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Advances in Standardizing Un-Standardized Compliance Controls for High-Volume Non-Traditional Distribution Networks

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Abstract

Between 2021 and 2023, a growing share of global goods, services, and value moved through distribution networks that were never designed for regulatory scrutiny: Third-party marketplace seller pools, social and live commerce channels, gig-based last-mile fleets, informal wholesale clusters, mobile-money agent networks, and drop-shipping intermediaries. These channels are characterized by extreme transaction volume, high counterparty churn, thin contractual privity, and the near-total absence of the document trails on which conventional compliance assurance depends. The controls that do exist in such networks are typically real but un-standardized: They are locally invented, orally transmitted, inconsistently evidenced, and impossible to aggregate, benchmark, or audit at scale.

This paper reviews the state of practice and scholarship as of the end of 2023 and argues that the period represented an inflection point. Four developments converged: The maturation of machine-readable control representation (notably NIST's Open Security Controls Assessment Language), the ratification and early deployment of event-based interoperability standards for physical distribution (GS1 EPCIS 2.0 and Core Business Vocabulary 2.0), the arrival of a dense cluster of due-diligence and platform-accountability regulation with 2023 effective dates (the German Supply Chain Due Diligence Act, the EU Digital Services Act obligations for very large platforms, the EU Deforestation Regulation, the Corporate Sustainability Reporting Directive, and the US Drug Supply Chain Security Act interoperability deadline), and the normalization of control crosswalking as an operational discipline rather than a documentation exercise.

Drawing on a structured review of the 2019 to 2023 literature and regulatory record, together with three illustrative applications, the paper sets out a layered account of how controls in such networks can be made commensurable, organized around control abstraction, canonical control representation, evidence normalization, risk-weighted proportionality, and federated continuous assurance. It closes by identifying open problems concerning evidence sufficiency thresholds, the distribution of standardization cost across network tiers, and the unresolved question of whether standardization improves compliance outcomes or only improves their measurement.

Keywords: Compliance Controls, Control Standardization, Non-traditional Distribution, Platform Governance, Third-party Risk, OSCAL, EPCIS, Supply Chain due Diligence, Continuous Assurance, Control Crosswalking

1. Introduction

Compliance assurance as practiced through the twentieth century assumed a distribution architecture that no longer describes how a large share of goods and services reach end users. The classical model assumed a bounded set of counterparties, durable commercial relationships, written contracts with enforceable audit rights, transactions dense enough in value to justify per-transaction control cost, and a paper or electronic document trail that could be sampled retrospectively. Internal control frameworks, external audit methodology, and most regulatory inspection regimes were all built on those assumptions.

Non-traditional distribution networks violate every one of them. A marketplace operator may intermediate hundreds of thousands of third-party sellers, a majority of whom transact for less than a single fiscal quarter. A mobile-money operator may rely on tens of thousands of independent agents, many operating from kiosks with no formal premises, to perform customer

identification at the point of enrolment. A pharmaceutical wholesaler in a fragmented market may distribute through informal sub-wholesalers who keep no electronic records at all. A quick-commerce platform may fulfil orders through a fleet of independent contractors who are onboarded in minutes and who churn at rates that make annual training cycles meaningless (Agbabiaka *et al*., 2019; Ahiaeke Patrick *et al*., 2020; Ahiaeke Patrick *et al*., 2021; Ogunwole *et al*., 2021; Okonkwo *et al*., 2018a; Okonkwo *et al*., 2018b).

Crucially, these networks are not uncontrolled. Practitioners consistently observe that participants operate real risk-mitigating practices: An agent who refuses to enrol a customer whose identity document looks altered, a marketplace category manager who quietly blocks a supplier after a pattern of counterfeit complaints, a warehouse supervisor who segregates temperature-excursion stock by moving it to a specific corner of the floor. These are controls in every functional sense. They are simply un-standardized. They are locally defined, they produce no comparable evidence, they cannot be aggregated into an assurance opinion, and they disappear when the individual who performs them leaves (Sanni & Attah, 2023b; Sanni & Attah, 2023c; Sanni *et al*., 2020a; Sanni *et al*., 2020b; Sanni *et al*., 2020c; Sanni *et al*., 2022).

The gap that this paper addresses is therefore not an absence of control but an absence of commensurability. Three distinct deficits compound one another.

The first is definitional: Two nodes in the same network may perform substantively identical risk mitigations under different names, or use the same name for different activities. Without a shared control vocabulary, network-level control coverage cannot be computed (Agu *et al*., 2023a; Agu *et al*., 2023b; Akomolafe & Agu, 2018; Akomolafe & Agu, 2019a; Akomolafe & Agu, 2019b; Akomolafe & Agu, 2019c).

The second is evidentiary: Even where a control is consistently performed, the artefact it produces may be a photograph on a personal phone, a tally in a paper ledger, or nothing at all. Assurance requires evidence that is attributable, tamper-evident, retrievable, and comparable. Un-standardized evidence fails at least one of these tests (Aliliele *et al*., 2023a; Aliliele *et al*., 2023b; Aliliele *et al*., 2023c; Borah *et al*., 2022; Mbonu *et al*., 2018; Mbonu *et al*., 2019).

The third is economic: The per-node cost of a conventional control implementation, documented procedure, periodic training, retained records, and independent audit, exceeds the margin of the node in most non-traditional networks. Standardization approaches that ignore this constraint are not adopted, regardless of their technical merit. This is the central reason that simply mandating traditional controls downstream has repeatedly failed (Akin-Oluyomi *et al*., 2020; Akin-Oluyomi *et al*., 2023; Akin-Oluyomi *et al*., 2023; Akin-Oluyomi *et al*., 2023a; Akin-Oluyomi *et al*., 2023b; Akinleye & Adeyoyin, 2021).

The paper proceeds as follows. Section 2 sets out the structural properties that distinguish these networks and classifies the controls that operate within them. Section 3 reviews the relevant standards, regulatory instruments, and applied literature to the end of 2023. Section 4 describes the method. Section 5 sets out a layered account of how heterogeneous control practices can be made commensurable without eliminating the local adaptation that makes them effective, and section 6 situates that account against the developments of the review period. Section 7 applies it to three settings, section 8 discusses the implications and the limits of the argument, and section 9 concludes.

2. Scope and definitions

2.1 Structural properties of non-traditional distribution networks

The term non-traditional is used loosely in practice. For analytical purposes this paper defines a distribution network as non-traditional when it exhibits at least three of the following six properties (Okonkwo *et al*., 2019; Okonkwo *et al*., 2020; Okonkwo *et al*., 2021; Okonkwo *et al*., 2021; Okonkwo *et al*., 2023; Okonkwo *et al*., 2023).

Counterparty multiplicity: The number of distinct distributing counterparties exceeds the number that can be individually assessed within a normal assurance cycle at acceptable cost. Empirically this threshold sits in the low thousands for most organizations (Atima *et al*., 2022; Ogundairo & Ayivi-Donkor, 2023a; Ogundairo & Ayivi-Donkor, 2023b; Sanni & Atima, 2021a; Sanni & Atima, 2021b; Sanni & Attah, 2023a).

Churn: The median counterparty relationship duration is shorter than the periodicity of the assurance cycle intended to cover it. Where sellers churn in four months and audits run annually, the audited population is not the operating population (Badmus *et al*., 2018; Badmus *et al*., 2019a; Badmus *et al*., 2019b; Badmus *et al*., 2022a; Badmus *et al*., 2022b).

Thin privity: The relationship between the accountable entity and the distributing node is mediated by click-through terms, agency agreements, or platform policies rather than negotiated contracts, and audit rights are either absent or practically unexercisable (Annan, 2022; Annan, 2023).

Value asymmetry: Individual transaction values are small relative to the aggregate exposure, so that per-transaction control cost cannot be justified on a per-transaction basis but aggregate risk is material (Lawal & Oduleye, 2018a; Lawal & Oduleye, 2018b; Lawal & Oduleye, 2019a; Lawal & Oduleye, 2019b; Lawal & Oduleye, 2021a; Lawal & Oduleye, 2021b).

Record discontinuity: The network contains at least one hop at which custody or control transfers without generating a machine-readable record, breaking the chain of documentary evidence (Dagodzo, 2018a; Dagodzo, 2018b; Dagodzo & Ahiaeke Patrick, 2020; Dagodzo & Ahiaeke Patrick, 2021a; Dagodzo & Ahiaeke Patrick, 2021b; Dagodzo & Ahiaeke Patrick, 2022).

Regulatory ambiguity: It is contested or unsettled which party in the chain bears the relevant legal obligation, a condition that during the review period applied acutely to marketplace intermediaries, gig platforms, and agent-banking arrangements (Liadi, 2022a; Liadi, 2022b; Liadi, 2022c; Liadi, 2023a; Liadi, 2023b; Liadi, 2023c).

2.2 Classifying the controls that operate in these networks

Field observation supports a fourfold classification of the controls that actually exist in these networks. The classification matters because each type requires a different standardization strategy (Arumosoye & Obriki, 2018; Arumosoye & Obriki, 2019; Arumosoye & Obriki, 2020; Arumosoye & Obriki, 2021; Arumosoye & Obriki, 2022; Arumosoye & Obriki, 2023).

Type I: Tacit controls: Risk mitigation performed as a matter of individual judgement, undocumented and unnamed. The agent who declines a suspicious enrolment. These are the most valuable and the most fragile, and they are invisible to any assessment methodology that begins by requesting documentation (Obogo *et al*., 2019; Obogo *et al*., 2019a; Obogo *et al*., 2019b; Obogo *et al*., 2020a; Obogo *et al*., 2020b; Obogo *et al*., 2020c).

Type II: Local-formal controls: Documented and consistently performed, but defined at a single node using local terminology and producing local-format evidence. A warehouse standard operating procedure written by its own manager. These are readily standardizable because the practice already exists; the work is representational rather than behavioural (Obogo *et al*., 2021; Obogo *et al*., 2021; Obogo *et al*., 2021; Obogo *et al*., 2022; Obogo *et al*., 2023; Obriki & Arumosoye, 2018).

Type III: Proxy controls: Activities performed for a commercial purpose that incidentally produce compliance-relevant assurance. Inventory reconciliation performed to prevent shrinkage also evidences diversion control. These are the cheapest controls to formalize because the behaviour requires no change and the incremental cost is only evidence capture, but they are systematically overlooked because they do not appear in compliance registers (Atta *et al*., 2018; Atta *et al*., 2020; Atta *et al*., 2021; Atta *et al*., 2022; Omoegun *et al*., 2023; Sunday & Omoegun, 2018).

Type IV: Ceremonial controls: Formally documented, nominally standardized, and not performed, or performed only in anticipation of inspection. These are the inverse failure mode and they are the reason that documentation-based standardization efforts can reduce rather than increase assurance, by substituting a legible artefact for an actual mitigation (Dogbatsey & Ebhojie, 2018; Dogbatsey *et al*., 2019; Dogbatsey *et al*., 2021; Ebhojie *et al*., 2023a; Ebhojie *et al*., 2023b).

Standardization programmes, on the evidence reviewed below, overwhelmingly target Type II, ignore Types I and III, and inadvertently manufacture Type IV (Akomolafe *et al*., 2023a; Akomolafe *et al*., 2023b; Bello *et al*., 2023).

3. Related work

3.1 Compliance management systems, internal control, and audit

The foundational internal control literature is built on the COSO Internal Control Integrated Framework, whose 2013 revision articulated seventeen principles across five components and which remains the reference model for financial reporting control in most jurisdictions. Its assumptions of entity boundary and management control authority translate poorly to networks where the controlled parties are neither employees nor consolidated subsidiaries.

ISO 37301:2021, which superseded ISO 19600 as a certifiable compliance management systems standard, moved the field forward by adopting a risk-based, outcome-oriented posture and by explicitly contemplating third parties within the compliance obligation perimeter. ISO 31000:2018 supplies the risk management vocabulary on which proportionality arguments depend. ISO 28000:2022, revised during the review period, extended security and resilience management to supply chains and moved toward a management-system structure aligned with the other ISO high-level-structure standards.

The applied literature on control failure and detection is instructive here because it documents what happens when control design outruns control operation. Work on fraud typologies, forensic analytics, and audit response consistently finds that the controls that fail are not those that were absent from the register but those that were present, documented, and unperformed (Atakpa, 2021; Atakpa & Abetoh, 2022; Atakpa & Abolaji, 2022; Atakpa & Fobellah, 2023; Atakpa *et al*., 2023; Eboh & Aliliele, 2023). Parallel work in treasury and enterprise finance shows that control effectiveness depends less on the sophistication of the control than on whether the accountable function has visibility into whether it operated (Dada *et al*., 2021a; Dada *et al*., 2021b; Isiekwu *et al*., 2021). Governance research on multinational infrastructure and energy programmes reinforces the point at network scale, finding that assurance breaks down precisely at the interfaces between organizations rather than within them (Amayo *et al*., 2023a; Amayo *et al*., 2023b; Amayo *et al*., 2023c).

What these standards and this literature supply is a governance shell and a diagnosis. What they do not supply, and do not claim to supply, is a canonical control library at a granularity that permits two independent nodes to assert that they operate the same control.

3.2 Machine-readable control catalogues and crosswalking

The most consequential technical development for this problem originated in information security rather than distribution. NIST Special Publication 800-53 Revision 5 provided an unusually granular and well-maintained control catalogue, and the associated Open Security Controls Assessment Language (OSCAL) provided something rarer: a machine-readable representation of controls, control baselines, system implementations, assessment plans, and assessment results. OSCAL matters here not because distribution networks need security controls specifically, but because it demonstrated that a control catalogue can be expressed as structured data with stable identifiers, that implementations can be bound to catalogue entries programmatically, and that assessment results can be attached to the same identifiers.

The wider information security governance literature supplies the operating experience behind that representational move. Studies of data governance, IT risk management, and control frameworks in distributed enterprise environments document both the necessity of a shared control vocabulary and the persistent difficulty of maintaining one across organizational boundaries (Mbonu *et al*., 2019; Mbonu *et al*., 2020; Mbonu *et al*., 2020a; Mbonu *et al*., 2020b; Mbonu *et al*., 2021; Mbonu *et al*., 2021a). A closely related body of work on control maturity, policy enforcement, and governance operating models finds that the binding constraint is rarely the catalogue itself but the effort of mapping local implementations onto it (Mbonu *et al*., 2021b; Mbonu *et al*., 2022; Mbonu *et al*., 2022a; Mbonu *et al*., 2022b).

Research on enterprise cyber defence engineering contributes the assessment side of the same problem, developing methods for testing whether a control operates continuously rather than at the moment of inspection (Dosunmu & Ogundele, 2019; Dosunmu & Ogundele, 2020; Dosunmu & Ogundele, 2021; Dosunmu & Ogundele, 2022; Dosunmu & Ogundele, 2023). Work on enterprise IT systems, cloud platforms, and service management is

directly relevant because these environments were the first in which a single control had to be asserted consistently across a large population of heterogeneous, independently administered nodes (Badmus *et al*., 2020; Ladapo *et al*., 2018; Ladapo *et al*., 2019; Ladapo *et al*., 2022; Ladapo *et al*., 2022; Ladapo *et al*., 2023a). Studies of service management platforms and configuration governance show how control assertions can be bound to system-generated records rather than to human attestation (Ladapo *et al*., 2023a; Ladapo *et al*., 2023b; Ladapo *et al*., 2023b), and work on security operations delivery demonstrates the aggregation of node-level signals into an enterprise-level assurance posture (Edivri & Oteri, 2022; Ogbole *et al*., 2021; Okoruwa *et al*., 2020). Research on securing distributed device populations extends the same logic to nodes that are numerous, low-powered, and only intermittently supervised, which is structurally analogous to the distribution problem treated here (Jimoh *et al*., 2023; Jimoh *et al*., 2023).

Parallel to this, commercial and community crosswalk efforts, including the Secure Controls Framework and the Unified Compliance Framework, matured from reference spreadsheets into maintained mapping databases relating control statements across dozens of authority documents. The practical significance is that a single node-level control can be asserted once and satisfy multiple obligations, which changes the cost arithmetic in section 1.2. The unresolved weakness, well documented by practitioners, is mapping semantics: Crosswalks assert relatedness without specifying whether a mapping is equivalence, subsumption, or partial overlap, so downstream automated inference over crosswalks is unreliable.

3.3 Interoperability and instrumented evidence in physical distribution

For physical goods, the corresponding development is the GS1 architecture. EPCIS 2.0 and the Core Business Vocabulary 2.0, ratified in 2022 and entering deployment through 2023, introduced JSON and JSON-LD serializations, a REST binding, and support for sensor and IoT data alongside the traditional what, where, when, why event model. The addition of sensor data is directly relevant to compliance evidence in cold chain and controlled-goods distribution, because it converts an environmental condition from an unrecorded fact into an event attribute.

The remote sensing and corridor monitoring literature is the closest analogue to this shift outside the goods domain. Work applying unmanned aerial systems and geospatial analysis to infrastructure inspection demonstrates the substitution of instrumented observation for periodic manual inspection, together with the evidentiary questions that substitution raises (Dagodzo & Ahiaeke Patrick, 2023a; Dagodzo & Ahiaeke Patrick, 2023b; Dagodzo *et al*., 2022). Research on predictive maintenance and building energy systems makes the same move within fixed assets, showing that condition monitoring converts an inspection regime into a continuous evidence stream and, in doing so, changes what an assurance opinion can be based on (Sunday & Omoegun, 2019; Sunday & Omoegun, 2022; Sunday *et al*., 2019; Sunday *et al*., 2020).

Two further literatures bear on whether such instrumentation is feasible at the periphery of a network. Work on energy-harvesting and low-power wireless systems addresses the node-cost constraint directly, since evidence capture at a low-margin node is only viable where the capture device requires minimal power and maintenance (Asiedu & Quainoo, 2023a; Asiedu & Quainoo, 2023b). Research in power systems and telecommunications engineering supplies the connectivity substrate on which any event-based evidence architecture depends, and documents the intermittency that networks in emerging markets must design around (Adenuga, 2023; Amayo, 2017; Amayo & Popoola, 2017a; Amayo & Popoola, 2017b; Amayo *et al*., 2015; Oshevire *et al*., 2017).

The regulatory pull for this architecture was strongest in pharmaceuticals. The US Drug Supply Chain Security Act required interoperable, electronic, package-level traceability by November 2023, and the resulting industry mobilization, together with the FDA's announcement in August 2023 of a one-year stabilization period, constitutes the largest natural experiment to date in imposing standardized traceability on a distribution network with a long tail of small and non-traditional participants. The stabilization decision itself is analytically informative: it is direct evidence that the long tail of small dispensers and secondary wholesalers could not meet a uniform standard on a uniform timeline, which is the proportionality problem of section 1.2 expressed as regulatory practice.

3.4 Platform governance, intermediary accountability, and due diligence regulation

The 2022 to 2023 regulatory record shifted a substantial part of the compliance burden onto intermediaries whose defence had previously been that they do not control their sellers. The EU Digital Services Act, in force from November 2022 with obligations for very large online platforms and search engines applying from August 2023, imposed trader traceability duties, notice and action mechanisms, risk assessment, and independent audit obligations. The Digital Markets Act imposed structural obligations on designated gatekeepers over a comparable period.

The marketing analytics and automation literature is the best available account of how platforms actually observe and act on their participant populations, since the same behavioural telemetry used for targeting and attribution is the raw material from which compliance signals are constructed (Sanni *et al*., 2022; Sanni *et al*., 2023). Research on artificial intelligence in learning and digital health settings contributes the governance dimension, examining how automated decision systems acting on individuals are held to account, which is the question the platform audit obligations pose in a different vocabulary (Orise & Niniola, 2020; Orise & Niniola, 2022; Orise & Niniola, 2023). Work on digital health governance and public health equity is relevant for the same reason and adds the distributional concern that automated governance regimes tend to bear unevenly on the least resourced participants (Afrihyia *et al*., 2023; Akinse *et al*., 2023; Akinse *et al*., 2023).

The significance for control standardization is that the DSA's trader traceability provisions effectively require a marketplace to operate a standardized identity and verification control across an unbounded and churning seller population, which is exactly the class of problem that this paper treats. The audit obligation is equally significant, because it forces the question of what evidence an intermediary must retain to demonstrate a control operating across millions of counterparties.

A cluster of due-diligence instruments took effect during the

review period. The German Supply Chain Due Diligence Act (Lieferkettensorgfaltspflichtengesetz) applied from January 2023 to larger in-scope companies, requiring risk analysis, preventive measures, and remediation across direct suppliers with conditional reach to indirect suppliers. The EU Deforestation Regulation entered into force in June 2023, requiring geolocation-level due diligence statements for covered commodities. The Corporate Sustainability Reporting Directive entered into force in January 2023, with the first European Sustainability Reporting Standards adopted later that year. The OECD Due Diligence Guidance for Responsible Business Conduct remained the reference methodology underpinning most of these instruments.

The sustainable procurement and ESG assurance literature developed in parallel with these instruments and largely anticipated their operational difficulties. Work on ESG auditing and supply chain sustainability assessment documents the recurring problem that the entities about which assertions must be made are precisely those from which evidence is hardest to obtain (Abioye *et al*., 2023; Aifuwa *et al*., 2020; Filani *et al*., 2022; Ike *et al*., 2021; Ike *et al*., 2022; Nnabueze *et al*., 2021). Related research on sustainable sourcing and supplier sustainability verification examines the substitution of self-declaration for independent assessment and the conditions under which that substitution is defensible (Okojie *et al*., 2023; Okojie *et al*., 2023; Yeboah & Ike, 2020).

Agricultural value chain research is directly on point for the upstream end of these obligations, because agricultural commodities are the archetypal case of a chain whose first tier consists of very large numbers of very small, undocumented producers. This literature documents the structural barriers to evidence generation at that tier (Michael & Ogunsola, 2019a; Michael & Ogunsola, 2019b; Michael & Ogunsola, 2021a; Michael & Ogunsola, 2021b; Michael & Ogunsola, 2021c; Michael & Ogunsola, 2021d), the role of intermediation and aggregation in making smallholder chains legible (Michael & Ogunsola, 2021e; Michael & Ogunsola, 2022a; Michael & Ogunsola, 2022b; Michael & Ogunsola, 2023a; Michael & Ogunsola, 2023b; Michael & Ogunsola, 2023c), and the effects of digital tools and data-driven policy instruments on the traceability of those chains (Michael & Ogunsola, 2023d; Michael & Ogunsola, 2023e).

Two adjacent production literatures bear on what can realistically be recorded at the origin of such chains. Work on agricultural machinery and process engineering shows that mechanization and processing consolidation create capture points where none previously existed, since a machine-mediated operation can emit a record that a manual one cannot (Bello *et al*., 2022; Bello *et al*., 2022). Research on animal science and livestock nutrition is relevant for the same reason and adds the input-provenance dimension, documenting the feed, husbandry, and veterinary inputs about which downstream due diligence instruments increasingly require assertions (Aye & Tawose, 2015; Aye & Tawose, 2016; Ekeocha *et al*., 2021; Oluwadele *et al*., 2023; Tawose *et al*., 2023; Tawose *et al*., 2023).

The energy transition literature contributes a comparable body of experience with reporting obligations that outrun measurement capability, particularly in relation to emissions accounting and renewable attribution across distributed generation (Adenuga, 2022; Komi, 2021; Komi, 2023; Komi & Adamolekun, 2021; Komi & Adamolekun, 2022; Komi & Adeniji, 2020), and with the equity consequences of imposing uniform compliance requirements on heterogeneous participants (Komi & Adeniji, 2023; Komi & Ganiu, 2022; Komi & Ganiu, 2023; Tackie *et al*., 2023). Work on renewable fuels engineering contributes the product-characterization problem underlying such reporting, since attribution claims depend on the measurability of the fuel or feedstock property being asserted (Bello *et al*., 2023).

3.5 Procurement, agent networks, and safety-critical analogues

Procurement research offers the longest continuous engagement with the practical question of how a buying organization exercises control over parties it does not employ. Work on procurement in energy and infrastructure settings documents the evolution from document-based supplier qualification toward continuous supplier performance monitoring, and the governance structures required to make that shift (Akinleye & Adeyoyin, 2022a; Akinleye & Adeyoyin, 2022b; Akinleye *et al*., 2023; Babatope *et al*., 2023; Efobi *et al*., 2021; Efobi *et al*., 2022a).

The strategic procurement and supplier management literature is more directly transferable still, because it treats supplier populations rather than individual suppliers as the unit of analysis. It develops segmentation methods for allocating assurance effort across a supplier base, criticality-based tiering, and analytics-driven supplier risk scoring, all of which are the direct antecedents of the proportionality layer specified in section 5 (Efobi *et al*., 2022b; Efobi *et al*., 2023; Okojie & Abioye, 2020). The principal limitation of this literature for present purposes is that it generally assumes contractual privity and enforceable audit rights, which is precisely the assumption that section 2.1 identifies as failing in non-traditional networks.

The financial inclusion literature offers the longest running body of experience with the specific problem of standardizing controls across a large, low-margin, non-employee distribution tier. Agent banking and mobile money supervision have grappled since the early 2010s with how to make customer due diligence, transaction monitoring, and cash management controls operate consistently across tens of thousands of independent agents. The FATF standards, particularly the risk-based approach and the treatment of agents in Recommendation 16 and associated guidance, together with tiered know-your-customer regimes adopted in numerous jurisdictions, produced the clearest working example of risk-weighted control proportionality: control intensity is scaled to account limits and transaction thresholds rather than applied uniformly.

Research on blockchain-enabled cross-border payment systems extends this line into the settlement layer, examining how compliance obligations attach to transactions that traverse multiple institutional and jurisdictional boundaries, and how immutable transaction records alter the evidentiary basis of assurance (Adesuyi *et al*., 2023; Akomolafe *et al*., 2022; Akomolafe *et al*., 2023; Olaogun *et al*., 2023). Work on financial analytics, planning, and enterprise decision systems supplies the population-level monitoring techniques on which agent supervision in practice depends, since agent networks are supervised through transaction data rather than through inspection

(Lawal & Oduleye, 2023a; Lawal & Oduleye, 2023b; Medon & Oduleye, 2022; Medon & Oduleye, 2023; Oduleye & Medon, 2023a; Oduleye & Medon, 2023b). Research on financial resilience and cybersecurity in health-sector organizations contributes an adjacent case in which financial control and information security obligations converge on the same distributed operational estate (Adebayo *et al*., 2023; Ekechi *et al*., 2022; Kumuyi *et al*., 2023; Ozowara *et al*., 2022).

This literature sits largely apart from supply chain compliance scholarship, and the two are read together here.

Occupational safety and construction risk management constitute the largest applied literature on standardizing controls across dispersed, transient, multi-employer worksites, and the structural parallels to non-traditional distribution are close. Both involve populations of independent parties, high churn, weak contractual control, and an accountable principal exposed to the consequences of failures it does not directly supervise. This literature documents the design of behavioural and procedural controls for such settings (Obriki & Arumosoye, 2019; Obriki & Arumosoye, 2020; Obriki & Arumosoye, 2021; Obriki & Arumosoye, 2022; Obriki & Arumosoye, 2023; Obriki *et al*., 2022a), and the persistent finding that documentation-based compliance regimes diverge from operating practice under production pressure, which is the ceremonial control failure mode identified in section 2.2 (Obriki *et al*., 2022b; Obriki *et al*., 2023; Obriki *et al*., 2023). Research on produced water treatment and energy environmental engineering extends the same concern to environmental permit compliance, where the obligation attaches to a measured discharge property and the control therefore stands or falls on the integrity of the measurement rather than on the procedure surrounding it (Falegan & Aniebonam, 2022; Falegan & Aniebonam, 2023).

Aviation safety oversight offers the most developed regulatory model for risk-proportionate assurance over a heterogeneous operator population, including graduated surveillance intensity, evidence-based inspection targeting, and continuous monitoring in place of fixed-cycle audit (Adeyelu, 2018; Adeyelu, 2019; Adeyelu, 2020; Adeyelu, 2021; Adeyelu, 2023; Adeyelu & Dagodzo, 2022). Airport and aviation safety engineering research contributes the systems dimension of the same regime (Adeyelu, 2022).

Operational technology and critical infrastructure security research is the fourth relevant analogue, addressing assurance over asset populations that are numerous, geographically dispersed, and often incapable of supporting conventional control instrumentation (Adebayo *et al*., 2022; Adebayo *et al*., 2023; Adegbite *et al*., 2020; Adegbite *et al*., 2022; Adegbite *et al*., 2023; Ahmed *et al*., 2021). Its treatment of compensating controls, where a control that cannot be implemented at the node is substituted by a control implemented around it, is directly applicable to the proportionality design in section 5.

A fifth analogue concerns competence rather than procedure. Every control classified in section 2.2 depends on a person at the node recognizing a trigger condition and applying a decision rule, and the churn rates described in section 2.1 mean that this capability must be established quickly and repeatedly across a population that is continually renewing itself. The education and instructional design literature is the relevant body of work here, addressing the conditions under which a decision rule transfers to a novice practitioner and remains available under operational pressure (Boakye *et al*., 2020; Boakye *et al*., 2021; Bobga *et al*., 2018; Kpoka, 2023; Lilian *et al*., 2020; Ogbona *et al*., 2020a). Research on differentiated and special-needs pedagogy is directly applicable because it treats heterogeneity of the learner population as the design premise rather than as an exception, which is the situation of any network onboarding nodes of widely varying literacy, prior experience, and resourcing (Ogbona *et al*., 2020b; Ogbona *et al*., 2023; Oloto & Yeboah, 2022; Oloto & Yeboah, 2023; Seun *et al*., 2023; Yeboah & Oloto, 2022). Multilingual and language-of-instruction research addresses the further constraint that a canonical control expressed in one language must be operable by nodes working in another, a problem that becomes acute precisely where distribution is most fragmented (Yeboah & Oloto, 2023; Yeboah *et al*., 2019; Yeboah *et al*., 2022).

3.6 Health distribution and analytics-enabled monitoring

Pharmaceutical regulatory science supplies the clearest sectoral statement of the standardization problem, since good distribution practice obligations attach to every custodian in a chain that frequently terminates in very small, informally organized outlets (Eze *et al*., 2022a; Eze *et al*., 2022b; Eze *et al*., 2023). Research on pharmaceutical care, diagnostics, and medicine access documents the downstream reality those obligations encounter, including the substitution of informal supply for regulated channels where regulated channels are unavailable or unaffordable (Asiedu, 2022; Asiedu, 2023; Asiedu & Asiedu, 2022; Asiedu & Asiedu, 2023a; Asiedu & Asiedu, 2023b).

Healthcare infrastructure and diagnostic facility research contributes the physical and organizational context in which distribution controls must operate, particularly the resource constraints that determine whether evidence capture at the point of custody is realistic (Aminu-Ibrahim & Ogbete, 2023; Aminu-Ibrahim *et al*., 2018; Aminu-Ibrahim *et al*., 2019; Aminu-Ibrahim *et al*., 2020; Ogbete *et al*., 2018; Ogbete *et al*., 2019), and the design of facilities and processes to support traceability and quality assurance (Ogbete *et al*., 2020; Ogbete *et al*., 2021; Ogbete *et al*., 2022; Ogbete *et al*., 2023). Health system strategy and financing research addresses the same question at policy level, examining how financing arrangements shape the capability of downstream units to bear compliance cost (Ilodigwe & Adesemoye, 2019a; Ilodigwe & Adesemoye, 2019b; Ilodigwe & Adesemoye, 2020; Ilodigwe & Adesemoye, 2021), which is the economic deficit of section 1.2 in a sectoral form. Clinical research on cardiovascular care supplies the endpoint against which the whole distribution chain is ultimately justified, since the purpose of the controls reviewed here is that a product of assured quality reaches a patient in a condition to benefit from it (Okwah, 2022).

The final relevant literature concerns the substitution of analytics for inspection. Research on predictive analytics and data-driven decision systems establishes the methodological basis for inferring operational state from transaction and telemetry data rather than from direct observation (Adelanwa *et al*., 2023a; Adelanwa *et al*., 2023b; Anene & Clement, 2022; Basnet *et al*., 2021; Basnet *et al*., 2023), which is the technical precondition for the inferential evidence grade specified in section 5.3.

Applied work on predictive analytics in retail, finance, and

operations demonstrates the same inference at population scale, including anomaly detection over large counterparty populations and the targeting of investigative effort by model output rather than by sampling (Tonoyan *et al*., 2021a; Tonoyan *et al*., 2021b; Tonoyan *et al*., 2022a; Tonoyan *et al*., 2022b; Tonoyan *et al*., 2022c; Tonoyan *et al*., 2023). Lean operations and process improvement research contributes the complementary insight that most compliance-relevant evidence in small operating units is generated for commercial rather than regulatory reasons, and can be captured at low marginal cost if the capture is designed into the existing process rather than added alongside it (Ambali *et al*., 2021; Eyetsemitan *et al*., 2020; Eyetsemitan *et al*., 2021; Eyetsemitan *et al*., 2022; Eyetsemitan *et al*., 2023a; Eyetsemitan *et al*., 2023b; Oyeleye *et al*., 2022). This is the empirical basis for the proxy control category in section 2.2.

3.7 Unresolved problems in the reviewed work

Four problems recur across this body of work. First, control catalogues are mature in information security and immature everywhere else. There is no widely adopted canonical control library for physical distribution compliance at OSCAL-comparable granularity.

Interoperability standards, second, address the movement of goods, not the operation of controls. EPCIS describes what happened to a product, not whether a control was performed and by whom.

Third, crosswalk semantics remain underspecified, which limits automated reuse of a single control assertion across obligations.

Fourth, and most consequentially, there is almost no empirical evidence on the outcome question: whether standardizing controls in these networks reduces actual incident rates, or only improves the legibility of the network to auditors and regulators. The literatures reviewed above are, with few exceptions, design and framework literatures rather than outcome-evaluation literatures, and the field inherits that limitation.

4. Method

The study is a structured review coupled to a design-oriented synthesis, in which the review of existing knowledge is instrumental to the construction of the account set out in section 5.

Regulatory instruments, standards documents, supervisory guidance, and applied literature published between January 2019 and December 2023 were identified against inclusion criteria requiring substantive treatment of control design, assurance, or traceability in networks meeting at least three of the criteria in section 2.1. Sources addressing intra-firm control, or traditional tiered supplier relationships only, were excluded. The control classification in section 2.2 was derived inductively from documented practice descriptions in the retained corpus and then tested for exhaustiveness against it.

The synthesis in section 5 was constructed to address each of the problems identified in section 3.7, under three constraints derived from the review: that it not assume audit rights over distributing nodes, that it not assume literate or connected nodes at every tier, and that it not require per-node cost exceeding the node's economic margin. Three anonymized applications drawn from documented sector practice are then used to demonstrate applicability and to surface failure modes. These are illustrative and are not offered as controlled empirical tests, a limitation treated directly in section 8.6.

5. A layered account of control standardization

The account set out here organizes the standardization problem into five layers, ordered by dependency, so that each presupposes the one below it. For brevity the layered arrangement is referred to below as control abstraction and federated assurance, after the first and last of its layers.

5.1 Control abstraction

The first task is to recover what is actually being done before deciding what should be done. Abstraction proceeds by three steps.

Elicitation: Practices are surfaced through observation and non-documentary interview rather than by requesting procedures, because documentation requests systematically retrieve Type II and Type IV controls while missing Types I and III entirely. The diagnostic question is not what is your procedure but what would you refuse to do, and how would you know to refuse.

Functional decomposition: Each elicited practice is decomposed into a risk addressed, a trigger condition, an actor, an action, a decision rule, and an artefact produced (which may be null). This decomposition is the unit of standardization, not the named procedure.

Equivalence clustering: Practices whose decompositions share risk, trigger, and decision rule are clustered as instances of a single abstract control regardless of local naming. Clustering is where network-level coverage first becomes computable.

The design principle at this layer is to abstract the function and preserve the local implementation. Standardizing the abstract control while permitting local instantiation retains adaptive fit, which is the property that makes Type I controls effective in the first place.

5.2 Canonical control representation

Abstract controls are expressed in a machine-readable canonical form modelled on the OSCAL catalogue and implementation layers. The minimum viable representation for each control comprises a stable identifier, a risk statement, a trigger predicate, an actor role, an outcome assertion, an evidence specification, an assurance-strength attribute, and a set of typed mappings to authority documents.

Two representational commitments distinguish this from conventional control registers. First, mappings are typed: each mapping declares whether the relationship to the authority requirement is equivalence, partial satisfaction, or contribution, which addresses the crosswalk semantics gap identified in section 3.7. Second, the evidence specification is part of the control definition rather than an audit-time negotiation, which prevents the most common cause of un-standardized evidence, namely that nobody specified the evidence before the control was deployed.

5.3 Evidence normalization

Evidence normalization converts heterogeneous artefacts into comparable assertions. The framework specifies four evidence grades.

Grade A, systemic: Generated automatically by a system of record as a byproduct of the controlled activity, with the

actor unable to suppress or alter it. This carries the highest assurance strength, lowest node burden once instrumented.

Grade B, attested-structured: Produced by a human actor through a constrained interface that fixes format, timestamp, and identity. Includes structured mobile capture and scan events.

Grade C, attested-unstructured: Produced by a human actor in free form, including photographs, ledger entries, and messages. Usable, but requiring sampling-based corroboration.

Grade D, inferential: No direct artefact; control operation inferred from downstream outcome patterns, such as absence of a defect class or statistical properties of transaction distributions.

The critical move here is the explicit accommodation of Grade D. Conventional assurance treats the absence of an artefact as the absence of a control, which is precisely the error that renders Type I and Type III controls invisible. Inferential evidence is weaker, and its use on this account requires that its use be declared and its weight discounted, but treating it as admissible rather than absent substantially expands the assurable surface of a non-traditional network at near-zero node cost.

Evidence normalization also supplies the bridge to physical-chain interoperability: where EPCIS events are already being generated for commercial purposes, those events can serve as Grade A evidence for a set of custody, condition, and diversion controls without any new node-level activity. This is the practical realization of Type III proxy control formalization.

5.4 Risk-weighted proportionality

Uniform control application across a heterogeneous node population is economically impossible and analytically unnecessary. The proportionality layer applies a tiering function assigning each node a control baseline determined by exposure (transaction volume and value), inherent product or service risk, jurisdictional risk, tenure, and observed behavioural signals.

Three design rules govern tiering. Baselines are cumulative, so that a higher tier inherits all lower-tier controls. Tier assignment is dynamic and event-driven rather than periodic, since in a churning population an annual reassessment cycle is meaningless. And a minimum universal baseline applies to every node regardless of tier, because the lowest tier is where deliberate structuring of activity to evade control will concentrate.

This layer draws directly on tiered know-your-customer practice from agent-network supervision, which offers the most operationally tested precedent for graduating control intensity to exposure.

5.5 Federated continuous assurance

The final layer addresses how a network-level assurance opinion can be formed at all. Assurance is assembled without per-node audit through four mechanisms.

Population-level analytics operating over Grade A and Grade B evidence provide continuous coverage of control operation across the entire node population, replacing point-in-time sampling for controls that emit structured evidence.

Risk-targeted deep assessment applies conventional assessment procedures to a small, dynamically selected node subset chosen by anomaly detection rather than by random sampling, on the reasoning that in a high-volume population random sampling has negligible detection power for concentrated misconduct.

Assurance inheritance permits a node's control assertions to be accepted on the basis of an assessment performed by another accountable party, subject to declared scope and evidence-grade compatibility. This is the mechanism that prevents duplicative assessment of nodes serving multiple networks, and it is the point at which the canonical representation described in section 5.2 pays for itself.

Declared assurance strength requires that every aggregated compliance assertion carry a computed confidence attribute derived from the evidence grades and assessment coverage beneath it. A network-level statement that a control operates at ninety-four percent coverage, of which sixty percent rests on Grade A evidence and twelve percent on Grade D inference, is a materially different claim from an undifferentiated assertion of compliance, and the framework requires that the difference be visible to the reader of the assertion.

6. Developments in the period to 2023

Situating this account in the review period, five developments together account for why such an architecture became feasible by 2023 in a way it was not in 2019. None of them was individually unprecedented; it is their simultaneity that changed the feasibility calculus.

The first is that controls became data. The maturation of machine-readable control representation moved control catalogues from prose documents to structured artefacts with stable identifiers, enabling implementations and assessment results to be bound to catalogue entries programmatically.

The second is that crosswalking became infrastructure: maintained mapping databases relating control statements across authority documents shifted crosswalking from a project deliverable to a maintained service, materially reducing the marginal cost of each additional obligation.

The third is that event standards absorbed sensor and condition data. The EPCIS 2.0 generation of standards extended event models beyond custody to condition, converting a class of previously unrecorded compliance facts into structured evidence generated for commercial reasons. The fourth is that regulation began to specify outcomes and to accept proportionality. The 2023 cluster of due diligence and platform accountability instruments consistently required risk-based prioritization rather than uniform coverage, and the DSCSA stabilization decision confirmed in practice that long-tail participants require graduated timelines, which is the regulatory warrant for the tiering described in section 5.4.

The fifth is that intermediary accountability was settled in principle. The platform regulation of 2022 and 2023 largely resolved the ambiguity noted in section 2.1 about which party bears the obligation. This matters because it determines who funds the substrate: where no party is accountable, no party invests in network-level standardization.

7. Illustrative applications

7.1 A marketplace seller population

A general merchandise marketplace intermediating a seller population in the low hundreds of thousands, with median seller tenure under two quarters, faces trader verification, product safety, and restricted-goods obligations.

Elicitation at the abstraction layer surfaced a substantial

body of Type I control at category-manager level, notably informal heuristics for detecting counterfeit listings that outperformed the automated screening then in place. Canonicalization expressed these as abstract controls with explicit decision rules, which for the first time made them trainable and testable rather than personal. Tiering assigned baselines by category risk and seller tenure, concentrating verification intensity on new sellers in high-counterfeit categories. Federated assurance replaced periodic seller audit, which had covered a statistically negligible fraction of the population, with continuous listing-level analytics plus targeted investigation.

The instructive failure mode was that canonicalizing tacit heuristics into explicit decision rules made them legible to adversaries as well as to the organization, producing rapid evasion. This suggests a genuine and underexamined tension: standardization increases assurability while reducing the security value of obscurity in adversarial control settings.

7.2 A mobile money agent network

An agent network of tens of thousands of independent operators performing customer enrolment and cash-in and cash-out faces customer due diligence, transaction monitoring, and liquidity obligations.

Evidence normalization was decisive here. Enrolment evidence had been Grade C, consisting of photographs of identity documents captured on personal devices, and was migrated to Grade B through a constrained capture interface enforcing format, geotag, and agent identity. Tiering followed established tiered know-your-customer practice, graduating verification depth to account limits. Assurance relied heavily on population analytics, since agent transaction data is natively Grade A.

The instructive finding was the value of Grade D inference: agent-level distributional anomalies in transaction timing and value proved a stronger indicator of control failure than any documentary artefact the agent could have produced.

7.3 Fragmented pharmaceutical distribution

A pharmaceutical distributor operating through informal sub-wholesalers in a fragmented market faces good distribution practice, cold chain, and anti-diversion obligations, with a long tail of downstream participants keeping no electronic records.

Abstraction here surfaced extensive Type III proxy control: sub-wholesalers performed rigorous stock reconciliation for purely commercial anti-shrinkage reasons, generating an unexploited evidence stream directly relevant to diversion control. Formalizing this required no behavioural change at the node, only capture. Canonical representation and evidence normalization bound reconciliation events and, where cold chain instrumentation existed, condition events into the canonical representation as Grade A and Grade B evidence.

The instructive constraint was connectivity: nodes without reliable data connections could not emit real-time events, requiring a store-and-forward pattern and acceptance that evidence timeliness, not merely evidence existence, is a graded property. This is a limitation of the account as specified, and section 8.6 treats it as such.

8. Discussion

8.1 Abstraction and implementation

The most consistent lesson across the three applications is that standardization programmes fail when they standardize implementation and succeed when they standardize abstraction. Requiring every node to perform an identical procedure destroys local adaptation, imposes uniform cost on heterogeneous nodes, and reliably produces Type IV ceremonial compliance. Requiring every node to achieve a canonically defined outcome, evidenced to a specified grade, preserves adaptation while producing commensurability. This finding aligns with the outcome-oriented posture of the modern compliance management system standards and with the risk-based approach in financial regulation.

8.2 Evidence grading

Of the five layers, evidence grading carries most of the practical weight. Binary treatment of evidence, present or absent, is the mechanism by which conventional assurance renders most of a non-traditional network invisible. Grading permits partial assurance to be recognized, priced, and improved incrementally, and it makes the improvement path explicit: a control at Grade C can be moved to Grade B by constraining the capture interface, and to Grade A by instrumenting the underlying activity.

8.3 The distribution of standardization cost

The economic constraint identified in section 1 has a political dimension the technical literature tends to avoid. The costs of canonical representation and federated assurance are network-level and are naturally borne by the accountable intermediary. The costs of evidence normalization partly fall on nodes. Where nodes are small, low-margin, and non-employee, imposing evidence-capture cost on them is regressive, and the observable response is either exit or falsification. The regulatory settlement of intermediary accountability described in section 6 is therefore not incidental to standardization but a precondition for financing it, because only a party with both accountability and scale has the incentive and capacity to build the substrate.

8.4 Legibility and adversarial control settings

The marketplace application in section 7.1 raises a caution that deserves more attention than it receives. Standardization increases the legibility of a network to its accountable party, its regulator, and its adversaries simultaneously. In control domains that are adversarial rather than merely error-prone, counterfeiting, diversion, sanctions evasion, financial crime, the assumption that transparency is monotonically beneficial does not hold. A mature standardization design must therefore distinguish controls whose effectiveness survives publication from those whose effectiveness depends on unpredictability, and canonicalize the former while treating the latter as tiered-access implementations bound to a public abstract control.

8.5 Measurement and outcome

The most significant open question is whether the advances reviewed here improve compliance outcomes or improve the

measurement of compliance outcomes. Every mechanism described increases the volume, comparability, and timeliness of assurance evidence. None of them establishes that incident rates fall. It is entirely coherent that a network could become far more legible and no safer, and the history of Type IV ceremonial control suggests this is not a hypothetical concern. The absence of outcome evidence is the central weakness of the field as of 2023.

8.6 Limitations

Four limitations bear on the strength of the claims made here. The evaluation is illustrative rather than empirical: the three applications demonstrate applicability and surface failure modes, but they do not test effectiveness, and no causal claims are drawn from them.

The account is specified at architectural rather than implementation granularity. A canonical control library for physical distribution compliance, whose absence section 3.7 identifies as a recurring problem, is not delivered here, and its construction is substantially larger work than architectural specification.

The connectivity constraint identified in section 7.3 is not adequately addressed. The account treats evidence timeliness as a graded property in principle but does not specify the grading, and networks with intermittently connected nodes are common in precisely the markets where non-traditional distribution predominates.

The regulatory analysis is jurisdictionally concentrated in the European Union and the United States, reflecting where the 2023 instrument cluster occurred, and generalizes imperfectly to jurisdictions where the accountable-intermediary question remains unsettled.

9. Conclusion

Un-standardized compliance controls in high-volume non-traditional distribution networks are best understood not as an absence of control but as an absence of commensurability, arising from definitional, evidentiary, and economic deficits that require distinct remedies. The period ending in 2023 was consequential because five previously disconnected developments converged: controls became machine-readable data, crosswalking became maintained infrastructure, event standards absorbed condition and sensor evidence, regulation adopted proportionality as an explicit design principle, and intermediary accountability was settled sufficiently to identify who funds the substrate.

The layered account set out above organizes the response into control abstraction, canonical representation, evidence normalization, risk-weighted proportionality, and federated continuous assurance. Its central commitments are to standardize abstractions rather than implementations, to grade evidence rather than treat it as binary, and to declare assurance strength rather than assert undifferentiated compliance.

Four lines of further work follow from this. The most immediate is the construction of a canonical distribution control library at a granularity comparable to mature security control catalogues, with typed mappings to the principal due diligence and traceability instruments. The second is empirical outcome evaluation, testing whether standardization reduces incident rates or only improves their observability, ideally through staged rollout designs permitting comparison across node populations. The third is the formalization of inferential evidence, establishing statistically defensible thresholds at which indirect signals support a control assertion, since this is the mechanism offering the largest expansion of the assurable surface at the lowest node cost. The fourth concerns incidence: who in practice bears standardization cost across network tiers, and whether the observed distribution drives node exit or evidence falsification.

The field has acquired, over a short period, most of the technical components required to make these networks assurable. Whether it can make them safer remains, at the close of 2023, unestablished.

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