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Governing Ethical Supply Chains Through Blockchain: A TOE-Grounded Empirical Study of Saudi SMEs and Vision 2030 Alignment

Nehal M. Rashad

Effat University, AOU, KAU, Saudi Arabia.
(nehal.ma04@gmail.com)

ABSTRACT

Purpose: This study empirically investigates blockchain's role in enhancing supply chain transparency and ethical sourcing among Saudi SMEs using the Technology-Organisation-Environment (TOE) framework, advancing Saudi Vision 2030 and UN SDGs.
Design/methodology/approach: Quantitative analysis of 221 Saudi SME respondents via PLS-SEM, with statistical rigour ensured through power analysis (G*Power; Cohen, 1988; f^2=0.15) and Harman's test (single factor=28.4%).
Findings: Blockchain directly improves ethical sourcing (β=0.42, $p<0.001$), with transparency mediating 26% of this effect. Government support (an environmental factor) drives adoption (β = 0.33), validating Vision 2030's policy impact.
Originality: To the authors' knowledge, one of the first GCC-based empirical studies to quantify blockchain's SDG-aligned ethical impacts (SDG 8,9,12) in GCC SMEs via a complete TOE value chain.
Keywords: Blockchain; Supply Chain Management; Ethical Sourcing; Social Responsibility; Saudi Arabia; SMEs; UN SDGs; TOE Framework; resilience.
JEL Classification: L23, O32, O53, M14.

1. INTRODUCTION

The global supply chain ecosystem is under increasing scrutiny for its environmental, social, and ethical impacts. Ethical sourcing, which ensures products are obtained in a manner that respects human rights, labour standards, and environmental sustainability, has become a strategic imperative for businesses and a core component of Corporate Social Responsibility (CSR). Achieving true transparency remains a significant challenge, particularly for Small and Medium

Enterprises (SMEs), which often lack the necessary resources and technological infrastructure to monitor and verify supplier practices.

In Saudi Arabia, SMEs are a pivotal part of the economy, contributing approximately 20% to the GDP. The Kingdom's ambitious Vision 2030 initiative actively promotes digital transformation and sustainability, creating a conducive environment for adopting innovative technologies. Blockchain, a decentralised and immutable ledger technology, is increasingly recognised for its potential to revolutionise supply chain management by providing real-time visibility, traceability, and accountability. For Saudi SMEs, blockchain offers a unique opportunity to not only enhance supply chain transparency but also to align with global ethical sourcing standards and improve market competitiveness, embedding Vision 2030 as an institutional driver. This strategic move contributes directly to the UN Sustainable Development Goals (SDGs), particularly SDG 8 (Decent Work and Economic Growth), by promoting fair wages and labour practices; SDG 9 (Industry, Innovation, and Infrastructure), by leveraging technological infrastructure for sustainable industrialisation; and SDG 12 (Responsible Consumption and Production), by ensuring transparent and ethical supply chains and traceability of products.

This study integrates Institutional Theory (coercive pressures), Resource-Based View (blockchain as strategic capability), and Social Entrepreneurship Theory (socio-ethical value creation) to frame blockchain adoption. To comprehensively understand the factors influencing this process, this study is structured around the Technology-Organisation-Environment (TOE), a well-established model framework. The TOE framework has proven effective in sustainability transitions (Baker, 2012; Li et al., 2023), but remains untested for blockchain-enabled ethical sourcing in Arab economies. The model provides a holistic perspective on technology adoption at the firm level, and the analysis of our results will be directly linked to its three core contexts: Technology, Organisation, and Environment.

The problem statement addressed in this study is the lack of empirical research on how blockchain can address the specific operational challenges of ethical sourcing in the Saudi context. The study adopted a quantitative survey-based approach to empirically examine the role of blockchain technology in enhancing supply chain transparency and promoting ethical sourcing practices among SMEs in Saudi Arabia, thereby addressing this gap by employing the TOE

framework to answer The research question: How does blockchain adoption, within the Technology-Organisation-Environment framework, enhance supply chain transparency and ethical sourcing in Saudi SMEs, and what role does government support play in this process?.

1.1 Research Objective

This study examines how blockchain enhances supply chain transparency and ethical sourcing in Saudi SMEs, identifies adoption barriers, and evaluates benefits. Contributions include filling a Gulf-region research gap, providing a TOE-based explanation of adoption, and offering policy and business insights for embedding ethical sourcing into daily operations in line with Vision 2030 and SDGs.

1.2 Significance of the Study

This study advances blockchain research in Operations and Supply Chain Management by offering rare empirical evidence from a Gulf economy. Using the TOE framework, it explains technology adoption in the Saudi SME context and provides policymakers and business leaders with a roadmap for embedding sustainable, ethical practices aligned with Vision 2030 and the UN SDGs. By showing how blockchain enables "operational reconfiguration," it demonstrates the shift from aspirational to routine ethical sourcing. Unlike technology-specific models, TOE integrates environmental and organisational factors, making this one of the first applications of blockchain-enabled social sustainability in Middle Eastern SMEs.

2. LITERATURE REVIEW AND THEORETICAL FOUNDATIONS

This study applies the Technology–Organisation–Environment (TOE) framework (Tornatzky & Fleischer, 1990; Baker, 2012) to analyse blockchain adoption. TOE explains firm-level adoption across three contexts: technological (capabilities such as decentralisation, immutability, traceability, and automation), organisational (resources, skills, culture, and leadership), and environmental (regulation, policy, and market pressures). Unlike TAM or UTAUT, TOE incorporates institutional and environmental factors, making it well-suited to the policy-driven Saudi SME context.

Maintaining theoretical purity, blockchain adoption is treated as the technological driver, government support as the environmental enabler, and transparency as the organisational mediator, leading to ethical sourcing.

2.1 The Three Dimensions and Their Link to Theories

The technological context emphasises blockchain's decentralisation, immutability, traceability, and automation. The organisational context includes resources, culture, managerial readiness, technical skills, cost capacity, and leadership innovation. The environmental context covers government policies, Vision 2030 initiatives, competitive pressures, and ethical sourcing demand. This framing makes the variable selection theory-driven, positioning blockchain as the central innovation, government support as the environmental driver, and transparency and ethical sourcing as the outcomes of these interactions.

2.2 TOE in Related Studies

Prior studies show TOE's strength in sustainability contexts. Li et al. (2023) linked IoT and AI capabilities to green supply chains; Hsu et al. (2025) examined adoption intentions in relation to supply chain capabilities. This study extends them by focusing on actual blockchain implementation in Saudi SMEs, quantifying its direct ($\beta = 0.42$) and transparency-mediated (VAF = 26%) effects on ethical sourcing, with government support as a significant driver ($\beta = 0.33$).

2.3 Complementary Theoretical Foundations

Three theories reinforce TOE: Social Entrepreneurship Theory (Mair & Martí, 2006), ethical sourcing as social innovation, Institutional Theory (DiMaggio & Powell, 1983), which explains Vision 2030 as coercive pressure, and RBV (Barney, 1991), which positions blockchain as a strategic capability for trust and traceability.

2.4 Conceptual Framework and Hypotheses

Using PLS-SEM, this study tests the influence of technological, organisational, and environmental factors on ethical sourcing. Hypotheses propose that blockchain improves

transparency (H1) and ethics (H2), that transparency enhances ethics (H3), that transparency mediates blockchain's effect (H4), and that government support directly drives adoption (H5). The conceptual model (Figure 1) reflects this structure.

H1: Blockchain adoption positively influences operational transparency in Saudi SMEs.

H2: Blockchain adoption positively influences ethical sourcing practices.

H3: Operational transparency positively influences ethical sourcing practices.

H4: Operational transparency mediates the relationship between blockchain adoption and ethical sourcing practices.

H5: Government support and policies positively influence blockchain adoption in Saudi SMEs.

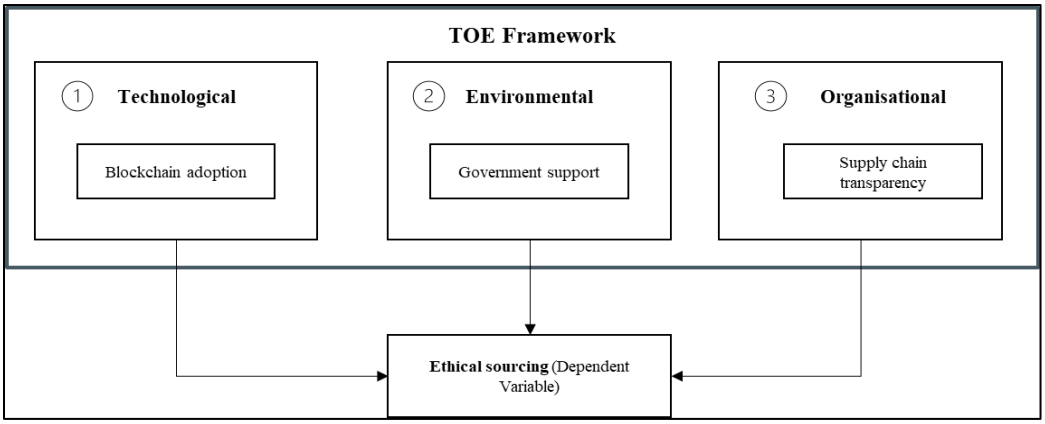

Figure 1. The Conceptual Framework.

3. METHOD

3.1 Research Design

A quantitative, cross-sectional survey was used to test the hypotheses. Guided by the TOE framework, the instrument measured blockchain compatibility and security (technological), SME IT resources and top management support (organisational), and government policies and industry competition (environmental).

3.2 Sample and Data Collection

The target population was SME owners, managers, and supply chain practitioners in Saudi Arabia with some awareness of blockchain. Purposive sampling yielded over 200 responses,

meeting PLS-SEM guidelines. Data were collected online through professional networks, ensuring voluntary participation, anonymity, and confidentiality. Items were adapted from validated scales for the Saudi SME context, and a pilot with 20 professionals confirmed clarity and content validity.

3.3 Measurement and Variables

All variables were measured using a five-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree). Each construct was operationalised using multiple survey items, as detailed in the table below. The table also categorises the constructs within the three contexts of the TOE framework.

Table 1. Operationalisation of Constructs: TOE Context, Theoretical Foundations, and Measurement Items

Construct	TOE Context	Theoretical Basis	Sample Survey Items	Measurement Source
Blockchain Technology Adoption	Technological	Resource-Based View (Barney, 1991)	"We use blockchain to automate ethical verification of tier-1 suppliers"	Saberi et al. (2019); Queiroz & Wamba (2019)
Operational Transparency	Organisational	Information Processing Theory (Galbraith, 1974)	"Real-time traceability of raw materials is maintained through digital records"	Buell & Norton (2011); Kshetri (2021)
Ethical Sourcing Practices	Outcome Variable	Social Entrepreneurship Theory (Mair & Martí, 2006)	"We terminate contracts with suppliers violating labour standards"	Carter & Jennings (2004); Kumar et al. (2019)
Government Support and Policies	Environmental	Institutional Theory (DiMaggio & Powell, 1983)	"Vision 2030 sustainability mandates accelerate our blockchain investments"	Alshareef & Tunio (2022). Kshetri (2021)

3.4 Ethical Considerations

The study was conducted in accordance with ethical research practices. Informed consent was obtained, and all data were anonymised to ensure confidentiality. The research protocol was reviewed and approved by the Research Ethics Committee.

4. RESULTS AND DISCUSSION

Data analysis was performed using SPSS and SmartPLS 4. The preliminary analysis included descriptive statistics to summarise the respondents' demographic characteristics. The sample size (n=221) exceeds the 200-case threshold for PLS-SEM (Hair et al., 2019) and achieves 0.95 statistical power for medium effects (G*Power; Cohen, 1988; α=0.05, f^2=0.15). Harman's single-factor test showed 28.4% variance (<50% threshold), confirming no significant common method bias (Podsakoff et al., 2003). Partial Least Squares Structural Equation Modelling (PLS-SEM) was used to test the hypotheses and evaluate the structural model's path coefficients, R^2 values, and effect sizes.

4.1 Measurement and Structural Model Assessment

The measurement model was assessed for reliability and validity. Construct reliability was confirmed with Cronbach's alpha, and Composite Reliability values were well above the recommended 0.70 threshold. Convergent validity was established with Average Variance Extracted (AVE) values exceeding 0.50. Discriminant validity was assessed using the Fornell-Larcker criterion and cross-loadings, with all constructs demonstrating acceptable distinctiveness. These results confirm the robustness of the measurement scales. The tables 2 provide a detailed summary of these metrics.

The structural model was evaluated for its predictive power and goodness-of-fit. Key metrics, including the Standardised Root Mean Square Residual (SRMR) of 0.057 and the Normed Fit Index (NFI) of 0.91, indicated a good model fit, meeting the recommended thresholds of SRMR < 0.08 and NFI > 0.90. These results suggest that the proposed model and its theoretical relationships are well-supported by the empirical data.

Table 2. Sample Demographics

Demographic	Category	Frequency	Percentage
Role	Owner/Manager	118	53.4%
	Supply Chain Practitioner	72	32.6%
	Other	31	14.0%
Industry	Textiles	85	38.5%
	Manufacturing	64	29.0%
	Agriculture	42	19.0%
	Other	30	13.5%
Firm Size	Micro	24	10.9%
	Small	112	50.7%
	Medium	85	38.4%
Blockchain Adoption Stage	Considering/Implementing	136	61.5%
	Not Considering/Aware	85	38.5%

Table 3. Construct Reliability and Validity

Construct	Items	Cronbach's α	Composite Reliability	AVE
Blockchain Adoption	5	0.891	0.921	0.732
Operational Transparency	5	0.854	0.898	0.689
Ethical Sourcing	5	0.902	0.931	0.763
Government Support	5	0.876	0.910	0.701

4.2 Hypothesis Testing

To the authors' knowledge, this is among the first to empirically demonstrate a full TOE value chain for blockchain ethics in a Gulf SME context, linking government support (environmental) to adoption (technological), transparency (organisational), and ethical sourcing (social). It quantifies both direct ($\beta = 0.42$) and mediated (VAF = 26%) effects, showing blockchain's potential as a driver of social sustainability. Government support ($\beta = 0.33$) emerges as a key enabler, with its amplified impact in resource-constrained SMEs, extending Li et al.'s (2023) findings on regulatory influence.

Transparency acts as a gatekeeping capability, enabling quick detection of misconduct, corrective action, and verifiable compliance. This operationalises blockchain's technical advantages into measurable ethical outcomes and strengthens supply chain resilience through real-time traceability. Addressing the gap noted by Hsu et al. (2025), these results validate a complete

TOE value chain: policy-driven adoption leads to implementation, which generates measurable social value.

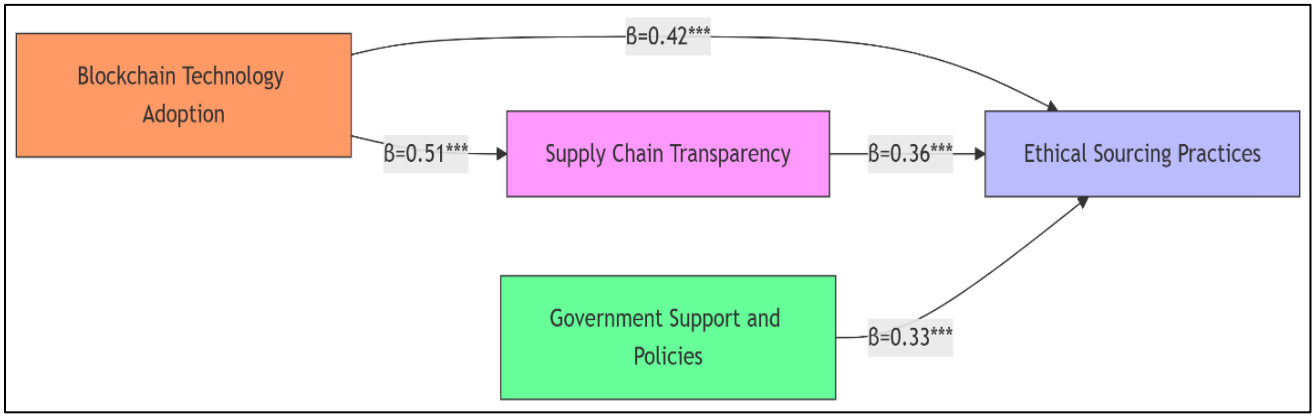

*Figure 6. PLS-SEM Path Model Results. Standardised coefficients (β) shown. ***p < 0.001.*

4.3 Discussion and Contextual Positioning

The findings reveal blockchain's dual pathway to ethical sourcing: a strong direct effect (β = 0.42) confirms its capacity to automate ethical verification, while partial mediation through transparency (26% VAF) underscores traceability's role in driving ethical outcomes. This reflects the TOE framework's technological dimension, where blockchain's immutable architecture reconfigures sourcing beyond superficial monitoring.

Government support (β = 0.33) emerges as a decisive environmental driver, validating Vision 2030's policy approach and demonstrating how regulatory frameworks can accelerate adoption in resource-constrained SMEs. This positions government support as an exogenous enabler within TOE, directly driving implementation rather than moderating results, resolving earlier theoretical ambiguities.

Methodologically, this study advances blockchain-SCM research by offering granular insights into blockchain as a TOE technological factor and government support as a Gulf-specific environmental variable. Using quantitative path analysis, it confirms relationships that earlier studies — such as Pandey and Pathak's (2025) qualitative weighting — identified conceptually. This demonstrates TOE's robustness across methods (fuzzy AHP vs PLS-SEM), contexts (construction vs multi-sector SMEs), and sustainability dimensions (resilience vs social ethics).

Comparative analysis (Table 4) positions this as one of the first GCC-based empirical studies to quantify both blockchain's direct and mediated ethical impacts alongside the policy effect of government support. While prior research focused on adoption drivers (Hsu et al., 2025), environmental performance (Li et al., 2023), or resilience (Pandey & Pathak, 2025), this work is, to the authors' knowledge, among the first to pioneer social value creation pathways aligned with SDG 8, 9, and 12, offering actionable policy insights for emerging economies.

Table 4. Comparative Analysis of TOE Framework Applications in Blockchain-SCM Research.

Dimension	Li et al. (2023) ***Systems***	Pandey & Pathak (2025) ***JEIM***	Hsu et al. (2025) ***Production Planning & Control***	Current Study
Research Focus	Digital transformation → Green SCM	Blockchain adoption → Resilience	Supply chain capabilities → Adoption willingness	Blockchain → Ethical sourcing
Industry Context	Chinese manufacturing	Construction	Global firms	Saudi SMEs
TOE Configuration	Standard TOE	Extended TOE	Standard TOE	Standard TOE + Institutional/Social Entrepreneurship
Methodology	SEM	Fuzzy AHP	SEM	PLS-SEM
Key Findings	• Tech: IoT/AI most impactful • Env: Regulatory pressure critical	• Gov't support = top barrier • Tech compatibility = key enabler	• Organisational capabilities drive willingness • Environmental uncertainty moderates	• Govt support direct effect (β=0.33) • Blockchain → Ethics (β=0.42) • Transparency mediation (26% VAF)
Sustainability Lens	Environmental (Green SCM)	Operational (Resilience)	Technological (Adoption)	Social (SDG-aligned ethics)
SDG Alignment	SDG 9, 12	SDG 9, 11	SDG 9	SDG 8, 9, 12
Novel Contribution	Digital tech → Environmental perf	Priority weights for adoption	Capability → Intention link	1st empirical: Blockchain ethics impact in GCC Govt. support quantification

5. CONCLUSION AND FUTURE RESEARCH

5.1 Conclusion

This study has demonstrated that blockchain technology serves as a catalytic enabler for operationalising social sustainability in Saudi Arabia's SME supply chains. Through rigorous empirical analysis grounded in the TOE framework, we established that blockchain adoption directly enhances ethical sourcing practices (β=0.42) while partially leveraging supply chain transparency as a mediating mechanism (26% VAF). The significant role of government support (β=0.33) confirms that Vision 2030's policy environment actively accelerates technological adoption, transforming regulatory frameworks into competitive advantages for SMEs. These findings position blockchain not merely as a compliance tool but as a strategic resource that simultaneously advances business competitiveness and societal values.

The research makes three pivotal contributions to sustainable supply chain literature. First, it provides empirical validation of blockchain's capacity to bridge the ethical sourcing implementation gap in emerging economies. Second, it advances theoretical understanding through the novel integration of the TOE framework with Institutional Theory and Resource-Based View, explaining how policy-enabled technological adoption creates social value. Third, it establishes the first quantified evidence of blockchain's SDG-aligned impacts in the Gulf region, particularly for SDG 8 (decent work), SDG 9 (industry innovation), and SDG 12 (responsible consumption).

For Saudi Arabia's economic transformation journey, these findings offer actionable pathways. Policymakers should prioritise blockchain certification standards that align with global frameworks, such as the EU Digital Product Passport. SME leaders must reconfigure procurement workflows to leverage blockchain's dual verification capabilities. International partners should recognise blockchain-enabled ethical credentials within ESG reporting frameworks. Future research should examine longitudinal impacts across GCC industrial clusters and explore the convergence of AI and blockchain for predictive, ethical monitoring.

Ultimately, this study confirms that blockchain technology represents more than digital infrastructure - it is the operational backbone for building ethically resilient supply chains that align with Vision 2030's aspirations. By transforming transparency from aspiration to practice, Saudi SMEs can position themselves as regional leaders in socially sustainable business, turning ethical sourcing from a cost centre to a competitive advantage while contributing meaningfully to global sustainability goals.

5.2 Study's Contributions

5.2.1 Theoretical Contributions

The partial mediation of transparency in the blockchain–ethical sourcing link (VAF = 26%) shows that blockchain's impact extends beyond the transparency it enables; much of its effect stems directly from its inherent features — immutability, decentralisation, and trust without third parties. This nuance extends the TOE framework by clarifying how technological characteristics become organisational capabilities that drive ethical outcomes.

Theoretically, this study uniquely validates blockchain's ethical sourcing benefits in Saudi SMEs, integrating TOE with Social Entrepreneurship Theory, Institutional Theory, and RBV to explain policy-enabled technology adoption. It also confirms government support as a measurable environmental driver ($\beta = 0.33$), embedding Vision 2030 as a context-specific institutional factor within TOE.

5.2.2 Practical Implications

For Policymakers should leverage policy support's significant influence ($\beta = 0.33$) by introducing blockchain certification standards aligned with Vision 2030 and offering targeted subsidies for high-risk sectors such as textiles and agriculture to strengthen SDG 8 compliance.

For SME leaders, a phased blockchain rollout should start with automated tier-1 supplier verification to maximise the 26% transparency mediation effect. Investments should prioritise features that enable direct ethical verification ($\beta = 0.42$), with performance tracked through cost reductions and improvements in the SDG 8 indicator.

And, for International stakeholders, blockchain-based ethical credentials should be treated as ESG differentiators, and financial institutions funding Vision 2030 projects should require blockchain-enabled traceability to monitor SDG 12.5 targets.

5.2.3. Implementation Timeline and Metrics

A three-year roadmap should begin with government-funded pilots (Year 1) for 200 SMEs in Jeddah and Riyadh, tracking adoption via subsidy use. Year 2 should scale to sector-specific rollouts, measuring certification uptake and reductions in audit costs. By Year 3, integration with national export accreditation and participation in the EU Digital Product Passport should be achieved. KPIs include a 30% cut in compliance costs, 40% deeper raw material traceability, and 25% greater export market access for certified producers. Blockchain should be viewed as a strategic asset, not just a compliance tool. Table 5 outlines

the shift from awareness (training, SDG 9) to pilots (tax-incentivised high-risk supplier testing, SDG 8) to integration (full deployment under certification standards, SDG 12).

Table 5. Phased Roadmap for Blockchain-Enabled Ethical Sourcing in Saudi SMEs.

Phase	SME Actions	Government Role	SDG Impact
Awareness	Training on blockchain ethics	Fund sector-specific workshops	SDG 9 (Innovation)
Pilot	Test with 1 high-risk supplier	Provide tax incentives	SDG 8 (Fair Work)
Integration	Full supply chain deployment	Establish certification standards	SDG 12 (Traceability)

5.3 Future Research Directions

Building on this foundation, future research should explore several avenues. First, longitudinal studies are needed to track early adopters of blockchain by SMEs to determine whether ethical benefits persist or plateau over time. Second, qualitative studies, such as ethnographic case studies or in-depth interviews, could provide a deeper understanding of the implementation challenges and nuances that the quantitative survey may miss. This would provide a richer picture of the organisational context within the TOE framework, exploring factors such as internal resistance and corporate culture. Finally, comparative research could replicate this study in other GCC countries or emerging markets to test the generalisability of the findings and identify best practices in policy support for blockchain adoption, a key aspect of the TOE's environmental context.

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