

A Hybrid Bibliometric-SEM-ANN Approach on Mapping the Intellectual Structure of Knowledge, Dynamic Capabilities, And Competitive Advantage

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Abstract

This study develops a hybrid framework integrating bibliometrics, Structural Equation Modeling (SEM), and Artificial Neural Networks (ANN) to explore the relationships among knowledge, dynamic capabilities, and competitive advantage. Bibliometric analysis, based on the Web of Science database, identifies high-impact literature, core academic networks, and research hotspots to construct the theoretical foundation for SEM. The SEM is used to validate key variables, such as knowledge and dynamic capabilities, and to analyze their direct and indirect effects on competitive advantage through linear relationships. To capture nonlinear patterns and address the limitations of SEM, ANN is employed to enhance model adaptability and predictive accuracy, uncovering deeper insights into latent relationships. This integrated approach advances the understanding of how these constructs interact. Contributions include (1) **Theoretical Advancement**: A comprehensive framework combining bibliometrics, SEM, and ANN; (2) **Methodological Progress**: Enhanced interpretability by combining linear and nonlinear techniques; and (3) **Practical Relevance**: A data-driven tool for improving decision-making and competitive advantage. This study provides valuable insights for both academic research and practical applications.

Introduction

The rapidly evolving business environment, marked by technological advancements, product obsolescence, and intense competition, necessitates a shift from traditional approaches to achieving competitive advantage. Innovation, defined as leveraging new knowledge to deliver products and services that meet customer needs, has become a cornerstone for business success (Afuah, 1998). However, innovation alone is insufficient; firms must effectively integrate and commercialize these innovations to remain competitive (Porter & Advantage, 1985). As traditional concepts like economies of scale and scope lose relevance in the knowledge-driven economy, organizations increasingly turn to frameworks such as Knowledge-Based Dynamic Capabilities (KBDC). KBDC integrates knowledge management with dynamic capabilities, enabling organizations to adapt, reconfigure resources, and sustain competitive advantage (Kaur, 2019).

Afuah (1998) first proposed the innovation profit chain model, emphasizing that firms must continuously acquire new knowledge and innovate to unlock infinite

possibilities and achieve long-term success. This model is rooted in strategic management theories, particularly the schools of thought on competitive advantage, capabilities, and knowledge. However, the model does not provide detailed discussions or empirical evidence on integrating these concepts, particularly the predictive relationship between dynamic capabilities and organizational competitive advantage.

Competitive advantage refers to an organization's ability to achieve and sustain superior market performance through cost leadership, differentiation, or focus strategies (Porter & Advantage, 1985). However, traditional strategies are no longer sufficient in today's dynamic markets, necessitating unique, valuable, and inimitable resources for long-term success (Barney, 1991). According to the Resource-Based View (RBV), these resources, including tangible assets like technology and intangible ones such as brand reputation and expertise, create barriers to entry and facilitate competitive differentiation (Barney, 1991).

Knowledge plays a pivotal role in achieving competitive advantage as a strategic resource. Tacit knowledge (experience and intuition) and explicit knowledge (formalized and documented) are essential for strategy development and enhancing organizational adaptability in high-tech industries (Grant, 1996; Nonaka, 2009). Knowledge management practices improve dynamic capabilities, enabling firms to sense, seize, and reconfigure resources in response to environmental changes (Nonaka, 2009).

Dynamic capabilities, defined as a firm's ability to integrate, build, and reconfigure internal and external competencies to adapt to market shifts, are a critical driver of competitive advantage (Teece et al., 1997). These capabilities are characterized by three core elements: sensing opportunities and threats, seizing those opportunities through effective resource allocation, and reconfiguring resources to maintain flexibility (Teece, 2007). Firms with robust dynamic capabilities can innovate, adapt, and sustain competitive advantage by leveraging knowledge effectively (Eisenhardt & Martin, 2000). Moreover, dynamic capabilities act as a mediator between knowledge management and competitive advantage, transforming knowledge into actionable strategies that ensure long-term success (Teece et al., 1997; Zollo & Winter, 2002). For instance, pharmaceutical companies utilize dynamic capabilities to reallocate R&D resources, enabling faster product launches and market responsiveness.

Despite its importance, the relationship between knowledge management and dynamic capabilities remains ambiguous. While knowledge can serve as a foundation for developing dynamic capabilities, it can also lead to organizational rigidity (Lee et al., 2016; Nieves & Haller, 2014; Prieto & Easterby-Smith, 2006). Additionally, the role of dynamic capabilities as a mediator between knowledge management and competitive advantage is underexplored (Cepeda & Vera, 2007;

Prieto & Easterby-Smith, 2006). Kaur and Mehta (2016b) proposed a linear structural model (SEM) linking these constructs but did not investigate their bibliometric dimensions. This study aims to address these gaps, providing a deeper understanding of these relationships and their implications.

To address these gaps, this study employs a multi-method analytical framework combining bibliometric analysis, Structural Equation Modeling (SEM), and Artificial Neural Networks (ANN) to explore the relationships among knowledge, dynamic capabilities, and competitive advantage (Liébana-Cabanillas et al., 2018).

Framework Overview

1. **Bibliometric Analysis:** Identifies reflective measurement indicators for PLS-SEM, providing a foundational understanding of the constructs (Henseler et al., 2009).
2. **SEM Analysis:** Tests hypotheses and evaluates causal relationships among constructs. SEM's strength lies in modeling complex pathways, but it assumes linear relationships, limiting its ability to capture nonlinear dynamics.
3. **ANN Integration:** Complements SEM by uncovering nonlinear interactions and enhancing predictive accuracy. ANN addresses subtle relationships that SEM cannot, though its "black-box" nature limits causal interpretability (Leong et al., 2015).

The first stage involves conducting bibliometric analysis to obtain reflective measurement indicators related to SEM for knowledge, dynamic capabilities, and competitive advantage (Henseler et al., 2009). The second stage involves conducting SEM analysis and ANN analysis. The hybrid SEM-ANN approach combines SEM's theoretical validation with ANN's nonlinear modeling (Albahri et al., 2022), providing a comprehensive view of the constructs. In various fields, the combined use of Structural Equation Modeling (SEM) and Artificial Neural Networks (ANN) as an approach to addressing topics, including concepts, advantages, challenges, and concerns, has become increasingly important (Sohaib et al., 2019). This methodology bridges gaps in existing research and enhances the analysis of complex relationships in dynamic business environments (Parasuraman & Colby, 2015; Sohaib et al., 2019). In the third stage, compared to previous studies, a new solution is proposed based on the principles of augmentation and complementarity. This involves a dual-stage analysis combining SEM and ANN to address both linear and non-compensatory relationships between constructs (Liébana-Cabanillas et al., 2018; Liébana-Cabanillas et al., 2017).

Research Methodology

This study employs a comprehensive multi-method approach integrating bibliometric analysis, Structural Equation Modeling (SEM), and Artificial Neural Networks (ANN) to investigate the relationships among knowledge management, dynamic capabilities, and competitive advantage. The research progresses through three stages: bibliometric analysis, SEM analysis, and ANN validation, combining linear and nonlinear perspectives for deeper insights.

Step1: Bibliometric Analysis

The study begins with bibliometric analysis to explore the intellectual structure of the research domain using the Web of Science (WoS) database. Keywords applying Boolean operators (AND, OR, NOT), truncation, and proximity searches to refine results, such as "Knowledge Management," "Dynamic Capabilities," and "Competitive Advantage" were searched using the query, TI=("dynamic capabilit*" OR "Competitive Advantage") AND AB=("knowledge management") OR ALL=("knowledge-based dynamic capabilit*") OR ALL=("dynamic knowledge capabilit*") OR ALL=("knowledge sensing capabilit*") OR ALL=("knowledge seizing capabilit*") OR ALL=("knowledge reconfiguring capabilit*") OR ALL=("knowledge dynamic capabilit*") OR TI=("Competitive Advantage") OR ALL=("knowledge-based view" AND "dynamic capability view") OR AB=("knowledge based" AND "dynamic capabilit*") OR AB=("knowledge management" AND "dynamic capabilit*"), and 500 documents are collected. Metadata such as author affiliations, keywords, and citation counts are extracted for analysis. The bibliometric tools help filter and map critical components, forming the basis for subsequent modeling. This phase identifies core publications, influential authors, and emerging themes through co-citation and keyword co-occurrence analyses. Network indicators, including Betweenness Centrality, Closeness Centrality, and PageRank, highlight the key variables that inform the SEM framework.

Step 2: SEM Analysis

The study constructs a theoretical SEM framework to examine linear relationships between knowledge management, dynamic capabilities, and competitive advantage. Latent variables are measured using indicators derived from bibliometric findings. SEM validates hypotheses and evaluates model fit through path coefficients and fit indices (e.g., RMSEA, CFI).

Hypotheses for SEM Analysis

- **H1:** Knowledge management has a significant positive impact on organizational competitive advantage.
- **H2:** Knowledge management has a significant positive impact on organizational dynamic capabilities.

- **H3:** Dynamic capabilities have a significant positive impact on organizational competitive advantage.
- **H4:** Dynamic capabilities mediate the relationship between knowledge management and organizational competitive advantage.
- **Mediating Role**
The influence of knowledge management on competitive advantage is mediated by dynamic capabilities (Kaur & Mehta, 2016a) (Lee et al., 2016). Specifically, knowledge management not only directly enhances competitive advantage but also fosters the development of dynamic capabilities. These dynamic capabilities act as a transformation mechanism, converting the benefits of knowledge management into sustained competitive advantage (Kaur & Mehta, 2016a; Lee et al., 2016).

Step 3: ANN Analysis

ANN is employed to address SEM's limitations by exploring nonlinear relationships. Factor scores from SEM serve as input for ANN, enabling the discovery of hidden patterns and complex interactions. Cross-validation ensures the model's robustness and generalizability.

Step 4: Integration

Results from SEM and ANN are compared to enhance the understanding of both linear and nonlinear dynamics, providing a holistic view of how knowledge management and dynamic capabilities influence competitive advantage.

The integrated methodology—bibliometric analysis for data foundation, SEM for linear validation, and ANN for nonlinear exploration—offers a robust framework for comprehensively analyzing the relationships among the constructs. This approach balances theoretical rigor with predictive accuracy, advancing both academic and practical insights. The research progress is shown in Figure 1.

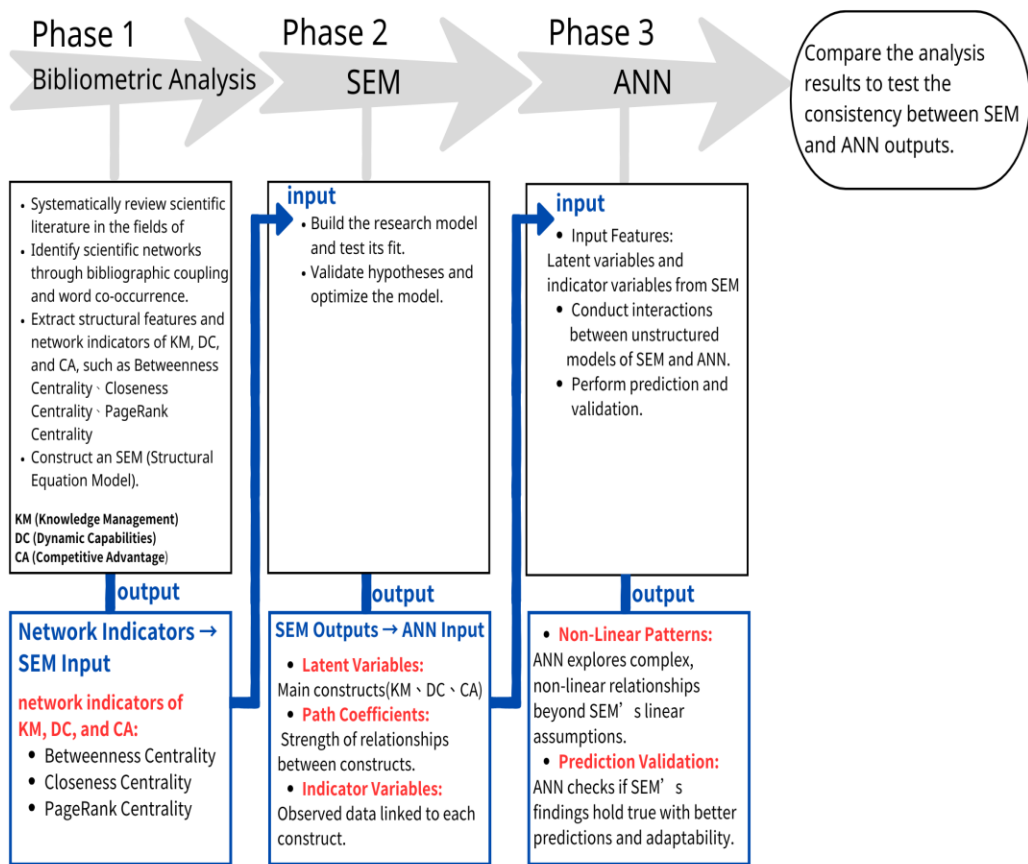


Figure 1. Research Progress.

Key Findings

The bibliometric analysis validated the direct, indirect, and nonlinear relationships among knowledge management, dynamic capabilities, and competitive advantage. The findings confirmed that dynamic capabilities act as a significant mediator in the knowledge-competitive advantage relationship, enabling organizations to translate knowledge management strategies into sustainable advantages. The bibliometric insights highlighted several key trends and concepts: In figure 1, core constructs: knowledge management, dynamic capabilities, and competitive advantage were the most frequently occurring terms in the analysis of document abstracts (517, 494, and 347 instances respectively).



Terms	Frequency
knowledge management	517
dynamic capabilities	494
competitive advantage	347
dynamic capability	171
innovation performance	108
sustainable competitive	83
knowledge-based dynamic	82
structural equation	82
supply chain	81
knowledge-based view	78
absorptive capacity	72
intellectual capital	52

Figure 1. Word Cloud (Counted by frequency).

Figure 2 shows the co-occurrence network as well as the centrality indicators, including Betweenness, Closeness, and PageRank, revealed that competitive advantage, knowledge management, and dynamic capabilities held pivotal positions within the intellectual structure of the field.

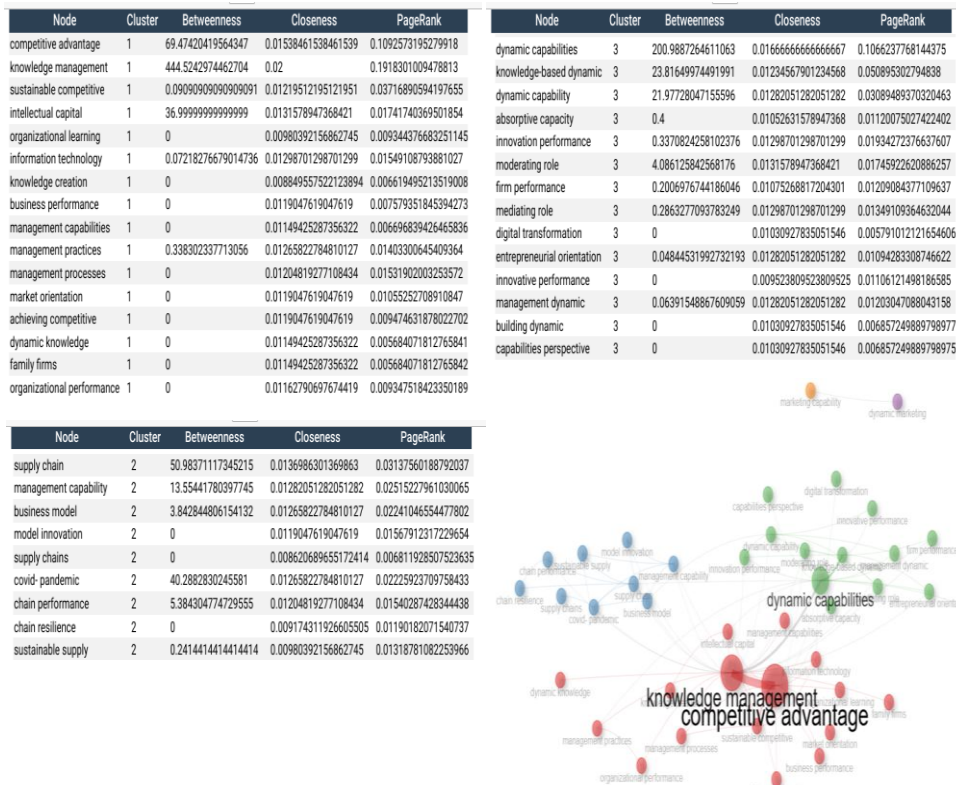


Figure 2. Co-occurrence Network.

In Figure 3, there are two dimensions, which show emerging themes, such as innovation performance, sustainable competitiveness, and knowledge-based dynamic capabilities were identified as critical elements influencing competitive advantage.

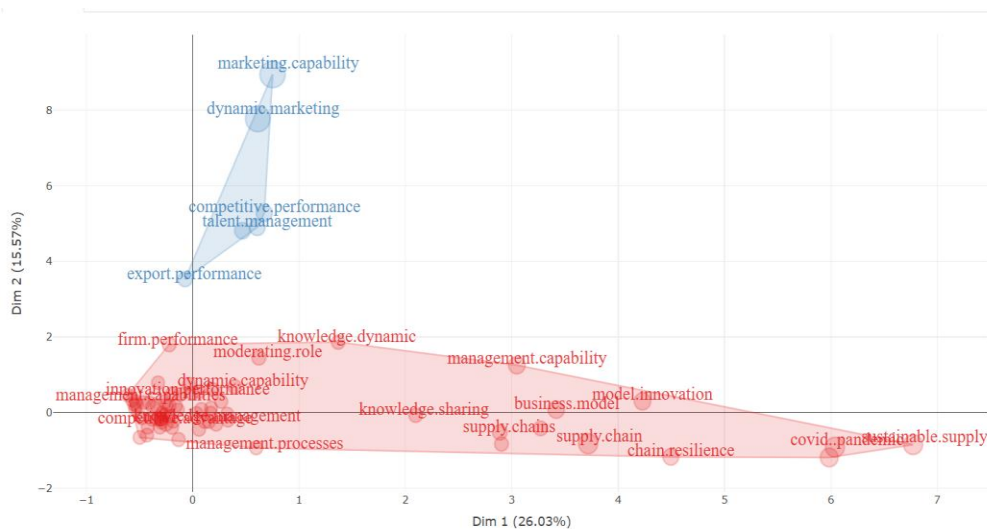


Figure 3. Factorial Analysis.

The constructs identified through bibliometric analysis—Knowledge Management (KM), Dynamic Capability (DC), and Competitive Advantage (CA)—serve as latent variables in the SEM model. Each construct is represented by measurable indicators: KM (Knowledge Acquisition, Knowledge Sharing, Knowledge Application), DC (Sensing Capability, Seizing Capability, Reconfiguring Capability), and CA (Market Performance, Innovation Output, Cost Leadership). These indicators provide the basis for testing the relationships among constructs illustrated in Figure 4. Key bibliometric metrics, such as Betweenness Centrality, Closeness Centrality, and PageRank, justify the inclusion and significance of specific indicators. For example, high Betweenness Centrality underscores KM’s pivotal role, Closeness Centrality supports DC’s intermediary function, and PageRank confirms CA’s prominence as the ultimate outcome. Bibliometric findings also substantiate the structural relationships in SEM, including the influence of KM on DC (γ_{11}), DC’s impact on CA (β_{21}), and KM’s direct effect on CA (γ_{21}). This integration ensures the SEM model is both theoretically grounded and empirically validated.

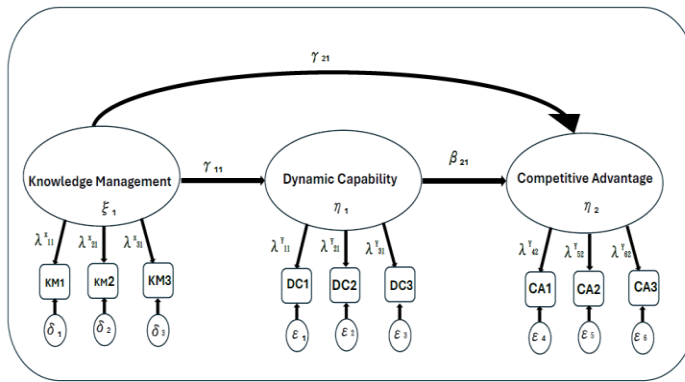


Figure 4. SEM analysis illustration.

SEM establishes linear relationships among constructs (e.g., γ_{11} , β_{21} , γ_{21}) and validates the theoretical framework through path coefficients and model fit. It generates refined latent variable factor scores for constructs (e.g., KM, DC, CA) and their indicators. These factor scores serve as inputs for ANN, enabling the exploration of nonlinear relationships and uncovering hidden patterns beyond SEM's linear assumptions, ensuring continuity and accuracy in the analysis. The illustration of ANN analysis is shown in Figure 5.

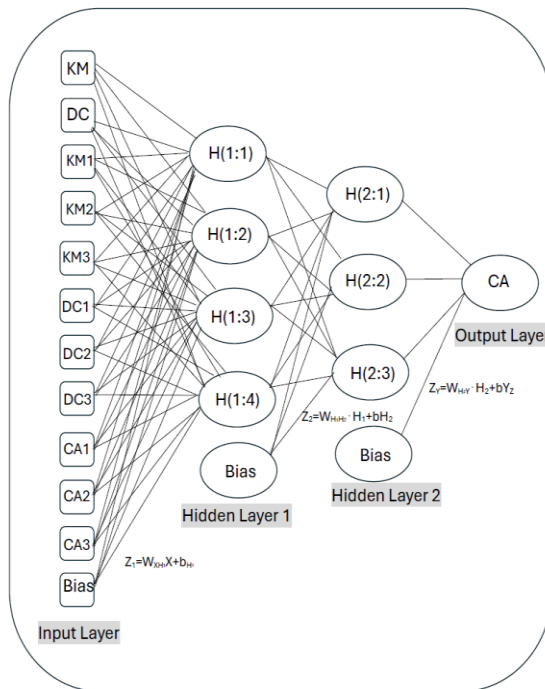


Figure 5. ANN analysis illustration.

Theoretical Contributions

Hybrid Framework Development: This study introduces a multi-level hybrid framework that integrates bibliometric analysis, SEM, and ANN to comprehensively explore linear and nonlinear dynamics within the knowledge-competitive advantage domain.

Intellectual Structure Advancement: The bibliometric analysis unveiled the intellectual connections and knowledge structure within the domain, as visualized in clustering and factorial mapping analyses. These analyses emphasized the interaction between knowledge-driven strategies and dynamic organizational capabilities.

Practical Implications

Strategic Decision-Making: The study provides actionable insights for firms to effectively leverage knowledge management practices and enhance dynamic capabilities, offering clear pathways to achieve and sustain competitive advantage.

Predictive Decision-Support Tool: Combining bibliometric analysis with SEM and ANN offers a robust, data-driven decision-support tool that balances theoretical insights with predictive capabilities.

Future Directions

Model Refinement: Future research could enhance the framework by incorporating additional datasets and diverse variables, broadening its applicability and robustness.

Cross-Industry Applicability: Investigating the framework's relevance across different industries and geographical regions could provide deeper insights into its universal applicability.

Framework Illustration: A synthesized visual framework encapsulates the integration of bibliometric analysis, SEM, and ANN.

This integrated approach bridges theoretical and practical gaps, ensuring a holistic understanding of the constructs while providing actionable insights. The results are both predictive and adaptable, marking significant advancements in strategic management research.

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