International journal of science, engineering, and information technology
Volume 10, Issue 02, June 2026
Journal homepage: https://journal.trunojoyo.ac.id/ijseit

An Analysis of the Trade Off Between Minimizing Operational Downtime and Selecting Ethical Suppliers: Implications for Cost Efficiency and Occupational Safety

Aldi Adi Pratama[a]

[a]Department of Interdisciplinary Engineering, Faculty of Engineering, Universitas Indonesia

A B S T R A C T

Operational downtime puts immense pressure on procurement decisions, often leading to the selection of fast and low-cost suppliers despite their unverified ethical and safety standards. This study aims to examine how decision-makers in the manufacturing industry perceive and manage the trade-off between downtime minimization and ethical supplier selection, as well as its implications for cost efficiency and occupational safety. Using a qualitative approach with a single case study at a mid-sized manufacturing firm, data was collected through semi-structured interviews with eight informants, observations of emergency procurement, and document analysis. The data was subsequently analyzed thematically and complemented by a Weighted Decision Matrix to compare two suppliers. The findings indicate that downtime pressure shifts priorities toward speed, causing ethical criteria to be postponed during emergency purchases. Components from unverified suppliers trigger recurring failures and increase near-miss incidents, whereas the certified supplier proves superior with a weighted score of 4.05 compared to 2.65. Consequently, this trade-off proves largely illusory in the long run when evaluated through Total Cost of Ownership. Companies are advised to implement supplier prequalification, dual sourcing, safety stock management, and emergency procurement pathways with minimum ethical screening, all supported by top-management mandates.

Keywords: Downtime, Ethical Supplier, Occupational Health and Safety (OHS / HSE), Procurement, Total Cost of Ownership (TCO)

Article History
Received 12 March 26 Received in revised form 10 March 26 Accepted 01 June 26

1. Introduction

In industrial engineering and operations management practice, asset availability is the most visible measure of plant performance. Every hour a production line stands idle interrupts the flow of value: output is lost, delivery schedules slip, idle workers are still paid, and customer trust erodes. Consequently, in daily production and maintenance meetings, the question asked most often is not "What caused the failure?" but "When will the machine be running again?" An important indicator of effective resource management is maximizing asset availability so that assets can continue to operate optimally in support of organizational productivity [1].

That pressure ultimately culminates in procurement decisions. When a critical component is unavailable, the buyer faces two options: wait for a trusted supplier with a longer lead time, or source from a supplier that can deliver faster at a competitive price but has an unverified track record. The problem is that the time saved is local and temporary, while the consequences may emerge later as recurring failures, premature replacements, and risk exposure that is not captured in downtime reports. Therefore, in supply chain and business operations management, the selection of suppliers or raw material providers plays a crucial role in the continuity and success of a business. Supplier selection must not be done carelessly or rely on intuition alone, because a wrong or unsuitable decision can affect the quality of the final product and threaten the continuity of overall business operations [2].

On the other hand, ethical sourcing requires suppliers to meet minimum standards: compliance with labor regulations, implementation of an occupational health and safety (OHS) management system, environmental compliance, and bribery-free business integrity. For engineers, these criteria are not merely a matter of image or ESG. Component quality, specification accuracy, contractor competence, and the quality of personal protective equipment (PPE) determine whether the plant's risk control system truly works. When such supply chain disruptions occur, their negative impacts and risk burden ultimately shift onto workers on the production floor, which in turn risks triggering performance decline, fatigue, and even operational errors (human error) caused by increased work pressure [3].

Tension arises precisely at the intersection of these two objectives. The fastest or cheapest supplier does not necessarily meet ethical and safety standards, while suppliers that do meet them often require longer lead times and higher upfront costs. The Total Cost of Ownership (TCO) approach and supply chain risk management provide tools for weighing the two, but in practice these tools are rarely used when decisions must be made within hours. The sustainable procurement literature extensively discusses the benefits of ethical suppliers under normal conditions, whereas decision-making under downtime pressure, along with its effects on cost and occupational safety, remains underexplored from the perspective of frontline decision-makers.

Building on this gap, this study qualitatively examines how decision-makers in the manufacturing industry perceive and manage the trade-off between minimizing operational downtime and selecting ethical suppliers, as well as the implications for cost efficiency and occupational safety. The findings are expected to help organizations design procurement systems that remain responsive in times of crisis without compromising ethical and safety standards.

2. Literature review

a. Operational Downtime and Failure Costs

In modern supply chain and manufacturing operations management, managing downtime is a crucial aspect that needs to be minimized. Integrating fast, data-driven decision-making systems, such as supplier selection and reconfiguration systems, plays an important role in responding to unexpected failures, thereby reducing downtime duration and

* *Corresponding author.*
E-mail address: aldi.adi@ui.ac.id

E-ISSN 2548-4214

maintaining the continuity of industrial supply chain operations [4].

b. Ethical and Sustainable Procurement

In general supply chain industry practice, applying ethical, transparent, and competitive procurement principles is essential to ensure the availability of high-quality and affordable goods and services. Achieving good governance in the supply chain requires business actors and stakeholders to uphold integrity, avoid discrimination and fraud, and comply with business ethics standards in order to prevent legal risks and operational losses [5].

c. Supply Chain Risk Management

In managing uncertainty and the dynamics of a competitive business environment, risk management is understood as a systematic process of identifying, evaluating, and mitigating various risk factors in order to achieve optimal operational outcomes and project objectives. Furthermore, within the scope of the supply chain, risk management serves as a crucial strategy for anticipating, withstanding, and learning from potential disruptions in order to minimize negative impacts on overall organizational performance [6].

d. Occupational Safety and the Supply Chain

The implementation of Occupational Health and Safety (OHS) in the supply chain plays a vital role in identifying, assessing, and controlling potential hazards in order to protect the workforce and ensure the optimal availability of safety equipment. A well-integrated supply chain, supported by appropriate risk mitigation at storage facilities, not only improves occupational safety standards but also supports smooth operations overall. This proactive approach is crucial for avoiding unnecessary costs and preventing operational disruptions and losses caused by downtime resulting from equipment damage or unavailability [7].

e. Conceptual Framework

The decision-making flow for balancing the minimization of operational downtime and the selection of ethical suppliers is systematically mapped in the following diagram:

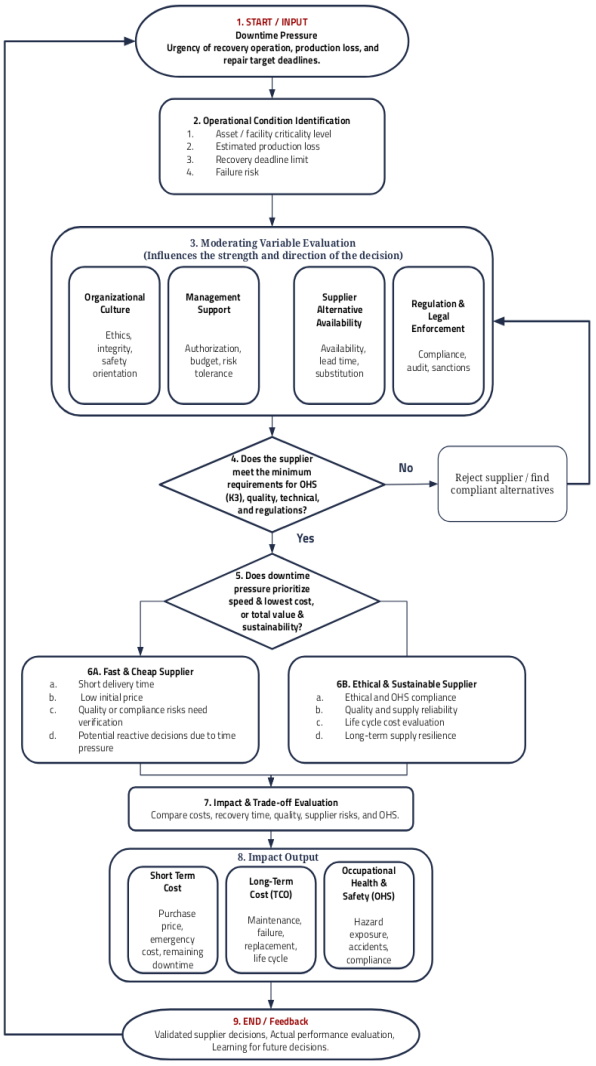


Figure 1. Operational Downtime vs. Ethical Supplier Selection Decision Flowchart

Total Cost and Downtime Cost Model

1. Total Cost (TC) Equation: TC = C purchase + C downtime + C failure + C HSE + C compliance
2. Downtime Cost (C downtime) Equation: E[t_downtime] x c hourly

Variable Description :

TC : Expected total cost
C purchase: Purchase price and shipping costs
C downtime : Production downtime losses
C failure : Repair or replacement costs due to recurring failures
C HSE : Occupational health and safety incident costs
C compliance : Fines, audit fees, and reputational risk costs

E (t downtime) : Estimated downtime duration (hours)
c hourly : Downtime loss cost per hour

3. Research Methodology

This study employed a qualitative approach with a single case study design in a medium-sized manufacturing company. This approach was chosen because the phenomenon under investigation is contextual, involves value judgments, and is difficult to measure through purely quantitative methods. The research process was iterative: data collection was repeated until no new information emerged, after which triangulation and report writing were carried out. Informants were selected purposively based on their direct involvement in procurement and operations decisions.

Table 1. Informant Details and Data Collection Techniques

Code	Role	Focus Explored	Technique
I1	Procurement manager	Supplier selection criteria and decisions	Interview
I2	Maintenance manager	Spare parts needs and recurring failures	Interview
I3	Production manager	Target pressure and downtime costs	Interview
I4	OHS officer	Incidents, near misses, and contractors	Interview, documents
I5	Finance staff	Cost calculation and TCO	Interview, documents
I6	Field supervisor	Practices during emergency repairs	Observation, interview
I7	Local supplier	Delivery capability and work standards	Interview
I8	Certified supplier	Lead time and compliance processes	Interview

Source: Primary data processed by the researcher (2026)

Data were collected through semi-structured interviews (45-60 minutes per informant), guided by questions about experiences in selecting suppliers during downtime, the criteria used, and their impacts. The interviews were followed by observation of emergency procurement processes and work area conditions, and then by document analysis of procurement policies, supplier codes of conduct, OHS incident reports, downtime reports, and purchasing cost records. The interview process also inquired about supplier performance. Previous studies indicate that optimal supplier performance is directly proportional to high order volumes, unit price competitiveness, and distribution speed. On the other hand, low-quality suppliers are characterized by high pricing and lengthy delivery lead times, which risk increasing operational costs and disrupting the supply chain [8].

Table 2. Research Operationalization Matrix

Research Question	Focus of Analysis	Data Source	Analysis Technique
1. Perception and management of the trade off	Decision flow, considerations, exceptions	Interviews with I1, I2, I3; observation	Inductive coding, themes
2. Drivers and barriers of ethical criteria	Target pressure, culture, supplier availability	Interviews with I1–I8; procurement policies	Coding, cross-informant comparison
3. Cost and safety implications	Failure costs, near misses, incidents	OHS reports, downtime reports, cost records	Document analysis, triangulation

Source: Primary data processed by the researcher (2026)

Thematic analysis followed the stages of Braun and Clarke: data familiarization, initial coding, searching for themes, reviewing themes, defining themes, and writing the report. Coding was conducted inductively, supported by qualitative analysis software or a manual matrix. Credibility was ensured through source and technique triangulation, member checking, and peer debriefing. Transferability was maintained through rich contextual description, while dependability and confirmability were established through an audit trail. Informants gave written informed consent, their identities were anonymized, and the data were stored securely.

4. Result and discussion

Company Overview : XYZ
The company operates a continuous production line with an estimated very high downtime cost per hour. Over the past two years, several unplanned stoppages have occurred due to machine breakdowns and delays in spare parts. The company has a supplier code of conduct, but its implementation varies between routine purchases and emergency purchases.

Thematic Findings

a. Finding 1
Downtime pressure shifts priorities toward speed. Procurement and production informants described emergencies as moments when ethical criteria are "put on hold." As I1 stated: "When the machine stops, the first question is when the part will arrive, not whether the supplier has a certificate." Observations showed that supplier assessment procedures were often bypassed in emergency purchases through a fast-track approval channel.

b. Finding 2
Hidden costs of fast and cheap suppliers. Maintenance and OHS informants reported that some spare parts from unverified suppliers had short service lives and had triggered repeated failures. As I2 put it: "Cheap on the invoice, but two months later we replace it again and the machine stops again." Document analysis revealed a pattern in which components from uncertified sources contributed to recurring stoppages, eroding the savings from the initial price.

c. Finding 3
The OHS officer (I4) highlighted that non-standard personal

protective equipment and components increase the potential for incidents, and that untrained supplier contractors introduce risks in the work area. Incident reports showed that near misses occurred more frequently during emergency repair periods involving new contractors. This is consistent with the concept of normalization of deviance, in which minor violations that are tolerated under time pressure become habitual.

d. Finding 4
Perceptions of ethical supplier costs. A finance staff member (I5) acknowledged that ethical suppliers generally charge higher prices on initial purchases, but stated that the company had not yet calculated TCO systematically. A certified supplier (I8) noted longer lead times due to quality and compliance processes, but said they offer better warranties and technical support.

e. Finding 5
Practices for balancing the trade off. The company has begun to experiment with dual sourcing (one primary ethical supplier and one verified backup), buffer stock for critical spare parts, and umbrella contracts with delivery SLAs. Informants who implemented these measures reported that the frequency of emergency purchases declined. Barriers include working capital tied up in inventory and the limited number of certified local suppliers.

f. Finding 6
The role of organizational culture and top management. Informants agreed that ethics becomes a real criterion only when top management provides a mandate and protection for procurement staff who reject problematic suppliers, even at the risk of prolonging downtime. Without this, staff tend to choose the option that is safest for their own production targets.

Table 3. Summary of Trade-Offs Between Supplier Characteristics and Risks

Aspect	Fast/cheap supplier (unverified)	Ethical/certified supplier
Lead time	Short	Tends to be longer
Initial price	Low	Higher
Risk of quality issues and recurring failures	High	Lower
Occupational safety risk	Higher	Lower
Reputational and compliance risk	High	Low
Total cost of ownership (TCO)	Tends to be higher	Tends to be lower

Source: Primary data processed by the researcher (2026)

The findings show that this trade-off is partly illusory over the long term. In the short term, a fast supplier appears to reduce downtime. However, once recurring failures, repair costs, safety incidents, and compliance risks are taken into account, that advantage diminishes. This supports the TCO and supply chain risk management perspectives: a decision that is locally rational (minimizing today's downtime) can be systemically irrational.

The tension remains real in crisis situations with limited alternatives. Therefore, the key is not to choose one over the other, but to design the system before a crisis occurs: supplier prequalification, standby contracts, critical stock, and clear escalation rules for exceptions. This pre-crisis planning includes the careful formulation of crisis management plans, the establishment of dedicated teams, and the provision of training for the team to be able to adapt and reduce potential errors and miscommunication when facing emergency situations [9]. The findings on the role of top management confirm that this trade-off is also a matter of governance and safety culture, not merely a technical procurement issue.

Implications Cost efficiency.

Ethical suppliers increase initial costs but have the potential to reduce the costs of recurring failures, repair overtime, claims, and fines. Companies need to adopt TCO analysis in supplier evaluation.

a. Occupational Safety
Ethical criteria (including the OHS standards of suppliers and contractors) function as an upstream risk control. Ignoring them during emergencies increases the likelihood of near misses and accidents.
b. Policy.
An emergency procurement pathway is needed that still includes minimum ethical checks (a pre-approved supplier list), rather than a total exemption.

Supplier Selection Decision Analysis

The supplier selection and decision-making process was conducted objectively using a Weighted Decision Matrix approach. This method integrates the relative importance weights of six main criteria with a supplier performance rating scale ranging from 1 (very poor or high risk) to 5 (very good and verified). The percentage weight for each criterion was determined based on the agreement of the decision-making team and the company's operational risk management priorities. The OHS performance and labor standards criterion was assigned the highest weight of 25%, because a workplace accident could potentially bring operations to a complete halt, result in legal sanctions, and damage the company's reputation. The Total Cost of Ownership (TCO) estimate and lead time criteria were each assigned a weight of 20%, to account for projected product life-cycle costs and the urgency of handling downtime. Meanwhile, the initial price and business ethics compliance criteria each carried a weight of 15%, and the quality reliability criterion was assigned a weight of 5%.

The weighted score was calculated by multiplying each supplier's criterion rating by its percentage weight and then summing all the resulting products. For Supplier A, which represents the fast and cheap but uncertified option, a lead time rating of 5 multiplied by a weight of 0.20 yielded a score of 1.00, and an initial price rating of 5 multiplied by a weight of 0.15 yielded a score of 0.75. A TCO estimate rating of 2 multiplied by a weight of 0.20 yielded a score of 0.40, while an OHS performance rating of 1 multiplied by a weight of 0.25 yielded a score of 0.25. Adding the ethical compliance score of 0.15 (a rating of 1 multiplied by a weight of 0.15) and the quality reliability score of 0.10 (a rating of 2 multiplied by a weight of 0.05), Supplier A obtained a final weighted total score of 2.65 out of a maximum of 5.00..

In contrast, the calculation for Supplier B, which is ethical and certified, produced a far superior accumulated score. Although Supplier B's lead time and initial price ratings were each only 3 (yielding weighted scores of 0.60 for lead time and 0.45 for initial price), this supplier recorded very high ratings on the heavily weighted criteria. A TCO estimate rating of 4 multiplied by a weight of 0.20 yielded a score of 0.80, and an OHS

performance rating of 5 multiplied by a weight of 0.25 yielded a score of 1.25. Adding the ethical compliance score of 0.75 (a rating of 5 multiplied by a weight of 0.15) and the quality reliability score of 0.20 (a rating of 4 multiplied by a weight of 0.05), Supplier B achieved a final weighted total score of 4.05 out of a maximum scale of 5.00.

Table 4. Weighted Supplier Selection Decision Matrix

Criterion	Weight (%)	Supplier A: fast, uncertified	Supplier B: certified
Lead time	20	5	3
Initial price	15	5	3
Estimated TCO	20	2	4
OHS performance and work standards	25	1	5
Ethical and business compliance	15	1	5
Quality reliability	5	2	4
Weighted score (maximum 5)	100	2.65	4.05

Source: Primary data processed by the researcher (2026)

Based on the narrative analysis of the calculation, Supplier A proved to offer only an apparent advantage on short-term parameters such as delivery speed and initial purchase price. Supplier A was eliminated because it received very low scores on the vital criteria (OHS, ethics, and TCO), and therefore failed to meet the minimum ethical gate requirement. In contrast, Supplier B, with a total score of 4.05, significantly outperformed Supplier A. Supplier B's dominant strengths in OHS, ethical compliance, and long-term TCO efficiency demonstrate that it is the most optimal, safe, and systemically rational procurement choice for the company's long-term operations. In building a sustainable supply chain management, supplier relationship management can no longer be underestimated or focused solely on minimizing transactional costs. Modern supplier relationship management practices require organizations to integrate ethical, environmental, and social responsibility standards from the partner selection stage to subsequent operations. Reliable suppliers must be evaluated holistically not merely based on speed or the cheapest price offers but through their ability to comply with ethical standards, religious values, and a commitment to long-term sustainability in order to avoid reputation risks and maintain stakeholder trust [10].

Conclusion

This study concludes that operational downtime pressure drives decision-makers to prioritize procurement speed, often leading to the neglect of ethics and occupational safety criteria during emergency purchases. While locally rational, such decisions are systemically detrimental: components from unverified suppliers trigger recurring failures and increase near-miss incidents, ultimately eroding initial cost and time savings through long-term expenses. The Weighted Decision Matrix results reinforce this finding, with Supplier B (certified) scoring 4.05 compared to 2.65 for Supplier A (fast and uncertified), primarily due to its superior performance in HSE (Health, Safety, and Environment), ethical compliance, and Total Cost of Ownership (TCO). Consequently, the trade-off between speed and ethics proves largely illusory over the long term, despite remaining very real during a crisis when supplier options are limited.

Companies are advised to design pre-crisis mechanisms through supplier prequalification, dual sourcing, safety stock for critical spare parts, umbrella contracts with SLAs, and emergency procurement pathways that retain minimum ethical screening, all backed by top-management mandates. Because this study is limited to a single case study within one mid-sized manufacturing firm, future research should incorporate quantitative data on costs and incidents while comparing multiple companies or industrial sectors.

REFERENCES

[1] F. M. Firdaus, D. Akmal, and I. A. Yakin, "Peningkatan efisiensi manajemen aset melalui pendekatan inovatif dan teknologi terkini," *JIKMA*, vol. 1, no. 5, pp. 345–357, Sep. 2023.

[2] S. Sapriadi, R. W. Dari, and I. Ilmawati, "Sistem pendukung keputusan pemilihan supplier terbaik dengan metode Simple Additive Weighting," *Teknois: Jurnal Ilmiah Teknologi Informasi dan Sains*, vol. 15, no. 2, pp. 234–243, Jul. 2025, doi: 10.36350/jbs.v15i2.319

[3] D. A. Safitri and Nelfiyanti, "Analisis resiko operasional produksi pada home industry konveksi dengan metode Failure Mode Effect Analysis (FMEA)," in *Prosiding Seminar Nasional Sains dan Teknologi 2025*, Universitas Muhammadiyah Jakarta, 2025, pp. 1–10.

[4] S. Park and S. N. Melkote, "Deep unsupervised learning-based supplier selection and ranking for assembly manufacturing," *Journal of Manufacturing Systems*, vol. 84, pp. 173–188, 2026, doi: 10.1016/j.jmsy.2025.12.004

[5] N. R. Sukma, M. Mashuri, and Humiati, "Pertanggungjawaban pidana terhadap penyedia dalam proses pengadaan barang dan jasa pemerintah secara e-purchasing," *Juris Delict Journal*, vol. 1, no. 2, pp. 96–115, Aug. 2025

[6] M. D. Vandhana, "Analisis risiko rantai pasok gudang peralatan safety PT. X menggunakan metode House of Risk (HOR)," *JIETech*, vol. 1, no. 2, pp. 109–117, Jul. 2025, doi: 10.36277/jietech.v1i2.48.

[7] A. D. Ayra and W. Santosa, "Peran resiliensi dalam memediasi pengaruh budaya manajemen risiko rantai pasok terhadap kinerja organisasi," *JMEB*, vol. 5, no. 1, pp. 332–346, Jan. 2025.

[8] A. Afra, A. Hananto, A. Hananto, and B. Priyatna, "Supplier clustering based on performance using K-means algorithm," *Jurnal Teknologi dan Sistem Informasi Bisnis*, vol. 7, no. 2, pp. 334–341, 2025, doi: 10.47233/jteksis.v7i2.1935.

[9] W. P. Sari et al., "Perancangan desain pedoman manajemen krisis berbasis teknologi artificial sebagai inovasi di bidang kehumasan," *Khatulistiwa: Jurnal Pendidikan dan Sosial Humaniora*, vol. 5, no. 3, pp. 547–560, 2025, doi: 10.55606/khatulistiwa.v5i3.7144.

[10] Y. S. Rioni, A. Adillah, and I. Muda, "A systematic review: Pengelolaan hubungan pemasok strategis dan integrasi rantai pasok," *NUSANTARA: Jurnal Ilmu Pengetahuan Sosial*, vol. 12, no. 12, pp. 4828–4843, 2025, doi: 10.31604/jips.v12i12.2025.4828-4843