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Rebuilding Trust in Food Safety through Tiered Supplier Management: A Two-Dimensional Risk-Based Framework

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Abstract

Food-safety incidents—from allergen mislabeling and pathogen contamination to raw-material adulteration—can rapidly destroy consumer trust, yet many food enterprises still rely on static, one-size-fits-all supplier audits. This paper develops a two-dimensional, risk-based framework for rebuilding food-safety trust through tiered supplier management. Two composite dimensions are constructed: Risk Exposure (ER), which captures the inherent risk of a supplier or product from raw-material sensitivity, supply-chain complexity, historical risk data, and substitution difficulty; and Management Capability (MC), which measures the effectiveness of a supplier's quality systems, traceability technology, testing capacity, and crisis response. A 3×3 risk-positioning matrix maps the two dimensions into four color-coded risk tiers (Red, Orange, Yellow, Green), each linked to a differentiated audit package, and a dynamic reassessment mechanism with quantitative trigger thresholds and a cost-minimization model is designed to keep audits aligned with changing risk. A case study of LRQA's engagement with a multinational food group covering 300 suppliers shows that the approach reduced the raw-material sampling failure rate from 5.2% to 1.8%, lowered annual audit costs from RMB 3.86 million to 2.17 million, and cut quarterly customer complaints from 47 to 9. The framework offers a practical, data-driven path from compliance-driven inspection to intelligence-led supplier assurance.

Keywords

Food safety; Supplier risk; Two-dimensional assessment; Risk matrix; Tiered auditing; Dynamic reassessment; Trust rebuilding

1. Introduction

1.1. Background

Whether caused by allergen mislabeling, pathogen contamination, or raw-material adulteration, every food-safety failure strikes consumers directly—and consumers are the most vocal critics when trust collapses. These risks are not theoretical: they

are unfolding in practice. In an era when a single incident can ignite global public opinion, the food industry must continually demonstrate that its supply chains are not merely compliant but resilient, transparent, and worthy of consumer trust.

The hard reality is that traditional supplier-audit and risk-management methods are no longer adequate. If enterprises continue to rely on a static, one-size-fits-all model, they will struggle to maintain the reliability of their supply chains. A more agile, data-driven approach is needed—one that segments suppliers by their degree of risk exposure, designs targeted risk responses, and ensures that resources are concentrated on the most critical links.

1.2. Significance

Enterprises show marked weaknesses in supplier risk assessment. Industry surveys indicate that while about 38% of companies use multi-dimensional data analysis, some 44% still rely on a single conventional measure, such as raw-material risk classification or food-safety certification status. This one-sided view creates blind spots and leaves firms exposed.

The food industry can no longer depend on outdated risk-management methods; the cost is too high. Without strategic supplier oversight, recalls will keep rising and consumer trust will erode further. By adopting tiered supply-chain management, enterprises can anticipate, assess, and resolve threats before they escalate into crises. The shift from compliance-driven auditing to intelligence-led supplier assurance is the path by which trust across the entire chain can be rebuilt.

1.3. Methods

This study combines literature review, case analysis, and empirical validation. First, relevant academic literature, industry reports, and regulations are reviewed to establish the theoretical and practical basis of food-safety trust and supplier management and to identify the limits of existing research. Second, representative food enterprises and suppliers are analyzed to distill practical lessons for building a tiered supplier-management system. Finally, the proposed framework is validated and refined through empirical application to ensure its scientific rigor and feasibility.

2. Construction of a Two-Dimensional Evaluation Index System

To build an accurate risk profile, enterprises must distinguish two core dimensions:

Risk Exposure: the inherent risk of a supplier or product, shaped by factors such as raw-material origin, historical incidents, geopolitical pressure, and environmental conditions.

Management Capability: the strength and practical effectiveness of the controls, audits, and verification processes through which a supplier mitigates risk.

2.1. Risk Exposure

Risk Exposure denotes the degree of risk a supplier may face in food production and operation. It is assessed through four dimensions:

Raw-material sensitivity: perishability, allergen content, and cold-chain dependence, together with source stability—whether materials originate from epidemic-affected areas and the pass rate of pesticide-residue tests.

Supply-chain complexity: the more tiers, suppliers, and logistics nodes involved, the higher the exposure. Cross-border suppliers may span multiple countries and regions, where temperature control and packaging during transport can affect food quality and increase risk.

Historical risk data: the number of recalls in the past three years and the customer-complaint rate.

Substitution difficulty: the share of exclusive or sole-sourced items and the number of days required to switch suppliers.

Table 1. Risk Exposure (ER) evaluation dimensions and weights

Evaluation dimension	Example quantitative indicators	Weight
Raw-material sensitivity	Perishability, cold-chain dependence, allergen content	30%
Supply-path complexity	Number of supplier tiers, cross-border transport nodes	25%
Historical risk data	Customer-complaint rate, recalls in the past three years	25%
Substitution difficulty	Sole-source share, supplier switching lead time	20%

Grading thresholds: ER ≥ 8 (high) | 5 ≤ ER < 8 (medium) | ER < 5 (low).

2.2. Management Capability

Quality-system certification: ISO 9001 and, of particular relevance to food safety, HACCP and FSSC 22000 certification indicate established quality systems and a certain degree of risk-control capability.

Traceability technology: the frequency of food-safety emergency drills (at least twice per year), the coverage of traceability systems (e.g., blockchain), and the response time (in hours) for batch traceability.

Testing capacity: the grade of the in-house laboratory (e.g., CNAS accreditation) and the sampling frequency.

Crisis response: the number of failed government inspections in the past two years and the efficiency of complaint handling (e.g., a 48-hour response rate).

Table 2. Management Capability (MC) evaluation dimensions and weights

Evaluation dimension	Example quantitative indicators	Weight
Quality-system certification	FSSC 22000 / HACCP certification validity (audit score)	30%
Traceability technology	Blockchain node coverage, batch traceability response time	25%
Testing capacity	Self-inspection lab grade (CNAS accreditation), sampling frequency	25%

Crisis response	Recall initiation time (mean of historical events)	20%

Grading thresholds: MC ≥ 7 (strong) | 4 ≤ MC < 7 (medium) | MC < 4 (weak).

3. Risk Matrix and Tiered Audit Strategy

3.1 Risk Positioning Matrix

The risk-positioning matrix is a tool built on the two-dimensional index system to locate and segment suppliers. Risk Exposure (ER) and Management Capability (MC) form the two axes of a two-dimensional plane; ER is divided into low, medium, and high intervals and MC into weak, medium, and strong. Each supplier is placed according to its two scores, which determines its risk tier.

Suppliers are assigned to four color-coded tiers. The highest-risk (Red) suppliers lie at the intersection of high exposure and weak management, whereas the lowest-risk (Green) suppliers lie at the intersection of low exposure and strong management; the intermediate combinations fall under Orange or Yellow.

Table 3. Risk-positioning matrix

	High exposure (ER ≥ 8)	**Medium exposure (5 ≤ ER < 8)**	**Low exposure (ER < 5)**
Strong management (MC ≥ 7)	Yellow Routine monitoring	Green Simplified process	Green Inspection-exempt filing
Medium management (4 ≤ MC < 7)	Orange Enhanced audit	Yellow Routine monitoring	Green Simplified process
Weak management (MC < 4)	Red Priority supervision	Orange Enhanced audit	Yellow Routine monitoring

3.2. Differentiated Audit Packages

A differentiated package of audit measures is designed for each risk tier to achieve precise oversight.

Red (high-risk): comprehensive, strict audits—including on-site inspections, sampling, and document review—with increased frequency; suppliers are required to strengthen internal management and complete corrective action to raise MC and reduce ER.

Orange (medium-high risk): half-yearly comprehensive audits combined with testing-technology training and video monitoring of key nodes, with mandatory corrective follow-up.

Yellow (medium risk): annual routine audits supported by monthly data monitoring and risk-warning subscription, encouraging continuous improvement toward the Green tier.

Green (low-risk): relatively light verification of quality systems and self-inspection reports; on-site inspections may be reduced while monitoring is maintained, within a trust-based partnership.

Table 4. Differentiated audit packages

Risk tier	Audit strategy	Specific measures
Red	High-frequency in-depth audit + technical intervention	Quarterly unannounced (flying) inspections Mandatory connection to the blockchain traceability platform 100% batch inspection of raw materials
Orange	Medium-frequency enhanced audit + capability support	Half-yearly comprehensive audit Provision of testing-technology training Video monitoring of key nodes
Yellow	Annual routine audit + data monitoring	Annual certification renewal review Monthly ERP data exchange Risk-warning subscription
Green	Simplified process + trust-based cooperation	Quality commitment letter in lieu of on-site audit Document review once every two years Priority in joint R&D and procurement

For example, a dairy enterprise applied the following measures to a high-exposure, weakly managed infant-formula raw-material supplier (ER = 8.2, MC = 3.5):

– installed IoT temperature and humidity sensors that transmit cold-chain data in real time;

– commissioned monthly third-party testing for aflatoxin;

– required FSSC 22000 certification to be completed within six months.

4. Dynamic Adjustment Mechanism

4.1. Threshold Conditions Triggering Reassessment

To keep pace with changes in supplier risk, a dynamic mechanism with quantitative trigger thresholds is designed.

Quality-sampling results: a failed national or local inspection, or repeated results close to the limit, triggers reassessment of the risk tier.

Internal management changes: withdrawal of a quality-system certification, a major change in internal processes, or turnover in key positions immediately starts a reassessment.

Market and policy changes: new food-safety regulations, heightened consumer concern, or intensified market competition that may alter risk exposure also requires reassessment.

Table 5. Threshold conditions triggering reassessment

Event type	Risk-level change rule
Proactive change	Supplier builds a new plant or replaces equipment → reassess MC within 30 days
Adverse event	One customer complaint → ER raised by 0.5 points; audit level upgraded
Technology upgrade	Deployment of blockchain traceability → MC + 2 points; audit level downgraded
Periodic reassessment	Red / Orange suppliers updated quarterly; all others semi-annually

4.2. Cost-Optimization Algorithm

The dynamic mechanism must balance audit cost against risk-control effectiveness. A cost-benefit analysis determines the optimal frequency, scope, and method of auditing so that supplier-management costs are minimized while food safety is

protected.

Audit-cost accounting: the cost of on-site inspection, sampling, and document review—including labor, time, and testing fees, as well as indirect costs borne by the supplier—is itemized.

Cost-benefit model: for a supplier at risk tier k with audit frequency κ, the total expected cost equals the direct audit cost plus the expected residual loss, where p_i is the probability of risk event i and L_i is its loss (including recall, penalties, and brand damage), as shown in Equation (1).

$$C_{total} = C_{audit} + \Sigma_i \, p_i \cdot L_i \quad (1)$$

The optimal audit frequency κ* is the value that minimizes the total expected cost in Equation (1), concentrating intensive audits on high-risk suppliers while avoiding redundant audits of low-risk suppliers.

5. Case Study: The LRQA Two-Dimensional Risk Matrix

5.1. Case Background

A multinational food group (with annual procurement exceeding RMB 5 billion) engaged LRQA to manage 300 suppliers worldwide. Its original audit model suffered from both missed high-risk suppliers and over-auditing of low-risk ones.

Allergen contamination: in September 2024, the UK Food Standards Agency (FSA), unable to trace the full extent of peanut contamination in the mustard ingredient supply chain, issued precautionary advice that people with a peanut allergy avoid foods containing mustard; the issue was traced to a supplier and the advice was withdrawn in October 2024 (FSA, 2024).

Pathogen outbreak: in October 2024, TreeHouse Foods, a major private-label frozen-waffle manufacturer, voluntarily recalled certain products over potential Listeria monocytogenes contamination and subsequently expanded the recall to all waffle and pancake products made at the affected plant (TreeHouse Foods, 2024).

Raw-material hazard: a year after the lead contamination of cinnamon-containing applesauce was disclosed, the safety of the global cinnamon supply chain remained under scrutiny; at least 542 children under six were identified with elevated blood lead levels, and the contamination was traced to a cinnamon supplier in Ecuador (CDC, 2024).

These failures impose heavy costs on consumers, brands, and regulators—collapsed trust, severe financial pressure, and disrupted supply networks. Their root cause is often an outdated risk strategy that cannot match the complexity of modern supply chains.

5.2. Implementation

5.2.1. Re-examining Supplier Risk

Many firms believe they have reliable supplier-qualification and audit systems, but can those systems respond dynamically to evolving risks? When evaluating current

methods, the following questions are key:

1) Do you truly understand where your raw materials come from?

2) Have you assessed the risks in the logistics links of the supply chain?

3) How important is your business to the supplier—a core customer or a marginal order?

4) When was the supplier risk-assessment standard last reviewed?

For many firms, supplier risk assessment remains a static process that neither responds to emerging threats nor uses real-time data—the central gap in supply-chain risk management. LRQA collected data on food category, production scale, supply-chain complexity, quality-system certification, internal processes, and personnel quality, and used the two-dimensional matrix to locate and segment suppliers.

5.2.2. Tiered Supply Chain Management

LRQA advocates tiered management that matches the intensity of verification and oversight to each supplier's actual risk:

1) intensify scrutiny of high-risk suppliers and simplify processes for low-risk ones;

2) shift from reactive recall response to proactive risk management;

3) integrate real-time data and external intelligence to improve verification;

4) leverage commercial influence to drive supplier performance.

Tiering improves compliance, strengthens supply-chain resilience, protects brand reputation, and rebuilds chain-wide trust. Only by moving beyond check-box auditing can enterprises implement genuinely effective risk strategies. LRQA applied strict, high-frequency audits to high-risk suppliers, regular audits and corrective follow-up to medium-risk suppliers, and flexible, light-touch audits to low-risk suppliers.

5.3. Implementation Results

Reduced food-safety risk: priority supervision of high-risk suppliers identified and resolved potential problems early, reducing the occurrence of food-safety incidents.

Improved management efficiency: differentiated audits allocated resources rationally and, while protecting food safety, lowered audit costs and improved economic returns.

Industry demonstration: the successful application provides a model for the industry and has encouraged wider adoption of tiered supplier management, advancing the rebuilding of the food-safety trust system.

Table 6. Implementation results

Indicator	Before (2021)	After (2023)	Change
Raw-material sampling failure rate	5.2%	1.8%	↓ 65%
Supplier audit cost	RMB 3.86 million / year	RMB 2.17 million / year	↓ 44%
Customer complaints	47 cases / quarter	9 cases / quarter	↓ 81%

6. Conclusion

In sum, building a scientifically sound system for rebuilding food-safety trust and managing suppliers by tier is essential for safeguarding food safety, strengthening consumer confidence, and supporting the healthy development of the industry. The two-dimensional index system, the risk matrix with differentiated audit packages, and the dynamic adjustment mechanism together enable effective, risk-proportionate supplier oversight, while the cost model prevents unnecessary expenditure. The LRQA case demonstrates that such an approach can simultaneously reduce food-safety risk, lower audit cost, and sharply cut customer complaints. Future work should extend the framework with larger data sets, automated real-time risk scoring, and quantitative calibration of the model's parameters, so that supplier management can continuously adapt to an evolving risk landscape.

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