

FROM COMPLIANCE TO CONNECTIVITY: A CONCEPTUAL FRAMEWORK FOR DESIGNING AND COORDINATING SUSTAINABLE HALAL FOOD SUPPLY CHAINS IN MALAYSIA

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Abstract: Malaysia's halal sector has reached a critical stage of development, moving beyond traditional certification approaches towards integrated supply chain connectivity. Guided by the Halal Industry Master Plan 2030 and the New Industrial Master Plan 2030 (NIMP 2030), the industry is shifting from a narrow focus on regulatory compliance to ensuring seamless coordination across the halal value chain. In this context, halal assurance is no longer confined to compliance at individual stages of production and distribution but depends on the synchronisation of sourcing, logistics, and information flows to safeguard halal integrity from farm to fork. This transformation is driven by the Halal 2.0 paradigm, which promotes a holistic framework built upon three interconnected dimensions. The first, structural connectivity, provides the physical foundation of the halal ecosystem through dedicated halal assets, specialised logistics hubs, and certified warehousing facilities that reduce contamination risks. The second, digital-information connectivity, enhances transparency through real-time traceability systems, Internet of Things (IoT)-enabled monitoring technologies, and interoperable data-sharing mechanisms. The third, governance-relational connectivity, represents the social architecture of the ecosystem, emphasising trust-based collaboration, shared standards, and coordinated problem-solving among stakeholders. By integrating these dimensions, Malaysia is transforming halal regulatory requirements into a strategic competitive advantage. The proposed framework positions halal integrity not only as a religious obligation but also as a driver of operational resilience and Environmental, Social and Governance (ESG) performance. In an era of increasing global supply chain uncertainty, enhanced connectivity enables greater transparency, rapid exception management, and continuous audit readiness. Ultimately, this integrated ecosystem strengthens Malaysia's position as a global halal leader by fostering supply chains that are compliant, digitally traceable, environmentally sustainable, and internationally competitive.

Keywords: Halal 2.0; Connectivity design; Coordination capability; Halalan-Toyyiban sustainability; Supply chain resilience

1. Introduction

Malaysia remains a global leader in the halal ecosystem, supported by a sophisticated regulatory architecture that includes JAKIM certification, the Malaysia Halal Management System 2020, and specialised standards such as MS 1500:2019 and MS 2400. While this

institutional foundation is robust, it faces a new frontier. The increasing complexity of global food systems has rendered isolated, plant-level assurance insufficient to meet contemporary market demands (Mohamed Suhaimi Yusof et al., 2026). In response, national strategic initiatives, particularly the Halal Industry Master Plan 2030 and the New Industrial Master Plan 2030 (NIMP 2030), place strong emphasis on value-chain integration and technological advancement. These policy directions recognise that fragmented information flows, disconnected operational processes, and limited data interoperability constrain the effectiveness of halal assurance. Consequently, the primary challenge has shifted from verifying compliance at individual nodes to ensuring end-to-end connectivity across the entire supply chain. Such connectivity requires the seamless alignment of product movement, process integrity, and digital traceability from source to consumer (Rossi et al., 2025).

At the same time, the growing complexity of global food supply chains, heightened Environmental, Social and Governance (ESG) expectations, and increasing consumer demand for transparency have exposed the limitations of conventional compliance-based approaches. Organisations may maintain rigorous internal certification systems, however still struggle to preserve halal integrity when products move through multiple intermediaries without effective coordination. This situation reveals a critical gap between regulatory compliance and operational reality. In the absence of integrated connectivity, decision-making becomes fragmented, information flows are delayed, and supply chains become more vulnerable to both physical contamination and data discontinuity.

As a result, the challenge is no longer confined to ensuring compliance at discrete stages of the supply chain. Rather, it involves designing supply chain systems capable of sustaining integrity, traceability, and operational efficiency across interconnected organisational networks. This transition is particularly important for sustainable supply chains, where continuous coordination among multiple actors determines whether halal integrity can be maintained consistently at scale. Despite Malaysia's regulatory maturity, evidence suggests that operational-level coordination remains a significant obstacle to achieving *Halalan-Toyyiban* outcomes across complex supply chain networks (Ab Talib et al., 2023). Furthermore, as digital interoperability becomes increasingly essential for supply chain resilience, transparency, and ESG accountability, the industry must move beyond traditional and largely manual compliance mechanisms (Mohd Helmi Ali et al, 2021).

Against this backdrop, this paper addresses the following question: How can connectivity design enable the coordination capability required to safeguard halal integrity while simultaneously enhancing sustainability performance? To answer this question, the paper proposes a multi-layered conceptual framework that links connectivity design comprising structural, digital, and relational dimensions to coordination capability and downstream performance outcomes. By reframing halal assurance as a network design challenge rather than a purely compliance-oriented exercise, this study offers a roadmap for transforming Malaysia's regulatory strengths into a dynamic, digitally orchestrated capability that supports competitiveness, sustainability, and long-term resilience in the global halal economy.

2. Background: Malaysia's Halal Governance and Industrial Context

2.1 *The Institutional Foundation: Beyond Certification*

Malaysia's halal governance architecture provides a strong institutional foundation for advanced supply chain design and is widely regarded as a benchmark for regulatory excellence. At the centre of this framework is a tiered standards system that extends beyond the conventional view of halal as merely an ingredient-based requirement. While MS 1500:2019 establishes the fundamental requirements for halal food production, preparation, handling, and storage (Department of Standards Malaysia [DSM], 2019), the MS 2400 series expand these assurance requirements to transportation and warehousing activities (DSM, 2019a, 2019b, 2019c). This extension is particularly important because halal integrity is often most vulnerable during product movement and storage, especially when third-party logistics providers are involved.

The regulatory framework is further strengthened through the Malaysia Halal Management System (MHMS) 2020, which formalises internal control mechanisms and establishes a comprehensive compliance structure (Jabatan Kemajuan Islam Malaysia [JAKIM], 2020). Under MHMS 2020, organisations are required to implement a Halal Assurance System (HAS), thereby embedding halal risk management within corporate governance and operational processes. This institutionalisation is significant because halal-related risks frequently arise at operational interfaces, including handling, storage, transportation, and subcontracting activities, where information must be exchanged among multiple stakeholders and physical custody is transferred across organisational boundaries (Charlebois et al., 2024; Otter & Robinson, 2024). By shifting the focus from ingredient verification to process-based control, Malaysia's halal governance framework seeks to minimise these interface risks through standardised and auditable procedures that maintain a continuous chain of custody throughout the supply chain.

At the strategic level, Malaysia's halal governance model has evolved from a predominantly regulatory approach towards a broader ecosystem-oriented perspective. The Halal Industry Master Plan (HIMP) 2030 positions halal development as a comprehensive economic and industrial agenda rather than a narrowly defined religious sector (Halal Development Corporation [HDC], 2023). Among its strategic priorities are enhancing the competitiveness of halal products, strengthening industry capabilities, and developing world-class halal infrastructure. These priorities reflect the recognition that maintaining Malaysia's leadership in the global halal market requires stronger integration among supply chain actors and the development of more resilient industrial networks.

This strategic direction is closely aligned with the New Industrial Master Plan (NIMP) 2030, which provides the broader framework for transforming Malaysia's manufacturing and industrial services sectors (Ministry of Investment, Trade and Industry [MITI], 2023). The NIMP 2030 promotes mission-based industrial transformation with a strong emphasis on digitalisation, technological upgrading, and ESG-oriented development. Within the halal sector, this alignment reinforces the view that halal assurance should not be separated from contemporary industrial developments such as Industry 4.0, digital transformation, and circular economy initiatives. Rather, these developments provide opportunities for halal-certified organisations to adopt advanced technologies, including blockchain-enabled

traceability systems and Internet of Things (IoT)-based monitoring solutions, to strengthen both halal assurance and sustainability performance.

On the whole, these regulatory and strategic developments indicate an important shift in the evolution of Malaysia's halal ecosystem. The sector is increasingly moving beyond conventional compliance-based approaches towards a model characterised by digital connectivity, environmental sustainability, and enhanced inter-organisational coordination (Mohamed Suhaimi Yusof et al., 2026). This transition is commonly described as *Halal 2.0*, a paradigm in which the *Toyyiban* dimension of halal, encompassing wholesomeness, ethical responsibility, quality, and sustainability receives greater emphasis alongside traditional compliance requirements. By 2026, the growing convergence between halal standards and ESG principles had become an increasingly important determinant of competitiveness and market access.

The digital transformation agenda promoted under the NIMP 2030 is particularly relevant in addressing the fragmented information flows that frequently characterise complex food supply chains. Enhanced digital connectivity enables information continuity even when physical products move through multiple intermediaries and operational stages. In this context, organisations can develop what may be described as a “digital halal twin”, namely a data-driven representation of a product's journey throughout the supply chain that supports real-time monitoring and verification. Such transparency strengthens traceability, facilitates auditing processes, and provides verifiable evidence of compliance to regulators, business partners, and consumers. This capability also supports the emergence of “Halal Integrity as a Service”, whereby manufacturers, logistics providers, and supply chain partners offer digitally verifiable assurance of halal compliance in response to growing demands for transparency and accountability in global markets.

2.2 Addressing Interface Risks through Coordination

As Malaysia's halal industry advances towards 2030, increasing attention must be directed towards inter-organisational coordination. Many of the most significant threats to halal integrity no longer arise solely from failures within individual organisations, but from inadequately managed interactions among manufacturers, logistics providers, warehousing operators, retailers, and digital platform providers. Although internal compliance remains essential, the preservation of halal integrity increasingly depends on the ability of multiple actors to coordinate activities across organisational boundaries.

Malaysia's institutional framework provides a strong foundation for such coordination through the establishment of common standards and shared operational principles. Standards such as MS 1500 and the MS 2400 series create a common governance framework that facilitates alignment among supply chain participants. This shared framework serves as an important mechanism for managing the interface risks identified by Charlebois et al. (2024). When manufacturers, logistics providers, warehousing operators, and retailers operate within the same MHMS 2020 framework, the likelihood of coordination failures is reduced. For example, the risk of halal products being exposed to non-halal contamination during transportation, storage, or handling can be minimised through standardised procedures, consistent documentation, and coordinated monitoring practices. Beyond safeguarding halal integrity, coordination capability also contributes to supply chain resilience.

In an increasingly volatile global environment, organisations must be able to respond quickly to disruptions while maintaining compliance requirements. The capacity to verify the halal status of alternative suppliers, identify certified logistics partners, or reroute products through approved warehousing facilities represents a dynamic organisational capability that enhances both operational continuity and risk management. Such responsiveness is particularly important in global supply chains where disruptions may occur unexpectedly and where delays in information exchange can compromise both product integrity and business performance. Malaysia's investment in Halal Malaysia Industrial Park (HALMAS) and dedicated digital infrastructure further strengthens this coordination capability. These initiatives provide the physical and digital foundations necessary for greater supply chain integration by creating environments in which firms, particularly small and medium-sized enterprises (SMEs), can operate within pre-certified and highly connected ecosystems. Such infrastructure supports information sharing, traceability, and coordinated decision-making, thereby enhancing both compliance effectiveness and operational efficiency.

In summary, Malaysia's halal governance framework has evolved beyond a narrow focus on certification and logo-based assurance. It now encompasses a comprehensive and multi-layered architecture that integrates regulatory standards, institutionalised management systems, digital technologies, and industrial development strategies. Through the alignment of the Halal Industry Master Plan (HIMP) 2030 and the New Industrial Master Plan (NIMP) 2030, Malaysia is repositioning its halal governance framework as a strategic source of competitive advantage. The growing emphasis on digital connectivity, supply chain coordination, and ESG alignment reinforces the Malaysian halal brand as a symbol not only of religious compliance, but also of traceability, safety, sustainability, and ethical integrity within an increasingly digitalised global economy.

3. Literature Review

3.1 Halal Supply Chain Integrity

The seminal work of Tieman et al. (2012) redefined halal supply chain design by shifting the focus from end-product certification to the active management of logistics processes and cross-contamination risks. By demonstrating that halal integrity depends on mitigating both physical contact with haram (prohibited) substances and negative consumer perceptions, their research redirected academic discourse towards a holistic, supply chain-wide approach. Recent studies have reinforced this perspective by highlighting that halal integrity extends beyond end-product certification and requires continuous monitoring, coordination, and traceability throughout sourcing, production, logistics, transportation, storage, and distribution processes to ensure compliance and product authenticity across the supply chain (Ab Talib et al, 2021; Alourani & Khan, 2024). Rather than treating halal status as a static attribute verified at the point of production, this perspective conceptualises integrity as a dynamic outcome shaped by the ongoing management of logistics activities and cross-contamination risks throughout the supply chain. This shift is particularly important, as Zawiah Abdul Majid et al. (2023) acknowledge that halal assurance becomes increasingly vulnerable once products leave controlled manufacturing environments and enter complex, multi-actor distribution systems.

Building upon this systemic foundation, Mohd Hafiz Zulfakar et al. (2014) conceptualised halal integrity as a multidimensional construct. They argued that integrity is not merely a by-product of isolated mechanisms but rather an outcome of an interacting governance system. Their model integrates formal mechanisms, such as certification, traceability systems, and regulatory compliance, with relational elements including trust, stakeholder commitment, and dedicated asset investment. This integration highlights that halal integrity is not solely a technical or regulatory issue but also a socio-organisational outcome that depends on the alignment of both structural and relational factors in fostering consumer trust (Nuradibah Abdul Rahman & Wan Rusni Wan Ismail, 2026).

Mohd Helmi Ali et al. (2017) extended this perspective into the digital and operational era by emphasising the integration of raw material management, production processes, service delivery, and information tracking. Such strategic supply chain integration enhances transparency while simultaneously strengthening halal integrity and organisational performance. Within the Malaysian context, these academic developments underscore a critical reality: halal assurance is fundamentally compromised when upstream and downstream functions remain fragmented. Consequently, achieving genuine halal integrity requires a shift away from siloed compliance practices towards a more integrated and connected system. In such a system, the physical movement of products must be supported by continuous, accurate, and reliable information flows. Dashti et al. (2024) further highlighted the importance of implementing segregation, certification, traceability, event recording, exception handling, and accountability mechanisms throughout supply chain operations to maintain halal integrity.

3.2 Halal Logistics, Traceability, and Information Visibility

Research on halal logistics highlights the continuing challenge of balancing strategic value creation with operational requirements. Suhaiza Zailani et al. (2017) observed that although logistics plays a critical role in enhancing the effectiveness and competitiveness of halal supply chains, its implementation is often constrained by high operating costs, the need for specialised facilities and dedicated assets, and differing levels of market readiness. These challenges are particularly evident in transportation and warehousing activities, where products are exposed to heightened risks of contamination and loss of integrity. Consequently, managing such interface risks requires not only physical segregation mechanisms but also more sophisticated forms of coordination supported by data-driven technologies, including RFID-enabled Internet of Things (IoT) analytics (Harsanto et al., 2024).

A recurring concern within the halal logistics literature is the management of interface risks, namely points at which products, information, or responsibilities are transferred between actors or operational systems. These interfaces represent critical moments of vulnerability because both physical contamination and information discontinuity may occur. Traditional halal logistics approaches have primarily relied on physical segregation, dedicated assets, and certification procedures to mitigate such risks. While these measures remain essential, they are increasingly insufficient in complex, multi-tier supply chains characterised by numerous intermediaries, limited visibility, and growing coordination challenges.

In response to these limitations, an expanding body of research identifies digital technologies as important mechanisms for enhancing supply chain visibility and reducing

systemic risks. Recent studies indicate growing interest in the application of blockchain technology and the Internet of Things (IoT) to strengthen halal supply chain security, transparency, and traceability (Rozita Zahari et al., 2025). However, adoption remains uneven across the industry, and the broader implications of digital technologies for sustainability performance are not yet fully understood. Mohd Helmi Ali et al. (2021) argue that although blockchain technology has considerable potential to improve sustainability outcomes, its effectiveness depends on implementation frameworks that recognise the resource constraints and operational realities faced by small and medium-sized enterprises (SMEs).

This perspective is consistent with wider developments in the agri-food sector, where effective data sharing across “farm-to-fork” ecosystems is increasingly regarded as a prerequisite for supply chain visibility, predictive decision-making, and operational resilience (Mohd Helmi Ali et al., 2021). In this context, digital traceability extends beyond monitoring product locations and movements. It provides a mechanism for institutionalising accountability by creating verifiable records of activities, transactions, and compliance throughout the supply chain. Such capabilities are particularly important in halal supply chains, where assurance depends heavily on the ability to verify product provenance and maintain process integrity across multiple organisational boundaries. Digital information visibility and real-time monitoring therefore play a crucial role in strengthening both halal assurance and stakeholder confidence (Mohamed Suhaimi Yusof et al., 2026).

Despite these potential benefits, the implementation of digital traceability systems remains inconsistent. Existing research frequently emphasises technological capabilities while giving less attention to practical implementation challenges, including financial constraints, interoperability issues, infrastructure limitations, and varying levels of digital readiness among SMEs. As a result, a significant gap remains between technological potential and operational practice. Furthermore, the relationship between digital traceability and sustainability performance remains underexplored, despite growing recognition that information visibility contributes to resource efficiency, waste reduction, risk management, and ESG accountability. From this perspective, digital connectivity should not be regarded merely as a technological enhancement but as a strategic enabler of supply chain integration and performance. By facilitating continuous information flows across organisational boundaries, digital systems transform halal assurance from a reactive process of verification into a proactive capability for real-time monitoring, coordination, and decision-making. Such capabilities are increasingly essential within globalised food systems, where maintaining visibility across dispersed actors is critical not only for preserving halal integrity but also for achieving broader sustainability objectives.

3.3 Coordination and Halal Integrity

Coordination has long been recognised as a critical determinant of supply chain performance, particularly in complex and interdependent systems such as agri-food networks. In the broader supply chain literature, coordination refers to the alignment of decisions, processes, resources, and incentives among multiple actors in order to achieve system-wide efficiency and effectiveness. Within halal supply chains, however, coordination assumes an even more significant role because it directly influences the preservation of halal integrity. Unlike conventional supply chains, coordination failures in halal supply chains do not merely reduce operational efficiency; they may also compromise religious compliance

and undermine stakeholder trust. Mohd Helmi Ali et al. (2021) demonstrate that effective coordination functions as an important stabilising mechanism in addressing the inherent uncertainties associated with food production, logistics, and market demand. Consequently, the selection of appropriate coordination mechanisms must be aligned with the structural characteristics and interdependencies of the supply chain.

A central component of effective coordination is information sharing. Extensive research indicates that stronger supply chain integration improves the quality, timeliness, and accessibility of information, thereby enabling organisations to make better decisions, respond more effectively to disruptions, and reduce operational uncertainty (Mohd Helmi Ali et al., 2021). Enhanced information flows also facilitate greater synchronisation among supply chain actors, contributing to improved operational performance and resilience. Without reliable information exchange, even well-developed physical infrastructure and regulatory systems may struggle to function effectively.

The importance of information sharing is particularly pronounced in halal supply chains, where assurance depends on maintaining an uninterrupted chain of trust across multiple organisational boundaries. Accurate and timely information regarding sourcing practices, certification status, segregation procedures, transportation conditions, and ritual cleansing (*sertu*) activities is essential for preserving halal integrity throughout the supply chain. When such information is incomplete, delayed, or inaccurate, the chain of trust is weakened, increasing the likelihood of contamination risks, compliance failures, and disruptions to product integrity.

From this perspective, coordination extends beyond conventional management objectives and becomes a fundamental prerequisite for halal assurance. Effective coordination enables supply chain actors to maintain visibility, accountability, and consistency in the implementation of halal requirements across interconnected operations. Conversely, fragmented coordination can have consequences that extend beyond operational inefficiency. It may compromise halal integrity, weaken consumer confidence, increase waste, and expose organisations to regulatory non-compliance. As noted by Mohamed Suhaimi Yusof et al. (2026), these outcomes have broader implications for both sustainability performance and long-term competitiveness within the halal industry. Overall, the literature suggests that coordination capability represents a critical mechanism through which halal integrity can be preserved within increasingly complex supply chain environments. The ability to align activities, share information, and coordinate responses across organisational boundaries is therefore essential not only for maintaining compliance but also for enhancing resilience, sustainability, and overall supply chain performance.

3.4 The Halalan-Toyyiban Sustainability Linkage

The concept of *Halalan-Toyyiban* represents an important evolution in halal supply chain thinking by extending the focus beyond religious permissibility to encompass quality, safety, ethics, and sustainability. While halal certification ensures compliance with Islamic dietary requirements, the *Toyyiban* dimension emphasises wholesomeness, responsible practices, and environmental stewardship. However, sustainability should not be regarded as an automatic consequence of halal certification. Rather, achieving sustainability outcomes requires deliberate operational integration and consistent implementation across the entire supply chain. Although halal principles and sustainability objectives overlap in areas such as

waste reduction, humane treatment, resource efficiency, and cleaner operations, the realisation of these complementary goals depends on effective coordination and integration among supply chain actors (Mohd Helmi Ali et al., 2021; Ab Talib et al., 2023).

From a conceptual perspective, the relationship between halal and sustainability is increasingly recognised as both logical and mutually reinforcing. Contemporary interpretations of halal extend beyond religious compliance to include broader concerns relating to quality assurance, safety, accountability, and responsible business conduct. As a result, the halal industry is progressively incorporating environmental and social considerations into its operational and strategic priorities (Mohamed Suhaimi Yusof et al., 2026). This evolution is reflected at the policy level through both the Halal Industry Master Plan (HIMP) 2030 and the New Industrial Master Plan (NIMP) 2030, which emphasise the integration of economic growth, ecosystem development, and sustainability as strategic imperatives for the future of the industry (HDC, 2023; MITI, 2023).

Within this emerging paradigm, sustainability is increasingly positioned as a natural extension of halal integrity rather than a separate organisational objective. The responsible use of resources, ethical sourcing practices, environmental stewardship, and long-term value creation are therefore viewed not only as business requirements but also as principles consistent with the broader objectives of *Halalan-Toyyiban*. Consequently, the preservation of halal integrity and the pursuit of sustainability can be understood as complementary goals that reinforce one another within modern halal supply chains.

Despite this growing recognition, an important gap remains within the existing literature. While many studies acknowledge the conceptual alignment between halal principles and sustainability objectives, relatively little empirical or theoretical work explains the mechanisms through which halal supply chain practices generate sustainability outcomes. In particular, there is limited understanding of how operational design, information visibility, connectivity, and coordination capabilities interact to support both halal integrity and sustainability performance simultaneously. This gap highlights the need for a more integrated conceptual framework capable of linking supply chain design and coordination processes with broader performance outcomes. Addressing this gap provides the foundation for the framework proposed in this study.

4. Theoretical Positioning

This study adopts a relational-network perspective of the halal food supply chain, which shifts the unit of analysis from individual organisations to the relationships and interactions that connect them. From this perspective, halal integrity and sustainability are not viewed as static outcomes verified at a single point in the supply chain. Rather, they are understood as emergent properties that arise from the ways in which actors, physical assets, operational processes, and information systems are interconnected and coordinated across the entire value chain (Mohamed Suhaimi Yusof et al., 2026). The central theoretical premise is that connectivity design functions as a structural antecedent that shapes the capacity of supply chain actors to coordinate their activities effectively. In turn, this coordination capability influences the overall performance of the supply chain in achieving both halal integrity and sustainability objectives (Mohd Helmi Ali et al., 2021).

The framework is further informed by the halal supply chain integrity literature, which argues that formal regulatory controls, although essential, are increasingly insufficient to

ensure compliance within complex and globally interconnected supply networks. Traditional auditing and certification mechanisms may struggle to address the dynamic risks that arise at operational interfaces where products, information, and responsibilities are transferred among multiple actors (Zulfakar et al., 2014). Consequently, maintaining halal integrity requires more than regulatory oversight alone. It depends on the effective integration of formal governance mechanisms, operational controls, and relational capabilities throughout the supply chain.

From this perspective, a reliable halal supply chain is supported by the interaction of both structural and relational elements. Structural elements include standardised operating procedures, dedicated halal facilities, certification systems, and real-time digital traceability technologies. Relational elements include trust, commitment, collaboration, shared accountability, and supportive institutional arrangements among stakeholders (Mohd Helmi Ali et al., 2021). The effectiveness of halal assurance therefore depends not on any single mechanism in isolation but on the alignment of these complementary dimensions within an integrated governance framework. Accordingly, this study conceptualises connectivity as a multidimensional socio-technical construct rather than merely a technological capability. Connectivity encompasses the physical, digital, and relational mechanisms that enable information exchange, operational synchronisation, and coordinated decision-making across organisational boundaries.

This position recognises that technologies such as blockchain and the Internet of Things (IoT), as well as dedicated infrastructure such as halal-certified warehousing and cold-chain facilities, can only realise their full potential when supported by effective governance structures and collaborative relationships among supply chain actors. By adopting this perspective, the study moves beyond conventional approaches that focus primarily on certification at specific stages of production. Instead, it emphasises the importance of network orchestration, whereby supply chain performance depends on the effective alignment of technical systems, organisational processes, and stakeholder relationships. Under this view, managers play a coordinating role in ensuring that connectivity design and coordination capability function together to preserve halal integrity throughout increasingly complex supply chain networks.

This theoretical positioning provides the foundation for examining how Malaysia's halal food industry can evolve from a predominantly compliance-driven model towards a more integrated and digitally enabled ecosystem. Such an ecosystem is capable of supporting not only religious compliance but also enhanced transparency, resilience, sustainability, and ESG accountability. By integrating insights from halal governance, supply chain management, and sustainability literature, the proposed framework contributes to bridging the gap between Islamic ethical principles and contemporary supply chain theory.

5. Propose Connectivity Design and Coordination Framework

5.1 Core Construct: Connectivity Design

Connectivity design is defined as the deliberate, strategic configuration of interfaces, linkages, and control points that synchronize actors, activities, assets, and data within a halal food supply chain. Moving beyond the narrow view of connectivity as a simple IT implementation, this paper proposes a multidimensional construct. It argues that for

connectivity to be effective in a halal context, it must be engineered across three interdependent layers: structural, digital, and relational.

(a) Structural Connectivity

Structural connectivity addresses the physical and organizational "skeleton" of the supply chain. In the halal industry, this dimension is the primary defence against physical cross-contamination. It encompasses:

Supplier Network Architecture: The strategic selection and clustering of certified suppliers to minimize logistical complexity.

Segregation Mechanisms: The physical separation of halal and non-halal flows, including dedicated loading docks and color-coded equipment.

Asset Dedication: The use of halal-only trucks, containers, and cold-room zones, as mandated by standards like MS 2400.

Certified Logistics Interfaces: The engineering of handover points (e.g., cross-docking stations) to ensure that the "halal status" remains protected during custody changes.

Structural connectivity reflects the degree to which the supply chain's physical backbone is engineered to mitigate risks and ensure the continuity of halal control from the point of production to the point of sale. Without robust structural connectivity, even advanced digital systems are insufficient to prevent contamination risks, as physical co-mingling remains one of the primary sources of halal integrity failure.

(b) Digital-Information Connectivity

This dimension refers to the interoperability, visibility, and traceability of data across the end-to-end supply chain. In the 2026 industrial landscape, digital connectivity acts as the "digital twin" of physical product flows. Key components include:

Data Interoperability: The ability of different systems (ERP, WMS, TMS) to communicate seamlessly using common standards.

Real-Time Event Capture: Utilizing Internet of Things (IoT) sensors to monitor temperature, humidity, and location, ensuring that "Toyyiban" (quality) is maintained alongside "Halal."

Blockchain-Enabled Traceability: Creating immutable records of certifications, ritual cleansing (sertu), and transit history.

Platform Synchronization: The alignment of firm-level data with national platforms like the Malaysia Halal Digital Hub.

Digital-information connectivity ensures that halal integrity and sustainability metrics are verifiable, auditable, and transparent. It transforms "passive compliance" into "active visibility," allowing stakeholders to verify provenance in real-time.

(c) Governance-Relational Connectivity

This dimension concerns the social and institutional architecture governing supply chain interactions. It is the "soft" infrastructure that makes "hard" technology work. It includes:

Trust-Building Mechanisms: Developing long-term relationships where information disclosure is seen as a mutual benefit rather than a risk.

Contractual Clarity: Explicitly defining halal and sustainability responsibilities in Service Level Agreements (SLAs).

Shared Standards & Role Definition: Alignment with regulatory-industry standards (e.g., JAKIM, HDC) to ensure everyone speaks the same "halal language."

Joint Problem Solving: The willingness of partners to collaborate on corrective actions when a breach occurs.

Relational connectivity is the critical enabler. As research shows, technological traceability remains inert unless actors are organizationally aligned to cooperate and maintain collective compliance.

5.2 Coordination Capability: The Link to Operational Excellence

Coordination capability refers to the collective ability of supply chain actors to align decisions, activities, and responses in a timely, reliable, and auditable manner. While connectivity design provides the structural, digital, and relational foundations of the supply chain, coordination capability reflects the extent to which these foundations are effectively translated into operational practice. In this sense, connectivity represents the enabling infrastructure, whereas coordination capability represents its functional execution.

Within the halal supply chain context, coordination capability is manifested through several operational mechanisms. First, synchronised sourcing enables procurement activities to remain aligned with supplier certification requirements and renewal cycles. Second, harmonised handling practices ensure that actors across organisational boundaries consistently implement the requirements of the Malaysia Halal Management System (MHMS) 2020. Third, effective exception management enables organisations to identify, isolate, and respond rapidly to potential integrity breaches before they escalate into broader compliance failures. Finally, continuous audit readiness ensures that both digital and physical records are maintained in a manner that supports regulatory inspections, traceability verification, and sustainability assessments.

The central proposition of the framework is that structural, digital, and relational connectivity function as the primary antecedents of coordination capability. When

connectivity is weak, supply chains are more likely to experience fragmented information flows, unclear responsibilities, delayed decision-making, and inconsistent operational practices. Conversely, stronger connectivity enables greater synchronisation, transparency, and responsiveness across supply chain actors. Under such conditions, halal assurance becomes embedded within routine operational processes rather than being treated as a discrete compliance activity.

5.3 Strategic Performance Outcomes

The proposed framework identifies three interrelated performance outcomes that emerge from enhanced coordination capability. Collectively, these outcomes reflect the broader transformation of Malaysia's halal food supply chain towards a more integrated, resilient, and sustainable ecosystem.

(a) Halal Integrity Performance

The first outcome concerns the preservation of halal integrity throughout the supply chain. This dimension extends beyond regulatory compliance and encompasses the ability to maintain consumer confidence through consistent adherence to halal requirements. Indicators of halal integrity performance include reductions in contamination risks, improved traceability, and sustained compliance with standards such as MS 2400 and the Malaysia Halal Management System (MHMS) 2020. Effective coordination strengthens the continuity of assurance processes across organisational boundaries, thereby supporting the credibility and reliability of halal-certified products (Mohd Helmi Ali et al, 2021).

(b) Operational Resilience and Efficiency

The second outcome relates to operational resilience and efficiency. Resilience refers to the ability of the supply chain to maintain performance and recover effectively from disruptions, while efficiency concerns the optimal utilisation of resources and processes. Enhanced coordination reduces duplication, minimises unnecessary verification activities, and lowers the costs associated with coordination failures, such as rejected shipments, product recalls, or delayed deliveries. In situations involving potential integrity breaches, coordinated supply chain actors are able to respond more rapidly and implement corrective actions more effectively, thereby reducing both financial and reputational risks (Mohamed Suhaimi Yusof et al., 2026).

(c) Sustainability Performance

The third outcome concerns sustainability performance, which is increasingly aligned with national initiatives such as Malaysia's i-ESG Framework and the New Industrial Master Plan (NIMP) 2030. Sustainability outcomes encompass both environmental and social dimensions of supply chain performance. Enhanced information visibility and coordination contribute to waste minimisation through improved demand forecasting, inventory management, and cold-chain optimisation. Resource efficiency can also be strengthened through more effective transportation planning and route optimisation, thereby reducing energy consumption and carbon emissions. In addition, greater transparency supports ethical accountability by facilitating compliance with labour standards, animal welfare requirements,

and broader principles associated with the *Maqasid al-Shariah*, particularly those relating to responsible stewardship of resources and social justice (Kurniawati et al., 2022).

On the whole, these outcomes suggest that coordination capability serves as the key mechanism through which connectivity design generates value within halal food supply chains. By linking connectivity with halal integrity, operational resilience, and sustainability performance, the framework provides a more comprehensive understanding of how supply chain design can support both religious compliance and broader organisational objectives.

5.4 Moderating Role of Malaysia's Institutional Environment

The proposed framework recognises that halal food supply chains operate within a broader institutional environment that shapes organisational behaviour and supply chain outcomes. In the Malaysian context, the regulatory and policy landscape functions as an important contextual moderator that influences the effectiveness of connectivity design and coordination capability. Unlike many less-developed or less-regulated halal markets, Malaysia benefits from a well-established governance framework that provides clear standards, strategic direction, and institutional legitimacy. A key strength of Malaysia's institutional environment lies in the availability of comprehensive regulatory standards, including MS 1500 and the MS 2400 series. These standards establish common expectations and operating procedures across the supply chain, thereby reducing governance uncertainty and facilitating greater alignment among supply chain actors.

In addition to regulatory standards, national strategic initiatives such as the Halal Industry Master Plan (HIMP) 2030 and the New Industrial Master Plan (NIMP) 2030 provide long-term policy direction for industry development. These initiatives encourage digitalisation, technological upgrading, sustainability integration, and ecosystem strengthening, thereby creating an enabling environment for firms to invest in connectivity-enhancing capabilities. Institutional trust also plays an important role in shaping supply chain relationships. The international reputation and credibility of Malaysia's halal governance system, particularly through JAKIM, contribute to a foundation of trust that supports cooperation among supply chain actors. This institutional legitimacy reduces uncertainty, strengthens stakeholder confidence, and facilitates greater willingness to engage in information sharing and collaborative problem-solving.

Overall, the framework suggests that connectivity design and coordination capability do not operate independently of their institutional context. Rather, the effectiveness of these capabilities is enhanced by Malaysia's mature halal governance ecosystem, which provides the regulatory legitimacy, policy support, and stakeholder trust necessary for achieving superior levels of halal integrity, operational resilience, and sustainability performance. In essence, the "Malaysian Brand" provides the trust, while the connectivity framework provides the tools.

6. Theoretical and Practical Contributions Discussion

The proposed framework advances halal supply chain scholarship and industrial practice in three significant ways, offering a comprehensive roadmap for the next generation of halal logistics.

6.1 Reframing Design: From Compliance to Orchestration

First, the framework reframes halal supply chain design from a traditional, static compliance-oriented perspective toward a dynamic connectivity-and-coordination view. Historically, halal research has focused on "point-of-origin" certification verifying that a single factory or ingredient meets Shariah requirements. However, this framework argues that in a globalised economy, integrity is a systemic property rather than an individual one. This shift is critical; while existing literature identifies various integrity factors, there remains a dearth of research explaining how these factors interact as a complex network design problem (Zulfakar et al., 2014; Mohd Helmi Ali et al., 2021). By positioning connectivity as the antecedent to coordination, the model provides a theoretical mechanism to explain how firms can maintain integrity across diverse and often volatile international supply nodes.

6.2 Digital Connectivity as the Sustainability Enabler

Second, the framework positions digital-information connectivity as the core enabler of sustainable halal supply chains. In contemporary practice, halal assurance is increasingly dependent on data continuity across a fragmented landscape of suppliers, manufacturers, logistics providers, and retailers. The *Halalan-Toyyiban* concept which encompasses both permissibility and wholesomeness requires proof of cold-chain consistency, ethical sourcing, and carbon footprint reduction. Without interoperable records and end-to-end visibility, both sustainability claims and halal integrity become significantly harder to verify, particularly in the context of globalized food systems (Rozita Zahari et al., 2025). The framework demonstrates that digital tools like Blockchain and IoT are not mere "add-ons" but are fundamental to the "Toyyiban" aspect of the chain, providing the transparency required for modern ESG (Environmental, Social, and Governance) reporting.

6.3 The Socio-Technical Imperative

Third, the proposed framework highlights that connectivity should be understood as a multidimensional socio-technical construct rather than a purely technological capability. One of the central contributions of this study is the recognition that technological solutions alone are insufficient to safeguard halal integrity across increasingly complex supply chain networks. While digital technologies such as blockchain, Internet of Things (IoT) applications, and advanced traceability systems can significantly enhance visibility and information management, their effectiveness depends on the presence of complementary structural, institutional, and relational mechanisms.

In this regard, physical infrastructure, dedicated halal assets, standardised operating procedures, shared governance frameworks, and trust-based relationships among supply chain actors remain essential components of effective halal assurance. This position is consistent with the halal logistics and halal integrity literature, which consistently demonstrates that certification alone cannot guarantee end-to-end halal compliance in the absence of effective coordination across organisational boundaries (Suhaiza Zailani et al., 2017; Mohamed Suhaimi Yusof et al., 2026). Accordingly, the framework rejects a technologically deterministic view of supply chain management. Instead, it emphasises that sustainable halal assurance emerges from the interaction between technical systems and

human relationships. This holistic view reminds managers that the "Chain of Trust" is built on human relationships and physical segregation as much as it is on digital code.

6.4 Policy Alignment for Malaysia's 2030 Vision

The proposed framework is particularly relevant within the Malaysian context, where the halal ecosystem has reached a level of institutional maturity that supports a transition from isolated certification practices towards more integrated forms of supply chain governance and coordination. Malaysia's regulatory infrastructure, established standards, and strategic policy direction provide favourable conditions for implementing a connectivity-oriented approach to halal supply chain management. This transition is strongly aligned with the objectives of both the Halal Industry Master Plan (HIMP) 2030 and the New Industrial Master Plan (NIMP) 2030. These national strategies emphasise ecosystem development, digitalisation, stronger domestic and international supply chain linkages, and sustainability-oriented industrial transformation as key priorities for future economic growth (HDC, 2023; MITI, 2023).

The framework complements these policy objectives by providing a conceptual basis for integrating connectivity design, coordination capability, and performance outcomes within halal supply chains. From a practical perspective, the framework offers guidance for organisations seeking to strengthen their competitiveness while simultaneously improving halal assurance, resilience, and sustainability performance. By encouraging investments in structural, digital, and relational connectivity, firms can move beyond a narrow compliance-oriented approach towards a more integrated and capability-driven model of halal supply chain management. Such a transition supports not only regulatory compliance but also broader national aspirations relating to industrial upgrading, digital transformation, and sustainable development.

7. Research Propositions

The conceptual framework developed in this paper culminates in a series of research propositions that specify the relationships among connectivity design, coordination capability, and supply chain performance outcomes. Consistent with the theoretical positioning advanced in this study, connectivity design is conceptualised as the primary antecedent of coordination capability, which subsequently influences halal integrity, operational resilience, and sustainability performance. In addition, the framework recognises the moderating role of Malaysia's institutional environment in strengthening the relationship between connectivity design and coordination capability.

7.1 Theoretical Pathways

The proposed relationships are grounded in the premise that well-designed structural, digital, and relational connections reduce uncertainty, improve information flows, and facilitate coordinated action across supply chain actors. When supply chain activities are effectively aligned and supported by appropriate governance mechanisms, organisations are better able to synchronise decisions, respond to disruptions, and maintain consistent

operational performance. Based on this theoretical logic, the following research propositions are advanced:

P1: Structural connectivity, encompassing dedicated physical assets and supply chain network architecture, positively influences coordination capability in Malaysia's halal food supply chains.

P2: Digital-information connectivity, characterised by data interoperability, traceability, and real-time information visibility, positively influences coordination capability in Malaysia's halal food supply chains.

P3: Governance-relational connectivity, characterised by trust, contractual clarity, stakeholder commitment, and collaborative relationships, positively influences coordination capability in Malaysia's halal food supply chains.

P4: Coordination capability positively influences halal integrity performance by reducing contamination risks, strengthening traceability, and supporting continuous compliance with halal requirements.

P5: Coordination capability positively influences operational resilience and efficiency by enabling more effective exception management, reducing coordination failures, and improving responsiveness to disruptions.

P6: Coordination capability positively influences sustainability performance by enhancing resource efficiency, reducing waste, and strengthening Environmental, Social and Governance (ESG) accountability.

P7: Malaysia's institutional environment, comprising regulatory standards, the Malaysia Halal Management System (MHMS) 2020, and the strategic directions of the Halal Industry Master Plan (HIMP) 2030 and the New Industrial Master Plan (NIMP) 2030, positively moderates the relationship between connectivity design and coordination capability.

On the whole, these propositions suggest that connectivity design influences supply chain performance indirectly through coordination capability, while the effectiveness of these relationships is strengthened by Malaysia's supportive institutional environment. The framework therefore provides a theoretically grounded basis for future empirical research examining how connectivity-oriented supply chain design contributes to halal integrity, resilience, and sustainability outcomes.

7.2 Summary of Model Relationships

Table 1 summarises the proposed relationships within the conceptual framework and illustrates the structural logic linking connectivity design, coordination capability, institutional context, and performance outcomes. The framework proposes that connectivity design functions as the primary antecedent of coordination capability, while coordination capability serves as the central mechanism through which performance outcomes are achieved. At the same time, Malaysia's institutional environment strengthens the effectiveness of this relationship by providing regulatory clarity, strategic direction, and institutional support.

Table 1. Proposition Relationships and Path Impacts

Proposition	Pathway	Role in the model	Impact
P1, P2, P3	Connectivity Coordination	Direct Effect (Antecedents)	Stronger socio-technical networks lead to superior operational synchronization.

P4, P5, P6	Coordination Performance □	Direct Effect (Outcomes)	Systematic synchronization secures integrity, boosts resilience, and optimizes waste reduction.
P7	Institutional Context x Connectivity	Moderating Effect	Robust regulatory support amplifies the efficiency and ROI of connectivity investments.

7.3 Analysis of Strategic Levers

The inclusion of Proposition 7 highlights the importance of institutional context in shaping the effectiveness of connectivity investments. The framework suggests that organisations operating within Malaysia's halal ecosystem may benefit from conditions that facilitate coordination more effectively than in environments characterised by weaker governance structures or less developed regulatory systems. Malaysia's established halal standards, including MS 1500, the MS 2400 series, and the Malaysia Halal Management System (MHMS) 2020, provide a common governance framework that reduces uncertainty and promotes consistency among supply chain actors. As a result, investments in structural, digital, and relational connectivity are more likely to translate into effective coordination outcomes because organisations operate within a shared regulatory and operational environment. In theoretical terms, the strength of the relationship between connectivity design and coordination capability is contingent upon, and enhanced by, the institutional environment in which firms operate.

A second important feature of the framework is its recognition of multiple performance outcomes arising from coordination capability. Rather than viewing halal assurance solely as a compliance objective, the model positions coordination capability as a mechanism that simultaneously supports halal integrity, operational resilience, and sustainability performance. This perspective reflects the increasingly integrated nature of contemporary halal supply chains. Effective coordination not only reduces contamination risks and strengthens compliance (P4), but also enhances responsiveness to disruptions and improves operational efficiency (P5). At the same time, improved coordination contributes to sustainability objectives through better resource utilisation, waste reduction, and enhanced ESG accountability (P6).

Accordingly, the framework suggests that halal integrity, resilience, and sustainability should not be viewed as separate or competing organisational priorities. Instead, they represent interconnected outcomes that emerge from effective coordination within a well-designed supply chain network. In this regard, coordination capability serves as the mediating mechanism through which connectivity design generates broader operational and strategic value. Overall, the propositions indicate that connectivity design influences organisational outcomes indirectly through coordination capability, while Malaysia's institutional environment strengthens this relationship. This integrated perspective provides a foundation for future empirical studies examining the pathways through which connectivity-oriented supply chain design contributes to integrity, resilience, and sustainability performance within the halal food sector.

8. The Conceptual Framework

The proposed Conceptual Framework of Connectivity Design and Coordination in Malaysia's Sustainable Halal Food Supply Chain is presented in Figure 1. The framework integrates insights from halal supply chain management, supply chain coordination, digital traceability, and sustainability literature to explain how connectivity design contributes to halal integrity, operational resilience, and sustainability performance. The framework is structured around three dimensions of connectivity design: structural connectivity, digital-information connectivity, and governance-relational connectivity. Structural connectivity refers to the physical and organisational arrangements that support halal operations, including dedicated facilities, logistics infrastructure, and supply chain network architecture. Digital-information connectivity encompasses data interoperability, traceability systems, and real-time information visibility that enable continuous monitoring and information exchange across the supply chain. Governance-relational connectivity captures the relational and institutional mechanisms that facilitate collaboration, trust, role clarity, and stakeholder commitment among supply chain participants.

The framework proposes that these three dimensions function as complementary antecedents of coordination capability, which serves as the central mediating mechanism within the model. Through enhanced coordination capability, supply chain actors are able to synchronise decisions, align operational activities, respond more effectively to disruptions, and maintain consistent implementation of halal requirements across organisational boundaries. In this way, connectivity design is expected to influence supply chain performance indirectly through its effect on coordination capability. The framework further identifies three key outcome domains: halal integrity performance, operational resilience and efficiency, and sustainability performance. Together, these outcomes reflect the broader objectives of contemporary halal supply chains, which extend beyond regulatory compliance to encompass resilience, transparency, resource efficiency, and ESG accountability. The model therefore conceptualises halal assurance not as an isolated compliance activity, but as an outcome of coordinated and integrated supply chain management.

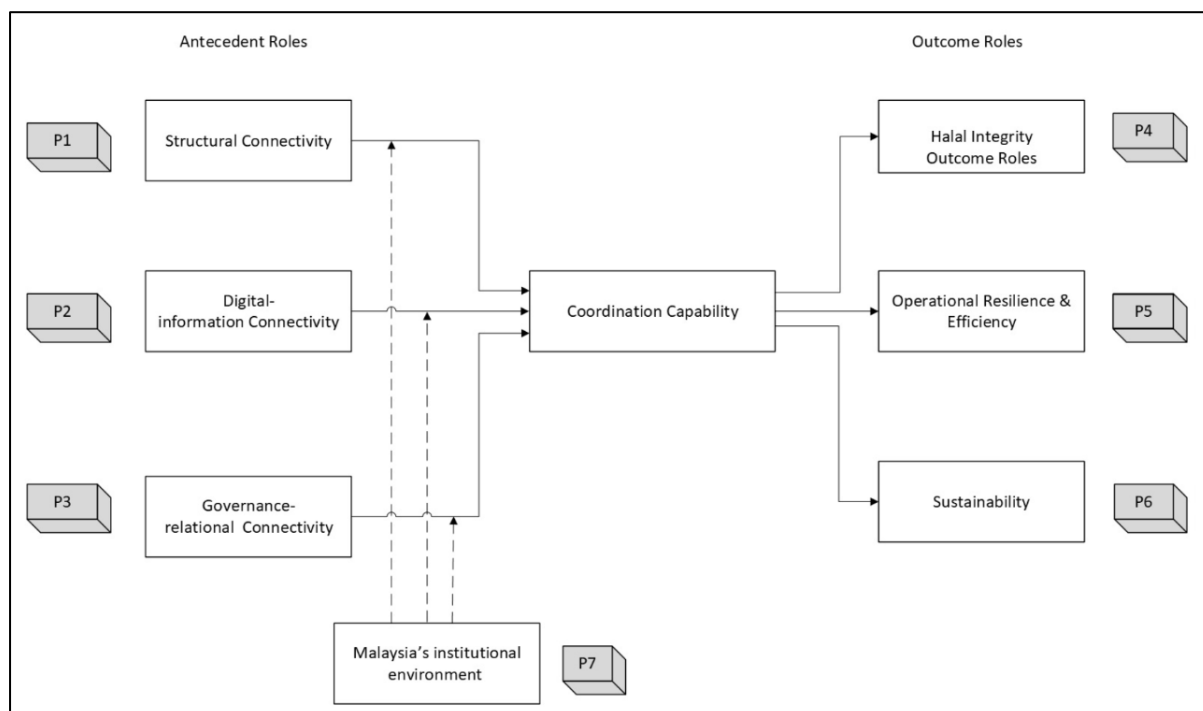


Figure 1. Proposed Conceptual Framework of Connectivity Design and Coordination in Malaysia's Sustainable Halal Food Supply Chain Model

9. Practical and Policy Implications

The framework developed in this study offers practical implications for key stakeholders within Malaysia's halal ecosystem. By adopting a connectivity-oriented perspective, organisations can move beyond viewing halal assurance as a compliance function and instead approach it as an integrated supply chain capability. This perspective is particularly relevant in increasingly complex supply chains where products, information, and responsibilities are distributed across multiple organisations. For instance, a manufacturer that relies on several third-party logistics providers must ensure not only physical segregation of halal products but also continuity of information throughout the supply chain. Failure to maintain either dimension may compromise overall halal integrity despite full compliance at individual operational stages.

9.1 For Managers: Moving Toward Systemic Integrity

For managers, the framework suggests that halal integrity and sustainability performance should be pursued through supply chain-wide design rather than isolated improvements within individual organisations. Historically, many firms have treated halal assurance primarily as an internal quality control or certification function. However, as supply chains become increasingly interconnected and geographically dispersed, many integrity risks emerge at the interfaces between organisations rather than within individual firms. Consequently, managers should complement internal compliance activities with a systematic assessment of halal-critical interfaces across the supply chain. Particular attention should be directed towards points where products, information, responsibilities, or certifications are transferred between supply chain actors.

The framework therefore encourages managers to view suppliers, logistics providers, warehousing operators, and other supply chain partners as interconnected participants within a shared assurance system. Effective halal assurance depends not only on the performance of individual organisations but also on the quality of coordination among all actors involved in product movement and information exchange. For example, a halal-certified manufacturer sourcing raw materials from multiple international suppliers may encounter difficulties in maintaining consistency across certification systems, documentation requirements, transportation arrangements, and information flows. Even when each supplier independently complies with halal requirements, discrepancies in certification records, delays in data sharing, or inconsistencies in handling procedures may create integrity risks. By adopting a connectivity-oriented approach, firms can strengthen both physical and digital integration across supply chain partners, ensuring that product flows and information flows remain aligned. This, in turn, reduces the likelihood of disruptions, enhances traceability, and improves overall supply chain reliability.

9.2 For Logistics and Warehousing: Data-Backed Assurance

For logistics providers and warehousing operators, the framework highlights the increasingly important role of transportation and storage functions in preserving halal integrity across the supply chain. Halal assurance depends not only on physical segregation and compliance with established standards but also on the ability to maintain accurate, auditable, and accessible information throughout product movement and storage activities. Consequently, compliance with transportation and warehousing standards such as MS 2400 should be viewed not merely as a certification requirement, but as a strategic component of broader supply chain connectivity. Organisations are also expected to support information continuity, traceability, and transparency across supply chain networks.

Investments in digital-information connectivity, including real-time tracking systems, automated compliance records, and integrated traceability platforms, can strengthen the ability of logistics providers to demonstrate and verify halal compliance throughout operational processes. Such capabilities contribute to greater confidence among manufacturers, retailers, regulators, and consumers by providing verifiable evidence of product handling, storage conditions, and compliance status. Enhanced information visibility also supports broader sustainability and ESG objectives by improving accountability, reducing operational uncertainty, and facilitating more effective monitoring of supply chain activities.

9.3 For Policymakers: Advancing an Integrated Halal Ecosystem

For policymakers, the framework highlights the importance of moving beyond a regulatory focus towards the development of a more integrated and digitally connected halal ecosystem. Malaysia's established halal governance infrastructure provides a strong foundation for facilitating greater coordination among industry participants and supporting the digital transformation of halal supply chains. In this regard, government agencies such as JAKIM and the Halal Development Corporation (HDC) can play an important role in promoting interoperable halal information systems, shared traceability frameworks, and common data standards across the supply chain. Greater interoperability would help reduce fragmentation

among certification, logistics, distribution, and market access functions, thereby improving both efficiency and transparency.

The framework further aligns with national priorities outlined in the New Industrial Master Plan (NIMP) 2030 and related digitalisation and sustainability agendas. By integrating halal governance objectives with broader industrial transformation strategies, policymakers can strengthen the resilience, transparency, and competitiveness of Malaysia's halal ecosystem. Such efforts may contribute to the development of a more connected supply chain environment in which products, information, and compliance data move seamlessly across organisational boundaries while maintaining high standards of halal integrity, traceability, and sustainability.

10. Conclusion and Future Research

This study argues that the future development of Malaysia's sustainable halal food supply chain depends not only on certification and regulatory compliance but also on the deliberate design of connectivity across supply chain networks. In increasingly complex and volatile food systems, halal integrity can no longer be assured solely through isolated compliance at individual operational nodes. Rather, it depends on the effective integration of structural connectivity, digital-information connectivity, and governance-relational connectivity across multiple supply chain actors.

The study contributes to halal supply chain literature by proposing a conceptual framework that links connectivity design, coordination capability, and performance outcomes. The framework positions coordination capability as the central mechanism through which connectivity influences halal integrity, operational resilience, and sustainability performance. It further recognises the moderating role of Malaysia's institutional environment, including established halal standards, the Malaysia Halal Management System (MHMS) 2020, and the strategic directions of the Halal Industry Master Plan (HIMP) 2030 and the New Industrial Master Plan (NIMP) 2030. In doing so, the framework advances a more integrated understanding of halal assurance as a supply chain-wide capability rather than a function of certification alone.

The framework also contributes to the evolving discourse on *Halalan-Toyyiban* by demonstrating how religious compliance, operational effectiveness, and sustainability objectives can be pursued simultaneously through connectivity-oriented supply chain design. By shifting attention from product-centred assurance towards network-based coordination, the study highlights the importance of information visibility, inter-organisational collaboration, and the management of interface risks in preserving halal integrity within increasingly interconnected supply chains.

Future research should empirically test the proposed relationships using both quantitative and qualitative approaches involving manufacturers, logistics providers, warehousing operators, retailers, certification bodies, and regulatory agencies. Particular attention should be given to the role of emerging technologies, institutional trust, and the economic implications of connectivity investments, especially for small and medium-sized enterprises (SMEs). Comparative studies across different institutional environments would also enhance understanding of how governance structures influence the effectiveness of connectivity design and coordination capability. In conclusion, the framework provides a foundation for rethinking halal supply chain management as a connectivity-driven and

coordination-oriented endeavour. By integrating connectivity design, coordination capability, and sustainability considerations within a single model, the study offers a theoretically grounded basis for understanding how halal integrity, resilience, and sustainability can be achieved within contemporary halal food supply chains.

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