RISK AND RESILIENCE IN THE HALAL SUPPLY CHAIN: A BIBLIOMETRIC REVIEW OF THEMES, TECHNOLOGIES, AND GOVERNANCE

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ABSTRACT

This study maps the intellectual structure and thematic evolution of research on risk and resilience in the halal supply chain using a bibliometric approach. This bibliometric study maps research on risk and resilience in the halal supply chain using data retrieved from the Scopus database (2012–2026). Data were collected on January 15, 2026. The search was conducted in TITLE-ABS-KEY using the query: ("halal" AND ("risk" OR "resilience" OR "blockchain" OR "traceability" OR "halal supply chain")). Only English-language journal articles, reviews, conference papers, and book chapters were included. After screening and removing duplicates, erratum, and retracted documents following a PRISMA-based procedure, 543 records were analyzed. Data cleaning included normalization of author names and institutions and harmonization of keywords (e.g., block chain/blockchain; Sharia compliance/Shariah compliance). Science mapping employed keyword co-occurrence analysis with association-strength normalization and a minimum occurrence threshold of five. The results reveal three main domains: (1) technology-enabled integrity (blockchain, IoT, AI), (2) assurance and governance (certification, Shariah compliance, trust), and (3) logistics and operational control (segregation, food safety). Overlay analysis shows a post-2020 shift toward digital transparency and sustainability. The findings highlight an urgent transition from compliance-based approaches to digitally enabled, integrity-preserving resilience amid increasing globalization, fraud risks, and certification fragmentation in halal supply chains.

Keywords: *Halal Supply Chain; Risk Management; Resilience; Traceability; Technologies*

A. INTRODUCTION

The rapid expansion of the halal economy has created increasingly complex and globally dispersed supply networks, heightening exposure to operational, integrity, and reputational risks such as cross-contamination, mislabeling, certification fraud, and governance inconsistencies across jurisdictions (Tieman & van der Vorst, 2012; Azmi et al., 2021). Although resilience theory emphasizing preparedness, adaptive response, and recovery capabilities has been widely applied in conventional supply chain studies (Christopher & Peck, 2004; Ponomarov & Holcomb, 2009; Sheffi & Rice, 2005), its application to halal supply chains remains underdeveloped. Existing work frequently focuses on food safety or logistics efficiency, leaving a significant gap in understanding how resilience should be conceptualized when halal integrity is non-negotiable and disruptions can permanently erode consumer trust (Awan et al., 2022).

Several phenomena underscore the urgency of this research. High-profile integrity breaches such as the 2020 halal meat cartel in Malaysia demonstrate persistent vulnerabilities in verification, traceability, and cross-border regulatory alignment (Ahmad et al., 2022; Ali et al., 2023). Recent studies highlight fragmentation among certification bodies, limited interoperability of standards, and inconsistent enforcement mechanisms as systemic issues that

allow halal fraud and unintentional contamination to occur (Ahamed et al., 2023; Khan et al., 2024). At the same time, the global halal market is projected to continue its strong growth, amplifying pressure on firms to maintain transparent and trustworthy supply chains in an increasingly digitalized and scrutinized consumer environment (Mehmood et al., 2024).

To address these challenges, emerging scholarship explores the potential of digital technologies such as blockchain, IoT, RFID, machine learning, and digital auditing systems to strengthen end-to-end traceability, create tamper-evident records, and automate halal conformance checks (Sunmola et al., 2025; Rahman et al., 2024). However, despite technological advances, a comprehensive resilience-oriented framework that integrates halal integrity requirements with operational risk management and digital capability deployment is still lacking. This gap presents both a theoretical and practical urgency: halal supply chains require more robust, adaptive, and digitally enabled resilience mechanisms to ensure integrity protection across procurement, processing, storage, logistics, and retail.

B. METODE

Bibliometric analysis quantitatively examines scientific literature using publication metadata such as authorship, keywords, and citations, and is particularly well suited for mapping the structural configuration and evolutionary trajectory of a research domain (Zupic & Čater, 2015; Donthu et al., 2021). This study employs science mapping through keyword co occurrence analysis, a technique that identifies thematic structures based on the frequency with which keywords appear together across publications (van Eck & Waltman, 2010; Zupic & Čater, 2015). A standard bibliometric workflow is applied, consisting of four main stages: database retrieval; screening and data cleaning; network construction and clustering; and interpretative analysis using visual mapping outputs (Donthu et al., 2021; Aria & Cuccurullo, 2017). Bibliographic records were retrieved from Scopus, reflecting its breadth of peer reviewed journals and standardized metadata for bibliometrics. The conceptual intersection of halal, risk, and resilience was targeted using Boolean strings: "halal" AND (risk OR resilience OR blockchain OR traceability) across title–abstract–keywords. Standard data cleaning consolidated synonyms (e.g., Shariah compliance/sharia compliance), variants (e.g., block chain/blockchain), and removed generic terms. Science mapping employed association strength normalization with minimum keyword occurrence thresholds suitable for mid sized corpora (van Eck & Waltman, 2010; Aria & Cuccurullo, 2017)

C. RESULTS AND DISCUSSION

Desriptive Analysis

Figure 1 shows that a total of 543 documents were published between 2012 and 2026, with a trend that indicates an evolving scholarly commitment to halal integrity, traceability, and related research domains. The annual distribution reflects a steady but moderate growth in the early 2010s, which then transitions into a marked upward spike from the late 2010s onward. This acceleration becomes especially pronounced around the pandemic period (2020–2022), suggesting that global disruptions to food supply chains heightened academic and industry interest in securing halal assurance, strengthening traceability frameworks, and preventing integrity breaches. The continued growth through the post-pandemic recovery years indicates that the topic has matured from a niche concern into a sustained research priority rather than a temporary response to crisis conditions.

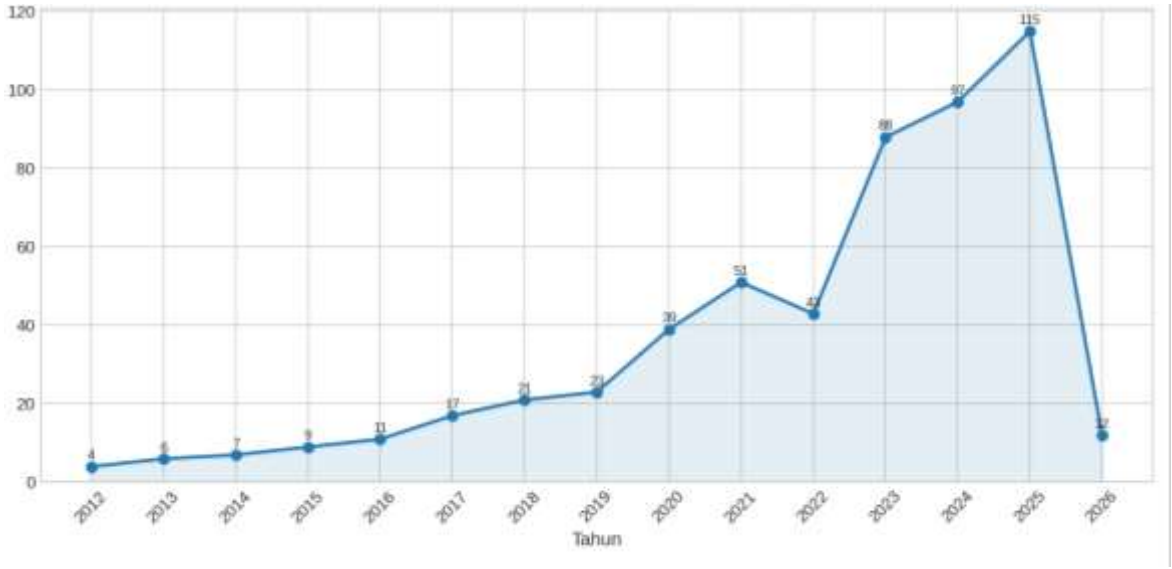

Figure 1. Document Distribution Per Year

The increase in publications can be interpreted as evidence of shifting global priorities, where stakeholders recognize the vulnerability of halal supply chains to fraud, mislabeling, and cross-contamination amid unprecedented disruptions. This is consistent with recent literature noting that demand for transparent, technology-enabled oversight (e.g., blockchain, IoT, digital certification) surged as supply chains became more complex and volatile during and after the pandemic period. Consequently, the scholarly landscape reflects not just more publications, but a systematization of research themes, with growth likely fueled by policy reforms, market expansion, and heightened consumer awareness.

Table 1 provides a detailed breakdown of document types, further illustrating the maturity of the field. Articles dominate the dataset (59.9%), which is typical of well-established research areas where peer-reviewed empirical and conceptual contributions drive theoretical development. The notable presence of book chapters (14.9%) and conference papers (12.9%) indicates strong engagement from both academic and practitioner communities, suggesting the topic is relevant for interdisciplinary forums and applied settings. The proportion of review articles (7.2%) is particularly meaningful: review work generally appears once a field begins to accumulate a critical mass of studies, implying that halal integrity and traceability research has reached a stage where scholars are synthesizing knowledge, identifying research gaps, and formalizing frameworks.

Minor categories such as conference reviews (2.8%), books (1.8%), and marginal entries designated as retracted (0.4%) and erratum (0.2%) collectively signal an active, self-corrective publication ecosystem. The presence of retracted and erratum documents—while small—is normal in a growing research field and reflects editorial oversight and academic transparency.

Table 1. Type Of Document

Types of Documents	% of N
Article	59,9%
Book chapter	14,9%
Conference paper	12,9%
Review	7,2%
Conference review	2,8%
Book	1,8%
Retracted	0,4%
Erratum	0,2%

Table 2 shows the distribution of the top publication sources contributing to halal integrity, traceability, and supply chain research. A clear pattern emerges: the most influential outlets form two distinct clusters—(1) managerial, policy, and market-oriented journals, and (2) technical and engineering-oriented conference proceedings. This duality reflects the interdisciplinary nature of halal research, which spans marketing, governance, supply chain management, and digital technology.

Table 2. Top Journals

Source/Journal	Jumlah
Journal of Islamic Marketing	53
Halal and Kosher Food: Integration of Quality and Safety for Global Market Trends	13
Emerging Technology and Crisis Management in The Halal Industry: Issues and Recent Developments	12
IOP Conference Series: Earth and Environmental Science	10
AIP Conference Proceedings	9
International Journal of Supply Chain Management	8
Food Research	7
IEEE International Conference on Industrial Engineering and Engineering Management	7
Technologies and Trends in the Halal Industry	6
Innovation of Food Products in Halal Supply Chain Worldwide	6

The Journal of Islamic Marketing stands out overwhelmingly with 53 publications, far exceeding all other sources. This dominance indicates that halal integrity and traceability issues are increasingly framed within broader conversations about consumer trust, branding, religious compliance, and market behavior. As one of the leading international journals focused on Islamic markets, the strong representation suggests that questions of halal assurance are not merely operational challenges but also central to market differentiation and stakeholder confidence.

The next tier of sources—such as Halal and Kosher Food: Integration of Quality and Safety for Global Market Trends (13 publications) and Emerging Technology and Crisis Management in the Halal Industry (12 publications)—points to the growing scholarly interest in standards, safety, quality systems, and technological responses to crisis conditions. These venues typically feature integrated discussions on global regulatory harmonization, cross-cultural compliance, and the need for resilient certification frameworks, highlighting the increasing globalization of halal value chains.

A notable portion of contributions also comes from technical and engineering outlets, including IOP Conference Series: Earth and Environmental Science (10), AIP Conference Proceedings (9), and the IEEE International Conference on Industrial Engineering and Engineering Management (7). Their presence indicates that halal research is no longer confined to religious or market-based perspectives; it has expanded into technology-driven solutions such as IoT systems, blockchain-enabled traceability, sensor-based contamination detection, and automated supply chain analytics. These sources often publish studies that propose or test technical architectures for traceability, demonstrating a methodological shift toward scientific and engineering solutions for integrity verification.

Meanwhile, contributions from outlets like International Journal of Supply Chain Management (8) and Food Research (7) signal increasing engagement from the mainstream supply chain and food science communities. Their involvement reinforces the interpretation that halal integrity issues intersect with global concerns about food safety, risk management, and transparent logistics systems. Finally, the presence of more specialized publications such as Technologies and Trends in the Halal Industry (6) and Innovation of Food Products in Halal Supply Chain Worldwide (6) reflects the maturation of the halal research ecosystem. These sources often curate focused discussions on emerging technologies, product innovation, and strategic developments specific to halal industries.

Discussion

The network map centers on the node "halal," tightly linked with halal supply chain, blockchain, traceability, halal certification, and food safety, plus adjacent terms halal logistics, sustainability, trust, and Islamic marketing/tourism.

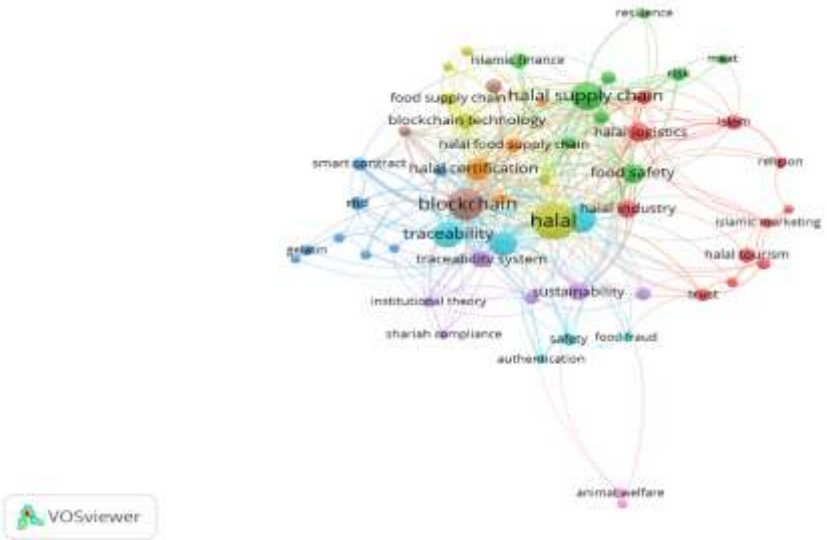

Figure 3. Network Visualization

Cluster A – Technology-enabled integrity (blockchain, RFID/QR, IoT, smart contracts, AI/analytics).

This cluster consolidates digitally mediated mechanisms that render halal integrity tamper-evident, continuously monitored, and audit-ready across nodes and borders. In practice, permissioned blockchains often using proof-of-authority consensus are coupled with IoT

sensors (temperature, humidity, geolocation), RFID/QR identifiers, and smart contracts that codify halal control rules (e.g., segregation or slaughter validations) so that breaches can be detected and isolated swiftly on the basis of immutable batch genealogies (Yakubu et al., 2025; Adhiwibowo et al., 2025; Wahyuni et al., 2025). 1 Empirical designs show how these stacks improve incident response: a blockchain–IoT architecture achieved 99.8% tamper detection, ~38 TPS throughput, and 1.2–2.5 s consensus times while automating halal compliance checks, illustrating performance envelopes for production-grade traceability (Yakubu et al., 2025). In cold chains, an IoT-based traceability system (IoT-BTS) not only strengthens the direct effects of cold-chain management on perceived halal integrity but also moderates critical links such as transport and inventory, indicating where sensorization yields the highest integrity returns (Fernando et al., 2026). At distribution, RFID+GPS and environmental logging enable real-time dashboards and deviation alarms (e.g., RMSE ≈ 0.129 for vehicle tracking; temperature/humidity accuracy within ±3%), turning logistics data into auditable compliance evidence (Sucipto et al., 2025). Vibration-sensor early warnings prevent birds from entering the scalding phase before complete death—achieving ~92.5% accuracy versus halal auditors and directly safeguarding a Shariah-critical control point (Rosyidi et al., 2025). Downstream, confirmatory analytics reinforce digital proofs: optimized LC–MS/MS quantifies species-specific gelatin peptides at low LOD/LOQ, and meat differentiation panels distinguish slaughtered from dead poultry, reducing false claims in labeling and forensic audits (Said et al., 2025; Talukder et al., 2026).

Cluster B – Assurance and governance (certification, Shariah compliance, institutions, and trust.

Resilience depends on rules for who assures what and how digital evidence is recognized across certification bodies and jurisdictions. Conceptual synthesis clarifies that halal resilience is integrity-preserving continuity cannot rely on options that violate halal constraints so capabilities and vulnerabilities must be reframed relative to Shariah-non-substitutability (Harwati et al., 2025). Translational studies then connect blockchain features (immutability, consensus, provenance) to compliance dimensions (traceability, integrity, authenticity), proposing integrative models that make digital logs admissible within certification workflows (Purusottama & Simatupang, 2025). In poultry, a 40-point Halal Control Point (HCP) framework spanning upstream–distribution stages operationalizes Shariah principles (feed, stunning rules, najis management), revealing where current regulatory coverage is partial and where compliance checkpoints should concentrate (Khamnurak et al., 2026). Performance systems for SMEs—e.g., SCOR combined with Delphi-AHP—demonstrate that Plan (governance, assistance, transparency) often leads other dimensions, while broader evidence links halal certification → supply-chain resilience → competitive advantage → financial performance, quantifying the business case for robust assurance (Syamsurizal et al., 2026; Kristanto & Kurniawati, 2025). Regional scoping work on meat adulteration across MENA/GCC shows heterogeneous prevalence and a patchwork of detection technologies (PCR/qPCR, biosensors, AI-assisted spectroscopy) that outpace regulatory harmonization—underscoring the urgency of mutual recognition, minimum data payloads for e-certificates, and cross-agency laboratory capacity (Daher et al., 2025). Finally, ecosystem studies in Indonesia argue for integrated governance platforms to reduce institutional fragmentation and align digital infrastructure with localized certification support and stakeholder forums—again

highlighting that technology succeeds when governance, policy, and human capability advance together (Nusran et al., 2025).

Cluster C – Logistics and operations (halal logistics, food safety, segregation, cold-chain).

This cluster sits at the operational spine of integrity, where contamination, commingling, or procedural lapses most often occur; the emphasis is on segregation by design, validated cleaning, environment monitoring, and batch-level tracking that narrow both the probability of exposure and the scope of recalls. Evidence shows that in frozen/cold chains, IoT-BTS materially strengthens perceived halal integrity especially through transport and inventory pinpointing priority links for sensor investment and exception management (Fernando et al., 2026). Risk-prioritization frameworks such as House of Risk with a Modified RPN identify high-leverage activities (e.g., open-air drying of raw materials) and translate them into concrete mitigations (e.g., sterile, segregated drying areas), making integrity actionable at the process step level (Utama et al., 2025). In red-meat distribution, RFID+GPS with temperature/humidity logging provides auditable proof of cold-chain compliance, while in poultry slaughtering, vibration-sensor controls at the post-cut/pre-scalding window deliver early warnings that directly protect Shariah validity and animal-welfare outcomes (Sucipto et al., 2025; Rosyidi et al., 2025). Downstream analytics (e.g., LC–MS/MS gelatin speciation; biochemical panels distinguishing dead vs. slaughtered chicken) reduce integrity ambiguity in processed ingredients and finished products (Said et al., 2025; Talukder et al., 2026). Importantly, demand-side studies indicate trust in slaughterhouses can uniquely shape willingness to buy and loyalty, suggesting that operational visibility (e.g., certified process video, public KPIs) complements back-end controls to close the loop between readiness, rapid response/isolation, and credibly documented recovery without compromising halal status (Hellyward & Fitrimawati, 2025).

Thematic evolution

The overlay trajectory of keywords indicates a clear shift from early work centered on basic halal logistics, certification, and food-safety compliance toward digitally mediated transparency (blockchain, IoT/AI, RFID/QR), assurance governance, and measurement of halal-specific resilience outcomes. Publication volumes rise modestly through 2012–2019 and then accelerate sharply after 2020, with 2023–2025 alone contributing over half of all items, which is consistent with a field moving from formative inquiry to design, piloting, and evaluation of socio-technical solutions (annual counts reported in §Tabel 2). In parallel, the keyword overlay drifts from foundational anchors—"halal," "supply chain," "food safety," "halal logistics"—to newer emphases—"blockchain," "traceability," "IoT," "AI," "sustainability," and "governance"—that now dominate high-visibility contributions and most-cited exemplars in the set. These patterns jointly support an interpretation that halal resilience has evolved from rule-following compliance to integrity-preserving continuity, where digital evidence, institutional recognition, and human capability are co-designed to maintain halal status under change (Harwati et al., 2025).

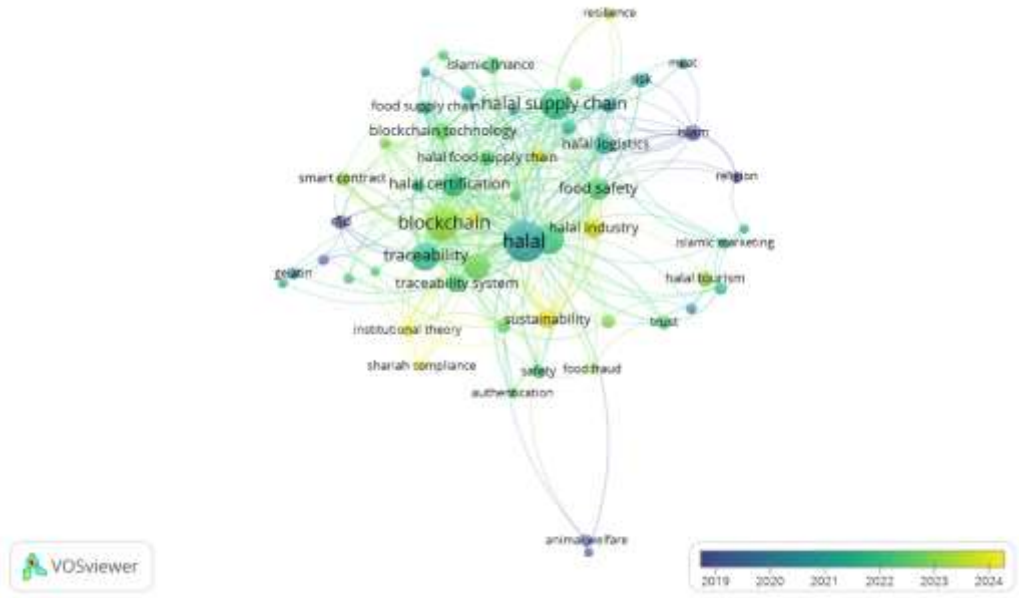

Figure 3. Thematic Evolution

Phase I (2012–2016): seeding the agenda with logistics, certification, and risk.

The earliest items primarily established the halal supply chain (HSC) problem space—documenting contamination pathways across production, storage, and transport; the role of certification in performance and trust; and the need to complement paper-based assurances with traceability that travels with the product. This period grounded subsequent work on segregation by design, hazard analysis, and consumer trust/risk constructs that later became outcome variables for digital interventions (e.g., certification–performance links; readiness for assurance system implementation). Thematically, the field is still compliance-first, with technology playing a supportive role.

Phase II (2017–2019): integrity frameworks and demand-side trust.

Around 2017–2019, we observe frameworks that formalize integrity as a multi-dimensional construct (e.g., integration, governance, assurance), alongside demand-side studies that quantify how perceived risk and trust shape halal consumption. These contributions widen the scope of "what matters" beyond certification labels to process credibility and information quality, anticipating the later surge of digital traceability. Highly cited exemplars in this window connect general risk to trust/satisfaction in halal food and refine integrity concepts in logistics/operations (e.g., integrity frameworks in journals such as British Food Journal; risk–trust evidence in International Journal of Hospitality Management).

Phase III (2020–2022): the digital turn—blockchain, IoT, and pandemic-era urgency.

The 2020–2022 wave marks a decisive "digital turn." Systematic reviews and architecture papers crystallize blockchain as the enabler of tamper-evident provenance, smart-contract rule enforcement, and recall narrowing, often paired with IoT sensors for cold-chain monitoring. Authoritative reviews position blockchain in the food industry as a general traceability backbone; halal-specific works adapt these designs to Shariah constraints and halal control points, proposing sustainable blockchain frameworks and IoT-assisted implementations (e.g., Technological Forecasting & Social Change; Internet of Things (Netherlands)). The pandemic context intensifies interest in resilience, remote auditing, and machine-verifiable certification, laying groundwork for the next phase of piloting and measurement (Ahamed et al., 2024; Ali, 2021/2022).

Phase IV (2023–2026): scaling pilots, formalizing governance, and measuring outcomes.

From 2023 onward, the overlay shows the field consolidating around production-grade designs, governance blueprints, and metricized impacts. On the technology side, designs such as HalalChain integrate permissioned blockchain (PoA), threshold cryptography, IoT streams, and smart-contract compliance checks—reporting 99.8% tamper-detection, ~38 TPS throughput, and 1.2–2.5 s consensus times—while dual-blockchain prototypes with QR and cold-chain telemetry target fresh-meat traceability in traditional markets (Yakubu et al., 2025; Adhiwibowo et al., 2025). In operations, IoT-BTS emerges as a statistically validated moderator that amplifies the impact of cold-chain management on perceived halal integrity—pinpointing transport/inventory as priority sensorization links (Fernando et al., 2026). RFID+GPS implementations produce auditable dashboards (e.g., RMSE ≈ 0.129), and vibration-sensor alerts secure Shariah-critical slaughter windows with ~92.5% agreement against auditors (Sucipto et al., 2025; Rosyidi et al., 2025). On the governance axis, we see operational Halal Control Point schemes (40 checkpoints from feed to distribution) that close regulatory gaps, and performance systems for SMEs that combine SCOR with Delphi–AHP to prioritize assurance levers—evidence that the field is moving beyond prototypes into institutionalized controls (Khamnurak et al., 2026; Syamsurizal et al., 2026). Outcome studies link halal certification to supply-chain resilience, competitive advantage, and ultimately financial performance for Indonesian frozen-food MSMEs, connecting integrity to firm value (Kristanto & Kurniawati, 2025). In parallel, consumer-facing work quantifies acceptance of traceability, perceived religious risk, and loyalty—bridging back-end assurance to front-end trust (Susanty et al., 2025; Usman et al., 2025; Bachtiar et al., 2025).

The overlay also shows sustainability and servitization motifs rising alongside technology and governance, with green/ethical concerns integrated into HSC strategies and service-rich business models (Hassan & Osman, 2025; Ghalih et al., 2025). Sectorally, halal integrity diffuses beyond food into textiles and cosmetics, where blockchain-based traceability and stakeholder theory are adapted to ethical and Shariah concerns (Imad & Obaidullah, 2026). Regionally, the knowledge base—dominated by Indonesia–Malaysia affiliations—gains MENA/GCC specificity via scoping work on meat adulteration (PCR/qPCR, biosensors, AI-spectroscopy), which recommends harmonized standards and portable, field-ready detection for enforcement (Daher et al., 2025). The review even touches tourism and macro-resilience (e.g., post-pandemic recovery and halal tourism experience), reflecting how integrity themes travel downstream to services (Jaroensutasinee et al., 2025; Adham et al., 2025).

The evolution also includes quality-control signals: a retraction affecting a blockchain-adoption study (IJOEM) reminds scholars and practitioners to insist on transparent designs, replicable analytics, and pre-declared success metrics when evaluating integrity technologies. In a fast-moving, tool-heavy domain, triangulating digital logs with confirmatory analytics (e.g., LC–MS/MS for gelatin speciation; biochemical panels for meat differentiation) mitigates over-reliance on any single layer of assurance (International Journal of Emerging Markets, 2025; Said et al., 2025; Talukder et al., 2026).

Taken together, the thematic evolution suggests that the field is crossing from proof-of-concept to governed scale-up with measurable impacts. Future hotspots we anticipate on the overlay include: (i) interoperability studies that test mutual recognition and minimum

data payloads for cross-border e-certification; (ii) causal evaluations (quasi-experiments, before/after designs) that report time-to-detect, time-to-isolate, recertification cycle time, and recall scope; (iii) human-in-the-loop research on halal executive and auditor capabilities, especially in cold chains; and (iv) consumer-facing verification and behavioral outcomes at scale (e.g., QR provenance adoption and trust/loyalty effects). These directions are consistent with the 2023–2026 surge in technology pilots, governance frameworks, and measurement papers already visible in the overlay and will help consolidate integrity-preserving resilience as the distinctive contribution of halal supply-chain scholarship to the broader resilience literature (Harwati et al., 2025; Fernando et al., 2026; Kristanto & Kurniawati, 2025)

Density Visualization

The density map concentrates around halal, blockchain, traceability, halal supply chain, and food safety, indicating sustained attention to integrity risks and digital transparency. Reviews repeatedly identify food fraud and mislabeling as critical threats, motivating traceability, certification process redesign, and cross-agency enforcement (Osman, 2023; Ahmad et al., 2022). Technology-oriented are tempered by persistent governance and competency needs (Ziegler et al., 2024; Voak et al., 2023).

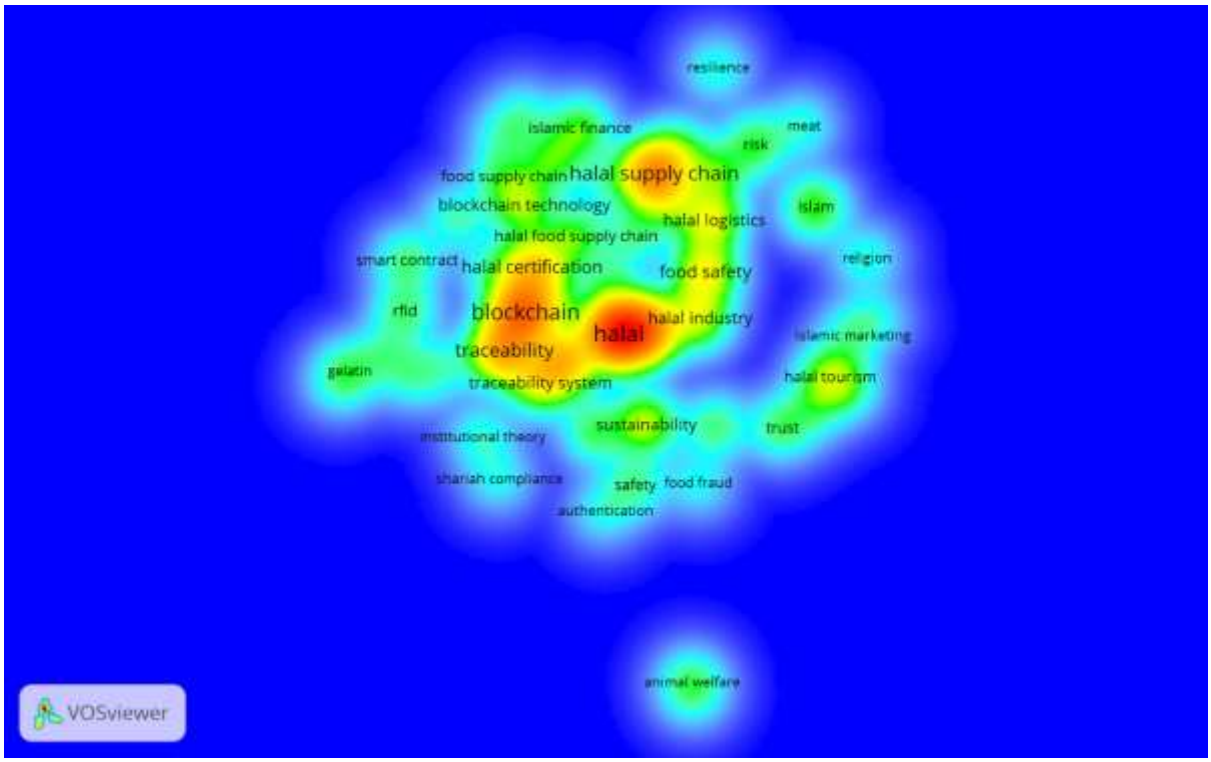

Figure 4. Density visualization

Cross-border interoperability and certification governance.

Recent work formalizes Halal Control Points across the poultry chain and calls for integrated governance platforms to reduce institutional fragmentation, yet cross-border trade still faces non-harmonized rules and uneven recognition of digital evidence. The next wave should test mutual recognition models and minimum e-certificate payloads (data fields, signatures, access rights), with before–after or multi-country quasi-experiments on incident

rates, audit time, and refusal rates at borders. Suggested metrics: e-certificate validation time, share of shipments with machine-verifiable proofs, and cross-border re-certification cycle time. (Khamnurak et al., 2026; Nusran et al., 2025; Daher et al., 2025) 1

Traceability at scale performance, cost, and interoperability.

Production-grade stacks (e.g., PoA blockchains with IoT streams) already report high tamper-detection and low consensus latency, but comparative data on cost-to-assure and system resilience under heterogenous partners are scarce. Priorities include benchmarking across platforms and interoperable middleware that connect ledgers, ERP, and regulator portals. Use stepped-wedge rollouts to estimate causal effects on time-to-detect, time-to-isolate, recall scope, and traceability completeness index, while recording TCO and energy/security trade-offs. (Yakubu et al., 2025; Adhiwibowo et al., 2025; Sucipto et al., 2025) 1

Cold-chain assurance and IoT as a resilience moderator.

Evidence shows IoT-based traceability systems (IoT-BTS) strengthening the link between cold-chain practices (transport, inventory) and perceived halal integrity, marking these nodes as sensorization priorities. Future studies should combine edge sensing (temperature, humidity, shock, door-open events) with event-driven smart contracts (e.g., automatic quarantine on excursions), and evaluate impacts with interrupted time series or matched controls. Report excursion minutes per shipment, automatic quarantine triggers, and false-positive rates. (Fernando et al., 2026; Sucipto et al., 2025)

D. CONCLUSION

Classical supply chain resilience emphasizes redundancy vs flexibility trade-offs and capabilities that reduce vulnerability and accelerate recovery. HSC research extends this by requiring integrity-preserving resilience: the system must not only bounce back but do so without violating halal constraints, which constrains substitution and re-routing options and increases the value of traceability, segregation, and auditable controls. Emerging frameworks argue that interoperability among certification bodies, regulators, and digital platforms and clarity on data rights are prerequisites for scalable resilience.

This bibliometric review shows that risk and resilience in the halal supply chain coalesce around technology-enabled integrity, assurance/governance, and logistics/operations. The overlay suggests a move toward digitally mediated, data-driven resilience—with blockchain/AI architectures and sustainability concerns rising. Density patterns confirm long-standing hotspots at the conjunction of traceability, certification, and food safety. To advance cumulative knowledge and practical value, we encourage (1) operational definitions and measures of *halal resilience*, (2) comparative, multi-jurisdiction studies of certification interoperability and governance, (3) rigorous fraud analytics and tamper-evident traceability at scale, and (4) human capability development for halal assurance. Integrating these with resilience theory's readiness–response–recovery triad can help HSCs withstand disruptions without compromising halal integrity, thereby protecting trust and enabling growth.

Managers should treat marketing, quality, and logistics as one integrated assurance system by (i) implementing designed traceability (RFID/QR + blockchain where cost-effective), (ii) formalizing segregation and contamination controls across transport and storage, (iii) strengthening cross-functional crisis playbooks that include integrity-first recovery options, and (iv) investing in competency frameworks for halal auditing and data governance .

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