

From Digital Tools to Decision Instruments: A Triad-Based Framework for Management Digitalization

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Abstract. *In industrial organizations, digitalization is increasingly used to enhance managerial responsiveness and decision quality under conditions of volatility, cost pressure, and rising requirements for quality, safety, and sustainability. Although the literature on digital transformation, management control, and decision-making acknowledges that value emerges when information supports timely and actionable decisions, empirical results remain uneven and often fail to translate technology adoption into consistent improvements in decision performance. Existing studies frequently analyze dashboards, analytics, or decision tools in isolation, leaving under-specified how decision instruments jointly structure managerial action across different time horizons. This paper adopts a conceptual research methodology based on integrative literature synthesis and framework development. The central research question examines how management digitalization can be operationalized through a coherent triad of managerial instruments that supports both operational decisions and long-term decision consistency. The main result is a triad of managerial instruments: state snapshots, trend dashboards, and routinized Multi-Criteria Decision Analysis (MCDA). State snapshots provide near-real-time operational views that reduce decision latency. Trend dashboards stabilize indicator meaning and reveal trajectories for monitoring, learning, and anticipatory control. Routinized MCDA formalizes trade-offs in multi-objective decisions, improving transparency and comparability over time. Together, the triad connects short-term responsiveness with long-term decision sustainability. The paper presents a conceptual framework that reconceptualizes management digitalization as an integrated triad of managerial instruments rather than a collection of tools. It specifies how these instruments jointly shape managerial decision-making across time horizons, providing a basis for implementation and offering design-relevant guidance for industrial organizations.*

Keywords: management digitalization, managerial instruments, dashboards, Multi-Criteria Decision Analysis (MCDA), managerial decision-making, decision quality, digital transformation.

Introduction

Digitalization has become a decisive managerial issue for industrial companies (Verhoef et al., 2021; Vial, 2019) but despite major investments in Industry 4.0 technologies such as IoT, digital twins, analytics and integrated platforms, the outcomes remain uneven: many initiatives increase visibility and local automation without producing consistent improvements in managerial decision quality (Frank et al., 2019). This gap suggests that the central challenge is not technology presence, but the conversion of digitalization into a repeatable managerial capability.

This paper addresses the research gap by conceptualizing management digitalization through a *triad of managerial instruments* - state snapshots, trend dashboards, and routinized MCDA. Together they translate operational data into decision-ready outputs within broader digital transformation value-creation logics (Elia et al., 2024). The core argument is that digitalization

becomes decision-consequential when this triad is coherently designed and enacted to perform three interdependent functions: (i) state snapshots, which provide shared and timely views of current operating conditions to support rapid managerial responses (Hjelle et al., 2024; Yigitbasioglu & Velcu, 2012), (ii) trend dashboards, which stabilize and interpret performance trajectories over time through governed indicators (Hjelle et al., 2024; Yigitbasioglu & Velcu, 2012), and (iii) routinized MCDA, which structures recurring trade-off decisions in a transparent and comparable manner (Sahoo & Goswami, 2023). Evidence from dashboard research supports treating dashboards as managerial instruments rather than neutral outputs: visualization and presentation choices affect decision quality (Hjelle et al., 2024), usability characteristics shape decision support effectiveness (Almasi et al., 2023), and interactivity can strengthen managerial decision-making in operations contexts (Yigitbasioglu & Velcu, 2012). Building on an integrative synthesis of these streams, the paper develops a mechanism-based framework that connects operational processes and data infrastructure with the triad. Drawing on recent guidance for conceptualizing and studying causal mechanisms in organizational research (Cornelissen & Werner, 2025), it explains how the triad contributes to managerial value creation.

The research question examines how management digitalization can be operationalized through a coherent triad of managerial instruments that supports both operational decisions and long-term decision consistency.

By focusing explicitly on three instruments (state snapshots, trend dashboards, and routinized MCDA) the paper advances existing knowledge by conceptualizing management digitalization at the instrument level and by specifying how these instruments jointly structure decision-making across time horizons. In doing so, it offers a structured vocabulary and provides a foundation for developing testable propositions to guide empirical research and managerial design in industrial organizations.

Literature review

Contemporary research typically frames digitalization in industrial organizations as part of a broader digital transformation (DT): an organization-level change process in which digital technologies reshape value creation and operations, and in doing so trigger strategic and structural responses (new routines, redesigned processes, reconfigured decision rights) (Verhoef et al., 2021; Vial, 2019). However, the literature also reports uneven and context-dependent results, with many initiatives delivering incremental visibility and automation but failing to systematically improve managerial decision-making (Hanelt et al., 2021; Vial, 2019).

This state-of-the-art indicates a shift from “technology presence” to “value realization,” although it often leaves under-specified the precise mechanisms by which digitalization becomes a management capability rather than a technical asset.

Digitalization in industrial organizations: from technology presence to value realization

In industrial organizations, digitalization is often associated with Industry 4.0 and smart manufacturing and framed in terms of technology diffusion and integration, such as IoT, cyber-physical systems, digital twins, analytics, and enterprise-wide platforms (Frank et al., 2019; Verhoef et al., 2021; Vial, 2019). More recent research, however, shifts the focus from technology deployment alone to value realization, emphasizing that performance gains depend on the organizational ability to convert digital resources into better decisions and outcomes (Verhoef et al., 2021; Vial, 2019). Empirical evidence remains uneven: many initiatives improve visibility and

local automation without generating sustained performance improvements or consistently stronger managerial decision-making, while failure risks and implementation pitfalls remain significant (Hanelt et al., 2021; Verhoef et al., 2021; Vial, 2019). Thus, although digital transformation literature provides an important foundation, it is less explicit about the specific managerial instruments through which digital infrastructures become decision-consequential in everyday industrial contexts.

Management control and performance management: dashboards, KPIs, and control cycles

Management control and performance management literature provides detailed insight into how organizations steer performance through measurement systems, KPIs, dashboards, and control cycles (Franco-Santos et al., 2012). A configuration (“package/system”) perspective further indicates that control effectiveness depends on coherent bundles of interdependent controls rather than isolated reporting artifacts, emphasizing the importance of internal consistency, complementarities, and fit (Bedford et al., 2016).

Recent work also shows that digitalization is reshaping management control activities and instruments, requiring adaptations in how control is organized, performed, and analyzed in data-rich environments (Bhimani, 2020). Accordingly, in digital transformation discussions, dashboards are often treated merely as outputs of digital systems, whereas a management control lens implies that they become decision-consequential only when embedded in an explicit control logic (e.g., cross-level KPI coherence, review cadence, escalation rules, and governance that preserves indicator meaning over time) (Bedford et al., 2016; Franco-Santos et al., 2012).

Decision-making and MCDA: formalizing trade-offs

Decision-making research and Multi-Criteria Decision Analysis (MCDA) emphasize that managerial choices in industrial settings involve persistent trade-offs (e.g., cost, quality, time, risk, safety, flexibility, sustainability). MCDA formalizes these trade-offs by making criteria explicit, supporting weighting and structured comparison, and improving transparency and auditability (Rodríguez-Carrillo et al., 2025; Sahoo & Goswami, 2023). Digitalization is highly relevant here because industrial data architectures and integrated platforms can provide timely, granular evidence for multiple criteria simultaneously (Verhoef et al., 2021). However, MCDA is often positioned as a specialized analytical technique rather than institutionalized as a recurring managerial instrument embedded in digitalized routines (Rodríguez-Carrillo et al., 2025).

Synthesis and research gap: toward management digitalization as an integrated architecture

Across the reviewed literature, a common insight is that industrial digitalization creates value when it moves beyond technology deployment toward reliable decision support and sustained performance. However, the literature remains less explicit about the concrete managerial instruments through which digital infrastructures are translated into repeatable decision-making.

Digital transformation research emphasizes value realization but does not clearly specify these instrument-level mechanisms; management control research offers dashboards and KPIs, though these are often treated as reporting outputs rather than decision instruments; and MCDA research formalizes trade-off analysis, but rarely frames it as a recurring managerial instrument embedded in digitalized operations.

Building on this synthesis, the present study contributes to the digital transformation literature by proposing state snapshots, trend dashboards, and routinized MCDA as an integrated triad through which operational data are translated into decision-ready outputs across distinct time horizons.

Methodology

Research design and approach

This paper adopts a conceptual research methodology oriented toward theory building. Its core method is an integrative literature synthesis, combined with concept clarification and framework development, with the aim of deriving a coherent triad of managerial instruments for management digitalization. In line with conceptual research logic, the study draws on prior research from three related literature streams: (i) digitalization in industrial organizations and the shift from technology presence to value realization, (ii) management control and performance management, especially dashboards, KPIs, and control cycles, and (iii) decision-making and Multi-Criteria Decision Analysis (MCDA) as a means of structuring trade-offs.

The study is both problem-driven and function-oriented. It addresses why digitalization initiatives often produce uneven results when digital technologies are not translated into stable managerial instruments, and it examines what digitalization must accomplish to support managerial decision-making consistently in industrial contexts.

The central premise is that management digitalization becomes decision-consequential when it is operationalized through a triad of managerial instruments - state snapshots, trend dashboards, and routinized MCDA - that structure decisions across different time horizons. State snapshots support rapid operational response, trend dashboards support medium-to-longer horizon decisions by framing performance trajectories, and routinized MCDA supports recurring trade-off decisions through transparency, comparability, and consistency.

The framework is developed as a mechanism-based chain linking operational processes and data infrastructure to the triad of instruments, and from there to decision quality and managerial value. Core constructs are defined with an explicit view toward future empirical operationalization, while boundary conditions - such as weak governance, unstable indicator definitions, or decoupling from decision routines - specify when the triad may fail to improve decision outcomes.

Grounded in internal coherence and convergence across the reviewed literature streams, the framework culminates in a set of conceptual propositions (P1 - P6) supported through mechanistic plausibility, consistency with established research, and explicit boundary conditions.

Rigor and quality criteria

To strengthen rigor in the absence of primary empirical testing, the study applies established quality criteria for conceptual research. These include theoretical triangulation across the three literature streams underpinning the triad, construct precision through clear differentiation between snapshots, dashboards, and MCDA routines, explicit articulation of boundary conditions, and actionability of the conceptual output. The propositions are formulated in ways that support direct empirical operationalization in future research, for example through measures of decision latency, indicator coherence, governance maturity, and decision traceability.

Outputs of the methodology

The methodological approach generates four main outputs: (i) a conceptual framework centered on a triad of managerial instruments, (ii) an instrument-level architecture that operationalizes

management digitalization as decision infrastructure, (iii) a differentiation between short-term responsiveness and long-term decision sustainability as outcome pathways, and (iv) a set of propositions and boundary conditions to support future testing and practical application.

Results and discussions

Given its conceptual nature, the results take the form of a theoretically coherent framework and a set of propositions validated by argument.

The central result is the identification of *a triad of managerial instruments* - state snapshots, trend dashboards, and routinized MCDA - as a single instrumented architecture through which management decision-making becomes decision-consequential.

Proposed conceptual contribution: a triad of managerial instruments

The primary theoretical result is that digitalization produces managerial value not through data availability alone, but through the disciplined use of a triad of managerial instruments that structures decision-making across different time horizons.

The triad is defined as an integrated set of three managerial instruments - state snapshots, trend dashboards, and routinized MCDA - that jointly structure decision-making across short, medium, and long-term horizons through the integration of real-time operational views, trajectory-based decision framing, and structured trade-off resolution.

Each instrument addresses a distinct decision logic: state snapshots support immediate operational response, trend dashboards support trajectory-based decision framing over time, and routinized MCDA supports structured trade-off decisions. Collectively, these instruments enable organizations to achieve both short-term responsiveness and long-term decision sustainability.

State snapshots represent the first element of the triad. They are short-horizon, high-frequency representations of current operating conditions that support rapid decisions under volatility and disruption. Their contribution lies in reducing decision latency by stabilizing what counts as the “current operational state” and by embedding thresholds, accountability, and escalation logic into routine decision processes. This result is consistent with prior research showing that timely and clearly framed operational information improves managerial responsiveness (Hjelle et al., 2024; Yigitbasioglu & Velcu, 2012), but it extends the literature by emphasizing snapshots as governed decision instruments rather than mere real-time displays.

Trend dashboards constitute the second element of the triad and operate over a medium-to-longer horizon. They stabilize indicator definitions and reveal performance trajectories, thereby supporting monitoring, coordination, and learning across organizational levels. This finding aligns with management control research that treats dashboards as attention-directing and behavior-shaping devices rather than neutral reporting tools (Yigitbasioglu & Velcu, 2012). Empirical and review-based studies on dashboard design and usability show that visualization choices, clarity, and consistency materially influence decision quality and perceived complexity (Hjelle et al., 2024; Almasi et al., 2023), supporting the argument that dashboards must be designed and governed as managerial instruments rather than technical outputs.

Routinized Multi-Criteria Decision Analysis (MCDA) forms the third element of the triad and addresses decisions characterized by persistent trade-offs. The conceptual contribution here is not MCDA as an analytical method per se, but its institutionalization as a recurring managerial routine. Prior MCDA research emphasizes transparency and comparability in multi-objective decisions (Rodríguez-Carrillo et al., 2025; Sahoo & Goswami, 2023); the present framework

extends this insight by positioning routinized MCDA as a mechanism for decision sustainability, enabling organizations to stabilize decision rationales over time and support cumulative learning.

Conceptually, the triad constitutes a concrete causal pathway through which digitalization generates value by shaping decision effects. It clarifies why some digital transformation initiatives do not translate into improved managerial performance despite enhanced visibility. Conversely, when the three instruments are coherently designed and governed as information products - aligned with operational decisions and long-term decision consistency - they make improvements in decision quality as a predictable outcome rather than as an incidental by-product of technology adoption.

To enhance understanding of the proposed framework, Figure 1 provides a visualization of the triad, highlighting the distinct role of each instrument and their integration into a closed decision loop across time horizons.

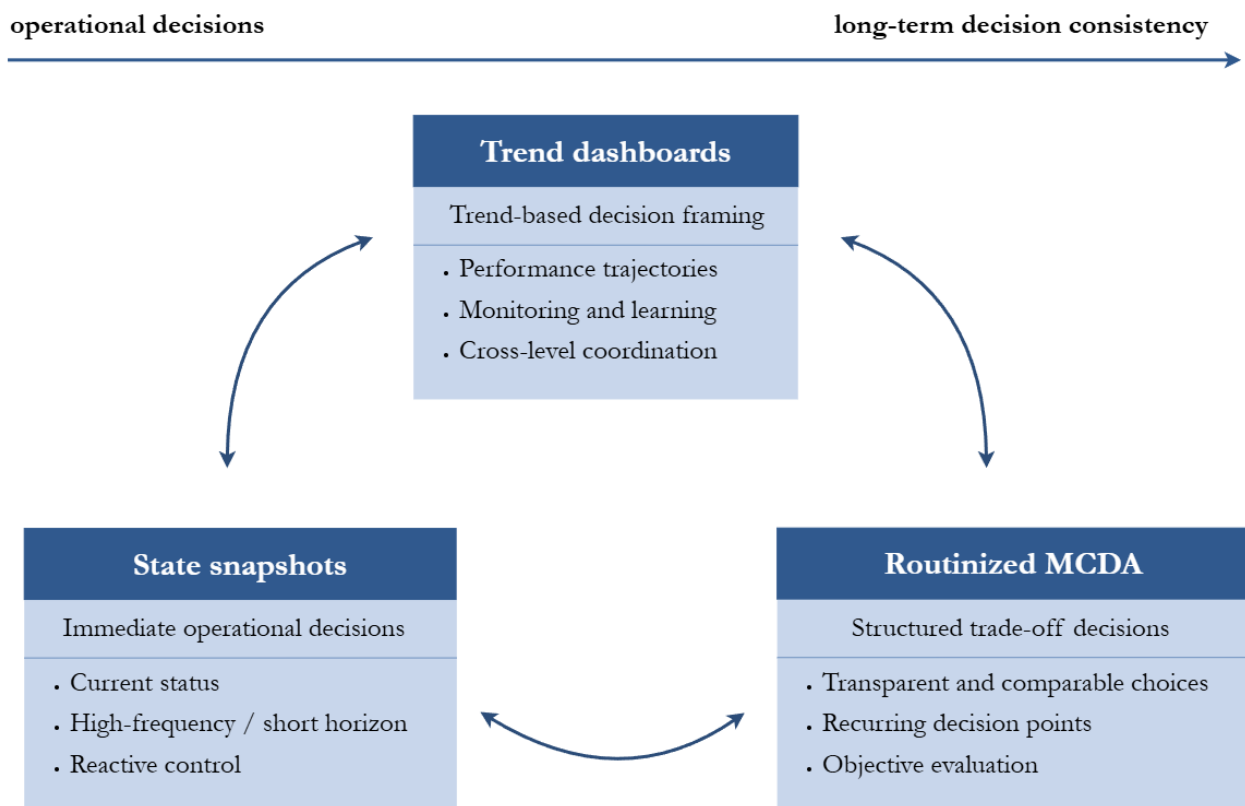


Figure 1. The triad of managerial instruments and their roles in structuring decision-making across time horizons

Source: Authors' own contribution.

As depicted in Figure 1, the proposed framework visualizes the triad as an integrated decision structure composed of three complementary managerial instruments - state snapshots, trend dashboards, and routinized Multi-Criteria Decision Analysis (MCDA). It highlights the distinct role of each instrument and illustrates, through bidirectional arrows, how their complementarities reinforce one another and jointly structure managerial decision-making across different time horizons within a closed decision loop.

The horizontal arrow from “operational decisions” to “long-term decision consistency” shows that the triad spans a temporal continuum - from immediate, operational decisions to consistent, sustainable decisions over time - and that each instrument occupies a distinct position on this continuum.

The curved bidirectional arrows indicate that the triad functions as a closed decision loop rather than as a set of isolated tools. State snapshots feed trend dashboards with operational signals; trend dashboards indicate when structured trade-off analysis (routinized MCDA) is needed; and MCDA outcomes, once implemented, shape the operational conditions that subsequently reappear in state snapshots. In this sense, the triad operates not only from data to decision, but also from decision to instrumentation: decisions influence what is measured, monitored, and acted upon. More specifically, routinized MCDA sets decision priorities, trend dashboards track the chosen criteria and targets over time, and state snapshots operationalize them through real-time thresholds, alerts, and exceptions, which may in turn trigger renewed trade-off decisions through routinized MCDA.

Overall, Figure 1 shows that managerial value does not come from any single instrument, but from their complementary use: state snapshots enable speed, trend dashboards enable direction and routinized MCDA enables consistency. Together, they transform digital data into a coherent digitalized decision infrastructure that links short-term action with long-term decision sustainability.

Illustrative application of the triad

Although conceptual, the framework can be illustrated through a typical industrial decision situation. Figure 2 presents a maintenance prioritization example, showing how state snapshots, trend dashboards, and routinized MCDA jointly structure decision-making.

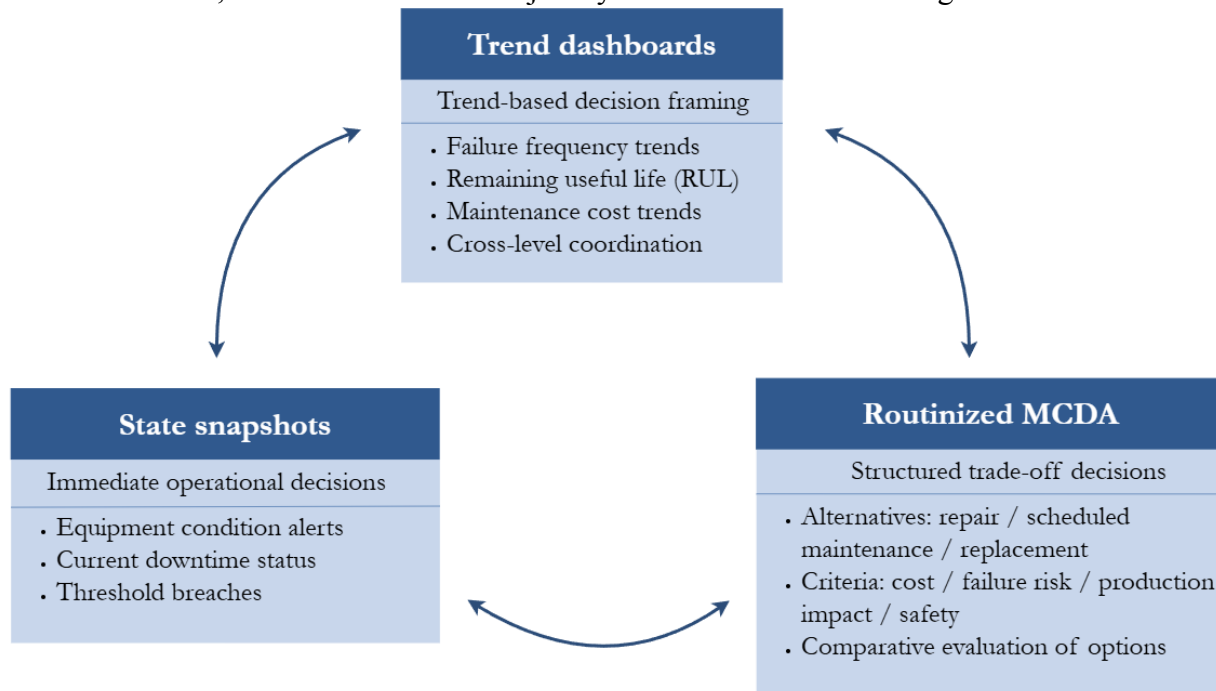


Figure 2. Illustrative application of the triad in maintenance prioritization

Source: Authors' own contribution.

As shown in Figure 2, state snapshots capture current equipment conditions, trend dashboards frame performance trajectories over time, and routinized MCDA supports the evaluation of alternative maintenance actions against explicit criteria. The figure also illustrates the closed-loop nature of the triad: MCDA outcomes, once implemented, shape the operational conditions that subsequently reappear in state snapshots.

Integration and comparison with related models

A key discussion point concerns the complementarity of the triad. Whereas much prior work treats dashboards, analytics, or decision techniques as stand-alone artifacts, the present framework argues that managerial value emerges when state snapshots, trend dashboards, and routinized MCDA are designed as an integrated set. Each instrument is necessary but insufficient on its own: state snapshots enable rapid operational action yet remain short-horizon and episodic; trend dashboards introduce temporal structure by framing trajectories and supporting learning, but they do not, by themselves, adjudicate competing objectives; and routinized MCDA formalizes trade-offs and stabilizes decision rationales, but it depends on stable and trusted inputs supplied by the snapshot and dashboard layers. The triad therefore explains how the weaknesses of any single instrument are offset through integration, resulting in a more coherent decision architecture across time horizons.

Relative to technology-centric Industry 4.0 or digital transformation accounts, the contribution shifts attention from the deployment of systems to the design of decision instruments that repeatedly structure managerial action. Relative to broader, high-level theorizing, the contribution is deliberately instrument-level: it specifies which instruments carry the decision logic and how they can be governed and combined. In this sense, the triad functions as an operational extension of existing perspectives by translating abstract aspirations - such as responsiveness, control, and decision sustainability - into concrete, observable, and designable managerial elements.

Implications and applicability

There are two theoretical implications of the triad. First, it clarifies why many digitalization initiatives generate visibility without sustained performance improvements: organizations may deploy individual instruments without integrating them into a coherent decision architecture. Second, it provides a basis for future empirical research by specifying instrument-level constructs that can be operationalized and tested.

From a practical perspective, the triad offers a design logic for structuring decision instruments in industrial organizations. When snapshots, dashboards, and MCDA are coherently designed and governed, they form a stable infrastructure that makes improvements in decision quality a predictable outcome, rather than an incidental by-product of digital technology adoption.

Propositions derived from the framework

The propositions specify the expected relationships and boundary conditions through which management digitalization, operationalized as a triad of managerial instruments, supports operational decisions and long-term decision consistency. The propositions focus on the distinct and joint effects of state snapshots, trend dashboards, and routinized MCDA, as well as on the contingencies and boundary conditions under which these effects are strengthened or weakened.

Proposition 1 (P1): Triad-based framework supports dual decision value

The extent to which the managerial triad - state snapshots, trend dashboards, and routinized MCDA - is coherently designed and governed is positively associated with adequate operational decisions to present conditions and decision sustainability over time.

Rationale. When the three instruments are consistently defined, trusted, and embedded in decision routines, they reduce ambiguity and delay in the short term while stabilizing learning, comparability, and anticipatory adjustment in the long term.

Proposition 2 (P2): State snapshots enhance operational responsiveness (contingent)

The use of high-frequency state snapshots reduces decision latency and improves responsiveness to unplanned events, contingent on clear decision rights and high data reliability.

Rationale. State snapshots accelerate the detection and escalation of deviations; however, their effect depends on unambiguous authority to act and on data that are sufficiently reliable to be treated as decision-relevant rather than merely informational.

Proposition 3 (P3): Trend dashboards support decision sustainability (contingent)

The use of trend dashboards improves decision sustainability by enabling trend-based decision framing, organizational learning, and anticipatory adjustment, contingent on indicator coherence across levels and formalized indicator governance.

Rationale. Trend dashboards support cross-period comparability and learning only when indicators carry stable meanings across organizational levels and are governed through explicit ownership, validation, and revision rules.

Proposition 4 (P4): Routinized MCDA enhance decision quality under trade-offs

The institutionalization of MCDA as a recurring managerial routine increases the consistency, transparency, and traceability of decisions involving competing objectives, particularly when criteria are linked to standardized, auditable, and comparable data sources.

Rationale. Routinized MCDA formalizes trade-offs and documents decision rationales, improving consistency and auditability over time; these benefits are strongest when underlying data and criteria are stable rather than contested or subjective.

Proposition 5 (P5): Integrated triad generates complementarity effects

The joint implementation of state snapshots, trend dashboards, and routinized MCDA as an integrated infrastructure delivers greater-than-additive improvements in adequate responsiveness and decision sustainability, compared with implementing these instruments in isolation.

Rationale. Integration links short-horizon operational awareness (state snapshots), medium-to-longer horizon decision framing (trend dashboards), and structured trade-off resolution (MCDA), compensating for the limitations of individual instruments and strengthening overall decision coherence.

Proposition 6 (P6): Boundary conditions constrain triad effectiveness

The positive effects proposed in P1 - P5 weaken or may become non-significant when the managerial triad is incomplete (limited coverage of critical processes), poorly governed (unstable indicator meanings or unreliable data), or decoupled from decision routines (unclear decision rights, escalation paths, or trade-off logic).

Rationale. Incomplete coverage undermines decision relevance, weak governance erodes trust and comparability, and decoupling prevents information from translating into action - each limiting the managerial value of the triad.

Practical applicability in industrial organizations

Although conceptual, the framework offers implications that are directly relevant for managerial design in industrial settings both as a diagnostic lens and as a design guide for management digitalization.

As a *diagnostic lens*, the triad helps organizations identify imbalances in their digitalization efforts - for example, overreliance on state snapshots for real-time visibility without sufficient trend dashboards for anticipatory decision framing or without routinized MCDA to govern recurring trade-offs. Such imbalances explain why increased data availability does not necessarily improve decision quality.

As a *design guide*, the framework supports the development of an integrated architecture in which state definitions and thresholds are governed for snapshots, performance trajectories and leading indicators are stabilized through dashboards, and MCDA is embedded as a recurring decision routine with clear decision rights and documentation standards. Five design principles follow: (1) start from recurrent decisions rather than systems; (2) ensure data trust through clear ownership and validation; (3) maintain indicator coherence across decision levels; (4) institutionalize MCDA as a routine for trade-off decisions; and (5) close the loop by monitoring outcomes and updating criteria and thresholds.

The framework is most applicable to industrial contexts characterized by repeatable processes and recurrent decisions, such as deviation management, production planning, maintenance, quality control, resource allocation, and investment evaluation. Implementation can be staged - beginning with state snapshots, followed by trend dashboards, and subsequently routinized MCDA - with continuous governance across all stages.

At the same time, implementing the triad may face important organizational and contextual challenges. Fragmented data infrastructures, low trust in indicators, unclear decision rights, limited analytical capabilities, and weak cross-functional coordination can reduce the effectiveness of state snapshots, trend dashboards, and routinized MCDA. Resistance may also arise when these instruments alter established routines, redistribute authority, or increase transparency around performance and trade-offs. For this reason, successful adoption depends not only on technical design, but also on organizational culture and change management. Cultures that support coordination, transparency, and continuous learning are more likely to institutionalize the triad effectively, whereas siloed or defensive cultures may limit its impact. In addition, the relative emphasis placed on the three instruments may vary across industries depending on process stability, regulation intensity, safety requirements, data maturity, and environmental volatility, requiring context-sensitive design and implementation.

Critical reflection and limitations

As a conceptual study, this paper cannot estimate effect sizes, causal magnitudes, or claim universal validity. The triad-based framework is most applicable where operational data are sufficiently reliable and timely to support state snapshots and trend dashboards, recurrent decisions can be formalized into routines (including criteria and escalation paths for routinized MCDA), and governance can sustain shared definitions and decision rights. Where data quality is weak, decisions are largely discretionary, or authority is fragmented, the triad should be treated mainly as a practical framework for analysis and design, rather than a predictive model.

Two risks are particularly relevant. First, unreliable data or unstable indicator definitions can lead to instrument distortion, generating conflicting signals, eroding trust in snapshots and

dashboards, and ultimately weakening trade-off decisions. Second, instrument overload may arise when snapshots, dashboards, alerts, and decision templates multiply without prioritization, increasing noise and administrative burden and slowing decision processes.

Overall, the implication is not “more measurement,” but well-governed, decision-linked instruments that preserve clarity, comparability, and disciplined use across the triad.

Conclusion

This paper proposes a triad-based conceptual framework for management digitalization in industrial organizations. Its main conceptual contribution is to specify a new instrument-level model built around three managerial instruments - state snapshots, trend dashboards, and routinized MCDA - through which digitalization becomes decision-consequential, shifting the emphasis from technology deployment to instrumented decision-making. Its theoretical contribution lies in linking this triad to the digital transformation literature by clarifying how digitalization creates value when translated into structured managerial decision instruments rather than treated as technology alone. The paper also offers an explanatory contribution by showing the mechanism through which the triad structures decision-making across time horizons, combining immediate operational response, trajectory-based decision framing, and structured trade-off resolution to connect short-term responsiveness with long-term decision sustainability.

From an application perspective, the framework can be used as both a diagnostic and a design guide. Firms can assess whether digitalization is over-focused on real-time visibility through state snapshots, while trend dashboards for trajectory-based decision framing or routinized MCDA for structured trade-off decisions remain underdeveloped. They can then design the triad through clear thresholds, governance arrangements, decision rights, and documentation standards. Typical use cases include deviation management, production planning, maintenance, quality control, resource allocation, and investment decisions.

Several limitations should be acknowledged. As a conceptual study, the framework does not provide empirical estimates of effect sizes or causal impacts; the propositions derived from the triad remain to be tested empirically. In addition, the framework is most applicable to settings with measurable processes, recurrent decisions, and sufficient governance to sustain shared definitions and decision rights. In contexts characterized by weak data quality, highly discretionary decision-making, or fragmented authority, the triad should be treated as a guiding framework rather than a predictive model.

Overall, the paper’s core implication is that industrial digitalization delivers sustained managerial value when it is designed and governed around a coherent triad of decision instruments. By aligning state snapshots, trend dashboards, and routinized MCDA within a single decision-and-control infrastructure, organizations can move beyond isolated visibility gains toward more consistent, transparent, and sustainable decision-making.

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