted by geopolitical factors that can restrict data movement or influence vendor viability, demands highly skilled personnel capable of adapting to fluid international conditions and understanding the security implications of different provider ecosystems. Businesses must carefully weigh these increased operational overheads and potential integration challenges against the benefits of risk diversification. Geopolitical factors can further complicate these strategies, for instance, by restricting data movement between clouds located in different geopolitical blocs or by making vendor choices more fraught due to national affiliations.

2) Layer 2: Data-Centric Security

Robust encryption remains a cornerstone of data protection, particularly when data traverse borders or reside in potentially untrusted environments [64]. Implementing strong encryption for data at rest and data in transit, using current algorithms like Advanced Encryption Standard (AES)-256 (often with Galois/Counter Mode—GCM for authenticated encryption) or ChaCha20-Poly1305, is critical. End-to-End Encryption (E2EE) should be employed for sensitive communications to prevent interception. The geopolitical adaptation here, informed by Layer 3 governance and Layer 1 architectural choices, lies in key management strategies. For example, if Layer 1 involves using a CSP in a geopolitically sensitive region, Layer 3 might mandate that encryption keys (Layer 2) are generated and held exclusively by vetted personnel located in a trusted, stable jurisdiction, or utilize Customer-Managed Encryption Keys (CMEK) or 'Hold Your Own Key' (HYOK) services offered by CSPs (e.g., Oracle Cloud Infrastructure (OCI) External Key Management Service [16]). This ensures the CSP (and by extension, the state where the CSP data center resides) cannot decrypt the data without authorization from key custodians operating under a different legal and geopolitical regime. The efficacy of encryption, particularly key management, relies critically on trained, trustworthy personnel who understand not only the data's intrinsic sensitivity but also its heightened risk profile due to geopolitical context, especially when considering lawful access demands or the potential for coercion of individuals in different jurisdictions. The effectiveness of encryption can be challenged by lawful access demands backed by state power, the complexities of key management across jurisdictions, and the performance overhead for certain applications. Geopolitical tensions may also lead to mistrust in encryption standards or products originating from adversarial nations, a factor human analysts in Layer 3 must evaluate.

Effective data classification is a prerequisite for applying appropriate security and localization measures. By categorizing data based on its sensitivity, regulatory requirements, and business criticality, organizations can make informed decisions about where data should be stored (Layer 1 choice) and what level of protection is required for such data (Layer 2 controls). This process is heavily reliant on human understanding of both the data's context and the shifting legal landscape. The framework operationalizes this by requiring data classification schemes to include a "geopolitical risk score" or tag, derived from Layer 3 intelligence. This score would trigger specific handling requirements, such as mandating storage in a particular jurisdiction or applying a more stringent encryption key management policy. The primary challenge lies in the consistent and accurate application of classification schemes by knowledgeable and geopolitically aware personnel across a multinational organization, especially when data flow across borders with differing legal definitions of sensitivity. The efficacy of data classification also hinges on personnel understanding its heightened risk profile due to geopolitical factors; for instance, data deemed nonsensitive in one jurisdiction may become highly sensitive in another due to political shifts or its potential intelligence value to a state actor.

Stringent access control mechanisms, guided by the principle of least privilege and embodied in Zero Trust Network Access (ZTNA) architectures, are vital to ensure that only authorized individuals and systems can access sensitive data and resources [66]. Robust Identity and Access Management (IAM) solutions are fundamental to enforcing these controls. From a geopolitical perspective, ZTNA becomes even more critical by strictly verifying every user and device regardless of location, reducing the risk from compromised accounts or coerced insiders in specific geographies—a key human element consideration. Access policies can be dynamically adjusted based on geopolitical threat intelligence from Layer 3; for instance, requiring stricter multi-factor authentication or limiting access to certain sensitive datasets for users connecting from regions experiencing heightened political instability or cyber threat activity. Implementing ZTNA effectively across diverse, multinational cloud environments (Layer 1) is complex and resource-intensive, again requiring skilled human oversight and management (human element within Layer 2 operations). Geopolitical instability can also heighten the risk of insider threats or compromised identities that bypass even sophisticated access controls, especially if state actors are involved in pressuring individuals, making the human vetting, continuous monitoring, and behavioral analytics aspects of access control even more critical.

Furthermore, Privacy-Enhancing Technologies (PETs) are gaining traction as a means to address data sovereignty concerns while still leveraging the capabilities of public clouds. Technologies such as homomorphic encryption (which allows computation on encrypted data without decryption), secure multi-party computation, and confidential computing (which uses hardware-based trusted execution environments) offer pathways to process sensitive data in potentially untrusted environments while maintaining control and confidentiality [29]. PETs can offer a technical route to mitigating some conflicting legal framework dilemmas; for example, if data subject to GDPR can be processed by a U.S. cloud provider using homomorphic encryption, the provider technically never "sees" the unencrypted personal data, potentially satisfying GDPR requirements even if the provider is subject to the CLOUD Act for access to the (still encrypted) data. While promising, many PETs are still maturing. Challenges include performance overhead for complex computations, limited standardization, the technical expertise required for implementation (a human skill consideration), and the "human trust" factor in the security of the underlying hardware or algorithms. Their legal acceptance and ability to satisfy all data sovereignty regimes under geopolitical stress are not yet fully established, making them a cautious exploration for most organizations in the short term rather than a universally scalable solution for current geopolitical data dilemmas.

The following table, Table IV, summarizes the key actionable takeaways from the multi-layered approach discussed, emphasizing the integration of geopolitical awareness into architectural, security, and governance layers, with a keen focus on the human element.

TABLE IV. ACTIONABLE TAKEAWAYS FOR MITIGATING GEOPOLITICALLY DRIVEN IT RISKS

Layer	Key Actionable Takeaway
1. Resilient Architectures	Informed by geopolitical intelligence (Layer 3), develop architecture patterns allowing rapid workload/data migration based on predefined geopolitical triggers; evaluate sovereign/hybrid options with explicit consideration of personnel risk (e.g., coercion, skill availability) in operating zones.
2. Data-Centric Security	Guided by governance (Layer 3) and architectural choices (Layer 1), implement encryption key management policies where custodianship by vetted, geopolitically-aware personnel explicitly avoids high-risk jurisdictions; integrate geopolitical risk scoring into data classification for specific handling.
3. Geopolitically-Informed Government	Establish a cross-functional team (legal, IT, security, business, geopolitical analysts) for continuous geopolitical intelligence monitoring and dynamic risk assessment; mandate tailored training on geopolitical threat vectors (e.g., sophisticated social engineering, personnel coercion tactics) for all relevant staff.

VI. CONCLUSION AND RECOMMENDATIONS

A. Key Findings

This research has demonstrated that the Russia–Ukraine conflict has fundamentally transformed the IT risk landscape for cloud computing in several ways:

- First, it has elevated data sovereignty to a central consideration in cloud strategy, accelerating regulatory fragmentation globally. The conflict has made starkly visible the vulnerabilities that arise when critical data and systems are subject to jurisdictions that may become adversarial or unstable. The war in Ukraine has acted as a case study, demonstrating how geopolitical conflicts impact the digital domain.
- Second, the targeting of cloud infrastructure by state actors has revealed how digital dependencies can become security vulnerabilities during conflicts. The sophisticated cyber operations observed throughout the conflict, such as Russia's concerted efforts to target Ukraine's critical infrastructure through cyberattacks and disinformation campaigns, demonstrate that cloud resources are both targets and vectors for state-sponsored attacks, impacting not just availability but also data integrity and confidentiality.
- Third, while valuable, existing IT risk management approaches require specific augmentation to adequately address the complex interplay of technical, regulatory, human, and geopolitical factors revealed by the conflict. Standard applications may not sufficiently account for the strategic, state-level threats or the crucial human elements—such as specialized skills for geopolitical analysis, cognitive awareness of influence operations, and susceptibility of personnel to coercion—that characterize modern geopolitical competition. The synthesized framework addresses this gap by explicitly integrating these dimensions, acknowledging that traditional IT risk management often falls short in addressing the range and pace of geopolitical risks [55].
- Fourth, the conflict has accelerated the evolution of defensive strategies, as organizations and providers have rapidly developed new approaches to build resilience against geopolitically driven threats. The proposed multi-layered approach—integrating geopolitically-informed governance, resilient

architectures, and adaptive data security, all underpinned by a profound understanding of the human element—offers a more holistic and proactive path forward than simply applying these components in isolation. Its novelty lies in this synergistic integration and the emphasis on how geopolitical insights directly shape technical and operational choices beyond standard best practices.

B. Recommendations for Organizations

Based on these findings, organizations are recommended to undertake several actions to enhance their resilience against geopolitically driven IT risks:

- Organizations should integrate geopolitical factors explicitly into their cloud strategy and risk management processes, considering potential political tensions, regulatory conflicts, and state-sponsored threats when designing architectures and selecting providers. This involves asking critical questions like: "What is the stability of the legal and political regime where our data will reside or transit, and what is the risk of coercion of local personnel (whether CSP employees or the organization's own staff)?" "What are the potential implications of a sudden change in diplomatic relations with countries hosting our CSPs?" "Have we mapped our critical data flows and dependencies against regions of high geopolitical risk, and do we have contingency plans for data/service migration, including the human expertise needed to execute them under pressure?" Operationally, this integration can be facilitated by subscribing to geopolitical risk intelligence services, utilizing scenario planning methodologies specifically designed for state-actor threats (e.g., wargaming exercises focusing on cyber-geopolitical triggers like sudden data localization laws or sanctions impacting CSPs), and developing internal frameworks for mapping data assets and IT infrastructure against geopolitical risk zones [55].

- Implementing a multi-layered defense incorporating technical resilience measures, with a strong human element focus, as outlined in Table IV, is crucial. This includes deploying resilient cloud architectures (e.g., multi-cloud, hybrid cloud, or carefully evaluated sovereign cloud solutions designed to minimize single points of jurisdictional failure and accounting for personnel risks in those zones) to avoid dependency on a single provider or jurisdiction [65]; utilizing advanced data-centric security (e.g., encryption with geopolitically aware key management by trusted personnel [16], PETs where mature [29], access controls informed by geopolitical threat intelligence) to protect data regardless of its location; and implementing robust data sovereignty controls to ensure compliance with relevant regulations.

- Developing specialized incident response capabilities for geopolitically triggered events is essential. Traditional incident response plans may not adequately address the unique challenges posed by state-sponsored attacks targeting cloud supply chains (as seen with Volt Typhoon targeting U.S. critical infrastructure [39]), sudden regulatory changes forcing data migration under duress, or politically motivated service disruptions by a CSP or nation-state. This includes preparing for scenarios where trusted communication channels might be compromised or access to certain technologies restricted, and ensuring personnel are trained to operate effectively, manage stress, and make sound decisions under such high-stakes, ambiguous conditions.

- Establishing cross-functional risk teams that combine technical, legal, security, and geopolitical expertise can provide a more comprehensive assessment of cloud-related risks. These teams should regularly reassess the organization's geopolitical exposures as the global landscape continues to evolve, explicitly considering the human element—from skill sets for managing complex international systems and understanding diverse legal orders, to insider risk heightened by geopolitical pressures, the ethical considerations of operating in certain regimes, and the need for enhanced digital literacy against sophisticated influence operations—in their risk assessments and mitigation planning. This requires a shift towards agile and adaptive governance to cope with a volatile world.

C. Future Research Directions

This study identifies several areas requiring further research. These include measuring the effectiveness and economic trade-offs of sovereign cloud solutions in addressing geopolitical risks, a task that demands metrics extending beyond traditional ROI to capture the value of geopolitical risk mitigation and the cost of potential innovation lag or reduced service capability [63]. One might begin to benchmark the resilience afforded by such a geopolitically-informed framework versus a traditional one through comparative analysis of outcomes from sophisticated, scenario-based simulations incorporating defined geopolitical triggers and varied organizational responses. Tracking the evolving tactics of state-sponsored threat actors targeting cloud infrastructure, particularly the abuse of legitimate cloud services and APIs for malicious purposes (e.g., use of stolen credentials for initial access is rising [6]), remains critical. Exploring frameworks that could reduce conflicts between competing data governance regimes, perhaps through new international accords (as suggested by the United Nations Conference on Trade and Development (UNCTAD) [19] and Khasru [29]) or technological safe harbors, is also vital.

Further research is also needed to assess the broader economic impacts of cloud fragmentation on innovation, global digital commerce, and the operational costs for businesses adopting complex mitigation strategies like extensive multi-cloud deployments or full sovereign cloud adoption. Deepening the investigation into the 'human element'—such as quantifying the skills gap in managing complex geopolitical IT risks (ENISA notes cybersecurity budget rises but gaps in future-oriented investment and skills shortages [56]), analyzing the dynamics of insider threats exacerbated by geopolitical loyalties or coercion (particularly within CSPs or managed service providers), developing effective, culturally nuanced strategies to enhance citizen and employee digital literacy against state-sponsored influence operations leveraging cloud platforms (e.g., AI-generated content noted by Microsoft [5]), and exploring the psychological impact on decision-makers operating under sustained geopolitical stress—would provide a more holistic understanding and actionable insights. The practical

scalability and legal acceptance of various PETs in mitigating cross-border data transfer risks under geopolitical pressure also warrant ongoing study. The development of robust, widely accepted international norms for cyberspace is a critical, albeit challenging, long-term goal. The Ponemon Institute reported on the economic value of prevention in cybersecurity [67], a concept that becomes even pertinent when considering the potentially catastrophic costs of geopolitically triggered cyber incidents. UNCTAD's work on global collaboration for inclusive AI also points towards the need for international cooperation in managing technological risks [68].

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