



Human-Centered Leadership Using Industry 5.0 in Managing Modern Slavery

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ABSTRACT

Modern slavery continues to threaten global supply chains through economic pressure, social exclusion, weak enforcement, environmental isolation, and opaque technologies. This paper develops a human-centered leadership framework to manage modern slavery risks within the Industry 5.0 paradigm. Building on PESTEL indicators, ethical leadership, supplier governance, and human–technology synergy, the study proposes a DEMETAL process—define, explore, measure, evaluate, transform, apply, and learn—integrated with DEMATEL causal analysis. The analysis identifies drivers and dependent outcomes that shape the detection, prevention, and continuous learning of slavery risk. Because expert scores have not yet been collected, the numerical DEMATEL component is presented as an illustrative structured analysis to be validated through expert judgment. The proposed model shows that ethical human-centered leadership, supplier governance, and political–legal enforcement act as dominant causal enablers, while technological transparency and Industry 5.0 capability depend on these leadership and governance conditions. The paper contributes to social sustainability and operations research by translating modern slavery prevention into a decision-support structure for managers and top management.

1. Introduction

Modern slavery is a severe social sustainability failure that persists inside formal and informal supply chains. It includes forced labor, debt bondage, human trafficking, and other forms of exploitation in which individuals cannot refuse or leave work because of coercion, deception, abuse of vulnerability, or threat. The 2022 Global Estimates prepared by the International Labor Organization, Walk Free, and the International Organization for Migration indicate that about 50 million people were living in modern slavery in 2021, including 28 million in forced labor and 22

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million in forced marriage [1]. For operations and supply chain management, this is not merely a compliance problem; it is a systemic risk stemming from cost pressures, limited supplier visibility, and weak worker voice.

Global supply chains connect buyers, contractors, labor brokers, and subcontractors across jurisdictions with uneven enforcement capacity. Modern slavery can therefore be hidden in upstream tiers, temporary employment, migrant labor arrangements, remote locations, and low-margin production. Traditional audits and codes of conduct often remain episodic and document-driven, while exploitation adapts quickly to new sourcing models. A stronger approach must integrate ethical leadership, multi-tier governance, worker-centered information, and digital transparency.

Industry 5.0 provides a useful lens because it repositions technology around human-centricity, sustainability, and resilience. The European Commission describes Industry 5.0 as a complement to Industry 4.0, moving industrial value creation beyond efficiency toward stakeholder value and worker well-being [2]. In modern slavery prevention, artificial intelligence, blockchain, digital twins, and Internet of Things technologies should therefore detect high-risk conditions, support transparent decision making, strengthen worker protection, and enable continuous organizational learning.

Accordingly, this paper asks: how can human-centered leadership and Industry 5.0 technologies be integrated to manage modern slavery in global supply chains? The contribution is threefold. First, it connects modern slavery indicators with human-centered leadership and Industry 5.0. Second, it translates the framework into critical success factors suitable for expert judgment. Third, it demonstrates how DEMATEL can structure cause-and-effect relationships among the factors, thereby guiding managerial priorities.

2. Literature Review and Research Gap

Modern slavery has been examined as an organizational and supply chain phenomenon in which exploitation survives through institutional weakness, economic dependence, and managerial distance. Crane [3] explains that slavery can appear as a management practice where firms or labor intermediaries control workers through isolation, debt, coercion, or lack of alternatives. Gold et al. [4] show that modern slavery creates a challenge for supply chain management because exploitation is often embedded in suppliers and subcontractors beyond the buying firm's immediate view.

Modern slavery risk is intensified by multiple PESTEL conditions. Economically, buyers' price pressure, narrow margins, and short delivery windows may encourage suppliers to cut labor protections. Socially, discrimination, low education, migration vulnerability, and informal work arrangements increase workers' dependence. Environmental and geographic factors reduce monitoring. Political–legal weakness and corruption reduce deterrence. Technological opacity, fragmented data, and misuse of surveillance tools can either hide or intensify worker vulnerability. Ethical leadership provides the moral direction needed to convert modern slavery prevention from a symbolic statement into routine decision-making. Leaders influence supplier selection, procurement incentives, incident escalation, worker voice mechanisms, and the willingness to report uncomfortable findings. Human-centered leadership extends this logic by treating workers as stakeholders rather than anonymous labor inputs. It emphasizes dignity, inclusion, empowerment, psychological safety, and fair treatment.

Industry 5.0 shifts attention from automation alone to human–technology collaboration. AI can identify unusual labor-risk patterns, blockchain can improve traceability, digital twins can simulate high-risk sourcing scenarios, and IoT or worker voice technologies can generate early warning signals. Recent Industry 5.0 research emphasizes human-centric, sustainable, and resilient systems [2,5,6]. The research gap is that Industry 5.0 studies often focus on manufacturing transformation, whereas modern slavery studies emphasize compliance and auditing. Less attention has been paid to the causal structure linking leadership, technologies, governance, and slavery-risk indicators.

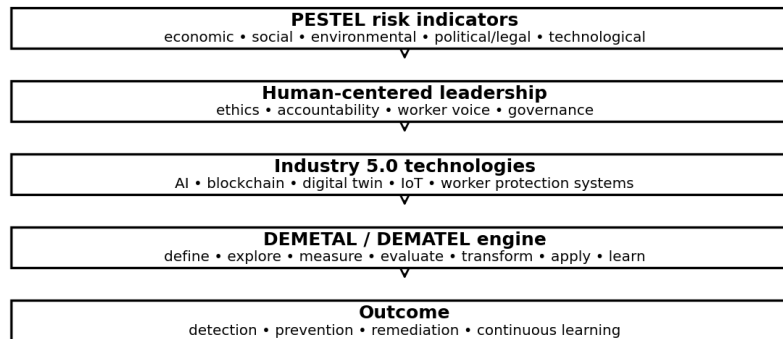
3. Proposed Theoretical Framework

The proposed framework has four connected layers. The first layer identifies vulnerabilities to modern slavery through PESTEL indicators. The second layer positions ethical and human-centered leadership as the central enabler. The third layer introduces Industry 5.0 technologies as instruments of detection, prevention, and protection. The fourth layer operationalizes the model through the DEMETAL process and DEMATEL causal analysis.

The DEMETAL process used here refers to an operational learning cycle: define the risk, explore supply chain tiers, measure vulnerabilities, evaluate severity, transform practices, apply preventive and reactive interventions, and learn continuously. This is distinct from DEMATEL, the Decision-Making Trial and Evaluation Laboratory method, which structures cause–and–effect relationships in complex systems [7,8]. In this paper, both ideas are integrated: DEMING structures managerial action, while DEMING structures causal prioritization.

Table 1. Critical success factors used in the proposed DEMATEL analysis.

Code	CSF	Indicative content	Role
C1	Economic vulnerability	Low wages, price pressure, debt dependence, margin squeeze	Risk foundation
C2	Social and labor vulnerability	Discrimination, migrant status, and informal recruitment	Risk foundation
C3	Political–legal enforcement	Regulatory weakness, corruption, and inspection quality	Institutional driver
C4	Technological transparency	Traceability, worker voice data, interoperable risk intelligence	Detection enabler
C5	Ethical human-centered leadership	Values, accountability, worker dignity, escalation, and remediation	Core driver
C6	Industry 5.0 capability	AI, blockchain, digital twins, IoT, and human–machine protection	Socio-technical enabler
C7	Supplier governance and collaboration	Multi-tier oversight, buyer–supplier partnerships, NGO/auditor collaboration	Governance driver

**Fig. 1.** Proposed human-centered Industry 5.0 framework for modern slavery management.

4. Methodology: DEMETAL Process and DEMATEL Analysis

The research design is conceptual and methodological. It converts the abstract problem of modern slavery into a structured decision-support model that can be applied by firms, researchers and policymakers. The expected empirical implementation would involve an expert panel comprising

academics, supply chain managers, labor compliance professionals, ESG officers, auditors, and representatives with expertise in worker protection.

Experts evaluate the degree to which one critical success factor influences another on a scale from 0 to 4, where 0 indicates no influence, and 4 indicates very strong influence. Because expert scores have not yet been collected for this conference manuscript, the numerical values reported below are explicitly presented as an illustrative structured analysis based on the proposed framework. They should not be interpreted as empirical findings. Their purpose is to demonstrate the complete DEMATEL procedure, explain how the model generates managerial priorities, and provide a ready instrument for subsequent expert validation.

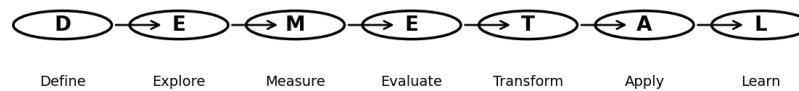


Fig. 2. DEMETAL operational learning process.

Let $A = [a_{ij}]$ be the direct-relation matrix, where a_{ij} indicates the influence of factor i on factor j . The normalized matrix X is obtained by dividing A by the maximum of the row-sum and column-sum totals. The total-relation matrix is computed as $T = X(I - X)^{-1}$. For each factor, D is the sum of row values in T and represents total influence given; R is the sum of column values and represents total influence received. Prominence is $D + R$, and relation is $D - R$. Positive $D - R$ values indicate cause-group factors; negative values indicate effect-group factors.

The illustrative direct relation matrix below was developed from the theoretical framework to illustrate the causal logic. In future empirical work, each cell should be replaced by the arithmetic mean or fuzzy-aggregated score derived from multiple experts.

Table 2. Illustrative direct-relation matrix A (0=no influence; 4 = very strong influence).

Code	C1	C2	C3	C4	C5	C6	C7
C1	0	3	2	1	1	1	3
C2	2	0	2	1	1	1	2
C3	3	3	0	2	3	2	4
C4	1	2	2	0	2	3	3

Code	C1	C2	C3	C4	C5	C6	C7
C5	3	4	3	3	0	4	4
C6	2	2	2	4	3	0	3
C7	3	3	3	3	3	3	0

5. DEMATEL Results and Interpretation

Table 3. DEMATEL prominence and relation values from the illustrative analysis.

Code	Factor	D	R	D+R	D–R	Group
C7	Supplier governance and collaboration	2.907	3.022	5.929	-0.115	Effect
C5	Ethical human-centered leadership	3.328	2.178	5.506	1.151	Cause
C3	Political–legal enforcement	2.783	2.336	5.119	0.448	Cause
C6	Industry 5.0 capability	2.661	2.309	4.970	0.352	Cause
C4	Technological transparency	2.229	2.315	4.544	-0.085	Effect
C2	Social and labour vulnerability	1.535	2.764	4.299	-1.229	Effect
C1	Economic vulnerability	1.815	2.336	4.151	-0.522	Effect

The illustrative DEMATEL analysis indicates that ethical human-centered leadership (C5), supplier governance and collaboration (C7), and political–legal enforcement (C3) are the most influential cause-group elements. This result is theoretically plausible because modern slavery does not disappear simply through technology. It requires leadership intent, institutional accountability, and governance routines capable of changing procurement incentives and supplier practices.

Technological transparency (C4) and Industry 5.0 capability (C6) are highly prominent, but their causal position depends on leadership and governance. This means that AI, blockchain, and digital monitoring can improve detection and traceability, but their value is contingent on how organizations interpret and act on the data. A worker voice system may reveal warning signs, but the response depends on remediation protocols, leadership accountability, and non-retaliation mechanisms.

Economic vulnerability (C1) and social and labor vulnerability (C2) are strongly connected to the rest of the system but behave more as risk conditions than controllable managerial levers. Firms cannot directly eliminate global poverty or migration vulnerability; however, they can change sourcing practices, recruitment fees, payment terms, supplier selection, and remediation pathways.

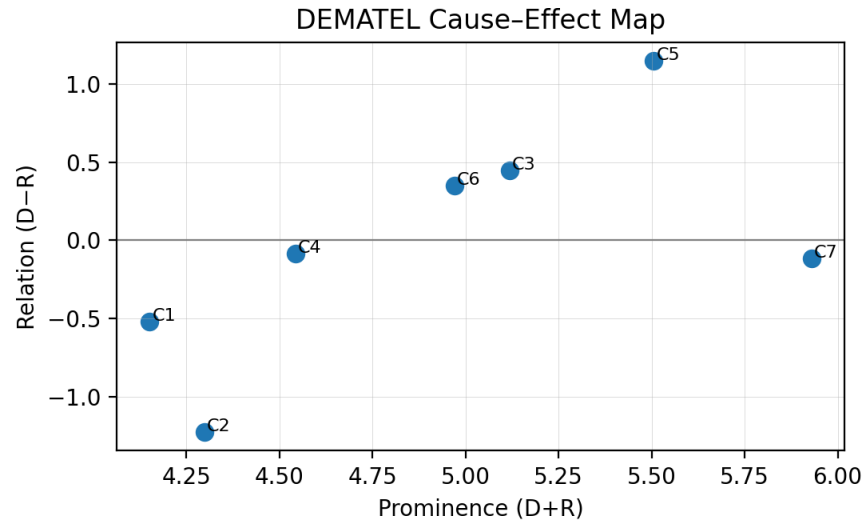


Fig. 3. Illustrative DEMATEL cause-and-effect map.

6. Discussion

The results support a central proposition: modern slavery management under Industry 5.0 must be led before it can be digitized. Human-centered leadership establishes the ethical purpose of data collection, supplier visibility, and technology adoption. Without this purpose, digital transformation may remain limited to compliance reporting. For this purpose, Industry 5.0 serves to protect people, increase transparency, and strengthen resilience.

The framework clarifies the difference between prevention, detection, and remediation. Prevention requires supplier governance, fair procurement, responsible recruitment, wage verification, and capacity building. Detection requires data integration, traceability, worker voice, anomaly identification, and risk mapping. Remediation requires leadership accountability, grievance handling, compensation, supplier improvement plans, and collaboration with legitimate labor actors.

From an operations research perspective, DEMATEL is suitable because modern slavery risk factors are interdependent. Legal weakness influences supplier governance; supplier governance influences technology adoption; technology affects visibility; visibility influences remediation; and leadership shapes each of these relationships. The method, therefore, helps avoid treating risk factors as independent checklist items.

Table 4. Managerial and policy implications.

Stakeholder	Implication
Top management	Set modern slavery prevention as a board-level objective; align procurement incentives with ethical sourcing.
Supply chain managers	Map multi-tier suppliers, labor brokers, and high-risk geographies; integrate risk scoring with supplier development.
Technology leaders	Deploy AI, blockchain, digital twins, and worker voice tools as human-protection systems rather than only efficiency tools.
Compliance and ESG teams	Use DEMETAL reviews to define risks, evaluate vulnerabilities, and monitor remediation learning over time.
Policy makers	Strengthen enforcement, reporting quality, victim protection, and cross-border collaboration for labor accountability.

7. Practical Implementation Roadmap

For top management, the framework can be implemented as a staged decision-support routine. The first stage is risk definition, in which the organization identifies products, sourcing countries, labor categories, and supplier tiers in which exploitation may occur. The second stage is data integration, where purchasing records, audit outcomes, grievance records, recruitment fee information, wage data, worker voice tools, and logistics visibility are consolidated into a common risk repository. The third stage is the causal review, in which leadership and compliance teams use DEMATEL results to determine whether weaknesses are driven primarily by governance, technology, enforcement, or social vulnerability.

The fourth stage is transformation. When supplier governance is identified as a causal driver, firms should revise supplier selection, contract clauses, payment practices, subcontracting controls, and remediation processes. When political–legal enforcement is weak, firms should increase independent verification and collaborate with credible local organizations. When technological transparency is weak, firms should deploy Industry 5.0 tools with explicit safeguards for worker privacy and non-retaliation. The final stage is organizational learning, where lessons from investigations, remediation cases, and supplier improvements are fed back into the model.

This implementation logic makes the framework practical for conferences, manufacturing firms, and supply chain managers because it connects strategic leadership with operational routines. It also supports policy dialogue by showing that modern slavery prevention cannot rely on disclosure

alone. Prevention requires a loop that turns risk signals into decisions, decisions into interventions, and interventions into measurable learning.

8. Conclusion and Future Research

This paper developed a human-centered Industry 5.0 framework for managing modern slavery in supply chains. It argued that modern slavery arises from the interaction of economic, social, environmental, political–legal, and technological vulnerabilities, and that meaningful prevention requires ethical leadership supported by Industry 5.0 capabilities. The integrated DEMETAL/DEMATEL model provides a practical way to identify the causal drivers of slavery risk and convert them into managerial action.

The illustrative analysis suggests that ethical, human-centered leadership, supplier governance, and political–legal enforcement are primary drivers, while technological transparency and Industry 5.0 capabilities serve as enabling mechanisms. The study is limited by the absence of actual expert judgment data. Future research should conduct a Delphi or structured expert survey, validate the matrix across industries and countries, compare results using fuzzy DEMATEL or hybrid MCDM methods, and test whether the framework improves detection, remediation, and worker well-being outcomes.

Disclosure of Interests

The author declares that there are no competing interests relevant to the content of this paper.

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