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Contents

Volume 2, Issue 2 · October 2026 · published 1 October 2026 · 7 articles · pages 1–47

RESEARCH ARTICLES

- | | | |
|-----------|--|-----------|
| 1 | Entrepreneurial Strategy and Firm Performance at Inter Enterprise in Tlemcen
<i>Meriem Chekroun</i> | pp. 1–6 |
| 7 | Philosophical Foundations and Pedagogical Approaches to Artificial Intelligence in Algerian Higher Education
<i>Fazilet Alachaher, Nadjima Tabheriti</i> | pp. 7–13 |
| 14 | Gatekeeping and Circular Supply Chains: Associations with Perceived Reverse Logistics Performance
<i>Waffa Amalou Hallil</i> | pp. 14–21 |
| 22 | Reported Adoption of Precision Agriculture and Organic Practices among Fruit Growers in Tissemsilt Province, Algeria
<i>Abdelkader Difallah, Slimane Bencherif, Malika Zoubeidi</i> | pp. 22–28 |
| 29 | Middle Eastern Oil Shares and Brent Prices: A Composite Index and Exploratory ARDL Analysis
<i>Amir Nekounam, Hamidreza Raufi</i> | pp. 29–35 |

CONCEPTUAL PAPERS

- | | | |
|-----------|--|-----------|
| 36 | Architecture and Artificial Intelligence: Defining the Architectural Project and the Architectural Profession in the Age of AI
<i>Rima Baba, Oussama Sebti, Nadia Chabi</i> | pp. 36–39 |
| 40 | Blockchain and Environmental Trust in Green Value Chains in the Middle East and North Africa
<i>Tebra Mokaddem, Abdelkarim Bestani</i> | pp. 40–47 |



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RESEARCH ARTICLE

Entrepreneurial Strategy and Firm Performance at Inter Entreprise in Tlemcen

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ABSTRACT

This study examines entrepreneurial strategy and performance at Inter Entreprise, a subsidiary of the Kherbouche Group in Tlemcen, Algeria. It uses a qualitative case study supported by descriptive indicators reported from company records. The case account relates innovation, proactiveness and risk-taking to the firm's strategic activities and considers how planning supports their implementation. Reported turnover increased between 2021 and 2023, while internal customer satisfaction indicators also improved. These observations are consistent with the proposed relationship between entrepreneurial strategy and performance, but they do not establish a causal effect or statistical significance. The interpretation is limited by the single-case design, incomplete documentation of the interview process and the lack of independent verification of company indicators. The study identifies strategic partnerships, learning and better performance monitoring as areas for managerial attention.

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1. Introduction

Entrepreneurial strategy brings together entrepreneurship and strategic management. Firms seek opportunities while developing the resources and activities needed to create competitive advantage (Hitt et al., 2001; Ireland et al., 2003). In uncertain environments, managers must decide which opportunities to pursue, what risks to accept and how to support innovation.

Organisational performance includes financial results as well as outcomes such as process quality and customer satisfaction. Managers therefore need to consider how the firm uses its resources and how its activities respond to market conditions. Growth in one indicator does not necessarily imply improvement in all aspects of performance.

This research examines the relationship between entrepreneurial strategy and organisational performance at

Inter Entreprise in Tlemcen, Algeria. The firm forms part of an established business group. The case provides a basis for discussing entrepreneurial practices within that organisation; it does not represent newly founded firms or the Algerian economy as a whole.

2. Literature review

Strategic entrepreneurship concerns the relationship between seeking opportunities and developing competitive advantage. The literature considers how firms combine resources, entrepreneurial behaviour and managerial decisions to create value (Hitt et al., 2001; Ireland et al., 2003). These ideas provide the framework for examining the activities of Inter Entreprise.

This study focuses on entrepreneurial orientation and strategic planning. Entrepreneurial orientation concerns

how firms approach innovation, proactiveness and risk-taking. Planning concerns the analysis of the environment, the setting of objectives and the allocation of resources. The two concepts are related, but they should not be treated as interchangeable measures.

Research also shows why the relationship needs to be examined in context. Jallad and Karadas (2024) study absorptive capacity and industry type in Palestinian manufacturing SMEs. Nofirda and Azhari (2025) examine technology and competitive intensity in Indonesian SMEs. These studies address mechanisms and settings that may differ from those of an Algerian infrastructure contractor. Their findings inform the discussion without providing direct evidence about Inter Enterprise.

3. The concept of entrepreneurial strategy

3.1. Theoretical foundations

Entrepreneurial strategy concerns how firms identify opportunities and organise the activities needed to pursue them. In their literature review, Allammari and Taqi (2023) discuss innovation, risk-taking and proactiveness as recurring dimensions of entrepreneurial orientation in SMEs. These dimensions provide a useful starting point for examining strategic behaviour.

Covin and Slevin (1989) examine entrepreneurial strategic posture through innovativeness, risk-taking and proactiveness. Lumpkin and Dess (1996) develop a broader framework that also includes autonomy and competitive aggressiveness. The present case discussion focuses on the three commonly used dimensions. The resource-based view provides a complementary explanation of competitive advantage through resources that are valuable, rare, difficult to imitate and without strategically equivalent substitutes (Barney, 1991).

Entrepreneurial strategy therefore links the pursuit of opportunities to decisions about resources and competitive positioning. Whether these decisions improve performance remains an empirical question, rather than an outcome implied by the definition.

3.2. Value creation and knowledge

Innovation can contribute to new products, services and processes, but firms also need ways to share and use knowledge. Qasim et al. (2025) report a mediating role for knowledge sharing in the relationship between entrepreneurial orientation and innovation performance in Jordanian telecommunications companies. Their study concerns innovation performance in a specific setting and does not establish an automatic improvement in every aspect of organisational performance.

Kusa et al. (2024) examine information management and knowledge management alongside entrepreneurial orientation. Their findings support attention to how firms manage knowledge when seeking better performance. In the present case, knowledge management provides a possible explanation for the value of learning and resource sharing, rather than a measured mediating variable.

3.3. Dimensions of entrepreneurial strategy

Strategic entrepreneurship combines opportunity-seeking and advantage-seeking activities (Ireland et al., 2003; Ireland & Webb, 2007). Entrepreneurial mindset, culture and leadership help explain how firms organise these activities. Innovation and strategic planning provide further areas for analysis.

3.3.1. Entrepreneurial mindset

An entrepreneurial mindset involves recognising possible opportunities and considering how to pursue them under uncertainty (Ireland et al., 2003). Managers must assess the resources and risks involved as they explore alternatives.

3.3.2. Entrepreneurial culture

An entrepreneurial culture supports the discussion of new ideas, experimentation and the pursuit of opportunities (Ireland et al., 2003). It concerns the values and practices through which members of an organisation interpret and act on those possibilities.

3.3.3. Entrepreneurial leadership

Entrepreneurial leadership concerns how managers encourage opportunity-seeking while maintaining direction and coordinating resources (Covin & Slevin, 2002). Leadership can support this process, but its contribution must be examined alongside the conditions in which the firm operates.

3.3.4. Strategic management of innovation

Schumpeter (1942) places innovation at the centre of economic change. At the firm level, managers must consider how an innovation relates to the resources needed to develop and sustain a competitive position (Barney, 1991). Innovation alone does not guarantee lasting advantage.

3.3.5. Entrepreneurial orientation

Entrepreneurial orientation concerns the firm's approach to innovation, proactiveness and risk-taking. Wiklund and Shepherd (2005) show the importance of considering financial resources and environmental dynamism alongside this orientation. Rauch et al. (2009) report a positive overall association with performance in their meta-analysis, while also identifying contextual influences.

3.3.6. Strategic planning practices

Strategic planning gives managers a means of analysing conditions, setting priorities and reviewing decisions. Brinckmann et al. (2010) find that the planning-performance relationship depends partly on context and discuss the value of combining planning with learning. Planning systems also differ across firms (Kukalis, 1989). Barringer and Bluedorn (1999) examine environmental scanning, planning flexibility, planning horizon, participation in planning and control practices.

Table 1 summarises planning practices relevant to the discussion. It describes concepts from the literature rather than classifying Inter Enterprise or dividing all

firms into fixed conservative and entrepreneurial categories.

Table 1 Strategic planning practices relevant to entrepreneurial activity

Practice	Meaning	Relevance to entrepreneurial activity
Environmental scanning	Examining developments in the firm's environment.	Supports the recognition of opportunities and threats.
Planning flexibility	Revising plans when conditions or opportunities change.	Allows managers to reconsider priorities and actions.
Participation in planning	Involvement of people at different organisational levels.	Allows knowledge from across the organisation to inform plans.
Strategic controls	Reviewing strategic activities and their longer-term implications.	Provides a basis for assessing progress beyond short-term financial results.

Source: Author's summary based on Barringer and Bluedorn (1999).

These dimensions provide a framework for exploring how a firm links opportunities to action. The case analysis focuses on entrepreneurial orientation and planning, while recognising that culture, leadership and resources may influence their relationship with performance.

4. The concept of firm performance

Performance measures can combine financial results with indicators of customers, internal processes and learning (Kaplan & Norton, 1992). In this case, turnover provides an indicator of business activity. It does not establish profitability or cash generation. The resource-based view relates sustained competitive advantage to the characteristics of a firm's resources (Barney, 1991).

Human capital provides another consideration when evaluating the capacity of a firm to perform (Dess & Picken, 1999). Hitt et al. (2011) also discuss strategic entrepreneurship in relation to value creation for individuals, organisations and society. These broader outcomes require their own evidence and cannot be inferred from a single financial indicator.

An assessment of the firm should therefore distinguish current reported results from its prospects for growth and continuity. It should also distinguish financial indicators, operational rates and perceptions of service quality.

5. Entrepreneurial strategy and firm performance

Research on entrepreneurial orientation offers reasons to expect a relationship with performance, but it also shows that the association varies with resources and environmental conditions. Entrepreneurial behaviour can support the pursuit of opportunities while exposing the firm to costs and uncertainty.

Covin and Slevin (1989) examine small firms in hostile and benign environments, linking strategic posture to its organisational context. Wiklund and Shepherd (2005) likewise argue that considering entrepreneurial orientation alone gives an incomplete explanation of performance. These studies support an examination of how entrepreneurial practices fit the circumstances of the firm.

Rauch et al. (2009) find a positive overall relationship between entrepreneurial orientation and performance across prior studies. Their meta-analysis provides broader empirical evidence; it does not demonstrate that the same effect occurs at Inter Enterprise. The present case examines whether its reported activities and indicators are consistent with that proposed relationship.

6. Entrepreneurial strategy at Inter Enterprise

6.1. The firm studied

Inter Enterprise (SPA) is part of the Kherbouche Group in Tlemcen. The group's company profile identifies 1976 as its founding year and describes activities in agro-industry, water engineering and hydraulic works (Groupe Kherbouche, n.d.). The case concerns the subsidiary's building and hydraulic infrastructure activities. It examines entrepreneurial practices within an established organisation.

6.2. Research methodology

The research uses a qualitative single-case approach supported by descriptive company indicators (Creswell & Creswell, 2018). Semi-structured interviews provide the account of entrepreneurial and planning practices. Company documents provide contextual figures, including turnover and internal customer indicators for 2021–2023.

The analysis relates the reported practices to entrepreneurial orientation and strategic planning, then compares them with the available performance indicators. It does not estimate a causal model or test statistical significance. Interview sample size, interview dates and a coding protocol are not reported, which limits the traceability and reproducibility of the qualitative interpretation. The underlying company records and survey responses have not been independently verified.

The principal proposition is that entrepreneurial strategy is associated with the performance of Inter Enterprise. Two related propositions guide the discussion:

Ha1: Entrepreneurial orientation, expressed through innovation, proactiveness and risk-taking, is associated

with firm performance.

Ha2: Strategic planning practices are associated with firm performance.

6.3. Qualitative findings

The case account describes a combination of entrepreneurial behaviour and planning practices. It identifies innovation, risk-taking and proactiveness in the firm's efforts to adapt to market developments.

The reported expansion into Senegal in 2019 illustrates the pursuit of opportunities beyond the domestic market. It is treated here as a reported example of internationalisation. The available material does not isolate its contribution to turnover or measure the commercial outcome of that project.

The qualitative account also describes the use of technology, environmental scanning and flexible planning. These practices may help managers respond to uncertainty, but the case does not measure their individual effects on performance.

Resource sharing within the group, the development of human capital and managerial leadership are further themes in the case account. They offer possible explanations for the firm's capacity to carry out its activities, rather than separately tested determinants.

Taken together, these themes describe how the firm combines opportunity-seeking with the organisation of resources. They provide the basis for interpreting the descriptive performance indicators below.

Table 2 Forecast and realised turnover for 2021 to 2023

Year	Forecast turnover MDA	Realised turnover MDA	Variance MDA	Forecast achievement %
2021	32,500	31,200	-1,300	96.0
2022	35,000	36,100	1,100	103.1
2023	38,000	38,500	500	101.3

Source: Company figures reported by the author. Variances and forecast achievement rates recalculated from the stated amounts. Underlying records have not been independently verified.

The case account reports activity of approximately 12-15 projects per year, a project completion rate of about 88% and on-time delivery of 70-80%. These figures describe different aspects of operations. The reporting period, project counts used as denominators and definitions of completion and timeliness are not supplied. The rates therefore remain descriptive and cannot establish improvement over time or performance relative to competitors.

The account also reports cost overruns of 10-20% and annual signed contracts valued at DZD 2.5-3.5 billion. No comparable sector benchmark is established. Contract awards and recognised turnover concern different measures, and their relationship depends on the timing and scope of projects. These amounts cannot be reconciled with annual turnover without further information on contracts and revenue recognition.

Table 3 reports customer satisfaction rates of 85%, 88% and 90% for 2021, 2022 and 2023, respectively.

6.4. Contextual factors

The interpretation considers organisational factors, including structure, culture and human capital; environmental factors, including competition and market conditions; and the role of managerial leadership. The study does not estimate the relative contribution of these factors. They identify relevant context for the case and possible questions for further research.

6.5. Performance assessment

The available indicators describe turnover, project activity and internally reported customer outcomes. The following assessment distinguishes what the figures show from explanations that would require additional evidence.

Turnover

Table 2 compares forecast and realised turnover for 2021-2023. Realised turnover increased from 31,200 MDA in 2021 to 38,500 MDA in 2023. The firm fell short of its forecast in 2021 and exceeded it in 2022 and 2023. These figures describe nominal turnover and performance against internal forecasts. They do not show profitability, inflation-adjusted growth or the effect of entrepreneurial strategy.

The forecast achievement rate is calculated as realised turnover divided by forecast turnover, multiplied by 100. The variance equals realised turnover minus forecast turnover. MDA denotes millions of Algerian dinars (DZD).

Complaint rates are 6%, 5% and 4%. The reported satisfaction rate rose by five percentage points over the period, while the complaint rate fell by two percentage points. The survey questions, sample sizes and denominators are not documented, so these internal rates cannot be treated as independently validated or necessarily comparable measures.

Table 3 Reported internal customer indicators

Year	Reported customer satisfaction %	Reported complaint rate %
2021	85	6
2022	88	5
2023	90	4

Source: Internal indicators reported by the author. Underlying survey responses and calculation methods have not been independently verified.

Corporate image

The qualitative account links the firm's reputation to materials, technical standards and relations with clients and institutional partners. Participation in tenders and project delivery may contribute to visibility. These statements describe the case account's interpretation of corporate image; the study includes no separate external measure of reputation.

7. Discussion

7.1. Entrepreneurial orientation and performance

The reported innovation and internationalisation activities are consistent with Ha1. They indicate opportunity-seeking behaviour, but the case does not quantify entrepreneurial orientation or separate its effect from market conditions and other influences. Lumpkin and Dess (1996) provide a framework for considering these contingencies. The observations therefore provide a qualitative

basis for discussion rather than confirmation of a causal hypothesis.

7.2. Strategic planning and performance

The account of environmental scanning and flexible planning, together with the reported turnover results, is consistent with Ha2. Ireland et al. (2003) offer a conceptual basis for considering how managers organise resources around opportunities. However, the reported completion and cost rates lack defined observation periods and independent benchmarks. They cannot demonstrate that formal planning caused better performance.

7.3. Overall interpretation

The principal proposition remains consistent with the case account, but it is not statistically validated. No comparison group, causal model or significance test is presented. Table 4 summarises the observations and the limits of the interpretation.

Table 4 Interpretation of the study propositions

Proposition	Reported observations	Interpretation
Ha1 Entrepreneurial orientation	Innovation, opportunity-seeking and reported internationalisation.	Qualitatively consistent with Ha1; no isolated effect or significance test.
Ha2 Strategic planning	Environmental scanning, flexible planning and turnover against forecasts.	Qualitatively consistent with Ha2; causality and benchmarks are not established.
Principal proposition	Entrepreneurial practices coexist with favourable reported indicators.	Consistent with the proposed association; not statistically validated.

Source: Author's interpretation of the reported case material.

7.4. Performance indicators and possible improvements

The interview account indicates that managers see value in the existing indicators while recognising a need for measures better suited to their activities. A more useful monitoring system would define each indicator's reporting period, calculation method and data source. It would distinguish turnover from profitability and contract awards, and define project completion and on-time delivery against clear denominators.

The interviews also identify strategic partnerships, shared experience and updated working methods as possible areas for improvement. Technology adoption may support these aims when managers connect it to specific operational needs and assess the costs and results.

These proposals are managerial implications of the case discussion. The study does not test the effectiveness of the proposed changes or establish that they will produce a particular performance gain.

8. Conclusion

This case study examines entrepreneurial strategy and performance at Inter Entreprise. The qualitative account describes innovation, opportunity-seeking and planning practices alongside increased reported turnover and improved internal customer indicators during 2021–2023.

These observations are consistent with a relationship between entrepreneurial practices and performance.

The study does not establish the size, statistical significance or causal direction of that relationship. Resource sharing, leadership and market conditions remain possible influences. Managers may use the discussion to examine how entrepreneurial initiatives connect to planning and to the indicators used to assess their results.

The interpretation has several limits. It concerns a single established firm and cannot be generalised to other firms or to the Algerian market. The interview process is incompletely documented, access to organisational records was limited, and company figures have not been independently verified. Undefined operational measures and undocumented customer survey methods further limit comparisons. Nominal turnover growth also provides no direct evidence of profitability or real growth.

Further research could examine multiple firms, document interview sampling and analysis, and use independently verifiable indicators with consistent definitions. A design that considers competing explanations and changes over time would provide a stronger basis for assessing how entrepreneurial strategy relates to firm performance.

Declarations

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RESEARCH ARTICLE

Philosophical Foundations and Pedagogical Approaches to Artificial Intelligence in Algerian Higher Education

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ABSTRACT

This study examines the pedagogical and philosophical implications of artificial intelligence (AI) use at four Algerian university sites. It combines a survey of 200 students, interviews with 20 faculty members and a review of institutional documents. Humanism, constructivism, pragmatism and critical pedagogy provide the interpretive framework. The reported student indicators show more use for writing and translation than for activities labelled critical analysis. Faculty accounts identify both practical uses and concerns about academic integrity, while participants also describe difficulties with access, training and institutional guidance. These findings concern the participating sample and perceptions of AI; they do not establish national adoption rates or measured improvements in learning. Incomplete reporting of recruitment, item-level denominators and institutional documentation limits the analysis. The article proposes that institutions evaluate AI through explicit educational aims, support for human judgement and attention to equitable access. The philosophical framework is an analytical proposal whose effectiveness requires further study.

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1. Introduction

Artificial intelligence has expanded the range of tools available for teaching, learning and academic work. Educational applications include language assistance, feedback and the analysis of learning data. Their value depends on the task, the conditions of use and the educational aims they serve. International guidance also identifies concerns about privacy, bias and human responsibility (OECD, 2019; UNESCO, 2021; Miao & Holmes, 2023).

In the Algerian settings examined here, students and faculty describe uses of AI alongside uncertainty about appropriate practice and institutional guidance. The study

considers these accounts in relation to the purposes of higher education. Individual use of a tool, a university-wide service and a formal institutional policy represent different forms of adoption and require different evidence.

The article asks how AI use can support learning, autonomy and critical judgement within the participating university sites. It applies four philosophical perspectives to the reported survey and interview material. These perspectives help frame questions about educational purpose; they do not provide a substitute for evaluating learning outcomes. Selwyn (2019) similarly draws attention to

the social and relational dimensions of teaching when considering AI in education.

2. Literature review

The OECD (2019) discusses human values, fairness and accountability in the wider use of AI. UNESCO's Recommendation on the Ethics of Artificial Intelligence, adopted in 2021, provides a framework for considering rights, inclusion and human oversight (UNESCO, 2021). For education and research, Miao and Holmes (2023) address the pedagogical evaluation of generative AI and the need to develop human capacity alongside institutional guidance.

Holmes et al. (2019) examine the promises and implications of AI for teaching and learning. Zawacki-Richter et al. (2019), in a systematic review of higher education applications, identify weak connections to pedagogical theory and a need for more critical attention to educational and ethical questions. These contributions support examining the purposes and contexts of AI use, rather than assuming that access to a tool is evidence of better learning.

Humanist approaches direct attention to personal growth and learner autonomy. Rogers (1969) considers self-directed learning, while Maslow (1943) offers a theory of human motivation. We use these ideas to ask whether an AI-supported activity respects the learner and

supports development. Piaget (1970) and Vygotsky (1978) provide perspectives on active knowledge construction and the social dimensions of learning. Applied to AI, these perspectives invite attention to what students do with feedback, how they discuss ideas and how they justify their conclusions.

Dewey's (1938) account of experience and education supports evaluating learning activities through their consequences for further inquiry. We apply this perspective to the assessment of AI-supported tasks. Freire (1970) provides a basis for examining dialogue, power and participation in education. The application of these ideas to contemporary AI systems is our interpretation, not a claim that these authors wrote about current technologies.

Research on AI applications includes assessment, adaptive systems and intelligent tutoring, but evidence about one system or task cannot establish the effectiveness of all AI tools (Zawacki-Richter et al., 2019). Cope et al. (2021) discuss knowledge and assessment in AI-enabled learning environments and distinguish the operations of computing from the work of human teachers. Williamson and Eynon (2020) place educational AI within historical, commercial and institutional contexts. Together, these sources support an examination of both educational aims and the conditions under which tools are used.

Table 1 Philosophical perspectives and questions for AI use in education

Perspective	Educational focus	Question for evaluating AI use
Humanism	Autonomy, dignity and personal development	Does the activity support the learner and preserve access to human guidance?
Constructivism	Active inquiry and social learning	Does the student explain, discuss and revise ideas when using the tool?
Pragmatism	Educational consequences of experience	Does evaluation show progress towards the intended learning aims?
Critical pedagogy	Dialogue, participation and power	Who has access, whose knowledge is represented and how can outputs or decisions be questioned?

Source: Authors' interpretation of Rogers (1969), Maslow (1943), Piaget (1970), Vygotsky (1978), Dewey (1938) and Freire (1970). The AI applications are proposed interpretations of these perspectives.

3. Research questions and propositions

The study asks how participants use AI in teaching and learning, what benefits and concerns they report, and how philosophical perspectives can inform the interpretation of these practices. It also considers what forms of guidance and support might help institutions respond to the issues identified.

Five propositions organise the enquiry. H1 concerns whether students report more use for writing and language support than for explicitly labelled critical analysis. H2 concerns possible differences in reported practices across faculty disciplines. H3 concerns differences between student and faculty perceptions of educational benefits and academic integrity. H4 concerns barriers involving access, training and institutional guidance. H5

proposes humanism, constructivism, pragmatism and critical pedagogy as a framework for responsible AI use. H1-H4 guide descriptive and thematic interpretation. H5 is a conceptual proposal; its effectiveness is not tested in this study.

4. Scope of the study

The research covers sites identified as Algiers, Tlemcen, Constantine and Oran. The student sample includes undergraduates and postgraduates in the humanities, sciences, engineering and social sciences. The faculty sample covers related disciplinary areas. The analysis uses these site labels because the precise institutional entities and campuses are not specified in the study record.

The findings concern the participating students and faculty. They cannot establish adoption rates for all Algerian universities or represent all institutions in each named city. The case accounts focus on participants' experiences and on questions of pedagogy. They do not constitute an independent audit of institutional AI deployment.

5. Methodology

The study reports a convergent mixed-methods design involving document analysis, semi-structured faculty interviews and a student survey. The survey and interview material is identified as 2025 fieldwork. The document review covers policies, course syllabi and guidance

issued during 2021–2023. This earlier document period is considered separately from participants' later accounts; it cannot establish whether an institution had adopted an AI policy by 2025.

The reported sample comprises 200 students, including 150 undergraduates and 50 postgraduates, and 20 faculty members. Faculty were selected for their engagement with digital teaching tools. The student recruitment procedure and the number invited are not documented, so a response rate cannot be calculated. Interviews addressed pedagogical aims, experiences with tools and ethical concerns. The study reports that interviews were recorded with consent and transcribed.

Table 2 Reported participant composition

Participant category	Reported number	Fields represented
Undergraduate students	150	Humanities, sciences, engineering and social sciences
Postgraduate students	50	Humanities, sciences, engineering and social sciences
Faculty members	20	Humanities, social sciences, engineering and natural sciences

Source: Sample information reported by the authors for the present study. Participants were drawn from four university sites; sites are not an additional participant category.

The student questionnaire includes usage, perceptions and open-ended items. The interview guide and questionnaire appear in the appendix. The study reports thematic analysis of interviews and open-ended responses and descriptive analysis of survey responses. Quantitative indicators and qualitative themes are brought together for interpretation through the philosophical framework. No inferential tests or direct measures of learning gains are reported.

Several reporting limits affect the interpretation. Item-level response counts, the handling of missing responses and the coding of purpose categories are not available. The questionnaire does not specify whether students could select multiple purposes of use. The percentages are therefore presented as reported indicators without reconstructing counts or treating the categories as an exhaustive distribution. A document inventory and site-level participant breakdown are also unavailable. Participation was voluntary, informed consent was obtained and responses were anonymised for analysis.

6. Findings

The findings combine descriptive student indicators with themes from the faculty interviews. They provide a basis for examining the research propositions within this sample.

6.1. Student use of AI

The study reports regular academic AI use at 78%. The reported purposes are writing assistance (62%), translation (58%), summarisation (49%), research support

(33%) and critical or analytical use (21%). Table 3 presents these indicators separately. The percentages for purposes total more than 100% and should not be read as shares of a single whole.

Table 3 Reported student use indicators

Indicator	Reported percentage
Regular academic use of AI	78%
Writing assistance	62%
Translation	58%
Summarisation	49%
Research support	33%
Critical or analytical use	21%

Source: Student survey percentages reported by the authors for 2025, with a total student sample of 200. Item-specific denominators and the multiple-response procedure are not documented.

Writing and translation have higher reported percentages than the category labelled critical or analytical use, which is consistent with the descriptive focus of H1. These task labels do not measure depth of thinking; writing, translation and summarisation can themselves involve critical reasoning. The available results also do not support comparisons between individual sites.

6.2. Faculty accounts by discipline

Faculty accounts describe uses such as programming support, simulation and data analysis in technical fields. Accounts from the humanities and social sciences place

emphasis on original writing and the risks of dependence on generated text. These themes suggest differences worth examining, but discipline-specific sample sizes and adoption counts are not reported. The study therefore cannot establish that one disciplinary group adopts AI more frequently than another or confirm H2 statistically.

6.3. Student and faculty perceptions

The reported student indicators show that 68% believed AI had improved their academic performance and 54% associated AI use with an increased risk of academic dishonesty. These responses concern perceptions, not independently measured learning gains or documented misconduct. Faculty interviews also raised concerns about writing standards, originality and intellectual development. The material allows comparison of themes, but it does not support a quantified gap between students and faculty because comparable faculty response counts are unavailable.

6.4. Reported institutional barriers

Participants described difficulties involving devices, internet access, professional development and clear guidance on acceptable AI use. These accounts are consistent with the concerns addressed by H4. They identify needs within the reported sample; they do not establish that every participating institution lacks a policy or that the same conditions apply nationally. National fixed-broadband subscription rates alone would not measure students' access to usable internet services, devices or campus support.

6.5. Assessment of the propositions

The reported student indicators are descriptively consistent with H1. Faculty themes offer material relevant to H2, but comparative adoption rates are unavailable. Student and faculty accounts inform H3 without establishing a statistically significant perception difference. Reports of barriers provide contextual support for H4, subject to the limits of the document review and sampling. H5 remains the authors' conceptual framework and cannot be described as empirically confirmed or endorsed by all participants.

7. Accounts from the four university sites

The following accounts summarise applications and concerns attributed to participants at each site. They draw on the reported interviews and survey material. Specific platforms, deployment records and institution-level evaluations are not identified, so the accounts describe reported experiences rather than verified university-wide programmes. The interpretations distinguish perceived convenience from demonstrated educational benefit.

7.1. Language assistance at the Tlemcen site

Students described using grammar checkers, translation platforms and writing assistants to revise essays, translate academic material and summarise readings. Faculty

acknowledged possible help with language barriers while emphasising ethical use and continued writing practice. These accounts do not establish how widely the tools are used across the institution or whether they improve assessed language proficiency.

A humanist interpretation asks whether such assistance supports confidence and learner autonomy. A constructivist interpretation asks how students respond to feedback and revise their understanding. An appropriate learning activity would require students to explain their choices and practise the language skills for which they remain responsible.

7.2. Chatbot services at the Algiers site

The site account describes chatbot use for registration questions, course information and scheduling. Participants associated these services with quicker access to routine information. The study does not identify a particular system or provide evidence of an institution-wide implementation. It therefore treats this material as an account of perceived service convenience.

Participants also described incorrect or generic responses and difficulty obtaining help with individual circumstances. These concerns point to the need for access to human staff when questions require judgement or personal guidance. Faster responses to administrative enquiries should be assessed separately from improvements in teaching or student learning.

7.3. Automated assessment at the Constantine site

The site account describes automated marking of multiple-choice questions and online quizzes. Faculty and students associated it with faster results and feedback. Automated scoring alone does not establish the use of AI: the underlying system and method are not documented here. The account therefore supports discussion of automated assessment without demonstrating the effects of a particular AI technology.

Faculty raised questions about the evaluation of sustained reasoning and creativity, while students expressed concerns about fairness and transparency. The educational issue is whether the assessment captures the intended learning and gives students a way to understand and challenge a result. Human review remains relevant where interpretation is required.

7.4. Research assistance at the Oran site

Postgraduate participants described using AI tools to organise information, explore literature and prepare initial drafts. They associated these uses with support for academic work and language difficulties. These are accounts of perceived usefulness; the study does not measure research quality or productivity.

Faculty stressed the need to check generated material, verify references and develop an argument grounded in disciplinary knowledge. From a pragmatic perspective, the value of a tool would depend on the quality of the resulting research process and output. A constructivist per-

spective would also ask whether the student can explain, evaluate and revise that work.

Table 4 Reported applications and questions arising from the site accounts

Site	Reported application	Perceived benefit	Issue for evaluation
Tlemcen	Language and writing assistance	Help with language and revision	Independent writing practice and verification of learning
Algiers	Chatbot information services	Quicker access to routine information	Accuracy and access to human advice
Constantine	Automated marking and feedback	Faster results	Whether the system uses AI and assesses the intended learning
Oran	Research assistance	Help with organising information and initial drafts	Verification of sources and development of the student's own argument

Source: Authors' synthesis of the reported 2025 fieldwork. Applications and benefits are participant accounts, not independently verified institutional outcomes.

Across these accounts, similar tools serve different purposes. Language assistance, access to administrative information, automated feedback and research support each require an appropriate form of evaluation. Educational purpose matters alongside access, system reliability and institutional arrangements. None of the accounts establishes a general effect of AI on learning.

8. Discussion

The study describes practical uses of AI together with concerns about integrity, access and guidance. The philosophical framework helps examine what would count as an educationally worthwhile use. Its contribution is interpretive: it connects reported practices to questions about autonomy, knowledge construction and responsibility.

A humanist perspective directs attention to students' dignity, development and access to human guidance. Constructivism directs attention to the learning activity, including discussion, revision and explanation. Pragmatism calls for an assessment of educational consequences. These perspectives suggest that institutions should evaluate student learning, rather than use tool uptake or speed as a sufficient measure of success.

Critical pedagogy directs attention to who can access a tool, whose knowledge it represents and who can question its outputs or the decisions made with it. Williamson and Eynon (2020) likewise place educational AI within wider political and institutional arrangements. Applying these questions to the present case requires caution: the sample does not measure the national distribution of digital inequality or the effects of a particular commercial system.

Students' reported optimism about academic performance and faculty concerns about original work raise questions for teaching and assessment. The study cannot quantify a reliable difference between these groups. Institutions could use structured discussion to clarify expectations, identify disagreements and connect permitted uses to the aims of particular courses.

9. Recommendations

The following recommendations draw on the reported concerns and the philosophical analysis. They are proposals for practice, not interventions whose effectiveness has been tested by this study.

Institutions should develop clear guidance with students and faculty on permitted assistance, disclosure, assessment and the handling of data. Course-level AI literacy should include checking claims and references, recognising limitations and explaining the student's own reasoning. Staff development should connect tools to disciplinary teaching aims and assessment design. Institutions should also assess barriers involving devices, connectivity and accessible alternatives before requiring a tool. Students need routes to human advice and review when an automated service or assessment cannot address their circumstances.

These proposals are consistent with the emphasis on human agency and pedagogical evaluation in UNESCO guidance (Miao & Holmes, 2023). Institutions would need to assess their effects through defined learning aims, participation measures and feedback from those affected.

10. Conclusion

This study examines reported AI use at four Algerian university sites through student indicators, faculty accounts and a philosophical framework. Writing and language assistance have higher reported percentages than explicitly labelled critical analysis. Participants also describe issues concerning academic integrity, access and guidance. These observations provide a basis for local discussion of educational aims and responsibilities.

Humanism, constructivism, pragmatism and critical pedagogy offer questions for evaluating the purposes and conditions of AI use. This study does not establish that the framework improves learning or that participants endorse every element. Its value lies in organising an examination of learner autonomy, active inquiry, educational consequences and power.

The findings are limited by incomplete reporting of recruitment, item-level denominators and institutional documentation, and by the absence of independently verified outcome measures. They cannot establish national adoption rates, institutional policy absence or causal learning gains. Further research should document sampling and analysis, identify the systems used and evaluate changes in learning with appropriate measures. A comparative design could also examine differences across sites and disciplines without treating reported impressions as adoption rates.

Declarations

Funding. This research received no external funding.

Conflicts of Interest. The authors declare no conflicts of interest.

Ethics Approval and Informed Consent. Participation was voluntary. Informed consent was obtained before data collection, and interviews were recorded with consent. Responses were anonymised for analysis.

Data Availability Statement. Requests for supporting research materials may be addressed to the authors.

Declaration of Generative AI Use. The authors used Grammarly solely for language refinement. They reviewed the content and take full responsibility for the published article.

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Appendices

Appendix Research instruments

The student questionnaire and faculty interview guide are reproduced below. They provide the wording of the instruments; the limitations concerning response procedures and analysis are described in the methodology.

Student survey questionnaire

Part A: General Profile

- 1 What is your academic level? (Undergraduate / Postgraduate)
- 2 What is your field of study? (Humanities / Sciences / Engineering / Social Sciences / Other)
- 3 Which university do you attend?

Part B: AI Use Patterns

- 4 How often do you use AI tools for academic purposes? (Daily / Weekly / Occasionally / Never)
- 5 Which AI tools do you most commonly use? (Please tick all that apply: ChatGPT / Grammarly / DeepL / Gemini / Other)
- 6 For what academic purposes do you primarily use AI? (Writing assistance / Translation / Summarisation / Research support / Critical analysis / Other)
- 7 Do you feel that your use of AI has changed how you approach your studies? If yes, please describe briefly.

Part C: Perceptions of AI in Learning

- 8 To what extent do you agree that AI has improved your academic performance? (Strongly agree / Agree / Neutral / Disagree / Strongly disagree)
- 9 Do you believe AI tools support or undermine your independent thinking? Please explain.
- 10 How confident do you feel in critically evaluating AI-generated content? (Very confident / Fairly confident / Somewhat confident / Not confident at all)
- 11 Do you think your university provides sufficient guidance on how to use AI responsibly?

Part D: Ethics and Academic Integrity

- 12 Do you agree that the use of AI increases the risk of academic dishonesty among students? (Strongly agree / Agree / Neutral / Disagree / Strongly disagree)
- 13 Have you ever submitted AI-generated content as your own original work? (Yes / No / Prefer not to say)
- 14 Does your university have a clear policy on the use of AI in academic work? (Yes / No / I am not aware of one)
- 15 Do you think AI use in your institution is fair to all students, regardless of their economic background or access to technology?

Part E: Looking Forward

- 16 Do you believe AI should be formally integrated into university teaching and assessment in Algeria? Please justify your view.
- 17 What types of training or support would you find most helpful in learning to use AI responsibly and effectively?

18 In your view, what is the most significant benefit of AI for students at Algerian universities?

19 What is the most significant risk or concern you associate with AI in your academic environment?

20 Is there anything else you would like to share about your experience of AI in your studies?

Faculty semi-structured interview guide

Opening and Context

1 Could you briefly describe your current teaching role and the disciplines you work in?

2 When did you first begin engaging with AI tools in your professional or teaching practice?

AI Use in Teaching and Learning

3 Which AI tools or platforms have you used in your teaching, and for what specific purposes?

4 How do you think AI has influenced the way students engage with course content and academic tasks?

5 Have you observed differences in AI adoption across different disciplines or student groups? Please describe.

Pedagogical Reflections

6 Do you feel that AI supports or risks undermining the core aims of higher education, such as critical thinking, creativity, and intellectual growth?

7 From your perspective, how should AI be positioned within the teaching and learning relationship?

8 What pedagogical principles do you feel should guide the responsible use of AI in your field?

Ethical and Institutional Concerns

9 What are your main concerns regarding the use of AI in academic assessment and student work?

10 Does your institution have any formal policies on AI use in teaching and learning? If so, how effective do you find them?

11 How do you address the issue of digital inequality among students when it comes to access to AI tools?

Future Directions

12 What forms of professional development or institutional support would help faculty integrate AI more responsibly?

13 How do you envision the role of AI in Algerian higher education evolving over the next decade?

14 Is there anything else you would like to add about AI in pedagogy that has not been addressed in this interview?



RESEARCH ARTICLE

Gatekeeping and Circular Supply Chains: Associations with Perceived Reverse Logistics Performance

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ABSTRACT

Background: Gatekeeping involves assessing return requests against defined criteria and directing them to appropriate pathways. This study examines how operational, strategic and relational aspects of gatekeeping are associated with perceived reverse logistics performance.

Methods: A sequential mixed-methods design combined ten semi-structured interviews with a survey of a non-probability judgement sample of 220 e-commerce logistics professionals. The interview guide addressed operational, strategic and relational practices; the thematic analysis informed the questionnaire. The initial 22-item instrument was reduced to 14 items using an exploratory principal component analysis with varimax rotation. Internal consistency and multiple linear regression were assessed in IBM SPSS Statistics 26.

Results: The reported Cronbach's alpha coefficients ranged from .75 to .84. Operational gatekeeping ($\beta = .413, p < .001$) and strategic gatekeeping ($\beta = .296, p < .001$) had positive conditional associations with perceived performance. The relational coefficient was positive but not statistically significant ($\beta = .079, p = .302$). These estimates describe the reported survey model; incomplete measurement and model-fit reporting limits their interpretation.

Conclusions: The findings connect operational and strategic gatekeeping practices with higher perceived reverse logistics performance in the participating sample. They do not establish causal effects, measured cost or environmental improvements, or indirect effects through customer trust and loyalty. Relational practices remain relevant to the interview accounts and require further study with customer-related measures.

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1. Introduction

Reverse logistics concerns the management of reverse flows of products, materials and related information for recovery or appropriate disposal. These flows include

commercial returns as well as products returned after use; they are not limited to post-consumption waste (de Brito & Dekker, 2004; Badenhorst, 2017). Repair, reuse, refurbishment and recycling can support circular supply chains, although their economic and environmental out-

comes depend on the products, recovery processes and transport involved.

Gatekeeping is an early decision process for assessing whether a return meets defined conditions and determining how it should be handled. Badenhorst (2013) discusses gatekeeping among practices for addressing reverse logistics costs, while Lambert et al. (2011) include it within a wider decision framework. Screening may help avoid unnecessary movements, but fewer accepted returns alone do not demonstrate better circular performance. Eligible returns and products requiring recovery still need an appropriate route.

This study examines associations between three aspects of gatekeeping and perceived reverse logistics performance. It considers operational procedures, strategic alignment and customer-facing communication. The aim is to develop an exploratory account of these relationships, rather than measure actual changes in logistics costs, recovery rates or emissions.

The research combines ten semi-structured interviews with a subsequent survey of 220 logistics professionals in e-commerce. The interviews inform the measurement domains, and multiple regression examines their conditional associations with perceived performance. The findings are interpreted within the limits of the sampling, measurement and cross-sectional design.

2. Literature review

2.1. Gatekeeping in reverse logistics

Gatekeeping involves checking information such as purchase records, return deadlines, product condition and reasons for return. These checks can inform acceptance, redirection and the choice of recovery pathway. Damage or prior use is not, by itself, evidence that a return is unjustified: the appropriate decision depends on the return conditions and the purpose of recovery. Badenhorst (2013) presents gatekeeping as one possible practice within a broader approach to reverse logistics costs.

The relevant literature addresses different levels of decision-making. De Brito and Dekker (2004) provide a general framework for reverse logistics. Lambert et al. (2011) propose a decision framework covering gatekeeping and other system elements and illustrate it through industrial cases. Badenhorst (2016) examines the perceived importance and implementation difficulty of practices intended to overcome operational barriers. These contributions provide a basis for studying structured return decisions; they do not establish a universal causal reduction in costs from gatekeeping.

Operational arrangements may include standard procedures, information systems and return merchandise authorisation. Badenhorst (2013) discusses authorisation systems alongside gatekeeping. Their practical value depends on how decisions are made and communicated. Badenhorst (2017) identifies strategic planning, staff training and supply chain collaboration among important

management practices. That study does not demonstrate that automated filtering itself produces customer trust.

Avoiding unnecessary transport and handling could reduce resource use, but this remains a conditional expectation. Badenhorst's (2013) study combines a literature review with a small South African survey of perceived practice importance and feasibility. It is not a before-and-after evaluation of retailers' carbon emissions. Environmental claims therefore require separate indicators of transport, waste and recovery outcomes.

Stock and Mulki (2009) examine returns-processing practices among manufacturers, wholesalers or distributors, and retailers. Their study provides empirical evidence about responsibilities, processing arrangements and disposition choices. These organisational arrangements are relevant when studying how firms manage reverse flows. Return rates and recovery outcomes also need to be interpreted within their specific sector, period and population.

At the supply chain level, Linton et al. (2007) discuss sustainability across production, consumption and product disposition. Their contribution supports considering the wider system when evaluating returns management. The present study consequently treats gatekeeping as one part of a wider reverse logistics system, whose outcomes depend on subsequent processing and recovery decisions.

2.2. Perceived reverse logistics performance

Reverse logistics performance can be examined through costs, processing time, recovery outcomes and environmental indicators. Customer experience is a related concern, but it is not interchangeable with the full social dimension of sustainability. Clift (2003) distinguishes techno-economic, ecological and social dimensions when considering supply chain sustainability metrics.

Banihashemi et al. (2019) review reverse logistics performance in relation to economic, environmental and social sustainability. Their review identifies an imbalance in attention across these dimensions, including limited treatment of social outcomes. Malindzakova et al. (2022) analyse a deposit and collection system for disposable beverage packaging in Slovakia, including investment requirements. This packaging-specific analysis does not establish that every product-return system improves profitability and environmental performance.

Wang et al. (2017) map the reverse logistics literature through bibliometric analysis. Their work identifies research themes and opportunities; it is not a direct test of whether return fairness, speed or flexibility causes customer loyalty. These customer-related outcomes are possible subjects for a separate study.

Shaik and Abdul-Kader (2013) develop a comprehensive performance measurement methodology for transportation in reverse logistics. This work supports aligning measures with organisational objectives and considering several aspects of performance. A short self-report scale,

however, does not replace a comprehensive operational or environmental assessment.

Kariuki et al. (2022) report a positive relationship between reverse logistics and performance in Kenya's horticultural sector. The sector and study design limit its use as evidence for the present e-commerce setting. Together, these sources motivate an examination of gatekeeping while leaving the direction, magnitude and transferability of its relationships open to empirical assessment.

The present analysis uses professionals' perceptions of reverse logistics performance. It considers whether operational procedures, strategic alignment and relational practices are associated with that perceived outcome. It does not assume that rejecting more returns improves performance or that a favourable perception establishes a measurable sustainability gain.

3. Methodology

A sequential mixed-methods design combined an exploratory qualitative phase with a subsequent quantitative phase. The interviews provided accounts of return-filtering practices and informed the questionnaire. The survey examined associations between the resulting measurement domains and perceived reverse logistics performance.

Ten semi-structured interviews were conducted between March and April 2024. Participants had direct experience in returns management in e-commerce, distribution or transport. They included logistics, quality, operations and after-sales managers, as well as field operational staff. Interviews lasted 30 to 45 minutes, took place in person or remotely, and were recorded with prior participant consent and transcribed.

The interview guide addressed three areas: operational practices, including procedures, validation criteria and tools; strategic considerations, including costs, value recovery and sustainability objectives; and relational practices, including communication, dispute management and perceived fairness. The reported thematic analysis organised recurring practices within these areas and informed the questionnaire. Because the guide already contained the three domains, the analysis is not treated as an independent inductive discovery or confirmation of them.

The quantitative phase surveyed e-commerce logistics professionals. The initial questionnaire contained 22 items covering three gatekeeping domains and perceived reverse logistics performance. All items used a five-point agreement scale, from 1 = strongly disagree to 5 = strongly agree.

The reported item-reduction procedure used principal component analysis (PCA) with varimax rotation. Fourteen items were retained: four operational, three strategic, three relational and four perceived-performance items. PCA is described here as exploratory data reduction, rather than a confirmatory factor analysis or a common-factor extraction method (Field, 2024; Tabachnick &

Fidell, 2019). The retained items were used in the reported internal-consistency and regression analyses.

A non-probability judgement sample of 220 professionals was selected for experience in returns management. The reported role distribution was 34% logistics managers, 28% after-sales service managers, 21% quality managers and 17% field operational staff. These percentages describe the sample; they do not establish population representation. The survey's geographical coverage, collection dates, recruitment denominator and response rate are not specified.

IBM SPSS Statistics 26 was used. The analysis included the Kaiser-Meyer-Olkin (KMO) measure, Bartlett's test of sphericity, exploratory PCA and Cronbach's alpha. Item wording, component loadings, communalities, eigenvalues, retention rules and scoring procedures are not reported. The available summaries therefore allow only a limited assessment of the measurement procedure.

Multiple linear regression used perceived reverse logistics performance as the dependent variable and the operational, strategic and relational scores as predictors. The results below present the reported standardised coefficients, t statistics and p values. A consistent overall model-fit summary is unavailable, so explained variance is not interpreted.

Regression inference depends on assumptions concerning functional form, residual variance, independence and error distribution, together with adequate control of multicollinearity (Field, 2024; Tabachnick & Fidell, 2019). Diagnostic results are not reported, so compliance with these assumptions cannot be established from the summaries.

4. Findings

4.1. Qualitative findings and hypotheses

The ten interview participants described operational, strategic and relational aspects of gatekeeping across the sectors identified in the methods. These accounts concern professional perceptions and experiences. They are not direct measurements of cost savings, emissions or customer responses.

Operational accounts concerned return criteria, preliminary checks and decisions about product condition, deadlines and reasons for return. A logistics manager described the perceived time benefit as follows:

"We filter from the beginning to avoid non-recoverable products or unjustified requests. This saves us a huge amount of logistical time."

Strategic accounts connected filtering with cost control, recovery potential and sustainability aims. An operations director stated:

"We cannot talk about sustainable logistics if we accept all returns without distinc-

tion. Sorting is the first step toward circularity.”

Relational accounts emphasised explaining decisions and supporting customers when requests were refused or redirected. An after-sales manager explained:

“We need to explain why some returns are refused. When we are clear, customers understand and frustrations are avoided.”

These quotations illustrate participants’ views. They do not show that every refusal saves resources, that customer frustration is always avoided, or that product sorting alone produces circularity. The reported benefits depend on appropriate acceptance and recovery decisions.

The interview material informed three survey domains. Operational gatekeeping covered filtering procedures, validation criteria and automation. Strategic gatekeeping concerned alignment with sustainability, profitability and value recovery. Relational gatekeeping covered communication, customer support and perceived fairness. This organisation provided a working conceptual framework, rather than an independent validation of the scales.

Three hypotheses addressed positive associations with perceived reverse logistics performance:

H1: Operational gatekeeping is positively associated with perceived reverse logistics performance.

H2: Strategic gatekeeping is positively associated with perceived reverse logistics performance.

H3: Relational gatekeeping is positively associated with perceived reverse logistics performance.

4.2. Quantitative findings

4.2.1. Exploratory measurement assessment and internal consistency

For the initial 22-item instrument, the reported KMO value was .812. Bartlett’s test was significant, $\chi^2(231) = 944.62$, $p < .001$. The 231 degrees of freedom are consistent with 22 items. These summaries indicate that the correlation matrix is not an identity matrix and offer a basis for exploratory reduction; they do not confirm a specific construct structure.

The reported PCA with varimax rotation was used to reduce the instrument from 22 to 14 items. The retained items were assigned to the three gatekeeping domains and the performance scale. Without item-level output or an independent validation sample, the distinctness and stability of these constructs cannot be established.

Table 1 Initial, retained and removed items

Construct	Initial items	Retained items	Removed items
Operational gatekeeping	6	4	2
Strategic gatekeeping	5	3	2
Relational gatekeeping	5	3	2
Perceived reverse logistics performance	6	4	2
Total	22	14	8

Source: Item counts reported for the study’s SPSS analysis.

Table 2 presents the reported Cronbach’s alpha coefficients for the retained scales. The coefficients range from .75 to .84 and provide an indication of internal consistency.

Alpha alone does not establish unidimensionality, construct validity or the absence of overlap between predictors and the outcome.

Table 2 Reported internal-consistency coefficients

Dimension	Number of retained items	Cronbach’s α
Operational dimension	4	.81
Strategic dimension	3	.77
Relational dimension	3	.75
Perceived reverse logistics performance	4	.84

Source: Scale summaries reported for the study’s SPSS analysis.

The 14 retained items preserve the intended domain labels. The interpretation remains exploratory because the item content, selection details and scoring are unavailable. In particular, agreement between operational practices and perceived operational performance may partly reflect overlapping content.

4.2.2. Multiple linear regression

The reported regression includes 220 observations and three predictors, with perceived reverse logistics performance as the outcome. The residual degrees of freedom are 216, consistent with an intercept and three predictors. Table 3 reproduces the coefficient summaries. It does not provide a complete assessment of model fit or predictive accuracy.

Operational gatekeeping has the largest reported standardised point estimate ($\beta = .413$, $t(216) = 6.582$, $p < .001$). Strategic gatekeeping also has a positive coefficient ($\beta = .296$, $t(216) = 4.217$, $p < .001$). Each coefficient describes its conditional association with perceived performance, holding the other two predictors constant. No test of the difference between these coefficients is reported.

The relational coefficient is positive but not statistically significant ($\beta = .079$, $t(216) = 1.034$, $p = .302$). This result does not demonstrate a zero association, establish the absence of organisational value or identify an indirect pathway. Statistical significance depends on uncertainty as well as the estimated coefficient.

Table 3 Reported multiple-regression coefficients

Independent variable	Standardized β	$t(216)$	p
Operational dimension	.413	6.582	< .001
Strategic dimension	.296	4.217	< .001
Relational dimension	.079	1.034	.302

Source: Coefficients reported for the study's SPSS analysis.

Within this reported model, the positive operational and strategic coefficients are consistent with H1 and H2. H3 is not supported at the conventional .05 level. These findings concern a cross-sectional perception measure and do not establish causal effects.

Trust, satisfaction, fairness and loyalty were not tested as mediators. Any indirect relational pathway remains a research hypothesis. The present results cannot be used to compare the timing of operational, strategic and relational effects.

5. Discussion

5.1. Interpretation of the findings

The study brings together professionals' accounts of gatekeeping and reported associations from an e-commerce survey. The interviews provide context for the operational, strategic and relational domains. The regression

summaries connect the first two domains with higher perceived performance in this sample. The evidence does not establish that the three coefficients differ statistically from each other.

Operational gatekeeping

The operational coefficient is consistent with the view that clear criteria and structured procedures matter to professionals' assessments of return handling. De Brito and Dekker (2004) provide a broader framework for reverse logistics, and Lambert et al. (2011) include gatekeeping within a structured decision process. The reported association complements these conceptual accounts without demonstrating the effect of a particular screening intervention.

Preliminary assessment may help determine the appropriate route before transport, inspection or storage resources are committed. The relevant objective is an appropriate decision, including acceptance or recovery where needed. A damaged product may require repair or another recovery route; refusal is not automatically the efficient or sustainable option.

Avoided unnecessary movements could have economic and environmental benefits. These benefits need to be assessed alongside collection, recovery and disposition outcomes. The sustainability review by Banihashemi et al. (2019) and the packaging-system analysis by Malindzakova et al. (2022) support examining such trade-offs, rather than assuming a benefit from every reduction in return volume.

The perceived-performance construct is described as covering operational fluidity, loss reduction, processing speed and sustainability contribution. These topics may overlap with respondents' assessments of operational gatekeeping. Because item wording and discriminant-validity evidence are unavailable, content overlap is an alternative explanation for part of the association.

Strategic gatekeeping

The positive strategic coefficient is consistent with respondents linking return decisions to wider organisational aims. Interview accounts also connected filtering with costs, sustainability and recovery potential. This is an interpretation of perceptions, not evidence that strategic alignment caused a measurable improvement.

Linton et al. (2007) argue for considering sustainability across the supply chain, while Banihashemi et al. (2019) examine reverse logistics performance across sustainability dimensions. These perspectives support evaluating repair, reuse, refurbishment, recycling and other disposition choices within the wider system. The survey does not determine which pathway is best for a particular product.

Relational gatekeeping

The non-significant relational coefficient leaves uncertainty about its association with the outcome used here. Interview participants nevertheless described communication as relevant to managing return decisions. These are different forms of evidence: professional accounts of rel-

evance do not require a statistically significant coefficient in a separate perception model.

The outcome's operational emphasis may be one possible reason why customer-facing practices were not clearly associated with it. Other possibilities include measurement limitations, sampling uncertainty and shared variance among predictors. None is resolved by the available summaries. Customer trust, satisfaction and loyalty require their own measures and cannot be inferred as mediators.

Wang et al. (2017) identify research themes and opportunities through bibliometric mapping. Their article helps situate further enquiry but cannot verify a specific customer-response mechanism in this study. Future work could examine relational pathways using customer data and an appropriate temporal design.

Integration of the two phases

The interviews informed the survey, so the two phases should not be treated as independent confirmations of the

same measurement structure. Their integration is interpretive: the interviews explain what professionals meant by the domains, while the survey summaries describe conditional associations with perceived performance.

The combined findings support further study of multi-dimensional gatekeeping. They also show why operational efficiency, environmental outcomes and customer experience should be measured separately before conclusions are drawn about a complete circular supply chain system.

5.2. Assessment of the hypotheses

Table 4 summarises the hypotheses in terms of associations. The decisions refer to the reported coefficient tests; they do not confirm causal mechanisms, validate the entire measurement model or establish out-of-sample prediction.

Table 4 Summary of hypothesis assessment

Hypothesis	Relationship	β	p	Decision
H1	Operational gatekeeping and perceived performance	.413	< .001	Supported
H2	Strategic gatekeeping and perceived performance	.296	< .001	Supported
H3	Relational gatekeeping and perceived performance	.079	.302	Not supported

Source: Hypotheses and coefficient summaries reported in the study. Outcome: perceived reverse logistics performance.

6. Limitations, implications and future research

6.1. Limitations

The quantitative phase concerns e-commerce professionals, whereas the interviews also include distribution and transport. These scopes should be considered separately. The results cannot be assumed to apply to other sectors. Geographical coverage, the survey period, the number of organisations represented and possible clustering of respondents within organisations are not documented, further limiting interpretation.

The non-probability judgement sample captures the perceptions of selected professionals with returns-management experience. It does not support population estimates. Recruitment counts, non-response information and a response rate are unavailable.

All survey constructs were measured from the same respondents at one point in time. Common-method variance may contribute to the associations. The possible overlap between operational gatekeeping and perceived-performance content is an additional measurement concern. Item wording, coding, scoring and respondent-level records would be needed for a fuller assessment.

The cross-sectional design does not establish temporal order or causality. No intervention was evaluated, and the

observed associations may reflect omitted organisational characteristics or other unmeasured factors.

Performance is perceived rather than independently observed. The study does not measure actual changes in costs, processing times, recovery rates, transport distance, waste or emissions. The incomplete PCA output, unavailable regression diagnostics and lack of a consistent model-fit summary limit statistical evaluation. The aggregate results presented here do not permit reproduction of the statistical analyses. Consent for interview recording is reported; the survey consent procedure is not described.

6.2. Managerial implications and contribution

The findings suggest that organisations could evaluate gatekeeping as a structured decision process. Clear criteria and staff guidance may support consistent handling, but their effects should be assessed through operational records and customer outcomes.

Eligibility checks can consider deadlines, purchase information, product condition and reasons for return. Decisions should distinguish an ineligible request from a product that needs repair, recovery or appropriate disposal. The purpose is to direct returns correctly, rather than simply reduce their number.

Digital authorisation and preliminary checks are possible ways to organise the process. This study does not test their effectiveness. Implementation would need to consider decision accuracy, clear explanations and a way to review disputed outcomes. Strategic planning, training and coordination are also relevant to the management-practice discussion in Badenhorst (2016, 2017).

Organisations could compare the costs and recovery opportunities associated with repair, reuse, refurbishment, resale and recycling. Environmental evaluation should include the consequences of both accepting and refusing a return, rather than count avoided transport alone. These are proposed management considerations, not measured benefits of the present survey.

The interview accounts also support attention to customer communication. The non-significant survey coefficient is not a reason to discard transparency or support. Whether an explanation improves fairness, trust or loyalty remains a question for customer-focused evaluation.

The study's contribution is an exploratory framework linking three gatekeeping domains with perceived performance. It combines interview accounts with survey coefficient summaries. It does not establish that all three scales are distinct, that the framework is the first of its kind, or that relational effects are indirect.

6.3. Future research

Replication across sectors and geographical settings could assess whether the reported associations recur. Probability-based recruitment, documented response rates and information about the number of participating organisations would improve the basis for generalisation.

Longitudinal studies or evaluated changes in return procedures could help establish temporal order. Combining professional perceptions with processing time, return costs, recovery rates, transport and emissions records would permit a clearer assessment of operational and environmental outcomes.

Future models could test customer satisfaction, trust, fairness or loyalty as possible mediators. Such models would require measures of these constructs and a design appropriate to the proposed pathway. A non-significant coefficient in the present model is not sufficient evidence for mediation.

Further work could examine digital authorisation, predictive tools and information-system integration as potential moderators or interventions. Item-level reporting, independent measurement validation, regression diagnostics and complete, internally consistent model summaries would strengthen statistical assessment.

Using several data sources, including professional assessments, customer responses and organisational records, could reduce reliance on a single questionnaire. Future measurement work should also examine whether operational practices and performance items are sufficiently distinct.

7. Conclusion

This sequential mixed-methods study examined operational, strategic and relational aspects of gatekeeping in relation to perceived reverse logistics performance. Ten interviews informed a survey of a non-probability sample of 220 e-commerce logistics professionals.

The reported operational and strategic coefficients were positive and statistically significant, while the relational coefficient was not statistically significant. These findings concern conditional associations within the reported model. They do not establish causal improvements, quantify explained variance reliably, or demonstrate an indirect customer-related mechanism.

The framework offers a basis for further investigation of how return decisions relate to professional assessments of performance. Evaluation of circular supply chains also requires objective recovery and environmental indicators, customer measures and fuller statistical reporting. Gatekeeping should be assessed by the appropriateness and consequences of its decisions, rather than the number of returns refused.

Declarations

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Declaration of Generative AI Use. The author used Grammarly solely for language refinement, reviewed the content and takes full responsibility for the published article.

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RESEARCH ARTICLE

Reported Adoption of Precision Agriculture and Organic Practices among Fruit Growers in Tissemsilt Province, Algeria

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ABSTRACT

Background: This study examines knowledge, reported practices and perceived barriers relating to precision agriculture (PA) and organic farming (OF) among fruit growers in Tissemsilt Province, Algeria. It distinguishes the use of particular practices from independently verified adoption or organic certification.

Methods: Fieldwork took place from 14 September 2025 to 21 January 2026. A purposive sample of 128 growers in eight communes completed a face-to-face questionnaire. Two institutional leaders participated in semi-structured interviews. The analysis combines descriptive survey indicators, an exploratory logistic model of reported organic practices and thematic interpretation of the institutional interviews.

Results: Reported familiarity with PA was 7.8%, reported use of a PA tool or practice was 4.7%, and intention to adopt was 35%. For OF, familiarity was reported at 80%, use of organic methods at 34%, intention at 90% and certification at approximately 1%. Cooperative membership and the extension-services measure had positive coefficients in the exploratory organic-practice model. Water scarcity was the most frequently reported barrier, at 94%. These indicators describe the selected sample; practices, certification and environmental outcomes were not independently verified.

Conclusions: The findings suggest a need to consider water access, usable advice and the costs of participation together. They do not establish that water infrastructure must precede every technical improvement or that a particular subsidy, extension method or label will improve adoption. Clear practice definitions, complete measurement documentation and follow-up data would strengthen further assessment.

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1. Introduction

Precision agriculture uses information about variation in crops, soils or field conditions to support management

decisions. It includes a range of technologies and practices, so the adoption of one tool should not be confused with the use of an integrated system. Lowenberg-DeBoer

and Erickson (2019) show why definitions matter when comparing adoption, and Say et al. (2018) review differences among technologies and settings.

Organic farming concerns a defined production system, while certification provides assurance against specified standards. The use of manure or the avoidance of some synthetic inputs does not by itself demonstrate compliance with an organic standard. The organic agriculture yearbook distinguishes production, operators and markets within this wider context (Willer et al., 2020). In this study, OF practice refers to respondents' reports, unless certification is explicitly mentioned.

The study asks how participating fruit growers in Tissemsilt understand PA and OF, which practices they report using, and which constraints they consider important. Adoption decisions involve knowledge, the fit of a technology with the farm and the support available. Aubert et al. (2012) examine expertise and compatibility in Canadian farms, while Tey and Brindal (2012) review factors associated with PA adoption. Their findings provide a basis for enquiry rather than a prediction about every grower in Tissemsilt.

Research on organic adoption also considers farmers' aims and policy conditions. Kallas et al. (2010), for example, examine adoption decisions in Catalan vineyards. Berkes (2012) offers a perspective on knowledge

developed through relationships with the environment. These sources help frame questions about local practices; neither traditional knowledge nor low input expenditure is sufficient evidence of organic compliance.

We examine reported knowledge and use, perceived barriers and accounts of institutional support. The survey provides descriptive evidence from a purposive sample, supplemented by an exploratory model of reported organic practices. It does not evaluate the causal effects of extension services, credit or water infrastructure.

2. Methodology

2.1. Study area

The research concerns fruit growers in Tissemsilt Province in Algeria. The province includes mountainous and high-plain settings, and the map in Figure 1 provides geographical context. WeatherSpark's city-level description identifies hot, dry summers and cold winters (WeatherSpark, n.d.). It is a local climate summary, rather than a province-wide rainfall normal.

Water access is a central issue in the growers' accounts examined here. Use of drip irrigation is treated as a reported characteristic of the survey sample. It is not presented as an independently verified adoption rate for all farms in the province.

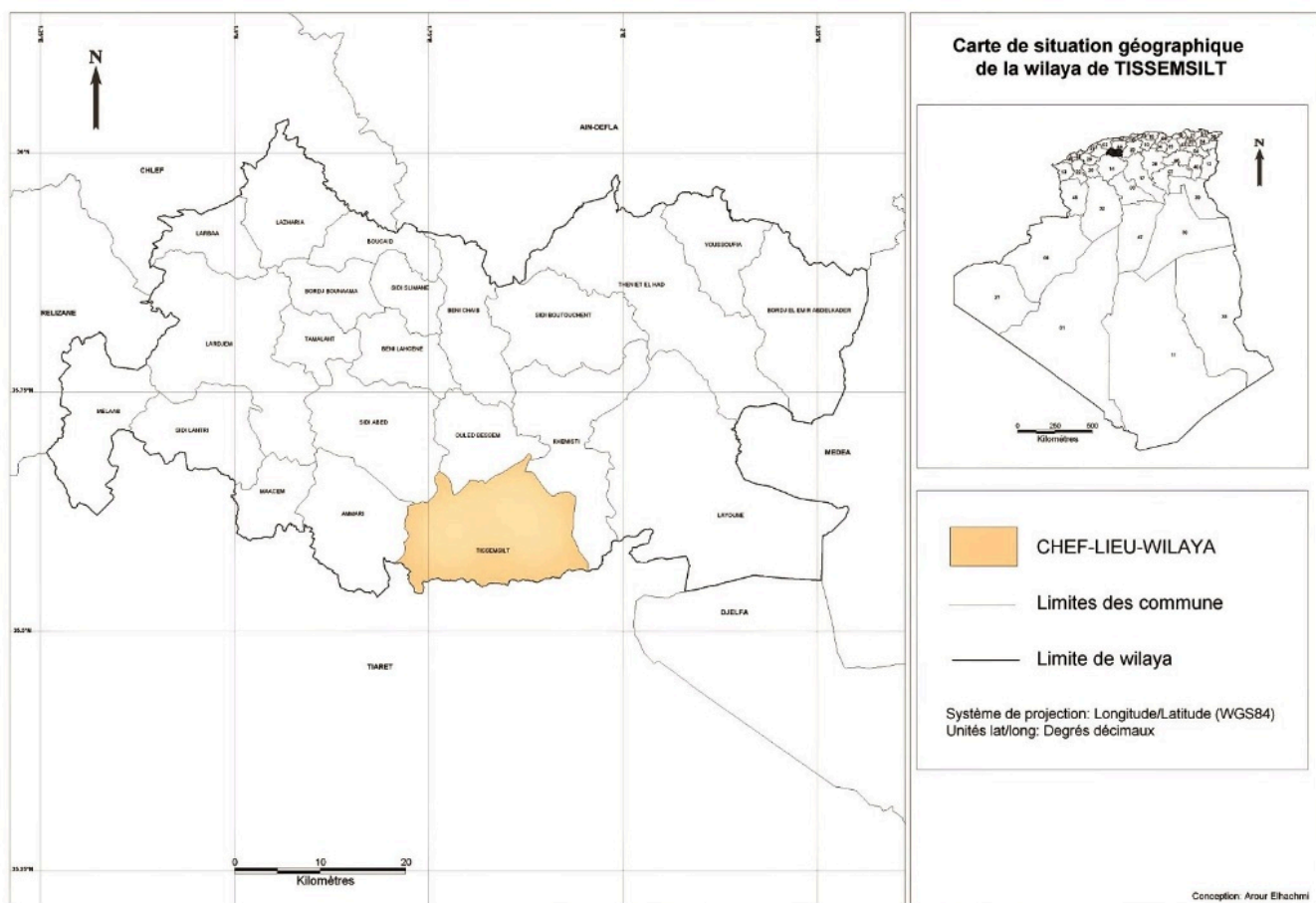


Fig. 1. Geographical context of Tissemsilt Province

Source: Map by Elhachmi Arour (2014). The map provides geographical context and does not identify the eight sampled communes.

2.2. Sampling and data collection

Data collection took place from 14 September 2025 to 21 January 2026. The mixed-methods design combined a grower questionnaire with two semi-structured institutional interviews.

2.2.1. Participants

The purposive sample comprised 128 fruit growers in eight communes. Selection targeted growers considered relevant because of their potential interest in, or use of, innovative methods. This approach may favour particular kinds of participants and does not establish statistical representation of the province. The commune-level allocation, recruitment denominator and response rate are not specified.

The institutional interviews involved the Director of Agricultural Services and the President of the Chamber of Agriculture of Tissemsilt. These two leadership perspectives cannot represent all extension staff or institutional actors.

2.2.2. Instruments

The structured questionnaire covered socio-demographic characteristics, farm characteristics, PA knowledge and use, OF knowledge and use, and perceived institutional support. A pilot with ten local growers was used to review terminology and administration. The relationship between the pilot participants and the final sample is not specified. Appendix A presents the questionnaire.

The institutional interview guide addressed support policies, training and extension, perceived barriers and possible responses, and future priorities. Interviews lasted approximately 25 to 30 minutes and were recorded and transcribed for thematic interpretation. Appendix B presents the guide.

Grower responses were coded for statistical processing. The instruments describe voluntary participation and confidentiality, and the institutional guide requests permission to record. Institutional roles are identified in the study, so complete anonymity cannot be assumed for those participants.

2.3. Analysis and interpretation

Survey records were organised in Microsoft Excel and analysed in IBM SPSS Statistics. Descriptive percentages summarise reported characteristics, knowledge, practices and barriers. Familiarity, a self-rated knowledge score, current use and intention are different measures and are interpreted separately. The available summaries do not give item-level response counts or missing-response procedures; rounded percentages are retained without reconstructing participant counts.

An exploratory binary logistic model examined associations with reported organic practices. The predictors were cooperative membership, an extension-services measure, education level, farm size and age. Education was described as an ordered score, and non-membership was the reference for cooperative membership. The sum-

maries do not fully specify the units or coding of age, farm size and extension. The supplied questionnaire also does not document every model predictor. These limits restrict the substantive interpretation and reproducibility of the coefficients.

The model is described through the reported coefficient tests, odds ratios and confidence intervals. The likelihood-ratio test, Nagelkerke pseudo- R^2 , Hosmer-Lemeshow test and apparent classification accuracy are also reported. They do not establish causality, external predictive performance or freedom from overfitting. PA use was rare and sensitive to the adoption definition, so its determinants are not interpreted inferentially here.

The institutional interviews were interpreted through thematic analysis, using Braun and Clarke (2006) as the methodological reference. The procedure described familiarisation, coding, development and review of themes, and interpretation. Themes are used to contextualise the survey rather than estimate their prevalence in the wider farming population.

3. Findings and discussion

3.1. Participant characteristics

The survey summaries report 59.4% of growers as older than 45 and 44.5% as having no formal education. These are different characteristics: absence of schooling is not a test of literacy, digital capability or willingness to adopt a technology. Age alone does not establish resistance to innovation.

Table 1 summarises the reported age, education and irrigation indicators. The reported drip-irrigation share is 64%. Drip equipment may offer a basis for further irrigation management, but its presence alone does not demonstrate PA adoption or measured water savings.

Table 1 Reported profile indicators in the grower sample

Indicator	Reported percentage
Older than 45	59.4%
No formal education	44.5%
Drip irrigation	64%
Gravity irrigation	36%

Source: Study survey, 2025-2026; total sample $n = 128$. Percentages describe the participating sample.

3.2. Knowledge and reported use

PA familiarity was reported at 7.8%, and the mean self-rated knowledge score was 2.1 on the questionnaire's five-point scale. Reported use of a PA tool or practice was 4.7%. Reported examples included mobile-controlled irrigation and occasional soil or water analysis. These reports do not establish the extent to which information was used to manage spatial or temporal variation. They are therefore described as reported use rather than verified system adoption.

Intention to adopt PA was reported at 35%. Intention is not a forecast of uptake or a substitute for observed use. Definitions and the range of technologies matter when comparing these indicators with adoption research (Say et al., 2018; Tey & Brindal, 2012; Lowenberg-DeBoer & Erickson, 2019).

For OF, familiarity was reported at 80%, intention at 90% and current practices at 34%. The practices described included manure use and avoidance of synthetic pesticides. These descriptions do not demonstrate compliance with a complete organic production standard. Approximately 1% of the sample was reported as certified, without independent inspection of certification records.

Table 2 Reported knowledge use and intention indicators

Measure	PA	OF
Familiarity	7.8%	80%
Intention to adopt	35%	90%
Reported current practice	4.7%	34%
Reported certification	Not reported	Approximately 1%

Source: Study survey summaries, 2025-2026; total sample $n = 128$. Measures are presented separately and are not parts of one percentage distribution. Certification and practice claims were not independently verified.

3.3. Exploratory associations with reported organic practices

Table 3 presents the reported logistic coefficients for organic practices. Cooperative membership and the extension-services measure have positive coefficients with $p < .001$. Education, farm size and age do not reach the .05 level in this model. The estimates concern conditional associations within the selected sample, not effects of membership or advisory services.

Table 3 Exploratory logistic model of reported organic practices

Predictor	B	SE	Wald χ^2	p	OR	95% CI for OR
Cooperative membership	1.815	0.549	10.938	< .001	6.144	2.095 to 18.017
Extension services	2.641	0.599	19.455	< .001	14.033	4.339 to 45.384
Education level	-0.132	0.229	0.332	.565	0.877	0.560 to 1.372
Farm size	-0.543	0.394	1.899	.168	0.581	0.268 to 1.258
Age	0.583	0.365	2.541	.111	1.791	0.875 to 3.665

Model summary as reported: $n = 128$; likelihood-ratio $\chi^2(5) = 68.847$, $p < .001$; Nagelkerke pseudo- $R^2 = .575$; Hosmer-Lemeshow $\chi^2(8) = 4.120$, $p = .846$; apparent classification accuracy = 81.3%. Nagelkerke R^2 is a pseudo- R^2 measure, not a percentage of outcome variance explained. A non-significant Hosmer-Lemeshow result does not prove model validity. Classification accuracy is an in-sample summary, and the classification threshold and an external validation result are not given.

Source: Coefficient summaries reported for the study's SPSS analysis. OR = odds ratio; CI = confidence interval. Estimates refer to the model's coded predictors. The units of age and farm size and the distinction between extension contact and frequency are not fully specified, so their odds ratios are not interpreted per year, hectare or additional visit.

Cooperative members had higher reported odds of organic practice than non-members in the fitted model (OR = 6.144, 95% CI 2.095 to 18.017). The extension measure also has a positive coefficient (OR = 14.033, 95% CI 4.339 to 45.384), but its coding limits interpretation of the contrast. The wide intervals indicate substantial uncertainty. These associations may reflect selection, shared characteristics or other unmeasured influences; the study cannot establish their direction over time.

The model makes advisory support and cooperative participation relevant topics for further investigation. It does not establish that organic adoption depends exclusively on social capital or that such support causes conversion. Kallas et al. (2010) examine different objectives and policy influences in another production setting, which reinforces the need for context-specific interpretation.

3.4. Reported barriers and institutional perspectives

Water scarcity was the most frequently reported barrier, at 94%. The institutional accounts also emphasised uncertainty about irrigation water and the difficulty of planning investment under that uncertainty. These perceptions identify a priority for the participating growers; they do not show that water availability is an absolute prerequisite for every use of sensors or other management tools.

Other reported barriers concern equipment costs and credit, the accessibility of information, technical complexity and market arrangements. Table 4 presents the reported grouped categories and percentages. A combined category does not establish separate prevalence rates for its components. In particular, the literacy-and-language category is a perceived barrier, not a measurement of functional illiteracy.

Table 4 Reported barriers in the grower sample

Reported barrier category	Percentage
Water scarcity	94%
High equipment costs and credit access	78%
Literacy and language barriers	47%
Technical complexity and lack of training	36%
Lack of certified markets or trust	15%

Source: Study survey, 2025-2026; total sample $n = 128$. Categories are separate indicators and need not sum to 100%. Item-level counts and the coding of the open-ended barrier responses are not detailed.

The institutional themes suggest a need to consider the accessibility of extension information, practical demonstrations and water-management concerns together. They support evaluating how advice is communicated and how growers assess possible investments. Comparisons among delivery methods, collective equipment and subsidies require evidence about costs, uptake and outcomes.

4. Limitations

The purposive sample cannot establish provincial adoption rates. The eight-commune selection and the recruitment of growers considered relevant to innovation may affect the observed profile. Practices, knowledge, certification and barriers are self-reported, and no field audit, price comparison or measurement of water savings is presented. The two institutional interviews provide a narrow leadership perspective.

Measurement documentation also limits interpretation. A consistent mapping between farm-size and educational categories and the questionnaire options is unavailable, and the questionnaire does not document all regression predictors. The coding of extension, farm size and age is incomplete. Item-level denominators, missing responses, recruitment counts and the overlap between the pilot and final sample are unspecified. The exploratory organic-practice model has not been externally validated, and the cross-sectional design cannot establish causal effects or temporal order.

5. Conclusion

The surveyed growers reported limited familiarity with PA and low use of PA tools or practices. Organic methods were reported more often, but these reports do not establish compliance with an organic standard; certification was reported at a much lower level. The exploratory organic-practice model identifies associations involving cooperative membership and extension, subject to the measurement and sampling limits.

Water scarcity was the most frequently reported barrier, alongside costs, accessible information and technical support. A response could combine attention to water reliability and management with practical advice suited to growers' needs. Infrastructure and technology options should be evaluated together, rather than assume a universally effective sequence.

Possible actions include demonstrations in languages participants understand, accessible written and visual material, and trials of shared equipment where demand and costs justify them. A local product label would require clear criteria, credible verification and evidence of market demand; branding alone would not establish organic status or guarantee a price premium. Follow-up research should use explicit adoption definitions, document predictor coding and compare reported practices with field and market evidence.

Consent information: The survey and interview instruments describe voluntary participation and confidentiality. The institutional interview guide requests permission to record.

Declarations

Author Contributions. Conceptualisation and methodology: D.A., B.S. and Z.M.; software, formal analysis, investigation and data curation: D.A.; writing of the original draft, review and editing, supervision and project administration: D.A., B.S. and Z.M.

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Data Availability Statement. The data presented in this study are available on request from the corresponding author.

Declaration of Generative AI Use. The authors used Google Gemini solely for language editing, grammar correction and proofreading. They reviewed and approved all content and take full responsibility for the accuracy, integrity and final version of the published article.

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Appendices

Appendix A Structured farmer questionnaire

Enumerator: _____ **Date:** _____ **Commune:** _____

Introduction and informed consent

Hello. We are conducting a study on agricultural practices in fruit arboriculture in Tissemsilt Province. Participation is voluntary and anonymous. The information collected will be used exclusively for scientific research. The interview will last approximately 25 to 30 minutes.

Section 1 Socio-demographic profile

1. Gender
☐ Male ☐ Female
2. Age group
☐ <30 years ☐ 30-45 ☐ 46-60 ☐ >60
3. Education level
☐ None ☐ Primary ☐ Secondary ☐ University
4. Farming experience
☐ <5 years ☐ 5-10 ☐ 11-20 ☐ >20

Section 2 Farm characteristics

5. Farm size
☐ <5 ha ☐ 5-10 ha ☐ 11-20 ha ☐ >20 ha
6. Land tenure
☐ Owner ☐ Tenant ☐ Family land ☐ Other
7. Irrigation system
☐ Rainfed ☐ Drip ☐ Well/Borehole ☐ Traditional
8. Main fruit crops

9. Number of permanent workers

- ☐ 0 ☐ 1-2 ☐ 3-5 ☐ >5

Section 3 Precision agriculture

10. Familiarity with precision agriculture
☐ Yes ☐ No
11. Knowledge level
☐ 1 (Low) ☐ 2 ☐ 3 ☐ 4 ☐ 5 (High)
12. Currently using any precision agriculture tool or practice
☐ Yes ☐ No
13. Main barriers to adopting precision agriculture

Section 4 Organic farming

14. Familiarity with organic farming standards or practices
☐ Yes ☐ No
15. Knowledge level
☐ 1 (Low) ☐ 2 ☐ 3 ☐ 4 ☐ 5 (High)
16. Currently applying organic farming practices
☐ Yes ☐ No
17. Main barriers to adopting organic farming

Section 5 Perceived institutional support

18. Access to agricultural credit
☐ Yes ☐ No
19. Main source of technical support
☐ Extension service ☐ Private advisor ☐ Input supplier ☐ Other farmers ☐ Internet ☐ Other
20. Farmer observations and quality assessment

Thank you for your time and your insights.

Appendix B Institutional interview guide

Interviewer: _____ **Date:** _____ **Institution:** _____

Introduction and informed consent

Hello. I am conducting a study on the adoption of precision agriculture and organic farming in Tissemsilt. This interview lasts approximately 25 to 30 minutes. Participation is voluntary, and the data will be anonymised. With your permission, this session will be recorded for transcription and thematic analysis.

Permission to record: ☐ Yes ☐ No

Axis 1 National and local support policies

1. Could you please introduce yourself and briefly present your institution?

-
2. Could you describe the current state of fruit arboriculture in Tissemsilt, including area, production and cropping systems, and assess the evolution of this sector in recent years?

-
3. Could you also indicate the potential number of fruit growers identified in Tissemsilt?

-
4. What specific institutional frameworks or subsidy programmes exist to support the transition to high-tech or organic arboriculture in this province?

Axis 2 Training and extension activities

5. How are extension services adapted to the local context, including language and literacy levels, to encourage the adoption of new agricultural practices?

Axis 3 Perceptions of adoption barriers and levers

6. In your view, what are the primary structural and economic barriers preventing fruit growers from adopting precision agriculture or organic certification?

7. What are the key psychological or institutional levers that have successfully motivated pioneer farmers in the region?

Axis 4 Future strategic perspectives

8. What are the priority strategic objectives for your institution over the next five years regarding modernising the fruit sector?

9. Do you have any final recommendations for policy changes at the Ministry of Agriculture to facilitate this transition?

Thank you for your time and expertise. This interview will be transcribed to support the thematic analysis of the research.



RESEARCH ARTICLE

Middle Eastern Oil Shares and Brent Prices: A Composite Index and Exploratory ARDL Analysis

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ABSTRACT

This study proposes the Middle East Oil Influence Index (MEOII), an equally weighted geometric mean of the region's shares of world oil reserves, production and crude oil exports. The index describes a relative market position; it does not directly measure market power or geopolitical influence. An exploratory autoregressive distributed lag (ARDL) analysis relates the index to the natural logarithm of annual average Brent prices, with the Index of Global Real Economic Activity (IGREA) as a demand-related control. The stated period is 2000-2025. The reported specification is ARDL(1,2,0), with a bounds F-statistic of 5.607 and an adjustment coefficient of -0.264. Positive short-run associations are reported, whereas neither explanatory variable has a reported statistically significant long-run coefficient. Incomplete documentation of the component series, variable transformation, unit-root results and bounds-test settings limits inference. The estimates therefore remain exploratory and do not establish cointegration, a causal price effect or the absence of a long-run relationship. The contribution is a transparent index formula and a framework for investigating regional oil shares alongside global demand conditions.

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1. Introduction

Oil price changes affect production costs, fiscal revenues and energy expenditure. Their interpretation depends on the shocks behind them. Supply disruptions, changes in demand and expectations can produce different economic responses (Kilian, 2008, 2009; Baumeister & Kilian, 2016a). An empirical association with prices therefore needs a more limited interpretation than a causal supply effect.

The Middle East is a major oil-producing and exporting region. Its resource base, current output and exports describe different aspects of its participation in oil markets (Energy Institute, 2026). Reserves concern resources recoverable under specified conditions; production and

exports concern flows. None of these measures alone establishes the ability of producers to set prices.

This study combines the region's shares of reserves, production and crude oil exports in the Middle East Oil Influence Index (MEOII). The name identifies the proposed indicator. Its operational meaning is a composite of relative shares, rather than an independently validated measure of influence.

We examine how the index relates to Brent prices in an annual ARDL specification with a demand-related control. The construction is intended to make the three components explicit. It does not establish that a composite is superior to separate indicators, since the study does not compare their explanatory or forecasting performance.

The annual sample is stated as 2000–2025. The demand-related control is the Index of Global Real Economic Activity, associated with Kilian (2009, 2019). Including this variable accounts for one observed dimension of demand conditions; it does not isolate an exogenous regional supply shock.

The reported estimates suggest positive short-run associations and no individually significant long-run coefficients for the two explanatory variables. These summaries are interpreted cautiously because the full coefficient and test results are not documented. In particular, a reported bounds statistic without its testing case and reference values cannot establish a verified cointegration conclusion.

The study's main contribution is the proposed index construction. The empirical exercise illustrates questions that this index can address, subject to data comparability, a short annual sample and incomplete estimation documentation.

2. Background and related research

2.1. Oil prices and regional market position

Kilian (2009) distinguishes supply shocks, demand for industrial commodities and oil-specific demand shocks. This distinction matters here: oil production and prices may respond to the same demand conditions, and producers may adjust output in response to prices. An observed relationship between regional shares and prices need not identify the direction of causation.

Baumeister and Kilian (2016a) review the causes of major oil price movements and the difficulty of predicting them. Their analysis of the decline beginning in June 2014 also considers demand, production and expectations (Baumeister & Kilian, 2016b). These studies do not support attributing a price episode to one regional indicator without identifying the relevant shocks.

Kaufmann et al. (2004) examine OPEC and oil prices. OPEC membership and the Middle East are different classifications: some OPEC producers are outside the region, while some regional producers are outside OPEC. Evidence about OPEC cannot be treated as a direct estimate of a Middle Eastern regional effect.

Inventories and expectations are further dimensions of oil price formation (Kilian & Murphy, 2014). Geopolitical risk is another distinct concept for which Caldara and Iacoviello (2022) develop a news-based measure. MEOII does not include inventories, production flexibility, transport vulnerabilities or geopolitical risk. It should not substitute for these measures.

The index combines resource endowment, current output and international sales. These components can be related, and production and exports may overlap economically. Equal weighting does not eliminate correlated information or establish the independent contribution of each component.

2.2. Measuring demand and composite indicators

IGREA is a shipping-based measure of cyclical activity in industrial commodity markets, rather than a direct measure of world GDP or oil consumption. The Dallas Fed describes the updated series as percentage deviations from trend and incorporates the correction discussed by Kilian (2019) (Federal Reserve Bank of Dallas, n.d.). Hamilton (2021) questions aspects of shipping-based measurement and favours world industrial production as an alternative. The choice of demand proxy is therefore a substantive modelling decision.

The OECD, European Union and EC-JRC (2008) discuss the importance of theory, weighting, aggregation and sensitivity analysis when constructing composite indicators. Combining variables produces a summary whose interpretation depends on those choices. The present study proposes a particular summary of oil shares, without claiming an exhaustive review or priority over every previous composite measure.

The empirical question is whether changes in this summary are associated with Brent prices after conditioning on IGREA and the specified dynamics. A comparison with separate component models and alternative demand proxies would be needed to evaluate whether the index adds explanatory value.

3. Construction of the Middle East Oil Influence Index

3.1. Components and scope

For year t , let $R_{ME,t}$ and $R_{W,t}$ denote regional and world proved oil reserves; $Q_{ME,t}$ and $Q_{W,t}$ denote regional and world oil production; and $X_{ME,t}$ and $X_{W,t}$ denote regional and world crude oil exports. Within each ratio, numerator and denominator must refer to the same year, product coverage and measurement unit.

The three relative shares are defined as follows:

$$ORS_t = R_{ME,t} / R_{W,t}$$

$$OPS_t = Q_{ME,t} / Q_{W,t}$$

$$OES_t = X_{ME,t} / X_{W,t}$$

ORS is the reserve share, OPS the production share and OES the crude oil export share. A regional aggregate requires a consistent set of countries across years and components. The estimation documentation does not list that set or the component series identifiers, which limits the reproducibility of the reported index.

3.2. Aggregation and interpretation

$$MEOII_t = (ORS_t \times OPS_t \times OES_t)^{1/3}$$

For positive fractional shares, the formula yields a dimensionless value between zero and one. Each component has an exponent of one third: a given proportional increase in any one component has the same proportional contribution to the index, holding the others fixed. A zero component makes the product zero; missing observations do not justify assigning zero.

A higher index value indicates a higher combined relative share. It does not necessarily imply an increase in absolute output or exports, because a regional share can rise when the rest of the world's activity falls. The formula gives no direct estimate of pricing power.

3.3. Rationale and limitations of the geometric mean

Geometric aggregation responds to proportional changes and gives a lower score to an imbalanced set of components than its arithmetic mean. It permits trade-offs between positive components, although compensation differs from additive aggregation (OECD et al., 2008). It does not guarantee robustness to outliers or prevent one component from driving changes over time.

Equal exponents are a modelling choice. They do not establish equal empirical importance or remove overlapping information. The study does not report comparisons with alternative weights or aggregation rules, so superiority over those alternatives is not established.

Expressing all three shares as percentages instead of fractions multiplies the composite by 100. That change affects the numerical interpretation of a level coefficient. The empirical index scale is not documented, so the reported summaries cannot support a numerical effect per index point.

3.4. Research question

The expected association with prices is ambiguous. Increased regional output or exports may add to available supply, while a rising regional share can also reflect disruption elsewhere or changing expectations. Reserves, production and exports need not move together.

The research hypothesis is that the short-run coefficients on changes in MEOII are jointly different from zero. This is an association hypothesis within the specified model. It is distinct from a test of an individual coefficient and from the bounds test on a levels relationship.

4. Data and variables

4.1. Sources and coverage

The stated sample contains 26 annual observations from 2000 through 2025 before lagging or other losses. Annual frequency limits the analysis of rapid price responses and the number of dynamic parameters that can be estimated.

The study identifies the Energy Institute's Statistical Review of World Energy 2026 as the source of its oil series. The edition is a documented publication, but citing the edition does not identify the exact reserve, production and export series used in estimation. Table identifiers, the

regional country list, the data vintage and the treatment of missing values are not specified.

Comparable product definitions also matter. For example, the Energy Institute's 2025 methodology includes condensates and natural gas liquids in its broad oil production definition and notes that its reserves tables were not updated in that edition (Energy Institute, 2025). A broad oil series cannot be relabelled as crude oil alone. These documentation issues prevent treating the index as a verified, consistently defined annual crude-only series through 2025.

The stated Brent variable is the annual average price in current U.S. dollars per barrel. No price deflator is specified, so the outcome is interpreted as nominal. The stated IGREA aggregation is the arithmetic average of the twelve monthly values for each year. The exact downloaded version used in estimation is not identified; access to an updated series does not establish which vintage generated the reported estimates.

4.2. Transformations and coefficient interpretation

Let $y_t = \ln(P_t)$, where P_t is the annual average Brent price. The logarithm of the annual mean is not the mean of monthly log prices. Only the former is specified here. Taking logs does not by itself remove heteroskedasticity, trends or structural breaks.

The model equations specify MEOII in levels, and that convention is used below. The study's numerical results are not accompanied by the estimation output needed to verify the implemented transformation. They therefore do not support an elasticity interpretation or a quantified effect per unit of the index.

IGREA remains in levels because it can take negative as well as positive values. Its units describe percentage deviations from trend; a one-point increase is not a one-percent increase in global output. In a log-price equation with level regressors, a coefficient describes a change in log price per regressor unit. For a finite change d and coefficient b , the implied conditional percentage price change is $100 \times [\exp(bd) - 1]$, rather than an elasticity.

4.3. Variable definitions

4.4. Scope of the controls

MEOII summarises regional oil shares, while IGREA represents one demand-related dimension. Neither variable is a pure structural shock. Their inclusion does not control for every supply or demand determinant, and the model does not separate feedback between prices and production decisions.

Table 1 Variables in the specified model

Variable	Definition and scale	Role	Expected sign
y or LnOIL	ln of annual average nominal Brent price in USD per barrel; log measure	Dependent variable	Not applicable
m or MEOII	Geometric mean of three regional shares; levels in the stated equation; implemented scale and transformation not verified	Main explanatory variable	Ambiguous
z or IGRFA	Annual arithmetic mean of monthly activity index; percentage deviations from trend; no log	Demand-related control	Positive hypothesised

A positive association with IGRFA is plausible, but it remains an empirical question. Exchange rates, inventories, interest rates, non-regional supply and geopolitical conditions may also affect prices. The short sample constrains the number of controls and does not remove omitted-variable bias.

5. Econometric framework

5.1. Dynamic specification

The ARDL framework allows lagged prices and explanatory variables in one equation. Bounds inference requires an appropriate integration structure, deterministic specification and reference distribution, including the absence of I(2) variables (Pesaran et al., 2001). A short sample alone does not guarantee that the approach gives reliable inference.

$$y_t = c + \sum_{i=1}^p a_i y_{t-i} + \sum_{j=0}^{q_m} b_j m_{t-j} + \sum_{k=0}^{q_z} g_k z_{t-k} + e_t \quad (1)$$

Here m_t denotes MEOII in levels, z_t denotes IGRFA in levels, c is an intercept and e_t is the regression disturbance. The dependent-variable sum starts at lag one; the explanatory-variable sums include the contemporaneous terms.

The reported choice is ARDL(1,2,0), with the variables ordered as y, m and z. Thus the model contains y_{t-1} , m_t , m_{t-1} , m_{t-2} and z_t . Zero is the maximum lag on z; it does not mean that the contemporaneous variable is absent.

5.2. Integration and breaks

The stated testing procedure uses augmented Dickey-Fuller tests (Dickey & Fuller, 1981) and a test allowing an unknown break in the trend function, associated with Vogelsang and Perron (1998). A reproducible classification requires the test statistic, deterministic terms, lag rule, break specification and critical values for each variable.

Stationarity around a broken deterministic trend differs from stationarity after first differencing. These outcomes cannot be collapsed into an unspecified I(0)/I(1) classification. Break detection in one unit-root equation also does not show that the estimated price relationship is stable across that break.

The reported summary identifies a 2015 break for log Brent prices, but does not document the complete level and first-difference results for every series. Accordingly, exclusion of I(2) behaviour and the relevant deterministic specification remain unverified.

5.3. Lag selection and sample size

The study reports selection by the Akaike information criterion (Akaike, 1974). This compares the candidate models considered; it does not establish a uniquely correct lag structure. Maximum candidate lags and the common selection sample are not documented.

For ARDL(1,2,0), the levels equation is:

$$y_t = c + a y_{t-1} + b_0 m_t + b_1 m_{t-1} + b_2 m_{t-2} + g z_t + e_t \quad (2)$$

There are five slope coefficients and an intercept. Two lags would leave at most 24 estimation observations from a complete 26-year dataset without pre-sample observations. Missing values or a longer common selection window could reduce that number further; the effective estimation sample is not reported.

5.4. Levels relationship and error correction

A levels test concerns a joint restriction. Its decision depends on the deterministic case, the number of explanatory variables and the applicable critical values. An F-statistic above the relevant upper bound can support rejection; a value between the bounds is inconclusive. The statistic alone is not a sufficient decision rule.

The reported bounds statistic is 5.607. The testing case, critical-value table and effective sample are not documented, nor is any t-bounds assessment where applicable. A definitive rejection at the 5% level is therefore not asserted here. Small-sample calibration and the integration and break assumptions also affect its interpretation.

5.5. Equivalent dynamic representation

An algebraic rewriting of Equation (2), with Δ denoting a first difference, gives:

$$\Delta y_t = c + \lambda y_{t-1} + \delta_m m_{t-1} + g z_{t-1} + b_0 \Delta m_t - b_2 \Delta m_{t-1} + g \Delta z_t + e_t \quad (3)$$

The coefficient identities are $\lambda = a - 1$ and $\delta_m = b_0 + b_1 + b_2$. Because the selected lag for z is zero, its lagged-level and first-difference coefficients in this rewriting are the same g . They are not independently estimated short-run and level parameters. Equation (3) states this restriction; it does not introduce a new regression result.

If a meaningful levels relation exists and $1 - a$ is nonzero, the implied coefficients are $\theta_0 = c / (1 - a)$, $\theta_m = (b_0 + b_1 + b_2) / (1 - a)$ and $\theta_z = g / (1 - a)$. This relationship does not by itself establish cointegration.

A negative adjustment coefficient is consistent with convergence in a suitably specified conditional model. It does not prove a stable economic equilibrium. Where a t -bounds test is applicable, its reference distribution is non-standard. A p -value without an identified reference distribution is insufficient for this decision.

5.6. Diagnostics and inferential limits

The stated diagnostic procedure includes Breusch-Godfrey tests for residual serial correlation, Breusch-Pagan-

Godfrey tests for heteroskedasticity, Jarque-Bera residual-normality tests, Ramsey RESET and CUSUM/CUSUMSQ stability checks.

Failure to reject a diagnostic null is limited evidence against the particular alternative tested. It does not prove homoskedasticity, normality, correct specification or parameter stability, especially in a short sample. The Durbin-Watson statistic is not an adequate stand-alone check when the equation contains a lagged dependent variable.

6. Reported empirical findings

6.1. Numerical summaries

Table 2 brings together the numerical results reported in the analysis. These are estimation summaries, not a reconstruction of the annual data or a re-estimated model. Means, dispersion, skewness and kurtosis are not documented numerically, so no distributional conclusion about the variables is drawn from them.

Table 2 Reported estimation summaries

Item	Reported value	Interpretive limit
Stated period	2000-2025	26 years before lags; effective sample unspecified
Selected model	ARDL(1,2,0)	Variable order y , MEOII, IGREA; AIC search settings unspecified
R^2	0.796	Fit for log prices in the estimation sample
Overall regression F	14.01; $p < .01$	Different null from the bounds test; degrees of freedom unspecified
Durbin-Watson	1.918	Not a sufficient serial-correlation check with lagged prices
Bounds F	5.607	Case and critical values unspecified; no verified rejection
Adjustment coefficient	-0.264; reported $p < .01$	Conditional interpretation; test and reference distribution unspecified
Price break year	2015	Reported endogenous break; full test output unspecified

The unit-root account describes stationarity after a break but does not provide enough detail to assign a verified integration order to each variable. The 2015 log-price break is retained as a reported finding, without inferring that it identifies the cause of the price decline.

6.2. Fit and coefficient interpretation

The reported R^2 of 0.796 describes fit to log Brent prices within the estimation sample. It is not a causal attribution to MEOII, an out-of-sample forecasting measure or a proportion of variation explained on the original dollar-price scale. Lagged prices are themselves part of the fitted model.

The reported overall regression F-statistic is 14.01, with $p < .01$ as stated in the analysis. This differs from the bounds F-statistic of 5.607: the two concern different

hypotheses. Without the full output, exact degrees of freedom and test settings cannot be checked.

The coefficient narrative describes the contemporaneous and lagged MEOII level terms as individually insignificant, yet also describes a positive significant short-run association. An individual term, a transformed coefficient and a joint test of short-run terms are different hypotheses. The coefficient vector, standard errors and joint test are not reported, so the claimed short-run significance is not treated as established.

6.3. Levels test and adjustment

The bounds statistic of 5.607 is retained without declaring verified cointegration. The missing reference values and testing case matter for the decision, while the short sample increases uncertainty. A significant joint levels

test would not require every individual long-run coefficient to be significant.

The reported adjustment coefficient is -0.264. Conditional on a valid error-correction representation, it corresponds to correction of about 26.4% of the preceding period's equilibrium error per year, holding other dynamics fixed. It does not mean that every price shock disappears at that rate. The accompanying $p < .01$ does not identify its test or reference distribution. It therefore cannot establish that an applicable bounds-testing requirement has been met.

The analysis describes positive short-run associations for MEOII and IGERA. Their sizes and uncertainty are not reported numerically. For IGERA, the zero-lag specification also constrains its dynamic representation as shown in Equation (3). A separate, freely estimated short-run IGERA effect is therefore not inferred.

6.4. Diagnostics and long-run coefficients

The analysis states that its residual and stability checks did not reject the relevant null hypotheses. Test statistics, p -values, lag choices and the CUSUM/CUSUMSQ plots are not documented, so these statements do not establish that the model satisfies all assumptions. The reported Durbin-Watson value of 1.918 does not resolve this limitation.

Neither MEOII nor IGERA is reported to have an individually significant long-run coefficient. The coefficient estimates, standard errors and confidence intervals are not given. This is insufficient evidence of an independent long-run association within the reported specification; it is not evidence that the corresponding economic effect is zero.

Nor does an insignificant long-run coefficient establish that short-run effects are stronger. Comparing horizons requires the relevant estimates and a test of their difference. The paper does not document such a comparison.

7. Discussion

The proposed index gives an explicit summary of three regional shares. Its usefulness depends on whether the component definitions and annual coverage are comparable. It does not measure spare production capacity, coordination among producers or the ability to change prices. Such influence cannot be inferred from the index label.

Changes in non-regional production, technologies or inventories could affect the relationship between regional shares and prices. This model does not identify those mechanisms. The absence of individually significant long-run coefficients cannot establish that diversification has reduced regional influence.

Positive short-run coefficients, if supported by a fully documented estimation, would describe conditional associations in annual data. They would not identify immediate trading responses or causal effects of production policy. Simultaneity and unobserved common shocks remain plausible explanations.

The reported negative adjustment coefficient is compatible with one interpretation of the fitted dynamics. Its economic meaning depends on a valid levels relation and stable specification. It therefore cannot establish that oil markets return to a uniquely determined equilibrium after every disruption.

The use of IGERA recognises the relevance of commodity-market demand conditions. It does not verify a particular demand-transmission channel in this sample. Alternative activity measures are relevant because the literature debates the construction and interpretation of shipping-based indices (Kilian, 2019; Hamilton, 2021).

The exploratory exercise can inform a more reproducible empirical comparison. That comparison would identify the regional coverage and annual component data, distinguish crude oil from broader liquids, disclose transformations and estimate alternative component and composite specifications on the same sample. These are extensions of the analysis, rather than results demonstrated here.

8. Conclusion and limitations

This study proposes MEOII as the geometric mean of three Middle Eastern shares in world oil markets. It combines resource endowment, current production and crude oil exports, with equal exponents. The result is a descriptive relative-share index, whose interpretation depends on source definitions and weighting choices.

The stated annual ARDL exercise covers 2000–2025 and reports a specification of (1,2,0), a bounds F -statistic of 5.607 and an adjustment coefficient of -0.264. The qualitative summaries describe positive short-run associations and individually insignificant long-run coefficients. Incomplete data and estimation documentation prevents treating these statements as verified significance, cointegration or causal findings.

The index may help organise information used to monitor regional oil participation alongside demand conditions. The analysis does not evaluate the effect of a production agreement, an investment policy or a diversification programme. It therefore provides no quantitative basis for prescribing such interventions or promising reduced volatility.

Several limitations affect interpretation. The sample is short and annual, and the effective estimation period is not specified. The regional country list, component series, scale, reserve coverage and missing-value treatment are not documented in sufficient detail. The implemented MEOII transformation is uncertain. Unit-root and break specifications, bounds reference values, coefficient uncertainty and diagnostic output are incomplete. The model also omits other price determinants and does not identify exogenous shocks.

Further research can examine the index with documented annual components and sensitivity to weights and aggregation, compare it with separate-share models and alternative demand proxies, and assess finite-sample and break-sensitive inference. Until those comparisons are

available, the index is a proposed descriptive tool and the reported price relationships remain exploratory.

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CONCEPTUAL PAPER

Architecture and Artificial Intelligence: Defining the Architectural Project and the Architectural Profession in the Age of AI

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ABSTRACT

Research aims: This article examines the architectural project and the architect's role when algorithms undertake part of the design process.

Design/Methodology/Approach: It adopts a qualitative, retrospective and interpretive approach, bringing literature on architectural design and digital tools into dialogue with professional discussion of AI. Publicly circulated AI-generated architectural proposals from 2022 to 2025 provide context for the discussion.

Research findings: The analysis suggests that architects can use AI to explore design alternatives while retaining responsibility for the brief, the site and the evaluation of proposals. Generated images alone provide no evidence of constructability or environmental performance.

Theoretical contribution: The article interprets AI-assisted architectural design as a process that requires human judgement, explicit constraints and critical evaluation.

Practical implications: Architects and educators should distinguish visual exploration from technical validation and assess the environmental, cultural and ethical implications of the tools they use.

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1. Introduction

This article examines how artificial intelligence (AI) affects architectural design and the professional responsibilities of architects. It considers what changes when designers use algorithms to generate or evaluate proposals, and which decisions still require contextual knowledge and professional judgement.

Architecture combines artistic expression with construction, social uses and economic constraints. Architects must consider form, function and technical feasibility

together (Fernandez, 2002). A proposal that succeeds in one of these dimensions may still require substantial revision in the others.

Debates about architectural form and artistic meaning have long shaped the discipline (Le Corbusier, 1926; Minguet, 1992). Contemporary practice also requires attention to user comfort, energy performance and the urban context. Architects therefore need tools that support both design exploration and communication among participants. Research on mediated collective design shows

the importance of examining how teams use these tools within their working process (Calixte, 2021).

Architects have developed their ideas through sketches, geometric drawing, stereotomy and, later, computer-aided design (CAD) and building information modelling (BIM). These methods influence how designers formulate and communicate an intention. The relationship between tools and architectural judgement remains central to current professional debate about AI (Ficat & Mohamed, 2025; Lescop, 2025). Design draws on experience, knowledge, dialogue and repeated evaluation as well as intuition.

Generative AI has extended the range of tools available for visual exploration. Designers can use text or image prompts to request alternative compositions and architectural appearances. The resulting images may resemble plans, elevations or sections, but that resemblance does not establish dimensional consistency, structural feasibility or compliance with a brief. A review of AI in conceptual architectural design also identifies approaches to generating and evaluating alternatives that extend beyond image production (Castro Pena et al., 2021).

The value of computational speed depends on the task and the reliability of the output. Designers may use AI within modelling, optimisation or environmental analysis, but each application requires appropriate inputs and checks. An attractive image and a validated technical model answer different questions. Architectural education consequently needs to address how students select tools, test their outputs and explain the decisions they retain.

The central question is therefore: what becomes of the architect's role and of the architectural project when algorithms undertake part of the design process, within a discipline that combines artistic, technical, social, environmental and economic concerns?

2. Methodology and scope

This study uses a qualitative, retrospective and interpretive approach. It relates literature on architectural conception, drawing and computational design to professional discussion of AI. Publicly circulated AI-generated architectural proposals from online platforms, specialised magazines and social networks between 2022 and 2025 provide contextual material. The discussion addresses how designers frame problems, represent proposals and assess the division of work between people and tools. The article does not report an item-level catalogue, a coding scheme or comparative results for those proposals. Its conclusions therefore concern conceptual and professional implications; they do not establish the frequency of particular practices, the performance of AI systems or the environmental benefits of the designs shown in public media. The literature discussion is selective rather than a systematic review.

3. Discussion

3.1. Architectural design

Architects develop a project by relating intentions to a possible built outcome. Mestelan (2005) treats the project as a central concept in architectural theory. The brief gives designers an initial account of intended uses, resources and constraints, which they refine as they explore alternatives (Tric, 1999; Safin, 2011). Architectural conception thus involves both imagining a future situation and assessing how it could take material form.

Designers work with requirements that can conflict. They must reconcile spatial and aesthetic intentions with construction, cost and the expectations of users. Clients, contractors, public authorities and residents also influence the choices available to the architect (Tric, 1999). Computational assistance has long included approaches in which designers describe desired properties and explore possible forms, as illustrated by declarative modelling and research on sunlight in architectural design (Hégron, 2003; Siret, 1997).

Architects revise both their proposals and their understanding of a problem as design proceeds. They use guiding ideas and architectural references to organise this work, returning to earlier decisions when a proposal fails to satisfy a requirement (Boudon et al., 1994; Fernandez, 2002). This iterative character matters when assessing AI: the designer must be able to question an output and reconsider the assumptions behind it.

Designers draw on experience, cultural knowledge and earlier architectural examples when interpreting a brief. Graphic representations help them develop and communicate possible responses (Fernandez, 2002; Halin, 2004). A reference can inform a spatial relationship, a construction principle or an aesthetic choice, without prescribing the final form. The architect must assess its relevance to the project at hand.

Architectural expertise also depends on the particular circumstances of a commission. Buildings have a strong relationship to their location, and designers must respond to site conditions rather than assume that a form can transfer unchanged between contexts (Raynaud, 2001; Halin, 2004). Standardised components and repeated building types do not remove this need for adaptation.

3.2. Architecture and digital tools

Architectural practice has expanded from hand drawing and physical models to CAD, digital modelling and BIM. These methods coexist, and architects combine them according to the stage and requirements of a project. AI adds further possibilities for generating or assessing alternatives. To understand its contribution, it is useful to distinguish drawing, information management and the evaluation of design proposals.

3.2.1. Hand drawing

Estevez (2001) distinguishes descriptive, prescriptive and speculative functions of architectural drawing. Designers use descriptive drawing to represent the appearance and

form of a proposal. Prescriptive drawings communicate information needed for construction, including dimensions and details. Speculative drawing supports the exploration of ideas. These functions can overlap during a project, but they serve different purposes.

In early design, architects can sketch a spatial arrangement, compare alternatives and revise relationships before committing to detailed documentation. This use of drawing as a means of thinking remains relevant when designers move between paper and digital environments (Estevez, 2001; Safin, 2011).

Sketches allow designers to record an intention with a selective level of detail. Orthographic drawings, including plans, sections and elevations, describe different aspects of the same proposal. Designers must check that these views agree. Perspectives and physical or digital models provide further ways to examine spatial relationships; they complement the information in technical drawings (Estevez, 2001).

3.2.2. Computer tools in architectural design

Computer graphics and digital drawing developed during the second half of the twentieth century and changed how architects produced and revised representations. CAD and three-dimensional modelling expanded the means available for visualisation and documentation. Their adoption did not eliminate hand drawing, and their role in design extends beyond replacing drawing instruments (Estevez, 2001; Halin, 2004).

Hégon (2003) distinguishes imperative modelling, in which a designer represents an object whose form is already envisaged, from declarative modelling, in which the designer specifies properties from which possible forms can be explored. This distinction shows why computational tools cannot all be described as mere drafting aids. Their contribution depends on how the designer represents the problem and which operations the software supports.

Architects use digital models to inspect geometry, prepare visualisations and coordinate information. They can also connect models to analytical tools for studies of daylight, energy use or other aspects of building performance. The reliability of these studies depends on the model, the input data and the assumptions used; visual realism alone does not establish accuracy.

BIM supports the organisation and exchange of building information across a project. Teams can derive drawings from a coordinated model and use model information in technical assessments. Energy consumption and constructability still require appropriate calculations, specialist review and checks against project requirements. A BIM model does not by itself confirm that a building is feasible or environmentally efficient (De Maestri, 2017).

The main organisational value of BIM lies in how participants share and manage information. Teams need to define responsibilities, maintain consistent data and coordinate revisions (De Maestri, 2017). Its use in architectural education also raises questions about how software instruction relates to the development of a project

(Samb, 2018). Learning a tool therefore needs to be connected to design reasoning and collaborative work.

3.2.3. Artificial intelligence in architecture

Architectural applications of AI include methods for generating design alternatives, searching possible configurations and evaluating selected criteria. The review by Castro Pena et al. (2021) examines AI in conceptual design, including approaches developed before current prompt-based image generators. Chaillou (2021) also considers AI in architectural practice. These contributions support a discussion of changes in design methods, but they do not justify treating all AI systems as equivalent or assuming that they reproduce human understanding.

At the 2025 conference organised by the Société française des architectes, Ficat and Mohamed discussed changes in professional practice, while Lescop considered the architectural value chain (Ficat & Mohamed, 2025; Lescop, 2025). Their contributions document professional perspectives on a changing field. The published programme abstracts do not provide experimental benchmarks for speed, accuracy or risk reduction. Claims about such outcomes require evidence for the specific task, system and comparison involved.

A prompt may leave important intentions unstated, and a generated proposal may satisfy its visible wording while failing other requirements. Architects must examine the output in relation to the brief and the site. Ficat and Mohamed (2025) emphasise the continuing importance of professional judgement and coordination. In practice, designers need to explain why they selected, altered or rejected a proposal rather than rely on its visual persuasiveness.

4. Conclusion

AI can expand the alternatives that architects consider during design. Architects still need to define the brief, interpret site conditions and judge whether proposals meet technical and social requirements. The conceptual discussion developed here supports this division of responsibility; it does not demonstrate that AI-generated designs have a smaller ecological footprint. Environmental claims require assessments of building operation, materials and the assumptions used in analysis. A rendered image cannot supply that evidence.

We therefore understand the architectural project in the age of AI as an iterative process in which architects use computational proposals while retaining responsibility for their interpretation and evaluation. This position requires attention to the limits of the tools, the possibility of repetitive forms and the difficulty of explaining some outputs. For architectural education, the practical task is to connect technical competence with the ability to assess cultural context, justify design choices and check performance claims.

Declarations

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CONCEPTUAL PAPER

Blockchain and Environmental Trust in Green Value Chains in the Middle East and North Africa

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ABSTRACT

Environmental claims in green value chains depend on information that buyers, investors and regulators may find difficult to verify. This article examines how blockchain could support the recording and review of that information in the Middle East and North Africa (MENA). It uses a conceptual narrative synthesis of research on organisational trust, supply chain governance and blockchain, together with selected policy material and published studies concerning the United Arab Emirates and Jordan. The proposed framework connects five trust-related problems with possible ledger functions and the conditions needed for their use. Shared records may improve access to evidence, provenance tracking and the detection of later changes. They do not establish the accuracy of physical measurements or environmental claims at the point of entry. Smart contracts can execute coded rules, while certification, data assurance and institutional responsibility remain necessary. The regional survey studies describe associations within particular samples; a separate supply chain model illustrates how incentives may differ among actors. These sources do not constitute a validation of the framework or proof of environmental improvement. The article proposes that organisations evaluate data quality, access rights, governance, interoperability and total costs before adopting blockchain for environmental purposes.

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1. Introduction

Green value chains seek to connect production and exchange with environmental objectives. Their credibility depends on how organisations measure, communicate and verify their impacts. The United Nations Environment Programme (UNEP, 2021) places economic activity within the connected climate, biodiversity and pollution crises, while Schaltegger and Burritt (2018) distinguish the motivations underlying corporate sustainability practices. An environmental claim therefore needs to be assessed through its evidence and scope, as well as the organisation's stated aims.

We use environmental trust to mean stakeholders' confidence that claims about environmental practices and outcomes are credible and open to scrutiny. Attributes such as carbon intensity, material origin and recycled content may be difficult for a downstream buyer to assess directly. The problem concerns access to reliable measurements, the basis of a claim and the responsibility for checking it.

Lyon and Montgomery (2015) review forms of misleading environmental communication. Darnall et al. (2018) examine how certification and sponsor trust relate to consumers' ecolabel use. These studies help explain why environmental claims require assurance; they do not

imply that every certification or reporting arrangement fails.

The question has practical relevance for MENA value chains. Lelieveld et al. (2016) examine projected heat extremes in the region, illustrating the need for credible assessment of environmental change. Blockchain-related research and policy material also address selected regional settings, including energy and industrial supply chains. These settings provide context for the present analysis without representing all MENA countries.

Blockchain provides a shared ledger whose records can be resistant to, and reveal evidence of, alteration under defined operating conditions. Access and control depend on the network's design. Tapscott and Tapscott (2016) discuss its wider business possibilities, while technical reviews describe its mechanisms and limitations (Yli-Huumo et al., 2016; Zheng et al., 2018). Yaga et al. (2018) distinguish tamper resistance from absolute immutability and explain the difficulty of checking external inputs.

For environmental purposes, a ledger could link records to products, materials or transactions and make the history available to authorised participants. Smart contracts could execute actions when specified digital conditions are met. These functions may support assurance processes, but the reliability of environmental measurements, input providers and organisational controls remains essential (Saber et al., 2019; Centobelli et al., 2022).

Adoption also involves costs, coordination and institutional arrangements. Kouhizadeh et al. (2021) analyse barriers to sustainable supply chain adoption, and Kshetri (2021) examines applications in developing-country settings. Neither technical capability nor adoption alone establishes that an organisation has achieved an environmental benefit.

This article asks how blockchain could support environmental trust, which conditions would make the records useful, and which responsibilities remain outside the ledger. We focus on a conceptual framework and use selected studies concerning the United Arab Emirates (UAE) and Jordan as contextual evidence. We do not estimate the causal effect of blockchain or undertake a comprehensive comparison of national legal systems.

2. Theoretical background and literature review

2.1. Environmental trust and green value chains

Organisational trust provides a useful starting point, but trust and trustworthiness are distinct concepts. Mayer et al. (1995) identify ability, benevolence and integrity as dimensions of perceived trustworthiness. Pirson and Malhotra (2011) show that the dimensions relevant to trust vary with stakeholder relationships. We apply these perspectives to environmental claims as an analytical interpretation, rather than treat either study as a ready-made measure of environmental trust.

Several information problems affect the assessment of green value chains. Producers and other upstream actors

may know more about processes than buyers. Some environmental attributes are difficult to observe through a purchase or ordinary product use. Effects may also occur at a different place or time from the transaction. O'Rourke (2014) discusses the measurement and information challenges of sustainable supply chains.

Responsibility is also distributed among organisations with different roles and bargaining power. Gereffi et al. (2005) analyse forms of global value chain governance. Ponte (2020) examines business, sustainability management and capital accumulation within global value chains. These perspectives suggest that access to environmental information should be considered alongside control over decisions and the distribution of costs.

Certification, reporting and audits can help address information problems, although their quality and incentives vary. Darnall et al. (2018) find that third-party certification can matter where consumers distrust business-sponsored ecolabels. Dauvergne and Lister (2013) critically examine corporate uses of sustainability. The appropriate question is how a ledger might complement assurance and oversight, rather than assume that digital records can replace them.

2.2. Blockchain as a recording and coordination infrastructure

A blockchain records transactions in linked blocks and uses agreed procedures to maintain a shared history. In a permissionless network, participation is relatively open; in a permissioned network, designated actors control participation and validation. Distribution of the ledger does not necessarily imply an equal distribution of organisational power (Yaga et al., 2018).

Decentralisation can reduce reliance on a single record holder, but control may remain concentrated among operators, validators or a consortium. Governance rules determine who may join, write records, change software and resolve disputes. These choices affect resilience and the opportunity for manipulation.

Transparency also depends on access rights. A shared ledger may allow authorised participants to inspect relevant records, while sensitive commercial or personal information may require restricted access. Visibility of a transaction history is different from independent confirmation of the environmental claim attached to it.

Tamper resistance can help preserve an audit trail after information is recorded. It does not make the original information true or prevent every attack, software change or governance failure. Environmental data may originate in human reports, sensors or other external systems. Checking these inputs remains a separate task (Yaga et al., 2018).

A smart contract executes programmed rules using information available to it. Network consensus concerns agreement on transactions and ledger state; it is not a measurement of pollution or compliance. A program using external environmental information relies on an

input mechanism, often called an oracle, whose reliability needs separate assessment (Yaga et al., 2018).

Kouhizadeh and Sarkis (2018) discuss opportunities and caveats for greener supply chains. Centobelli et al. (2022) examine trust, traceability and transparency in circular supply chains. These contributions motivate possible applications, including tracking material provenance and recording evidence for environmental claims. They do not remove the need to establish the physical connection between an asset and its digital record.

2.3. Reengineering assurance processes

We use reengineering to describe redesigning how organisations record, share and review environmental information. Hammer and Champy (1993) provide the broader process-redesign concept. Its application to environmental assurance here is our conceptual extension.

Some reconciliation or verification tasks could be automated, potentially changing the role of intermediaries. Organisations would still need people or institutions to define environmental criteria, inspect physical processes and address disputes. Any saving should be assessed against implementation, data assurance and coordination costs (Sabeti et al., 2019; Kshetri, 2021).

Shared records can help identify who supplied information and which actions followed. Accountability also requires assigned responsibilities, access to explanations and a means of correcting or contesting a decision. A distributed ledger alone does not distribute legal responsibility or establish effective oversight.

A token may represent an asset or an environmental attribute within a digital system. The representation does not by itself establish a valid environmental benefit, exclusive ownership or a liquid market. Systems need rules connecting issuance, transfer and retirement to the underlying asset or claim. This is a design and assurance requirement, rather than an automatic outcome of tokenisation.

2.4. Selected empirical studies and policy context

The sources considered here provide different kinds of evidence. The UAE and Jordan studies use cross-sectional survey data. A separate circular supply chain study uses mathematical models, and official policy material describes aims and implementation considerations. These sources should be interpreted according to their methods.

Mothafar et al. (2024) analyse blockchain technology enablers and sustainable supply chain outcomes using interviews and a survey of 462 employees in UAE firms. Their structural model reports positive social and environmental coefficients. The direct economic coefficient is negative but not statistically supported, so it should not be read as evidence of economic harm. The study also reports indirect pathways involving green hydrogen acceptance. These are sample-specific model results, not an evaluation of measured emissions before and after deployment.

AlMaaitah (2026) examines blockchain-based financial technology and environmental, social and governance (ESG) compliance in Jordanian energy supply chains using a cross-sectional survey and partial least squares structural equation modelling. The study reports a positive adoption-compliance relationship, but the proposed moderating role of supply chain governance is not supported. That result does not establish that institutions are unnecessary; it limits the evidence for the particular moderation relationship tested.

Akbarzadeh Sarabi et al. (2026) model a circular closed-loop supply chain using Stackelberg and evolutionary game approaches. Their results illustrate how blockchain costs, consumer responses and carbon-policy incentives can affect participants differently under the model's assumptions. This is theoretical evidence about incentives, rather than an observed MENA implementation or a finding that subsidies always fail.

The Emirates Blockchain Strategy 2021, launched in April 2018, provides historical context for UAE government interest in blockchain (UAE Government, n.d.). Its transaction-conversion and savings statements are policy aims, not environmental outcomes established here. The United Nations Economic and Social Commission for Western Asia (ESCWA, 2024) discusses digital infrastructure, skills and institutional conditions in its report on the Arab region's sustainable energy transition. Such policy material helps identify questions for implementation; it does not validate the present framework.

3. Research questions and analytical propositions

The central question is how blockchain could support credible environmental information and accountable decision-making in MENA green value chains. We consider the relationship between the information problem, the proposed ledger function and the institutional conditions needed for its use.

Four questions guide the analysis:

1. Which recording and coordination functions could address particular environmental trust deficits?
2. Which data, institutional and infrastructure conditions are necessary for these functions to be useful?
3. How could provenance records and programmed actions support traceability and accountability?
4. Which costs, risks and governance problems could limit their contribution?

3.1. Analytical propositions

The propositions organise conceptual enquiry. They are conditional expectations for future investigation, rather than hypotheses statistically tested in this article.

P1. Shared access to relevant, reliable records may reduce information asymmetry and help stakeholders assess environmental claims.

P2. The contribution of a ledger depends on data assurance, governance, institutional arrangements and usable digital infrastructure.

P3. Provenance records, tamper-resistant histories and programmed checks may support accountability when responsibilities and procedures for challenge are clear.

P4. Fragmented systems, incompatible standards, unequal incentives and limited organisational capacity may increase costs and constrain useful adoption.

4. Methodology

We use a conceptual qualitative design based on a narrative synthesis of literature and selected policy material. We relate trust and governance concepts to blockchain functions, then consider published studies concerning the UAE and Jordan. The article collects no new interviews, survey responses or operational measurements.

4.1. Conceptual synthesis

The synthesis starts with difficulties in accessing, checking and assigning responsibility for environmental information. It maps five analytical problem areas to possible ledger functions: information asymmetry, hard-to-observe environmental attributes, audit vulnerability, fragmented accountability and verification costs. These categories organise the framework and are not empirically validated latent constructs.

The analysis distinguishes record integrity from input accuracy and environmental performance. A consistent transaction history may assist an audit, while the claim itself still depends on measurement and assurance. This distinction applies throughout the framework.

4.2. Policy and institutional context

We use the UAE strategy and ESCWA report to discuss policy objectives and implementation conditions. The UAE and Jordan survey studies offer context for selected organisational relationships. We do not rank national institutional quality or infer a country's entire regulatory position from one study.

The policy discussion considers questions about access rights, responsibility, evidence, data protection, interoperability and dispute handling. It identifies matters for project design and jurisdiction-specific assessment. It does not constitute a comprehensive legal analysis or establish that records and smart contracts lack recognition throughout MENA.

4.3. Use of published studies

Mothafar et al. (2024) and AlMaaitah (2026) provide contextual survey evidence. Akbarzadeh Sarabi et al. (2026) provide a theoretical comparison of incentives. We consider the sources' research designs and the outcomes they examine before relating them to the propositions.

These sources are illustrations drawn from the literature, rather than a newly assembled sample of operational blockchain projects. A survey of adoption perceptions, a government strategy and a mathematical model do not by themselves document a live environmental application. We therefore make no claim to an independent deployment or impact audit.

4.4. Sources and analytical approach

Sources include research on organisational trust, sustainability and supply chain governance; blockchain studies and technical guidance; and selected official policy material. We compare the proposed mechanism with the evidence needed to support its environmental interpretation. The technical overview from the National Institute of Standards and Technology (NIST) provides a basis for distinguishing ledger functions from claims about external data (Yaga et al., 2018).

The synthesis is purposive and interpretive. It does not use a documented systematic search protocol, exhaustive screening process or formal quality-scoring procedure. We do not calculate pooled effects or treat agreement among sources using different methods as an independent validation of the framework.

The analytical sequence is to identify a trust-related problem, describe a relevant ledger function, specify necessary data and governance conditions, and distinguish a possible information benefit from an environmental outcome. Table 1 summarises these relationships.

4.5. Limitations

The narrative selection of sources may omit relevant evidence. The regional discussion concentrates on selected UAE and Jordan studies and cannot represent the diversity of MENA countries or sectors. The article offers no estimate of the prevalence of blockchain deployment across the region.

The framework has not been tested against new field data. Survey associations, mathematical model results and policy aims answer different questions and cannot be combined as a causal estimate of blockchain effectiveness. In particular, perceived ESG compliance is not equivalent to independently measured environmental improvement.

Published descriptions may also give more attention to proposed benefits than to failed implementations, operating costs or distributional effects. Further research needs independent project evidence, baseline comparisons and information about data quality, governance and lifecycle resource use.

5. Analytical findings

5.1. Potential contributions to environmental assurance

The conceptual mapping identifies ways to make environmental information easier to trace and review. A shared history may reduce duplicated reconciliation, link claims to evidence and help reveal later changes. Each contribution depends on the completeness of records, access rights and the credibility of the data source.

Distributing validation may reduce dependence on one record holder. It does not eliminate collusion, unequal influence or dependence on a platform operator. Decisions about participation, permissions and software changes remain important to the quality of assurance.

A tamper-resistant history can help an auditor identify which information was entered and when. It cannot correct a faulty sensor reading or a misleading original report. An environmental claim still requires a defined measurement method and checks on the underlying process.

Shared visibility can help users inspect evidence where they have access and the skills to interpret it. It should not be equated with open public access or guaranteed market discipline. The relevant design question is whether the intended user can examine sufficient evidence to assess the claim.

Blockchain can therefore change the way participants organise information and assurance. Trust remains directed towards data providers, technical operators, governance rules and the institutions responsible for environmental standards. The ledger complements these relationships.

5.2. Institutional and infrastructure requirements

The literature raises implementation questions concerning rules, infrastructure and organisational capacity. These are conditions for evaluating a project, rather than findings from a comprehensive survey of national legal systems. Kouhizadeh et al. (2021) and Kshetri (2021) discuss adoption barriers and institutional context, while ESCWA (2024) considers regional energy-transition requirements.

Participants need clear arrangements for who submits data, who reviews it, which evidence supports a decision and how an error or dispute is handled. Recognition and enforceability require assessment in the relevant jurisdiction and application. A coded action does not settle questions of responsibility.

Operational systems also need reliable connectivity, compatible data definitions and a practical means of linking actors, assets and records. Digital identification can be one component, but a particular national identity architecture is not a universal prerequisite for every blockchain design. Interoperability concerns the meaning and quality of shared data as well as technical connections.

Staff need sufficient capability to manage records, security, environmental measurement and the rules governing automated actions. Technical installation alone does not establish that an organisation can maintain or challenge the resulting decisions. Training and continuing oversight are therefore proposed implementation priorities.

5.3. Traceability and accountability

Provenance records may help follow products, materials and claims across stages of a value chain. Their value depends on maintaining the connection between the physical asset and its record, recording relevant transformations and identifying information providers. Traceability describes the history available for review; it does not establish a favourable environmental outcome (Centobelli et al., 2022).

Smart contracts could trigger a payment or reporting action when defined digital conditions are met. The program's output depends on its code and inputs. Environmental certification may still require an authorised assessment outside the program. Program execution, technical transaction validation and environmental assurance are separate functions.

The UAE and Jordan surveys offer contextual evidence of relationships between blockchain-related practices and perceived sustainability or compliance. They do not isolate ledger provenance or automation as the causal mechanism. The unsupported governance moderation in AlMaaitah (2026) also cautions against claiming that every governance relationship in the framework has empirical support.

5.4. Costs and risks

Implementation can require investment in integration, security, data collection, assurance and coordination. Some costs may fall on smaller suppliers or actors with limited influence over the system. Adoption needs a comparison with feasible alternatives, including a conventional shared database, rather than an assumption that blockchain is always necessary (Saber et al., 2019).

Energy use depends on consensus and network design. Proof-of-work can require substantial computation, while other mechanisms can use less energy. Permissioned access is an access-control arrangement, not itself a consensus algorithm or a guarantee of environmental efficiency. Evaluation should include the wider system and its operating requirements (Yaga et al., 2018; ESCWA, 2024).

Governance risks include concentrated control, exclusion from records, weak arrangements for correction and uncertainty about responsibility. Sensitive information also requires suitable access and security controls. A permanent shared history can create practical difficulties where information is wrong or should no longer be widely accessible.

Incentives may differ among participants. Akbarzadeh Sarabi et al. (2026) show within their model that the distribution of costs and policy incentives can affect adoption and profitability differently across supply chain members. These conditional results motivate attention to cost sharing; they do not establish that fragmentation has a particular probability or that a national strategy guarantees scalability.

6. Discussion

6.1. Proposed framework for environmental trust

Table 1 connects five trust-related problems with potential recording or coordination functions and their limits. It is a conceptual guide for designing questions and evaluating projects. The proposed contributions require evidence in each application.

Table 1 Environmental trust problems and potential blockchain contributions

Trust problem	Potential function	Possible contribution	Conditions and limits
Information asymmetry	Shared ledger access	Users can inspect relevant evidence and its history.	Access rights, completeness and user capability determine what can be checked.
Hard-to-observe attributes	Provenance records	Claims can be linked to identified materials, assets or transactions.	Physical links, measurement and independent assurance remain necessary.
Audit vulnerability	Tamper-resistant history	Later alterations may be harder to conceal.	The original input may still be wrong; security and governance remain relevant.
Fragmented accountability	Attributed records and coded checks	Contributors and programmed actions can be traced.	Responsibilities, external inputs, review and dispute procedures must be defined.
Verification costs	Automated reconciliation and rule execution	Some repeated processing may require less manual work.	Net savings depend on integration, assurance, operating and coordination costs.

Source: Authors' conceptual synthesis of the literature discussed in the text, including Yaga et al. (2018), Saberi et al. (2019), Kouhizadeh et al. (2021) and Centobelli et al. (2022).

The framework separates information access, record integrity, physical verification and responsibility. An organisation could improve one of these while leaving others unchanged. Evaluation should therefore specify which problem the project addresses and which outcome would demonstrate improvement.

6.2. Assessment of the analytical propositions

The synthesis provides a rationale for investigation rather than a statistical test of P1-P4.

P1 is plausible where participants can access relevant evidence and have confidence in its source. The literature motivates shared visibility, but this article does not measure a reduction in information asymmetry or an increase in environmental trust.

P2 identifies data assurance and institutional arrangements as design conditions. It is not confirmed as a universal moderation relationship. In particular, AlMaaitah (2026) does not support the specific supply chain governance moderation tested in that study.

P3 distinguishes a record of actions from effective accountability. Provenance and programmed checks may help an investigation, while responsibility, meaningful review and reliable inputs remain necessary. No direct accountability or environmental-performance effect is estimated here.

P4 draws attention to compatibility, capacity and the distribution of incentives. Adoption-barrier research and the circular supply chain model motivate these concerns. Comparative project evidence is needed to establish how they affect implementation in particular MENA settings.

6.3. Implications for policy and practice

The proposed implications concern project evaluation and governance. They should be adapted to the relevant sector and jurisdiction and assessed against measurable objectives. A decision to use blockchain should follow a clear information problem and a comparison of alternatives.

6.3.1. Rules and responsibilities

Before implementation, participating organisations should specify data ownership and access, submission and review roles, security responsibilities and procedures for errors and disputes. The applicable treatment of digital evidence and automated agreements requires a jurisdiction-specific assessment.

Controlled experimentation could help evaluate the process before expansion. An assessment should examine whether participants can question a record or decision, how incorrect information is addressed and which environmental evidence supports a claim. These are proposed safeguards, rather than a finding that any particular country lacks them.

6.3.2. Infrastructure and interoperability

Projects need compatible identifiers, data definitions and evidence requirements across participating systems. A shared ledger is useful only if participants can interpret the records and connect them with the underlying activity. Infrastructure decisions should account for suppliers with limited technical capacity.

Interoperability planning should include data quality, permissions and the continuity of records across systems. Regional cooperation could help where chains cross borders, but its benefits need to be assessed against sector-specific requirements and existing arrangements.

6.3.3. Organisational capacity

Training should connect ledger operation and cybersecurity with environmental measurement and assurance. Firms, auditors and relevant public bodies need to understand the limits of automated checks as well as their possible uses. Responsibility for reviewing inputs and maintaining the system should remain explicit.

Project evaluation also needs participation from technical, environmental and governance specialists, together with those who bear the costs of collecting data. This

would help identify practical burdens and the evidence needed to assess a proposed benefit.

6.3.4. Integration with environmental objectives

Organisations should define an environmental objective before choosing the technology. A project intended to reduce emissions, improve recovery or verify material origin needs indicators appropriate to that objective and a credible baseline.

Operating costs, energy requirements, participation and information quality should be assessed alongside the target outcome. Greater transaction visibility is an information result; an environmental gain requires evidence about the physical process or impact.

Coordination with wider digital and environmental policies may help avoid duplicate systems and clarify responsibilities. Pilot evaluation and independent scrutiny should determine whether expansion is warranted. The appropriate scale and governance model depend on the application.

7. Conclusion

Blockchain may support environmental trust by helping participants share records, trace provenance and detect later changes. Its contribution depends on reliable inputs and an appropriate connection between digital records and physical processes. It does not establish the truth of an environmental claim simply by recording it.

The proposed framework links five trust-related problems with possible ledger functions and the conditions needed for their use. The selected UAE and Jordan surveys provide contextual associations, while the circular supply chain model illustrates conditional incentives. Together, these sources motivate further investigation but do not validate the framework or demonstrate a regional environmental effect.

Future research could compare operational projects with feasible alternatives, examine data-assurance arrangements and track costs and environmental outcomes over time. Customer, supplier and regulator perspectives would help determine whether more accessible records improve trust and accountability in practice. For policy and management, the main task is to match the information problem with a proportionate technical and institutional response.

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