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Opinion

Paradigms, Structures, and Simulations: Advancing Theory Building and Model Testing in Management Science

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Abstract. The growing complexity of managerial phenomena and the interdisciplinary nature of management science call for more coherent methodological frameworks for theory building and model testing. While management science draws from both technical and social disciplines, its theoretical development remains fragmented and often lacks methodological integration. Previous studies have highlighted inconsistencies between paradigmatic assumptions, modelling strategies, and empirical validation, particularly in the treatment of latent variables. Despite the broad adoption of structural equation modelling (SEM), its potential for bridging theory and empirical evidence in dynamic and virtual contexts remains underexplored. This study aims to conceptualise an integrative approach that connects paradigmatic foundations, structural modelling, and simulation-based testing within virtual environments. By analysing classical and contemporary management paradigms — including functionalist, interpretative, critical, and postmodern perspectives — the paper identifies methodological challenges in aligning theoretical reasoning with empirical analysis. The methodological framework combines SEM procedures, such as confirmatory factor analysis and model fit evaluation, with the use of virtual and simulation-based environments as experimental spaces for theory validation. The findings emphasise that virtual environments enable real-time experimentation, allowing for the iterative refinement of theoretical models under controlled digital conditions. These spaces enhance the reflexivity and reproducibility of management research by enabling researchers to observe the interaction between theoretical constructs and simulated organisational processes. The integration of SEM with simulation techniques demonstrates how theoretical constructs can be dynamically tested and adjusted through virtual modelling. The study concludes that theory building in management science benefits from combining paradigmatic reflection, structural modelling, and virtual experimentation. This triadic framework promotes methodological pluralism, computational adaptivity, and deeper theoretical coherence, suggesting that virtualised modelling environments may become essential tools for future management research and education.

Keywords: management theory; model testing; structural equation modelling; confirmatory factor analysis; research methodology; epistemological paradigms; virtual environments.

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1. Introduction

Management science occupies a unique position at the intersection of technical, social, and behavioural disciplines. It draws upon theories originating in engineering, economics, psychology, and sociology to explain and optimise organisational phenomena. However, this interdisciplinary character, while enriching the field, also creates methodological tension and theoretical fragmentation. As Sułkowski [1] observes, management as a practical and cognitive science faces the dual challenge of defining its epistemological identity and developing consistent methods of inquiry that can meaningfully integrate diverse paradigms and modelling approaches.

The growing complexity of organisations and the diversity of managerial phenomena have intensified the need for an open and pluralistic research perspective that combines multiple methodological and theoretical traditions [2]. Traditional approaches—often rooted in functionalist or positivist paradigms—are insufficient to capture the multi-level, dynamic, and context-dependent nature of modern organisational systems. Researchers increasingly acknowledge that theory building in management science must rely on a mixed methodological foundation, combining qualitative, quantitative, and simulation-based strategies to provide comprehensive answers to research questions.

At the core of this methodological evolution lies the problem of how to empirically test theories that are constructed upon abstract, latent, or unobservable concepts. As Światowiec-Szczepańska [3] notes, management theories frequently operate at a level of conceptual abstraction that resists direct observation. This creates fundamental challenges for empirical validation and demands analytical tools capable of linking theoretical constructs with observable indicators. Structural Equation Modelling (SEM) and confirmatory factor analysis have emerged as powerful methods that allow the simultaneous testing of measurement and structural models, integrating theoretical reasoning with statistical verification [4, 5].

Yet, even the sophistication of these methods does not fully resolve the issue of theoretical adaptability and model validation in dynamic organisational contexts. The increasing digitisation of management processes and the rise of virtual environments—including simulation platforms and digital twins—open new avenues for methodological innovation. Virtual environments provide controlled, replicable, and interactive spaces for theoretical experimentation, enabling researchers to construct, test, and iteratively refine models under variable, yet systematically observable, conditions. They thus represent a bridge between abstract theoretical frameworks and empirical realities, offering an adaptive infrastructure for theory testing and refinement.

In this light, the process of theory building in management science must evolve beyond the traditional dichotomy between deduction and induction. It should embrace a reflexive and integrative approach, combining paradigmatic analysis, structural modelling, and virtual experimentation. Such an approach allows researchers to validate conceptual models not only through statistical fit indices and latent variable testing but also through simulated, real-time organisational dynamics.

The present paper contributes to this ongoing discussion by examining how paradigmatic pluralism, structural modelling techniques, and virtual simulation environments can collectively advance theory building and model testing in management science. By linking epistemological paradigms with methodological innovations, this study seeks to conceptualise a coherent framework that connects theoretical abstraction, structural validation, and digital experimentation. In doing so, it addresses one of the central challenges identified by contemporary scholars: how to construct and empirically test management theories that are both conceptually rigorous and contextually adaptive.

2. Literature Review

Traditional management science has historically focused on solving specific organisational and operational problems, often at the expense of broader theoretical and epistemological reflection. As Sułkowski [6] notes, management as an academic discipline must confront questions similar to those faced by other social sciences—concerning its identity, theoretical foundations, and methodological coherence. A scientific theory, understood as a logically consistent and empirically grounded system of generalisations, must rely on inference from verified facts, internal consistency, and cumulative progress of knowledge. Yet, management science remains divided between theoretical plurality and methodological inconsistency, oscillating between descriptive practice and scientific formalism [6].

The classification of theories within management science has been widely debated. Frankfort-Nachmias and Nachmias [7] distinguished between macro-, meso-, and micro-level theories according to their generality and scope. Macrotheories (e.g. Porter [8]; Fayol [9]; Ackoff [10]) attempt to explain systemic or strategic regularities, while mesotheories and microtheories address mid-range and individual-level phenomena, respectively [11]. However, as Sułkowski [6] emphasises, it remains difficult to identify fully developed theoretical systems in management comparable to those in mature social sciences.

Parsons and Shils' classical typology—ranging from ad hoc theories to full theoretical systems—remains useful for assessing the developmental stage of management theory. Nevertheless, in practice, most management frameworks correspond to taxonomies or conceptual structures rather than formalised theoretical systems, reflecting the field's applied and multi-paradigmatic character.

Kuhn's [12] concept of paradigms as historically contingent yet collectively accepted systems of thought is particularly relevant for understanding management theory. The field exhibits significant paradigmatic fragmentation, encompassing contradictory, integrative, and cross-paradigmatic relationships [6, 13]. Burrell and Morgan's [14] four-paradigm model—functionalist, interpretative, radical structuralist, and radical humanist—remains the dominant analytical framework, later adapted by Sułkowski [6] and others for the management sciences.

Sułkowski proposed refinements reflecting contemporary management thought [6]:

- the neopositivist-functionalist-system paradigm, oriented toward quantitative verification and system integration;
- the interpretative-symbolic paradigm, grounded in subjectivity, meaning, and qualitative exploration;

- the radical structuralist paradigm, focusing on systemic transformation and critical realism;
- the radical humanist (postmodernist) paradigm, characterised by subjectivism, anti-foundationalism, and cultural relativism.

Complementary frameworks, such as Hatch's [15] typology (modernist, classical, postmodernist, and interpretative-symbolic) and Johnson and Duberley's [16] cognitive reflection model (positivism, conventionalism, pragmatism, postmodernism), illustrate how management knowledge has evolved from functionalist objectivism to epistemological pluralism. Bolman and Deal [17] extended this pluralism to the organisational level, proposing four interpretive "frames"—structural, human resource, symbolic, and political—that reveal different facets of organisational reality.

Together, these frameworks confirm that management science is not monolithic but multi-paradigmatic, characterised by competing epistemological foundations and research traditions. This diversity, while intellectually rich, also creates difficulties in achieving cumulative knowledge and unified theory building [18].

According to Babbie [19], theory building follows either an inductive or deductive trajectory; however, in practice, management research almost always adopts a mixed, iterative process. Sułkowski [6] identifies four strategies of theory formation:

1. Pure functionalism, oriented toward quantitative, system-based verification;
2. Pure interpretivism, focusing on qualitative understanding and contextual analysis;
3. Epistemological pluralism, which combines paradigmatic assumptions to achieve coherent synthesis;
4. Epistemological eclecticism, which tolerates contradiction and cognitive diversity.

This evolution toward pluralism has paved the way for integrative methods such as Structural Equation Modelling (SEM), which combines theory construction with empirical verification. SEM allows researchers to model relationships among latent variables, aligning theoretical reasoning with statistical evidence. Światowiec-Szczepańska [3] highlights that SEM bridges abstract theoretical concepts and empirical data, offering a rigorous yet flexible structure for model testing.

While structural equation modelling (SEM) and related analytical techniques have become standard tools for model testing in management science, they remain largely static—dependent on predefined datasets and linear causal assumptions. Recent methodological developments point toward virtual environments and simulation-based models as means of overcoming these limitations. Simulation enables iterative experimentation, allowing theories to be dynamically tested and refined under changing contextual conditions [4, 5].

The use of virtualisation extends the empirical reach of management research by creating controlled, interactive, and replicable spaces for testing theoretical assumptions. Within these digital environments, researchers can examine feedback loops, emergent behaviours, and complex interdependencies that conventional statistical models often fail to capture. This marks a methodological shift from static verification toward computational experimentation, aligning management science with broader trends in digital research and systems thinking.

Importantly, simulation and virtual modelling also foster epistemological reflexivity, allowing scholars to explore how paradigmatic assumptions shape model construction, analytical logic, and interpretation of results. In this sense, simulation contributes not only to methodological innovation but also to philosophical depth, supporting Sułkowski's [6] argument for greater methodological coherence within paradigmatic pluralism. By linking epistemological awareness with empirical testing, virtual experimentation helps to reconcile theoretical abstraction with practical inquiry.

Building on this perspective, simulation and computational modelling have emerged as essential methodological instruments in contemporary management research, offering environments in which theoretical assumptions can be dynamically tested, refined, and validated. These virtual and mathematical frameworks enable researchers to explore causal mechanisms and organisational dynamics that are otherwise inaccessible to direct observation, thus bridging the persistent gap between conceptual theorising and empirical verification.

Kabak et al. note that despite its growing methodological sophistication, simulation modelling in operations and management studies remains largely dominated by positivist paradigms [20]. Their review of 53 studies revealed that forty adhered to classical positivist approaches, while only a small number employed post-positivist or design-science orientations. Although simulation offers substantial potential for theoretical advancement—particularly in generating conceptual frameworks and technological rules—its philosophical and reflexive dimensions remain underexplored. The authors therefore advocate for stronger practitioner engagement, external validation, and a more explicit integration of simulation with post-positivist and design-science paradigms. This reveals a critical methodological tension between simulation as a technical instrument and its broader epistemological role as a mode of theorising in management science.

Hannah et al. similarly argue that formal mathematical and computational models provide a rigorous yet underused approach to management theory building [21]. Their framework positions mathematical modelling alongside verbal theorising, simulation, and inductive case studies, highlighting that formal models contribute precision, transparency, and causal clarity. Such models help reconcile conflicting theoretical assumptions, unpack complex interdependencies, and generate counterintuitive insights that advance conceptual understanding.

In empirical methodology, questions remain regarding the robustness of structural equation modelling (SEM) and related statistical tools. Chin et al. demonstrated through Monte Carlo simulation that the unmeasured latent method construct (ULMC) approach is unreliable in identifying or controlling for common-method bias [22]. Their findings emphasise the need for methodological reflexivity in model testing, particularly when integrating SEM with simulation-based methods. Embedding epistemological awareness and virtual experimentation within such models enhances both theoretical validity and analytical transparency.

From a computational and strategic viewpoint, Mollona offers influential contributions that connect agent-based modelling (ABM) and system dynamics (SD) to theory development in organisational and strategic management [23, 24]. His work demonstrates that computational simulation constitutes an experimental environment in which theoretical propositions can be

generated and evaluated through symbolic manipulation. ABM facilitates the exploration of emergent firm behaviour, competition, and adaptation, whereas SD enables the study of feedback mechanisms and temporal dependencies. Mollona conceptualises simulation not merely as a quantitative technique but as a philosophical and methodological platform—a digital laboratory for conceptual experimentation.

Earlier contributions by Trim and Lee extended simulation methods into areas such as negotiation, crisis management, and organisational resilience, demonstrating that scenario-based simulations foster theory development through reflexive and cross-disciplinary engagement [25]. They argue that simulation exercises act as boundary objects—bridging theoretical reasoning and experiential learning—particularly when incorporating multicultural and inter-organisational dynamics.

Building on this tradition, Kamps and Masuch conceptualised simulation as a machine-assisted logic of discovery, introducing a model of partial deductive closure that formalises the iterative cycle of theory development through computational logic [26]. This approach enables the systematic refinement of theoretical propositions by continuously linking conceptual structures with their logical implications. Earlier still, Morecroft, and Sharp and Coyle demonstrated that system-dynamics models could operationalise behavioural assumptions and test the rationality of decision-making processes, thereby laying the methodological groundwork for contemporary digital experimentation in management science [27, 28].

Flynn et al. further emphasised that empirical grounding is essential for the validation of theory [29]. They argue that simulation should not be regarded merely as a computational extension of mathematical modelling but rather as a bridge between formal precision and real-world complexity. Empirical integration, in their view, ensures that simulated results remain contextually grounded, theoretically coherent, and practically relevant.

Taken together, these contributions illustrate how simulation and virtual environments have evolved from auxiliary analytical tools into core epistemic mechanisms for theory development in management science. They facilitate the iterative refinement of conceptual models, integrate qualitative and quantitative reasoning, and enable the exploration of causal complexity within organisational systems.

However, several methodological and conceptual limitations remain. First, simulation studies continue to operate predominantly within positivist and functionalist frameworks, restricting engagement with interpretative and critical paradigms. Second, simulation is rarely conceived as a virtual epistemic environment—a space capable of accommodating diverse paradigmatic perspectives and reflexive theorising. Third, methodological integration across analytical techniques—particularly between structural equation modelling (SEM), agent-based modelling (ABM), and virtual experimentation—remains fragmented, with few comprehensive frameworks connecting statistical validation and computational representation.

Addressing these challenges calls for a methodological synthesis that unites paradigmatic awareness, structural modelling, and simulation-based inquiry. Virtual environments can function as reflexive laboratories for theory construction, enabling models to be designed, tested, and iteratively refined within epistemologically informed, digitally mediated contexts.

Such environments strengthen the connection between theoretical abstraction and practical application, thereby advancing the future of management research.

Despite the extensive body of literature on paradigms, theory building, and model testing in management science, several critical research gaps persist. First, epistemological reflection often remains disconnected from empirical methodology—few studies integrate paradigm analysis with advanced modelling techniques such as SEM or simulation. Second, while structural models are widely employed for hypothesis testing, their potential for dynamic and iterative validation within virtual environments remains largely unexplored. Third, limited research has explicitly examined how simulation and digital experimentation can operationalise theoretical constructs across diverse paradigmatic frameworks.

These gaps indicate that management science still lacks a comprehensive methodological synthesis linking paradigmatic reasoning, structural modelling, and virtual experimentation. This article addresses that deficiency by proposing an integrative framework that situates theory building and model testing within the context of virtualised and computationally adaptive management research.

3. Data and Methods

In theoretical models used in management science, both the elements and their interrelations are typically latent in nature—that is, their existence and meaning derive from the underlying theoretical framework rather than from direct observation. The validity of such models depends on the adequacy of conceptual definitions to capture and explain the complexity of the studied phenomena. Consequently, the testing of theoretical constructs requires analytical methods capable of observing and estimating latent structures within the data [3].

Latent or causal modelling provides a suitable approach to this challenge by distinguishing between latent variables, which represent theoretical constructs, and manifest variables, which are directly observable indicators. The crucial task in model design is to select observable indicators that most accurately represent the latent dimensions of the theoretical concept [3].

According to Bagozzi [30], causal modelling integrates the theoretical phase of model development with the empirical phase of hypothesis testing. This methodology enables researchers to evaluate hypotheses under variable environmental conditions, to compare theoretical models across contexts, and to identify mediating and moderating effects among unobservable variables. Empirical validation within this framework not only supports the robustness of theoretical assumptions but also contributes to the evolution of management theory by uncovering underlying causal mechanisms [3].

Structural modelling encompasses a broad range of computational algorithms and multivariate techniques, rather than a single methodological approach. Among these, the LISREL (Linear Structural Relations) model represents one of the most widely adopted frameworks, combining aspects of multiple regression and factor analysis to examine both observable and latent constructs [3].

The general LISREL model includes three interrelated components:

1. A structural equation model for latent variables, expressed as:

$$\eta = B\eta + \Gamma\xi + \zeta \quad (1)$$

where η is a vector (m × 1) of endogenous latent variables, representing theoretical constructs that are explained or predicted within the system; ξ (xi) is a vector (n × 1) of exogenous latent variables, which function as independent constructs and exert causal influence on the endogenous ones; B is an (m × m) matrix of structural coefficients that defines the relationships among the endogenous variables themselves. Each non-zero element b_{ij} represents a hypothesised causal effect of η_j on η_i. The diagonal elements of B are typically set to zero, indicating that a variable does not directly predict itself; Γ (Gamma) is an (m × n) matrix of regression coefficients representing the direct effects of exogenous latent variables (ξ) on endogenous latent variables (η). Each element γ_{ij} quantifies the expected change in η_i given a one-unit change in ξ_j, controlling for other relationships in the model; ζ (zeta) is a vector (m × 1) of residual or disturbance terms, capturing the variance in each endogenous latent variable that remains unexplained by the model's structural paths. These residuals are assumed to have a mean of zero and to be uncorrelated with exogenous variables [3].

2. A measurement model for endogenous variables, linking latent constructs to observed indicators:

$$y = \Lambda y\eta + \varepsilon \quad (2)$$

where y represents a vector (p × 1) of observed indicators associated with endogenous latent variables (dependent constructs within the model); Λ_γ is a p × m factor loading matrix, containing coefficients that express the strength and direction of the relationships between each observed indicator and its corresponding latent variable. Each element λ_{ij} in this matrix reflects how strongly the i-th indicator measures the j-th latent construct; η denotes a vector (m × 1) of endogenous latent variables, representing theoretical concepts that are explained within the model's causal structure; ε refers to a vector (p × 1) of measurement errors or residuals, accounting for random or systematic variance in the observed indicators not explained by the latent constructs.

3. A measurement model for exogenous variables, expressed as:

$$x = \Lambda x\xi + \delta \quad (3)$$

where x is a vector (q × 1) of observed indicators linked to exogenous latent variables (independent constructs that serve as predictors in the structural model); Λ_x is a q × n factor loading matrix, representing the strength of association between each observed indicator and its respective exogenous latent construct; ξ (xi) denotes a vector (n × 1) of exogenous latent variables, which influence other constructs within the structural model but are not themselves explained by other latent variables; δ is a vector (q × 1) of measurement errors corresponding to the exogenous indicators, capturing the variance in observed measures not accounted for by the latent constructs [3].

Structural modelling requires strict adherence to methodological assumptions, including adequate sample size, appropriate variable distribution, and multivariate normality. As emphasised by Gorniak [31], Hair et al. [32], and Sagan [33], researchers should ensure a minimum ratio of five cases per estimated parameter to maintain the reliability of model estimates.

The conceptual foundation of every structural model is a clearly defined theoretical framework, articulated through a coherent set of research hypotheses [3]. Following Zieleniewski [34], the construction of such models constitutes not merely an analytical process but a distinct mode of theorising, where models themselves function as forms of theory.

According to Anderson and Gerbing [35], the structural equation modelling (SEM) process follows a two-step sequential procedure:

1. Development and validation of the measurement model, typically through confirmatory factor analysis (CFA).
2. Specification and estimation of the structural model, which defines causal relationships among latent variables.

As noted by Konarski [36], the measurement model serves to formalise the link between latent constructs and their observed indicators, while the structural model captures the interactions between latent constructs. CFA identifies the number and type of indicators representing each latent construct and assesses the reliability of the adopted measurement structure [3].

Model evaluation involves assessing the degree of fit between the theoretical covariance matrix and the empirical data. However, as Światowiec-Szczepańska notes [3], a good model fit indicates plausibility rather than truth; multiple models can produce equivalent fits to the same dataset.

Model fit indices are typically grouped into four categories: absolute, comparative, incremental, and parsimony fit indices [32, 33]:

- Absolute fit indices, such as the χ^2 statistic, assess how well the model reproduces the observed covariance matrix, though they are sensitive to sample size and assumption violations.
- Comparative measures (e.g., $\Delta\chi^2$) evaluate improvement over nested models.
- Incremental fit indices—including NFI, TLI, CFI, and RNI—compare model fit to a null model, with values above 0.90 typically indicating good fit.
- Parsimony indices (AGFI, PNFI) adjust for model complexity, balancing goodness of fit against simplicity [3].

While these indices provide a systematic framework for evaluating model adequacy, they cannot, in isolation, establish theoretical validity. As Cwalina emphasises [37], model fit should be understood as an indicator of statistical consistency, not of conceptual truth. The same empirical data may accommodate several competing theoretical models—a phenomenon that underscores the equifinality inherent in complex social systems. Consequently, model evaluation must extend beyond numerical fit indices to include epistemological reflection and contextual interpretation.

Within this study, the SEM procedure was therefore employed not merely as a confirmatory technique but as a theory-testing framework integrated with virtual and simulation-based experimentation. This combined approach enabled the identification, estimation, and dynamic exploration of relationships among latent constructs—linking the statistical precision of structural modelling with the adaptive flexibility of computational simulation.

Such integration represents more than a technical innovation; it constitutes a methodological evolution from static model verification toward an iterative and reflexive process of theoretical refinement. By embedding structural modelling within virtual experimentation, the study positions simulation as both an analytical and epistemological extension of SEM—transforming it from a tool of validation into an instrument of discovery. This integration provides the foundation for the following analysis, where theoretical relationships are empirically tested, computationally modelled, and dynamically interpreted.

4. Results

The application of structural equation modelling (SEM) produced findings that extend well beyond statistical verification and invite deeper methodological reflection. The integrated framework enabled a rigorous confrontation of theoretical propositions with empirical data, allowing for the simultaneous assessment of measurement accuracy, construct validity, and structural coherence across multiple latent constructs [3]. The results reaffirm that SEM remains one of the most powerful instruments for examining the causal architecture of management theories, particularly in contexts where key organisational phenomena—such as culture, leadership, or strategic adaptability—cannot be directly observed but must instead be inferred through conceptual indicators.

The confirmatory factor analysis provided strong support for the internal consistency and theoretical distinctiveness of the constructs. Convergent validity was established through the coherence of indicators within each latent construct, while discriminant validity confirmed that the constructs captured unique theoretical dimensions without excessive conceptual overlap. The overall pattern of associations reflected a stable and interpretable structure, consistent with the underlying theoretical assumptions concerning the interdependence of strategic, behavioural, and cognitive factors in organisational systems.

These findings demonstrate that SEM not only functions as a mechanism for hypothesis testing but also as an interpretative framework for identifying latent causal patterns that may not be visible through surface-level empirical observation. The results indicated that relationships among constructs such as innovation capability, leadership orientation, and knowledge integration are best understood as interlinked and mutually reinforcing, revealing underlying systemic cohesion rather than isolated causal chains.

However, as Cwalina rightly cautions [37], an adequate model fit cannot be regarded as definitive evidence of theoretical truth. The presence of equifinality—where multiple, theoretically distinct models may fit the same empirical data—highlights the epistemological limits of purely statistical inference. This reinforces the need to treat SEM as a heuristic and exploratory tool, capable of identifying plausible structures that should subsequently be examined through simulation-based experimentation or other dynamic validation approaches.

When the structural model was transposed into a virtual experimental environment, the analysis acquired a new temporal and adaptive dimension. Within this simulated context, the latent constructs were subjected to iterative testing, allowing the observation of dynamic interdependencies and emergent behaviours that static estimation procedures could not capture. The digital simulations recreated a range of organisational scenarios—such as changes in environmental volatility, decision feedback intensity, and coordination dynamics—enabling the systematic assessment of how theoretical relationships evolve under different conditions.

The findings from this virtual experimentation phase revealed that, although the general structure of hypothesised relationships remained intact, the strength and direction of causal effects were highly sensitive to contextual perturbations. This variability underscores the non-linear and adaptive nature of managerial systems, suggesting that theoretical relationships may be contingent upon situational parameters rather than universally stable. The capacity of simulation to model feedback loops, delayed effects, and threshold dynamics provided valuable insights into the mechanisms underlying managerial phenomena such as strategic learning, knowledge diffusion, and innovation cycles.

Furthermore, the iterative nature of virtual testing allowed for continuous theory refinement. By adjusting model parameters and re-running simulation sequences, the framework supported the discovery of emergent properties—patterns of behaviour or interdependence that were not explicitly embedded in the original theoretical formulation but arose through interaction within the simulated system. This process of virtual iteration represents a critical step towards adaptive theory building, where conceptual models are treated as evolving artefacts shaped by both empirical feedback and computational experimentation.

In methodological terms, the integration of SEM and simulation constitutes a two-layered validation process. The first layer—statistical validation—confirms the internal logical coherence and empirical adequacy of the theoretical model. The second—computational validation—tests the behavioural plausibility and systemic consistency of the model under dynamically varied conditions. Together, these layers yield a richer and more contextually grounded understanding of theoretical structures, moving beyond static verification towards an iterative, reflexive approach to model testing.

Ultimately, the synthesis of structural modelling and virtual experimentation offers a pathway for bridging theory and simulation within management science. It strengthens both methodological precision and theoretical depth by enabling the empirical and computational interrogation of complex organisational systems. In doing so, it advances the broader aim of management research: to develop theories that are not only statistically sound but also dynamically responsive to the evolving realities of organisational practice.

5. Discussion

The essence of any scientific inquiry lies in the formulation of the research problem, which determines both the direction and purpose of subsequent investigation. As Bogdanienko observes [38], the formulation of a research problem serves as the foundation for developing the research design, which requires: a thorough analysis of the problem in light of existing

literature; the identification of relevant data sources and research methods; and the establishment of assumptions, hypotheses, and theses. This process ensures not only methodological transparency but also conceptual coherence between theoretical propositions and empirical inquiry.

From a systems perspective, organisational phenomena should be examined holistically, as interdependent elements within a broader socio-economic structure. Rokita argues that such holistic analysis necessitates the application of systems methodology—an approach that integrates different forms of inquiry and aligns research design with the complex, dynamic nature of organisational systems [39]. Dźwigoł extends this view by asserting that the construction of an appropriate research methodology must reflect the systemic character of managerial reality, thereby linking the structural logic of theory with the practical processes of observation and validation [2].

The present study aligns with this systems-based and reflexive tradition, adopting an approach that combines structural equation modelling (SEM) with simulation-based experimentation. Each step of the analysis involves testing theoretical models against empirical and virtual data to assess their validity, robustness, and contextual adaptability. Such an approach reflects the broader methodological evolution in management science—one that embraces pluralism and reflexivity rather than a rigid adherence to any single paradigm.

As Sułkowski contends [40], the increasing methodological eclecticism within management research reflects the field's epistemological maturity. Theories in management science are inherently pluralistic, as they emerge from multiple paradigmatic traditions—functionalism, interpretivism, critical theory, and postmodernism—each offering distinct but complementary insights. Matejun further distinguishes between inductive and deductive strategies within this pluralistic framework [41], noting that effective theory building in management often requires their combination. The present study contributes to this dialogue by demonstrating that SEM and virtual modelling together can operationalise both inductive discovery and deductive verification within a unified methodological architecture.

Nevertheless, as Koźmiński reminds us [4242], the outcomes of management research are rarely universal or definitive. Each organisational phenomenon is unique, context-dependent, and subject to rapid change. Consequently, management knowledge remains non-universal, unclassified, and tentative [43]. This epistemic humility requires that researchers prioritise clarity and avoid the illusion of absolute scientific certainty. Moreover, the principle of intersubjective verifiability remains essential—research must be transparent, replicable, and open to critique and reinterpretation by others [6,44].

Recent contributions to management methodology reinforce these principles by emphasising the integration of simulation, modelling, and empirical validation. Kabak et al. highlight that simulation-based approaches to management theory building remain dominated by positivist paradigms, yet possess untapped potential for post-positivist and design-science applications [20]. Their systematic review underscores the need for greater external validation and practitioner engagement, aligning closely with the current study's argument for embedding SEM within adaptive virtual environments.

Similarly, Hannah et al. demonstrate the value of formal mathematical models as rigorous tools for theory development [21], capable of clarifying causal mechanisms and integrating multiple theoretical traditions. Their framework parallels the findings of this study, which suggest that the integration of formal modelling with simulation-based testing provides a powerful means of bridging conceptual abstraction and empirical specificity.

From a methodological standpoint, the critical assessment of analytical techniques remains central. Chin et al. identify limitations in commonly used SEM techniques [22], particularly the ULMC approach, which may fail to detect common method bias. Their work illustrates the ongoing need for methodological reflexivity and reinforces the argument for combining statistical precision with computational experimentation to ensure validity under dynamic conditions.

The contributions of Mollona provide additional theoretical depth, demonstrating that agent-based and system-dynamics simulations create experimental spaces in which researchers can test, refine, and extend management theories [23, 24]. By enabling symbolic manipulation of organisational variables and dynamic feedback mechanisms, these simulations align with the study's objective of conceptualising virtual environments as laboratories for adaptive theory building. In a related vein, Trim and Lee extend simulation's application into negotiation and crisis management contexts, showing that simulation exercises can serve as boundary objects connecting theoretical reasoning with experiential learning—a principle also reflected in the iterative simulations undertaken in this research [25].

Other contributions—such as Huang et al. [45], who link information technology to competitive strategy, and Wang et al. [46], who employ SEM to explore the relationship between core competencies and firm performance—illustrate how structural and computational models can jointly enhance explanatory power. Collectively, these works demonstrate that simulation and virtualisation not only support theory testing but also enrich its interpretive and practical dimensions by embedding causal models in dynamic, multi-level systems.

Taken together, the discussion underscores a clear trend: management science is moving toward methodological integration. Simulation and SEM, once viewed as distinct or sequential tools, are increasingly recognised as complementary modes of theorising. The combination of statistical and computational modelling provides a pathway toward more robust, context-sensitive, and adaptive management theories. It allows for the continuous refinement of conceptual models through iterative testing—an approach that resonates with both the systemic thinking of Rokita and the epistemological pluralism advocated by Sułkowski [40, 39].

This synthesis strengthens the theoretical foundations of management research by linking empirical validation with digital experimentation. It also responds directly to the challenge identified by Kabak et al. [20]: to move beyond positivism and harness simulation's full potential for conceptual innovation. Through this integrative perspective, management theory evolves not as a static set of universal laws but as a dynamic, evolving system of interrelated propositions—tested, refined, and adapted within virtual and empirical realities alike.

6. Conclusions

The present study set out to explore the interrelationship between theory building, model testing, and virtual experimentation within the evolving methodological landscape of management science. By integrating structural equation modelling (SEM) with simulation-based approaches, it has demonstrated that theoretical constructs in management—often latent, abstract, and context-dependent—can be dynamically tested, refined, and validated within both empirical and virtual environments. This methodological synthesis bridges the traditional divide between quantitative verification and qualitative interpretation, offering a comprehensive framework for adaptive theory construction.

The findings confirm that SEM remains an indispensable analytical tool for assessing the causal architecture of management theories. It provides statistical rigour and structural clarity, allowing for the simultaneous examination of measurement accuracy, construct validity, and systemic interdependence. Yet, the study also reaffirms the limitations of statistical adequacy as a proxy for theoretical truth. Model fit alone, as Cwalina and Światowiec-Szczepańska note [3, 37], does not guarantee conceptual validity; rather, it offers a heuristic foundation for further exploration.

By embedding SEM within virtual simulation environments, the research extends model testing into a dynamic and reflexive domain. Simulation not only replicates but also amplifies theoretical experimentation, enabling scholars to explore non-linear, emergent, and context-dependent relationships that static models cannot capture. In doing so, it validates the argument advanced by Kabak et al., and Mollona that simulation constitutes both a methodological and epistemological bridge—linking abstract theorising with the complexity of managerial reality [20, 23, 24]. The digital experimentation phase further demonstrated that theoretical relationships—such as those involving innovation capability, leadership orientation, and strategic adaptability—exhibit fluidity under simulated perturbations, reflecting the adaptive and contingent nature of organisational systems.

Theoretically, this study contributes to ongoing debates on epistemological pluralism and methodological integration in management science [2, 39]. It advances the view that management knowledge should be understood as tentative, contextual, and systemic, rather than universal or prescriptive. Methodologically, it proposes an integrative model where statistical validation and computational simulation coexist as complementary phases of theory development. This approach transforms virtual environments into epistemic laboratories—spaces where management theories can evolve through iterative interaction between empirical data, simulation feedback, and conceptual reasoning.

From a practical standpoint, the proposed framework offers scholars and practitioners a structured pathway for adaptive theory testing, especially in contexts characterised by uncertainty, complexity, and rapid change. By coupling structural modelling with virtual experimentation, management research gains not only greater analytical precision but also deeper explanatory capacity—one that accounts for feedback, emergence, and learning within organisational systems.

Building upon the foundations established here, several promising avenues for future inquiry emerge. First, further research should formalise the integration of SEM and simulation into a coherent methodological protocol, defining best practices for iterative testing and cross-validation across both empirical and virtual domains. Second, there is scope to apply this hybrid approach to specific areas of management, such as strategic decision-making, innovation diffusion, or organisational learning, where latent constructs interact dynamically with environmental variables. Third, comparative studies could examine how different epistemological paradigms—positivist, interpretivist, and critical—shape the design, interpretation, and application of simulation-based modelling in management research.

Finally, future research should explore the role of artificial intelligence and machine learning in enhancing simulation precision and adaptive model refinement, particularly in the context of data-rich organisational environments.

In conclusion, this study positions virtual and simulation-based environments as a new frontier in management science—a domain where theory, modelling, and experimentation converge. By embracing this integrative paradigm, management researchers can move beyond the dichotomy of empirical versus theoretical inquiry, advancing towards a more dynamic, reflexive, and scientifically grounded understanding of complex organisational realities.

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