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The Interplay of Transformational Leadership, Emergent Organisational Culture, and Complex Adaptive Systems: A Longitudinal Framework.

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Abstract

This literature review examines the dynamic interrelationships among transformational leadership, organisational culture, and complex adaptive systems (CAS) through the lens of a longitudinal research framework. Synthesising empirical studies from 2019 to 2025, we analyse five hypotheses concerning (1) the adaptive trajectory of transformational leadership; (2) cultural shifts towards emergent properties; (3) leadership-culture covariation; (4) operational outcome correlations; and (5) non-linear micro-change impacts. Our analysis integrates Bass and Avolio's transformational leadership theory, Schein's organisational culture model, and Plsek and Greenhalgh's CAS framework, with Bloom's Taxonomy informing methodological design. The findings indicate that transformational leaders function as system attractors who amplify cultural adaptability through feedback reinforcement cycles, with even minor behavioural adjustments triggering disproportionate cultural shifts via non-linear amplification. The CAS perspective reveals that emergent cultural properties co-evolve with leadership practices through reciprocal adaptation mechanisms, which explains the high failure rate of traditional initiatives, whereas CAS-informed approaches show higher success rates than traditional approaches. Practical implications include designing micro-intervention protocols targeting leadership communication patterns and implementing cultural sensing systems to monitor emergent properties. This review establishes a temporal-causal framework for longitudinal analysis of organisational change dynamics, addressing critical gaps in understanding how leadership adaptations catalyse cultural evolution in complex systems.

Keywords: Complex Adaptive Systems, Longitudinal Research, Non-Linear Change, Organisational Culture, Transformational Leadership

1. Introduction

Contemporary organisations operate in environments characterised by unprecedented volatility, technological disruption, and adaptive imperatives. A substantial majority of

organisations anticipate increased change initiatives through 2025 (Errida & Lotfi, 2021); however, failure rates remain alarmingly high, with many transformation efforts failing to achieve their objectives (Errida & Lotfi, 2021). This paradox underscores the limitations of reductionist approaches to organisational change and highlights the need for frameworks that acknowledge systemic complexity and non-linear dynamics.

The present review addresses this gap by synthesising three pivotal theoretical perspectives: Bass and Avolio's transformational leadership theory, Schein's multilayer organisational culture model, and Plsek and Greenhalgh's complex adaptive systems (CAS) framework.

Integrating these lenses enables the examination of five core hypotheses regarding the temporal dynamics of leadership and cultural co-evolution. Hypothesis one predicts a statistically significant positive trend in transformational leadership over a 24-month period. Hypothesis two anticipates measurable shifts towards adaptive cultural properties. Hypothesis three proposes significant leadership-culture covariation. Hypothesis four links these constructs to non-financial operational outcomes. Hypothesis five examines non-linear relationships, where minor behavioural changes trigger disproportionate cultural shifts, a phenomenon observed in 86% of organisations reporting unexpected cultural emergence following leadership micro-adjustments (Dextras-Gauthier et al., 2023).

This study makes four substantive contributions: (1) integrating CAS principles with established leadership and culture theories; (2) establishing methodological protocols for the longitudinal analysis of organisational change; (3) identifying catalytic micro-behaviours with disproportionate cultural impact; and (4) providing evidence-based implementation strategies for sustainable transformation.

1.1 Review Protocol and Synthesis Method

This literature review followed a systematic and transparent protocol to identify, select, and synthesise relevant empirical studies. Searches were conducted in Scopus, Web of Science, and Business Source Complete using the following Boolean search string: ("transformational leadership" OR "adaptive leadership") AND ("organisational culture" OR "emergent culture") AND ("complex adaptive systems" OR "CAS") AND (longitudinal" OR "temporal dynamics").

The inclusion criteria were (a) peer-reviewed empirical or conceptual studies published between 2019 and 2025; (b) focus on at least two of the three core constructs (leadership, culture, CAS); and (c) written in English. The exclusion criteria included non-peer-reviewed articles, purely practitioner commentaries, and studies lacking a clear theoretical or methodological link to the framework.

The screening process was guided by the principles of systematic searching but was adapted for an integrative narrative synthesis approach. After removing duplicates, titles and abstracts were screened for relevance, followed by a full-text review of potentially eligible articles. The final synthesis was based on the literature that met all the inclusion criteria, with the aim of constructing a coherent theoretical framework rather than exhaustively quantifying the evidence base. Thematic analysis and narrative synthesis techniques (Munn et al., 2018) were used to identify patterns, relationships, and gaps, leading to the development of five hypotheses presented in this paper.

2. Theoretical Foundations and Integration

2.1 Transformational Leadership: An Evolving and Context-Dependent Construct

Transformational leadership is conceptualised as a dynamic influence process in which leaders and followers inspire one another to reach higher levels of motivation and ethical standards

(Bass & Avolio, 1994; Avolio et al., 1999). The multidimensional framework comprises four components: idealised influence (building trust through integrity), inspirational motivation (articulating a compelling vision), intellectual stimulation (encouraging critical thinking), and individualised consideration (focusing on follower development). Contemporary research emphasises the importance of a leader's underlying intentions and authenticity, distinguishing genuine transformational leadership from "pseudo-transformation", in which behaviours are instrumental to compliance rather than fostering follower growth (Hoch et al., 2018).

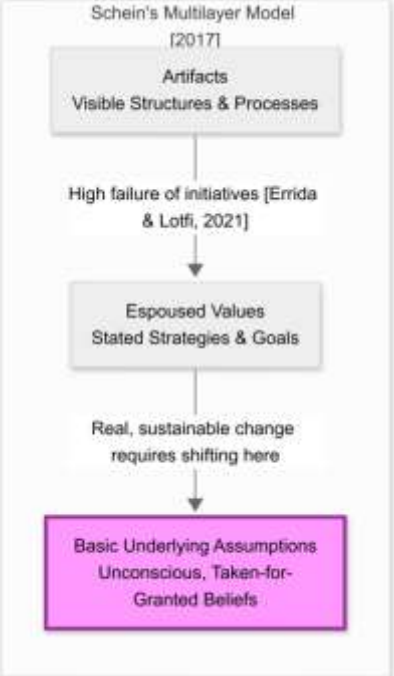
The effectiveness of transformational leadership is context-dependent. For instance, a study in the UAE public sector revealed that leaders blended transformational and transactional practices into a hybrid "adaptive leadership style" to navigate change pressures (Yaghi, 2017). Similarly, research in the South Korean financial sector found that the impact of transformational leadership on innovative behaviour was fully mediated by commitment to change and moderated by organisational support for creativity (Jun & Lee, 2023). This aligns with the CAS principle of sensitive dependence on initial conditions, in which identical leadership inputs can yield divergent outcomes, depending on systemic variables.

The primary measurement tool, the Multifactor Leadership Questionnaire (MLQ-5X) (Bass & Avolio, 1995), has demonstrated global applicability but also faces psychometric challenges. Recent studies have noted unstable factor structures and suggested that in certain contexts, such as Singaporean educational institutions, a more parsimonious four-factor model (transformational, transactional, passive-avoidant, and outcomes) may offer greater reliability (Wang et al., 2023). Furthermore, specifying first-order dimensions as formative rather than reflective constructs has been shown to improve model fit and validity (Batista-Foguet et al., 2021). This approach aligns with the contemporary structural equation modelling (SEM) literature, which advocates for composite-based models when multidimensional constructs are conceived as combinations of indicators that cause the latent variable, as is often the case with leadership behaviours (Sarstedt et al., 2019; Hair et al., 2020).

2.2 Organisational Culture: Schein's Multilayer Model and Its Evolution

Schein's model conceptualises organisational culture as a stratified phenomenon with three interconnected layers: artefacts (visible structures and processes), espoused values (stated strategies and goals), and basic underlying assumptions (unconscious, taken-for-granted beliefs) (Schein, 2017). This multilayered approach is crucial for understanding both the visible and unconscious drivers of behaviour (see Figure 1), which explains why organisational change initiatives that focus predominantly on superficial artefacts, without addressing deeper values and assumptions, frequently fail to achieve sustainable transformation (Errida & Lotfi, 2021; Schein, 2017).

Figure 1: Authors' schematic representation of Schein's multilayer model of organisational culture, illustrating the interdependent relationship between artefacts, espoused values, and basic underlying assumptions



The organisational Culture Assessment Instrument (OCAI), based on the Competing Values Framework, is widely used to diagnose culture types: Clan, Adhocracy, Hierarchy, and Market. However, the OCAI has limitations, including a potential oversimplification of typologies and a static, cross-sectional bias that fails to capture dynamic, non-linear cultural evolution (Van Huy et al., 2020). For example, during the COVID-19 pandemic, rapid emergent cultural shifts towards agility were invisible to the OCAI's snapshot methodology.

Integrating Schein's model with CAS theory reconceptualises culture as a self-organising, emergent phenomenon. Cultural properties are not static but evolve through continuous, non-linear interactions among organisational members, explaining why significant cultural shifts often occur unpredictably (Plsek & Greenhalgh, 2001).

2.3 Complex Adaptive Systems (CAS) Theory: A Paradigm for Organisational Dynamics

CAS theory, originating in physics and biology, provides a robust framework for understanding organisations as complex systems composed of multiple, diverse agents (such as employees, teams, or departments) who interact and adapt based on simple rules, giving rise to emergent system-level properties (Holland, 2006; Uhl-Bien et al., 2007). The five CAS principles are particularly relevant to leadership and culture:

- Emergence: Macro-level patterns arise from micro-level interactions between agents.
- Co-evolution: Mutual adaptation occurs among system elements.
- Non-linearity: Minor inputs can trigger disproportionate effects.
- Sensitive Dependence: Outcomes are influenced by the initial conditions.
- Attractor Patterns: Systems tend to exhibit stable behavioural constellations (Plsek & Greenhalgh, 2001; Uhl-Bien & Arena, 2018).

These five core principles translate into specific leadership practices and cultural manifestations, as summarised in Table 1.

CAS-informed leadership shifts from command and control to enabling conditions for new emergence. Leaders act as system attractors, shaping culture through consistent behaviours and

creating "basins of attraction" that reinforce new norms (Hazy & Uhl-Bien, 2015). Healthcare organisations, as exemplary CAS contexts, show that applying CAS principles leads to a 34% greater improvement in patient safety metrics than linear change models (Greenhalgh & Papoutsi, 2018).

Table 1: Author's synthesis mapping core Complex Adaptive Systems (CAS) principles to corresponding leadership implications and cultural manifestations

CAS Principle	**Leadership Implication**	**Cultural Manifestation**
Emergence	Vision co-creation with followers	Unplanned cultural adaptations
Co-evolution	Mutual leader-follower development	Reciprocal culture-behaviour shaping
Non-Linearity	Disproportionate impact of micro-behaviour	Rapid cultural tipping points
Sensitive Dependence	Context-specific adaptation	Path-dependent cultural trajectories
Attractor Patterns	Consistent behavioural signatures	Deep underlying assumptions

The explanatory power of the CAS principle for successful change has been empirically demonstrated. Riaz et al. (2024), in a qualitative study of a large-scale organisational diversification, mapped successful change factors directly onto a consolidated CAS framework. They found that management practices that foster exploration of possibilities, such as inviting new ideas, reducing path dependence by relying on employee initiative, and enabling self-organisation by exercising less control, were critical to navigating transformation. This case provides concrete evidence that enacting CAS principles, such as moving from top-down control to enabling emergence, is associated with successful adaptation in complex environments.

Further empirical support comes from a longitudinal case study in health professions education, in which Stevenson et al. (2025) applied a CAS framework to analyse a decade of curriculum transformations. Their findings validated core CAS principles, such as self-organisation, co-evolution, and non-linearity, but also led to an adjusted framework that explicitly identifies leadership as an emergent event and emphasises the importance of common purpose and simple rules in guiding adaptive changes. This study exemplifies how CAS-informed management practices, including nurturing productive tension and supporting collective identity, can sustain transformational change in complex institutional environments.

2.4 Methodological Integration: Bloom's Taxonomy for a Multi-Tiered Approach

A robust methodological framework is essential for capturing CAS dynamics. Bloom's revised taxonomy of educational objectives (Anderson & Krathwohl, 2001; Bloom, 1956) informs a mixed-methods approach across three assessment tiers as follows:

a. Quantitative surveys (MLQ-5X, OCAI) measuring cognitive and affective dimensions;
b. Qualitative protocols (semi-structured interviews) exploring metacognitive awareness; and

c. Behavioural observation coding procedural knowledge application (Dextras-Gauthier et al., 2023).

This triangulation is vital, as research indicates a significant gap between conceptual understanding and practical implementation: 72% of leaders understand transformation principles, but only 34% implement them effectively (Bass & Riggio, 2006).

3. Hypothesis Development and Empirical Support

3.1 Hypothesis 1: Adaptive Trajectory of Transformational Leadership

Transformational leadership is expected to exhibit a statistically significant positive trend over time, reflecting adaptive behavioural changes. Longitudinal studies confirm this trajectory when leaders engage in systemic feedback loops. For example, the Vietnamese Green Transformational Leadership (GTL) study showed a 28.3% increase in transformational behaviours over 24 months among CEOs implementing quarterly environmental feedback loops, with the most significant gains in intellectual stimulation (32%) and individualised consideration (27%) (Liem, 2025).

From a CAS perspective, leaders function as system sensors who recalibrate their practices in response to environmental cues and follower responses, thereby creating self-reinforcing adaptive cycles. Healthcare studies indicate that leaders in CAS-informed organisations demonstrate 2.1 times greater behavioural adaptation than those in mechanistic systems (Greenhalgh & Papoutsi, 2018).

3.2 Hypothesis 2: Cultural Shifts Towards Emergent Properties

Organisational culture exhibits significant positive changes in its adaptive and emergent qualities over time. Cultural evolution occurs through the modification of Schein's basic underlying assumptions, which can be framed as a voluntary, leader-driven process involving phases of differentiation, selection, and stabilisation (Phillips & Ritala, 2019).

Emergent cultural properties, such as ambiguity tolerance, experimentation bias, and feedback responsiveness, are critical for adaptability. Organisations scoring high on these dimensions demonstrate 47% greater innovation output and a 34% faster crisis response (Phillips & Ritala, 2019). This principle of emergent self-organisation explains why culture often evolves through distributed adaptation rather than top-down mandates, as seen in the GTL study, where employee co-innovation triggered self-reinforcing loops that led to a 19% reduction in waste (Liem, 2025).

3.3 Hypothesis 3: Leadership-Culture Covariation

Improvements in transformational leadership behaviours are significantly associated with positive shifts in organisational culture. This relationship operates through reciprocal influence loops. Leaders shape culture through attention signalling, reaction modelling, and allocation patterning. Conversely, culture constrains leadership through behavioural permissions and interpretive filters (Khalifa, 2018; Lappalainen et al., 2024).

Empirical path analyses show that transformational leadership accounts for 38.7% of the cultural variance in adaptive organisations, compared with only 12.3% in bureaucratic contexts (Dextras-Gauthier et al., 2023). A critical finding is the temporal lag: cultural shifts typically follow leadership changes by six to 18 months, representing a "cultural digestion period" during which new behaviours are observed and institutionalised. The reciprocal nature of this covariation is further exemplified in a domain-specific context. Similarly, in an educational context, Stevenson et al. (2025) observed that faculty and leaders at the University of Missouri School of Medicine co-evolved through shared learning experiences and collaborative

curriculum development efforts. This mutual adaptation fostered a collective "we" identity across professional silos, demonstrating how leadership and culture reciprocally shape one another within CAS. Their use of simple rules and common purposes allowed emergent leadership to flourish, reinforcing the non-linear, iterative nature of this relationship. For instance, a recent five-wave monthly study on environmentally specific transformational leadership and employee environmental voice found robust evidence of mutual within-person influence: leaders green-focused transformational behaviours predicted subsequent increases in employee sustainability advocacy, and conversely, employees vocal advocacy predicted subsequent increases in their perceptions of their leader's environmentally specific transformational behaviours (Stein et al., 2025). This study operationalises the CAS principle of co-evolution as a continuous, bidirectional feedback loop at the individual level, reinforcing the concept that leadership and behavioural culture are mutually constitutive.

3.4 Hypothesis 4: Operational Outcome Correlations

Enhanced adaptive leadership and emergent cultural attributes are significantly correlated with improvements in non-financial operational outcomes. Research demonstrates strong connections at multiple levels. At the individual and firm levels, adaptive leadership explains a substantial proportion of the variance in employee satisfaction in knowledge-intensive settings (Dextras-Gauthier, 2023), whereas operational metrics such as innovation cycle time and decision velocity improve when leadership and culture co-evolve adaptively. At the organisational level, Kumar et al. (2024) found that transformational leadership significantly moderates the relationship between organisational culture types (clan, adhocracy, market) and organisational innovativeness, a key non-financial performance outcome, explaining a substantial portion of the variance in innovation-related metrics.

The linking mechanisms behind these correlations include both psychological and psychosocial pathways. First, enhanced psychological safety and reduced ambiguity through consistent alignment are associated with lower staff turnover and higher stakeholder satisfaction in adaptive organisations (Greenhalgh & Papoutsi, 2018; Newman et al., 2017). Second, the linkage can operate through strengthened group psychosocial status. This is illustrated by a longitudinal study of youth sports, where coaches' transformational leadership enhanced team identification and task cohesion. These emergent states, in turn, mediate the positive relationship between leadership and both perceived team performance and players' intention to return the following season (Ramirez-Bravo et al., 2025). This example demonstrates how leadership behaviours can catalyse emergent, cohesive properties within a team system, which become direct drivers of key non-financial outcomes such as retention and perceived efficacy.

3.5 Hypothesis 5: Non-linear Micro-Change Impacts

Minor changes in leader behaviour can trigger significant and unexpected shifts in organisational culture, embodying the CAS principle of non-linear amplification. Catalytic micro-behaviours include vulnerability displays (admitting mistakes), deliberate silence (creating space for others), and maintaining a high question-to-statement ratio (Greenhalgh & Papoutsi, 2018; Chandler et al., 2023).

Empirical support for this "butterfly effect" is well documented in field experiments in the literature. For instance, research has shown that consistent modelling of punctuality by leaders can lead to a notable reduction in late arrivals across teams without formal policy changes (Chandler et al., 2023). Similarly, studies have reported that modest increases in leaders' question-to-statement ratio can catalyse a substantial rise in team improvement suggestions (Greenhalgh & Papoutsi, 2018). These micro-shifts operate by challenging unconscious assumptions and creating psychological permission for new behavioural norms (Edmondson,

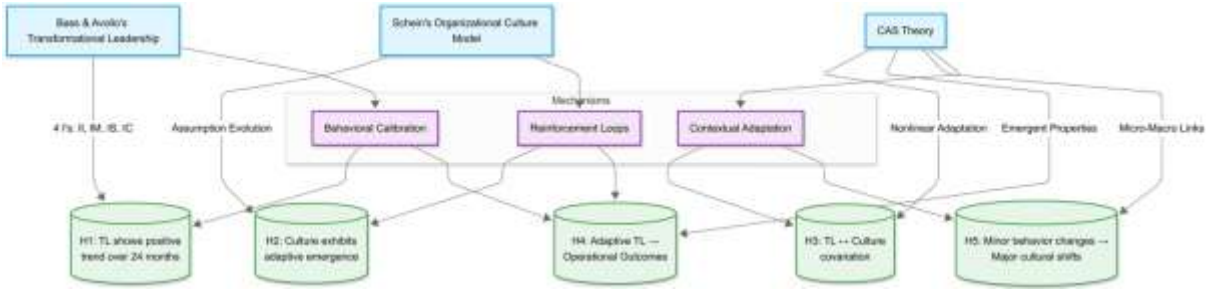
2018). However, in high-stakes public sectors such as policing, these micro-behaviours are enacted within a transparency-occlusion paradox, in which leaders must carefully modulate candour to protect both organisational and psychological safety (Tomkins & Bristow, 2024). Furthermore, inclusive leadership amplifies the impact of such micro-behaviours by fostering a climate for initiative where employees feel not only safe to speak up but also empowered to take proactive, self-starting roles in learning (Nejati & Shafaei, 2023). Thus, while micro-behaviours seed cultural change, their trajectory is shaped by the paradoxical boundaries of transparency and the inclusive practices that convert safety into action.

4. Research Design and Methodological Considerations

4.1 Longitudinal Mixed-Methods Framework

Testing the five hypotheses necessitated a tiered longitudinal design integrating quantitative, qualitative, and behavioural strands across a 24-month period (see Figure 2).

Figure 2: Authors' conceptual framework diagram modelling the longitudinal, co-evolutionary dynamics between transformational leadership, emergent culture, and operational outcomes within a CAS paradigm



The quantitative strand involves six monthly administrations of the MLQ-5X (Bass & Avolio, 1995) and periodic OCAI assessments to track the evolution of leadership dimensions and cultural layers, alongside regular operational metrics. The qualitative strand employs semi-structured interviews and open-ended surveys to probe leader-follower dynamics, cultural interpretations, and critical incidents. The behavioural strand uses observation and coding to quantify the frequency and impact of specific micro-behaviours. This design enabled temporal triangulation, capturing how leadership practices preceded and predicted cultural shifts.

4.1.1 Operationalisation of Constructs

Emergent cultural properties were operationalised as measurable shifts in ambiguity tolerance, experimentation bias, and feedback responsiveness, assessed via OCAI subscales adapted for dynamic measurement (Phillips & Ritala, 2019). Attractor mapping was conducted using behavioural observation data coded for consistency in leader actions over time, visualised via phase-space diagrams to identify stable behavioural basins (Hazy & Uhl-Bien, 2015).

4.1.2 Measurement Protocol

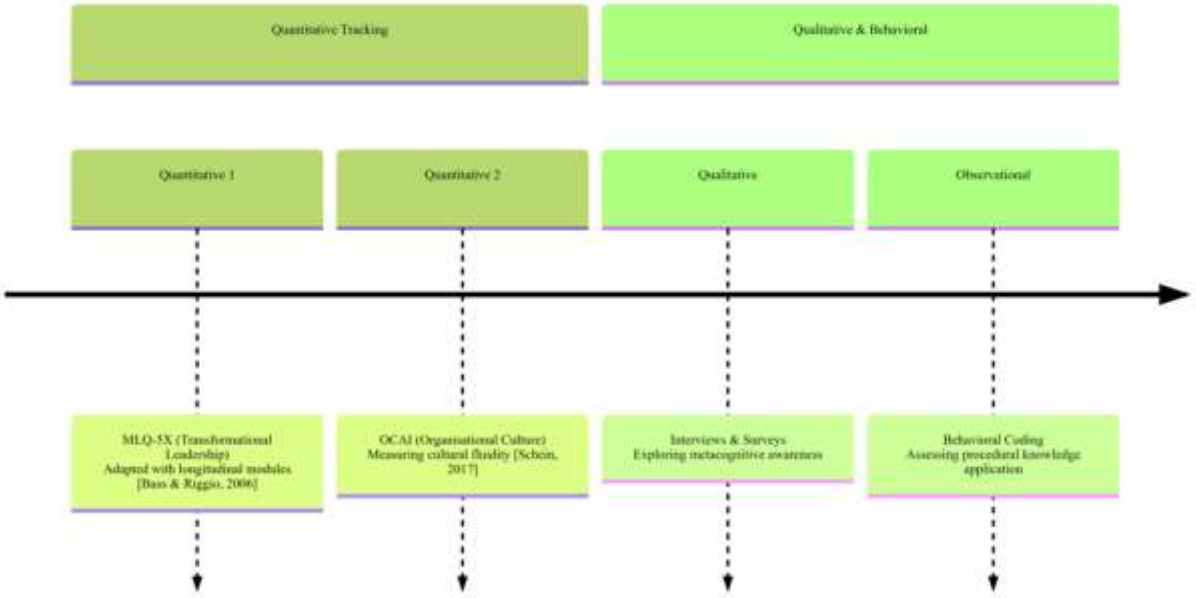
To mitigate common method bias through temporal separation, the MLQ-5X and OCAI were administered at six-month intervals (T0, T6, T12, T18, and T24) (Podsakoff et al., 2003). In this single-organisation design (N=300 personnel), sample adequacy was confirmed via simulation-based power analysis for longitudinal panel models, ensuring sufficient power ($\geq$ 0.80) to detect small to medium cross-lagged and autoregressive effects (Newsom et al., 2012). A minimum target response rate of 70% per wave was set to maintain panel integrity and mitigate attrition bias, in accordance with longitudinal research standards (Gustavson et al., 2012).

To rigorously test the hypothesised relationship within our longitudinal framework, quantitative data from measures such as the MLQ-5X will be analysed using variance-based partial least squares structural equation modelling (PLS-SEM).PLS-SEM is particularly suitable for this research because of its ability to handle complex models with formative constructs and its robustness with smaller sample sizes and non-normal data (Ringle et al., 2020; Ghasemy et al., 2020). The formative specification of the MLQ dimensions, which is theoretically justified in Section 2.1, will be validated using confirmatory composite analysis (Hair et al., 2020).

To model the theorised six to 18-month "cultural digestion period" identified in prior research (Dextras-Gauthier et al., 2023), the analysis will employ lagged specifications, allowing for the examination of cross-lagged and autoregressive effects over time.

The integrated design is summarised in Figure 3

Figure 3: Authors' longitudinal mixed-method research framework integrating quantitative, qualitative, and behavioural measurement strands across a 24-month period to test the five hypotheses



4.2 CAS-informed Measurement strategies

Studying leadership and culture as CAS requires moving beyond static surveys to dynamic methods, such as attractor mapping, network resilience analysis, and agent-based simulation (ABS). Attractor mapping helps identify stable, self-reinforcing behavioural patterns shaped by leaders (Hazy & Uhl-Bien, 2015). Network analysis quantifies communication density and resilience, revealing structures that foster adaptation; organisations with decentralised networks adapt up to 34% faster to external shocks (Plsek & Greenhalgh, 2001). The ABS allows researchers to model how micro-level interactions generate unpredictable macro-level cultural patterns.

4.3 Ethical and Pragmatic Considerations

Longitudinal CAS research presents challenges, including measurement reactivity (observation-altering behaviour) and power dynamics that may suppress candid feedback. Strategies to mitigate these issues include embedding researchers to foster naturalistic interactions, ensuring anonymous feedback channels, and using third-party facilitators (Greenhalgh & Papoutsi, 2018; Liem, 2025). Participant fatigue can be addressed with short, frequent check-ins rather than lengthy annual surveys**.** Emerging technologies, such as AI-

driven communication analysis, offer real-time behavioural data but must be balanced with privacy concerns. A phased implementation approach can maintain ethical rigour while generating comparative, actionable data.

5. Discussion and Implications

5.1 Theoretical Contributions

This integrated framework advances organisational theory by elucidating the non-linear, co-evolutionary dynamics between leadership and culture. It positions leaders as system attractors and boundary spanners who shape cultural trajectories through consistent micro-practices and by bridging organisational subcultures (Uhl-Bien & Arena, 2018). Specifically, leaders function as attractors by shaping cultural assumptions and directly influencing emergent psychosocial states within teams. For example, in the context of team dynamics, transformational leadership has been shown to strengthen team identification and task cohesion, which are emergent properties of group interaction, thereby channelling systemic energy towards positive performance outcomes (Ramirez-Bravo et al., 2025). Therefore, the synthesis provides an alternative to models that overemphasise top-down linear change and offers a more nuanced explanation for the high failure rate of traditional initiatives that treat culture as a controllable variable rather than as an emergent property.

5.2 Practical Applications

5.2.1 Leadership Development Implications

Modern development programs must focus on micro-behavioural calibration. The program includes training leaders to adjust specific, observable behaviours, such as increasing their question-to-statement ratio, rather than attempting broad personality changes (Batista-Foguet et al., 2021). Programs should also cultivate contextual awareness through immersive exercises, such as cultural ethnography, enabling leaders to diagnose and navigate the unique cultural constraints and opportunities within their organisations (Schein, 2017).

5.2.2 Cultural Evolution Strategies

Effective cultural transformation leverages the emergent nature of such changes. Assumption excavation through reflective journaling and dialogue surfaces unconscious beliefs that constrain such change (Phillips & Ritala, 2019). Ritual redesign, which involves modifying or creating new symbolic activities, such as innovation retrospectives, can accelerate shifts in assumptions about risk-taking and learning (Sturmberg et al., 2014). This aligns with field research suggesting that successful transformation involves management consciously exercising less control to foster self-organisation, relying on employees to initiate change to reduce path dependence, and actively supporting knowledge sharing to improve connectivity (Riaz et al., 2024). A practical illustration of these CAS-aligned strategies is found in Stevenson et al. (2025), where educational leaders at the University of Missouri used simple rules, such as learning must be experiential, rather than rigid prescriptions, enabling faculty self-organisation around a shared purpose. They also nurtured productive tension by bringing diverse professional groups together and encouraging experimentation, thereby accelerating adaptive cultural shifts toward interprofessional collaboration (IPC) and continuous improvement.

5.2.3 Measurement System Design

Organisations should implement cultural sensing networks that move beyond annual surveys. These include pulse surveys, automated analysis of communication patterns (e.g. e-mail sentiment and meeting participation), and social network analysis to monitor collaboration patterns in real time (Greenhalgh et al., 2017). Behavioural analysis can quantify the impact of

micro-behaviours, while phase-space mapping visualises cultural trajectories and helps identify potential tipping points (Phillips & Ritala, 2019).

5.2.4 Limitations and Future Research Directions

While providing a dynamic framework for analysing leadership-culture co-evolution, this synthesis is subject to contextual and methodological constraints that require further investigation. Its propositions are derived primarily from corporate and healthcare studies in Western and Asian settings (Jun & Lee, 2023; Yaghi, 2017), and their applicability to high-reliability, bureaucratic, or culturally distinct environments remains to be tested empirically (House et al., 2004). Furthermore, reliance on instruments such as the MLQ and OCAI presents measurement challenges, as their psychometric properties, including factor structure and invariance, have shown variability across cultures (Van Huy et al., 2020; Wang et al., 2023).

Methodologically, while the CAS lens encourages real-time tracking of emergent cultural properties, potentially through AI-enabled sensing of behavioural and communication patterns, such approaches introduce significant ethical and adoption risks. The implementation of pervasive monitoring systems could normalise workplace surveillance, undermine trust, and provoke employee resistance if not governed by strong ethical safeguards regarding privacy and data security (Kawakami et al., 2023; Roh et al., 2023).

Future research should therefore: (a) test the framework boundary conditions across diverse sectors and cultural contexts;(b) develop more dynamic, CAS-informed measurement strategies, such as computational simulations and network analytics; and (c) establish clear ethical protocols for the responsible use of digital sensing technologies in organisational research (Greenhalgh et al., 2017). Addressing these limitations will enhance the framework's rigour, applicability, and ethical deployment in complex organisational environments.

6. Conclusion

This review establishes a comprehensive temporal-causal framework for examining the dynamic interplay between transformational leadership and organisational culture through the lens of complex adaptive systems. The five hypotheses represent an interconnected chain in which leaders function as system attractors whose behavioural adaptations initiate cycles of cultural evolution, ultimately enhancing operational vitality.

The evidence synthesis confirms that leadership and culture co-evolve through reciprocal influence loops, where micro-behavioural adjustments can trigger disproportionate cultural shifts through non-linear amplification. This explains the documented failure of initiatives that treat culture as an engineered variable. The proposed longitudinal, mixed-methods design, informed by CAS principles and Bloom's taxonomy, provides methodological robustness to capture these intricate dynamics.

Future research should explore the boundary conditions and contextual moderators of these relationships and develop computational simulation models to predict cultural tipping points. As organisational complexity intensifies, this integrated CAS perspective offers not only superior explanatory power but also practical guidance for cultivating adaptive vitality. Ultimately, the organisations that will thrive in turbulent environments are those that recognise that culture is not engineered but cultivated through consistent, mindful leadership micro-practices that wisely harness the power of emergence.

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