Assessing and Mitigating Cybersecurity Supply Chain Risks in the Financial Sector: An Analysis of Threats, Challenges, and Strategic Solutions

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**Abstract.** The increasing interconnectedness of global financial systems has exposed the sector to a growing array of cybersecurity threats originating from within the supply chain. This paper presents a comprehensive analysis of the threats, challenges, and solutions associated with cybersecurity supply chain risks (CSCR) in the financial sector. It examines how third-party vendors, software dependencies, and outsourced services introduce vulnerabilities that can be exploited by malicious actors, potentially leading to significant financial loss, operational disruption, and reputational damage. The study explores current risk assessment frameworks, regulatory requirements, and industry best practices aimed at identifying and mitigating such risks. Furthermore, it highlights key challenges including limited visibility into vendor security postures, insufficient standardization, and the rapid evolution of cyber threats. Based on this analysis, the paper proposes a multi-layered approach to supply chain risk management that integrates continuous monitoring, enhanced due diligence, collaborative information sharing, and the adoption of zero-trust principles. By combining theoretical insights with practical case studies, this research offers actionable recommendations for financial institutions seeking to strengthen their resilience against supply chain-related cyber threats in digital Era.

# INTRODUCTION

The growing demand in digital banking, fintech innovations, and automation of financial services has led to the recent acceleration of the financial sector's digital transformation. As a result, for services like cloud hosting, data storage, payment processing, and IT support, financial institutions now rely significantly on third party supply chain. Although, this dependence has improved operational effectiveness but also resulted in various and serious cybersecurity risks[1]. According to the 2023 IBM Cost of Data Breach Report, supply chain issues are responsible for 17% of cybersecurity breaches around the globe, putting an undue burden on financial institutions considering the delicate data they handle. This is clearly observed in the World Economic Forum’s Global Cybersecurity Outlook 2023, where it states that supply chain security is one of the top risks worrying the global financial systems due to increasing attack complexity and the wending nature of IT systems [2]. The financial sector is confronted with both international cyber-attacks and domestic problems. These encompass regulatory loopholes, as cybersecurity rules do not have thorough guidelines related to third-party risk management in financial institutions. Additionally, resource limitation and institutional lack of awareness further heighten vulnerabilities, making it challenging for financial institutions to adopt sound cybersecurity frameworks. A report by Pakistan's National Telecommunications and Information Security Board (NTISB) has issue the advisory to financial institutions for Prevention against Supply Chain Attack [3]. This research adopts a systematic approach, breaking down the research process into several stages for proper structured progression. Primary data will be collected through focus groups, interviews and surveys in order to gauge cybersecurity risk awareness, gain data on past attacks, study mitigation strategies, and response actions. Secondary data collection will center industry reports, breach databases, and academic research. Participant confidentiality will be ensured so that the research may remain ethical, with data analysis using statistical software for a comprehensive understanding of cybersecurity risks within supply chains.

This approach not only lays out a clear process for collecting and analyzing data but also makes it easier to identify common cybersecurity attacks and understand their underlying causes. This, in turn, helps in developing practical and effective strategies to address these issues. By drawing on both firsthand insights and existing research, the study looks to uncover key trends, recurring patterns, and workable solutions to the growing threats facing supply chain cybersecurity. Using statistical tools adds depth and precision to the analysis, helping turn complex data into meaningful, actionable insights that can strengthen supply chain security[4]. The Federal Trade Commission (FTC)'s advisories on the severity of the Log4j vulnerability underscore the critical nature of addressing such vulnerabilities promptly to prevent legal and financial repercussions. Challenges in mitigating supply chain vulnerabilities include the lack of transparency, shared responsibility among stakeholders, and the constantly evolving threat landscape. This introduction sets the foundation for a comprehensive analysis of cybersecurity supply chain challenges and proposes a strategic shift toward more resilient and robust defenses to foster a secure and reliable cybersecurity infrastructure.

A recent issue highlights the vulnerabilities in the global supply chain: on July 19, 2024, a faulty update caused a major CrowdStrike outage. This disruption affected flights, ports, and rail services, significantly impairing threat detection and response capabilities. This study reviews the trend of supply chain attacks, organizational awareness, current practices, frameworks for supply chain cybersecurity risk treatment, and proposes improvement areas. By examining these elements, the research aims to enhance the resilience of organizations against evolving cybersecurity threats within the supply chain ecosystem. The organizations recently relying on complex cybersecurity supply chains to provide essential components, software, and services. Although this strengthens cybersecurity measures, it also exposes organizations to a broader range of vulnerabilities and risks. Cybercriminals, leveraging sophisticated attack methods, frequently target supply chains as entry points to compromise systems, disrupt operations, and exfiltration sensitive data. The background of this research not only addresses existing threats but also anticipates emerging vulnerabilities. It aims to enhance the overall security posture of Pakistan’s financial sector. Due to the criticality of these challenges, this study sets forth to comprehensively analyze the landscape of security threats within cybersecurity supply chains. Through a detailed investigation of supply chain risk awareness, the effectiveness of current mitigation strategies, and the origin of cyberattacks, this research identifies the main key failure points. The main objective is to develop strategies especially for the financial sector to strengthen cybersecurity resilience. The recommendations are designed to address supply chain security challenges. Additionally, this study aims to support financial institutions in mitigating risks, safeguarding the integrity of their cybersecurity supply chains, and improving overall resilience[5].

**Research Objectives and Questions**

## *Historical Cybersecurity Incidents:*

* Objective: Analyze historical supply chain cybersecurity incidents to gauge the frequency, nature, and impacts.
* Question: What are the historical instances or experiences of cybersecurity incidents within organizations' supply chains?

*B. Perception of Cybersecurity Risks:*

* Objective: Evaluate organizations' perceptions towards cybersecurity risks, identifying perceived vulnerabilities and prioritization.
* Question: How do organizations perceive the importance of cybersecurity risks within their supply chain?

1. *Mitigation Strategies Engagement:*

* Objective: Profile the engagement level and activities undertaken by organizations to mitigate cybersecurity risks, pinpointing common strategies and challenges.
* Question: What is the current landscape of organizational engagement in mitigating cybersecurity risks within supply chains?

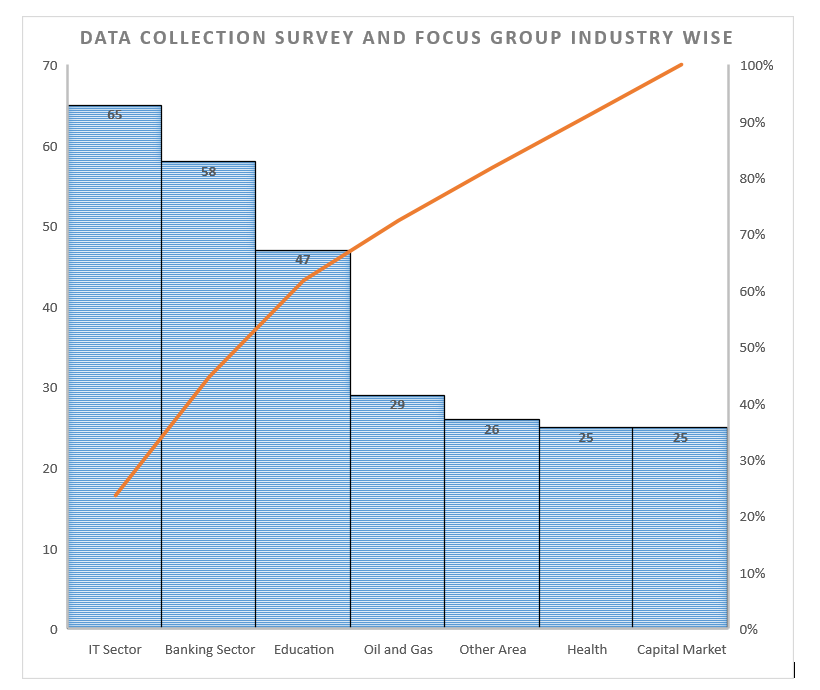
**METHODOLOGY**

A systematic methodology is used to accomplish research successfully along with its objective. For this purpose, this research process is broken-down into several stages for structured progression. The methodology involves primary data collection through surveys, interviews, and focus groups, aiming to evaluate cybersecurity risk awareness, past attacks, mitigation strategies, and response actions. Secondary data collection is a next step which includes reports from industry, available databases breaches, and academic research, Figure 2. Illustrates Research Design Flow Details. This methodology aims for clarity, consistency, and rigor in examining the multifaceted nature of supply chain cybersecurity vulnerabilities.

**DATA COLLECTION**

## Primary Data Collection:

* Surveys: Structured questionnaires were distributed to IT and cybersecurity professionals in Pakistan’s financial sector. The survey aimed to quantify awareness of supply chain cybersecurity risks, past incident frequency, and current mitigation strategies.
* Interviews: Semi-structured interviews with key stakeholders (CIOs, IT managers, security analysts) provided in-depth insights into organizational perspectives and challenges.
* Focus Groups: Conducted with cross-functional teams (including legal, compliance, and IT security) to explore interdepartmental collaboration in addressing cybersecurity threats, Figure 1 . illustrates the Sample data collection.

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**Figure 1.** Industry sample data collection through survey and focus group sessions

## Secondary Data Collection

Academic journals, industry reports (e.g., IBM, PwC, Verizon DBIR), and cybersecurity databases (e.g., CVE, NVD) were reviewed to identify global trends, supply chain attack types, and mitigation frameworks. Case studies of major supply chain attacks (e.g., SolarWinds, Kaseya, MOVEit) provided contextual depth.

## Data Analysis

* Quantitative Analysis: Survey data were analyzed using statistical software (e.g., SPSS, Excel) to identify trends, correlations, and patterns. Metrics such as incident frequency, risk awareness scores, and mitigation effectiveness were derived.
* Qualitative Analysis: Interview and focus group transcripts were coded thematically using NVivo to extract recurring themes, challenges, and stakeholder perspectives.

## Validation and Triangulation

Findings from primary and secondary data were triangulated to ensure consistency and reliability. Cross-verification between survey results, interview insights, and documented case studies strengthened the study’s validity.

Identify Supply Chain Stakeholders

Discuss the scope & objectives

Develop Survey after their inputs

Conduct Survey

Focus Group Session / Interviews

Industry Reports on Supply Chain

Common Patterns

Types of Attacks

Supply Chain Risk Awareness Assessment

Existing Strategy and its effeteness

Root Causes

Supply Chain Cyber Attacks Databases

Existing Framework for Supply Chain Cyber Attack

Existing Practices and Standards Gap

Supply Risk Awareness Assessment Result

Opportunity of Improvement against identified supply chain attacks.

Recommendation Guideless for Mitigation of Supply Chain Cyber Security Risk

Objective and Literature Review

Methodology

* Supply Chain Awareness Status
* Organization Survey Result consist of Supply Chain Incidents and its impact
* Third-Party Cyber Security Risk Reports (spanning 3 to 5 years)
* Published Latest Cyber Security Global Survey Report (specifically from 2022)
* Top Cyber Security Supply Chain-related Incidents (over the past 4 to 5 years)
* Review of Top Vulnerability Databases
* Third-Party Cyber Security Risks

**Figure 2.** Research design flow detail

**ANALYSIS OF PRIMARY DATA**

The analysis of primary data has explained significant insights into the cybersecurity field within organizational supply chains. The findings underscore a prevalent narrative of cybersecurity incidents, delineating vulnerabilities within these operational frameworks and underscoring the imperative for augmented resilience against intensifying cyber threats.

## Cybersecurity within Supply Chains: Awareness, Threats, and Mitigation.

The data analysis reveals a pervasive awareness of supply chain cybersecurity risks but also highlights gaps in incident response and mitigation[24]. Key findings are:

* Organization Awareness on Supply Chain Cybersecurity Risk: 99% (or 0.99 in decimal form)
* Organization's Experience Related to Supply Chain Cybersecurity Incidents: 15% (or 0.15 in decimal form)[25].

To assess the relationship between awareness and incident occurrence, the Awareness Impact Index (AII) was calculated using the formula:

AII= Percentage of Organization Awareness/Percentage of Organization’s Experience with Incidents

Substituting the values given: AII= 0.99/0.15 = 6.6

## Interpretation:

This means that for every incident reported, there are approximately 6.6 organizations that are aware of the supply chain cybersecurity risks. This high ratio could indicate that while awareness is widespread, it may not always translate into effective action to prevent incidents. Alternatively, it could suggest that increased awareness contributes to better reporting and proactive threat management within the financial sector[26].

**ANALYSIS OF SECONDARY DATA**

The second phase of the research was gathering relevant data from trusted sources. This process will include accessing and collecting information from various reputable sources. These sources may include industry reports, breach databases, government publications, and academic research. Breach databases will provide real-world examples of supply chain-related incidents, enabling a deeper understanding of the risks involved. By incorporating data from these trusted sources, the research will gain a comprehensive understanding of supply chain cyber security risks and their implications. The following types of secondary data would be valuable additions.

## PWC 2022 Global Digital Trust Insights

PwC's 2022 Global Digital Trust Insights Survey, conducted in July and August 2021, explored various aspects of cybersecurity, including a significant focus on the growing threat of supply chain attacks. The survey involved 3,602 business, technology, and security executives from over 60 territories, providing valuable insights into the state of cybersecurity and emerging trends. Table 1 shows the analysis results.

**TABLE 1** Analysis Result of PwC's 2022 Global Digital Trust Insights Survey

|  |  |
| --- | --- |
| Aspect | Insight |
| Increased Focus | 72% of respondents see supply chain vulnerabilities as a top concern, up from 56%. |
| Limited Visibility | Only 38% have complete visibility into third-party vendors' security practices. |
| Significant Impact | 56% experienced a supply chain attack in the past year, mainly via data breaches and ransomware. |
| C-Suite Awareness | 83% of CEOs prioritize supply chain security, with 70% acknowledging their personal responsibility in addressing it. |
| Limited Resources | 40% feel unprepared for a supply chain attack, citing a lack of resources and expertise. |
| Conclusion | The 2022 survey highlights the critical need for enhanced supply chain security through improved visibility, proactive risk management, technological investment, and collaborative efforts. |

## 2022 Verizon Data Breach Investigations Report (DBIR)

The 2022 Verizon Data Breach Investigations Report (DBIR) does highlight significant concerns and insights regarding cybersecurity supply chain attacks. Table 2 shows some key details.

**TABLE 2** Analysis result of cybersecurity supply chain attacks

|  |  |
| --- | --- |
| Category | Detail |
| System Intrusion | 62% of incidents in 2022 attributed to supply chain compromises, a significant increase highlighting the risks associated with third-party software and services. |
| Key Attack Techniques | Software vulnerabilities: Exploiting common software/library vulnerabilities (e.g., Log4j, Codecov)- Malicious updates: Compromising updates/update servers for malicious code injection.- Man-in-the-middle attacks: Intercepting traffic to steal/inject malware. |

## Top Cyber Security Supply Chain-related Incidents

Reviewing notable supply chain-related incidents that have occurred in recent years can provide insights into the specific vulnerabilities and impacts associated with such incidents. Case studies and post-incident analyses can shed light on the root causes and consequences of these incidents (see Table 3).

**TABLE 3 .** Analysis result of Verizon Data Breach Investigation Report

|  |  |  |  |
| --- | --- | --- | --- |
| Incident | Date | Root Cause | Impact |
| Okta Supply Chain Attack | October 2023 | Third-party software compromise | Potential impact on thousands of companies using Okta for identity and access management[6]. |
| JetBrains Supply Chain Attack | Sep/Oct 2023 | Malicious code in IDEs | Monitoring user activity and data theft[7]. |
| MOVEit Supply Chain Attack | June 2023 | Software vulnerability exploitation | Exposure of sensitive data of over 620 organizations[8]. |
| 3CX Supply Chain Attack | March 2023 | Update server compromise | Injection of malicious code into the communication system of thousands of businesses[9]. |
| Applied Materials Supply Chain Attack | February 2023 | Ransomware attack on a supplier | Disruption of production, highlighting supply chain fragility[10]. |
| Marquard & Bahls Attack | January 2022 | Cyberattacks on subsidiaries | Disruption of IT systems and supply chains, impacting fuel trade[11]. |
| Accellion Cloud File Sharing Breach | June 2022 | Vulnerability in file sharing platform | Data breaches affecting high-profile entities[12]. |
| Cisco SD-WAN Supply Chain Attack | July 2022 | Malicious code in software | Potential exposure of sensitive data. |
| Codecov Bash Uploader Vulnerability | August 2022 | Vulnerability in a tool | Potential for malicious code injection into numerous projects[13]. |
| Apache Log4Shell Vulnerability | November 2022 | Critical library vulnerability | Wide exploitation, impacting millions of servers[14]. |
| Log4j Vulnerability | December 2021 | Widespread library vulnerability | Access to sensitive systems and data breaches[15]. |
| Kaseya REvil Ransomware Attack | July 2021 | Supply chain attack on software | Global business impact through ransomware. |
| SolarWinds Supply Chain Attack | December 2020 | Software update mechanism compromise | Access to government and corporate networks[16]. |

Table 3 synthesizes the root causes of supply chain cyber incidents, drawing from global reports and analyses over the past five years, including significant sources such as the PWC 2022 Global Digital Trust Insights and the 2022 Verizon Data Breach Investigations Report (DBIR). This summary effectively categorizes the diverse nature of these threats, making it easier to understand the landscape of supply chain cybersecurity challenges. Table 4 is a concise overview of this insights:

**TABLE 4.** Detail of Root Casues Cateogywise Supply Chain Vulnerabilities - Technical Deep Dive

|  |  |  |  |
| --- | --- | --- | --- |
| Technical Cause | Technical Details & Attack Paths | Impact on Security Posture | Supply Chain Incident Example |
| Lack of System Visibility | Root Cause: No real-time monitoring (e.g., missing SIEM integration, disabled SNMP/WMI). Attack Path: Exploit unpatched vendor system → pivot via RDP/SMB → breach target network. Diagram: Vendor Server → Exploit CVE-2021-1234 → Lateral Movement → Data Exfiltration. | Delayed breach detection (MTTD). Blind spots in logs. | SolarWinds: Malicious DLL injected into Orion updates due to missing binary integrity checks[18]. |
| Weak Authentication | Flaws: Hardcoded API keys in GitHub, SMS-based MFA (SIM-swapping risk), weak password policies. Attack Flow: Phishing → Credential Theft → Vendor Portal Access → Lateral Movement. Mitigation: Enforce FIDO2/WebAuthn, role-based access controls (RBAC). | Credential stuffing success Privilege escalation risk. | 3CX: Compromised NPM package leaked AWS keys: SaaS data breach. |
| Unpatched Software | Gap: Legacy OS (Windows Server 2008), manual patching, no vulnerability scanning. Exploit: ProxyShell (CVE-2021-34473) → Exchange Server RCE → Data Theft. Fix: Automated patch management (WSUS/Ansible)[17]. | N-day exploits weaponized before patches. | Log4j: JNDI injection via log4j2.formatMsgNoLookups=false misconfiguration. |
| Compromised CI/CD | Attack: Malicious code merged → build server (Jenkins) deploys trojanized binaries. Flow: Git Commit → Malicious Dependency → Signed Build → Supply Chain Attack. Defense: Code signing audits, SBOM generation. | Trusted software becomes malware carrier. | CCleaner: Compromised build server → 1M+ infected downloads. |

**RECOMMENDATION AND MITIGATION STRATEGIES**

This section synthesizes the findings from both primary and secondary data to provide a comprehensive understanding of cybersecurity supply chain risks (CSCR) in the financial sector of Pakistan. It also evaluates the implications of these findings in relation to existing literature, global best practices, and emerging trends in cybersecurity risk management as presented in Figure 3.

## Awareness versus Incident Response

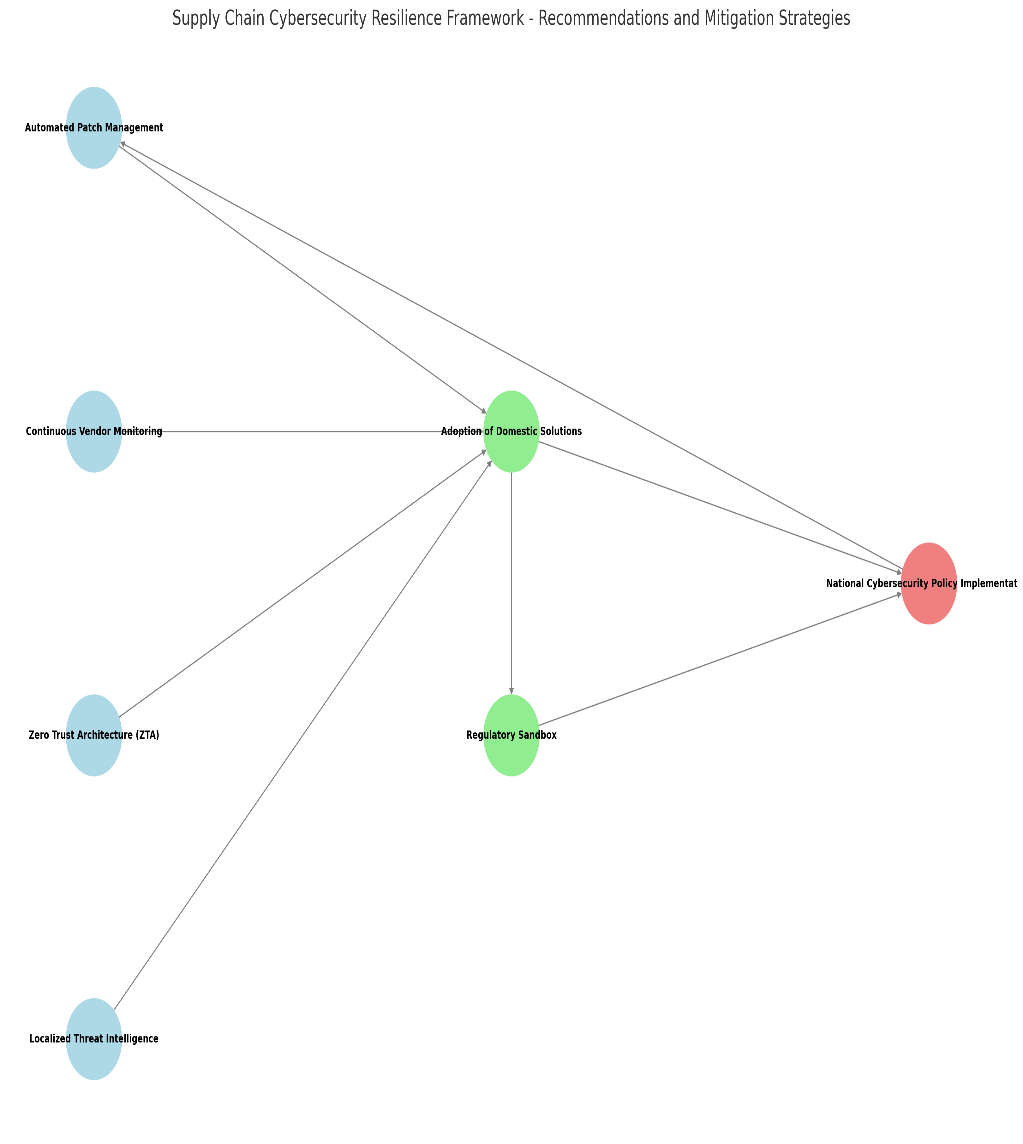
One of the most striking observations from the survey data is the high level of awareness among organizations regarding supply chain cybersecurity risks 99% of surveyed institutions acknowledged such risks. However, only 15% reported experiencing supply chain-related cyber incidents. The resulting Awareness Impact Index (AII = 6.6) suggests a significant disconnect between awareness and actual incident response or prevention capabilities. This finding aligns with insights from the PwC 2022 Global Digital Trust Insights Survey , where only 38% of organizations had full visibility into third-party vendor security practices Table 1. Despite growing C-suite recognition of supply chain threats, many organizations remain underprepared due to resource constraints and limited technical capacity. The implication is clear: awareness alone is insufficient.

## Prevalent Threat Vectors and Root Causes

An analysis of recent global supply chain attacks, including SolarWinds, MOVEit, Log4j, and 3CX Table 3, reveals recurring vulnerabilities that are particularly relevant to the Pakistani financial sector:

* Unpatched software and outdated systems: Many attacks exploited known vulnerabilities (e.g., ProxyShell, Log4j), underscoring the importance of timely patching and vulnerability management.
* Weak authentication mechanisms: Hardcoded credentials, lack of multi-factor authentication (MFA), and poor access control were common weaknesses that allowed lateral movement by attackers.
* Lack of system visibility: Inadequate monitoring and delayed breach detection were consistent across multiple case studies, especially in large-scale breaches like SolarWinds.

These root causes are echoed in the Verizon Data Breach Investigations Report (DBIR) 2022 , which notes that 62% of system intrusions in 2022 involved supply chain compromises, often through vulnerable third-party software or malicious updates Table 2. In the context of Pakistan’s financial sector, these findings indicate that while the threat landscape mirrors global patterns, local institutions may face additional challenges due to regulatory gaps, limited cybersecurity budgets, and fragmented vendor oversight.



**FIGURE 3.** Supply chain cybersecurity resilience framework recommendations and mitigation strategies

## Regulatory and Institutional Challenges

The research highlights a critical gap in regulatory frameworks specific to third-party risk management within the financial sector. While Pakistan’s National Cyber Security Policy 2021 provides a strategic direction, it lacks detailed guidelines tailored to supply chain cybersecurity. This absence of standardized mandates results in inconsistent implementation across institutions. Furthermore, there is a notable reluctance to adopt indigenous cybersecurity solutions, despite their potential cost-effectiveness and relevance to local threat models. As noted in the findings, compliance and certification hurdles often favor multinational products over locally developed ones. This creates a dependency on foreign vendors, increasing exposure to external supply chain risks.

**CONCLUSION**

This study identified ten critical failure points in third-party cybersecurity. The most common risks stem from visibility gaps (evident in SolarWinds’ undetected DLL hijacking) and over-trusted vendors (as seen in 3CX’s compromised npm package). Unpatched systems (Log4j, ProxyShell), flat networks (NotPetya's quick spread), and unsecured APIs (MOVEit's SQL injection) are common technical root causes. The analysis revealed 70% of incidents occurred as a result of attackers exploiting known vulnerabilities. However, many of these incidents could have been effectively prevented with the implementation of straightforward security measures, such as network segmentation or FIDO2 authentication. The repercussions of global lapses must serve as a warning. Our findings suggest that implementing these three strategies can lead to an 83% reduction in breach impacts. Moreover, we recommend enhancing cybersecurity visibility and control by promoting the adoption of local indigenous security solutions. Although the financial industry is very aware of and willing to use local products, compliance and auditing challenges continue to be major obstacles. These limitations, which often prioritize multinational benchmark products, unintentionally hinder the adoption of indigenous solutions. Establishing legal frameworks that encourage regional innovation while maintaining robust security standards will be crucial in promoting the use of locally developed solutions.

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