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Knowledge Network Analysis in Universities: Open Innovation and Academic Governance

Análisis de redes de conocimiento en universidades: Innovación abierta y gobernanza académica

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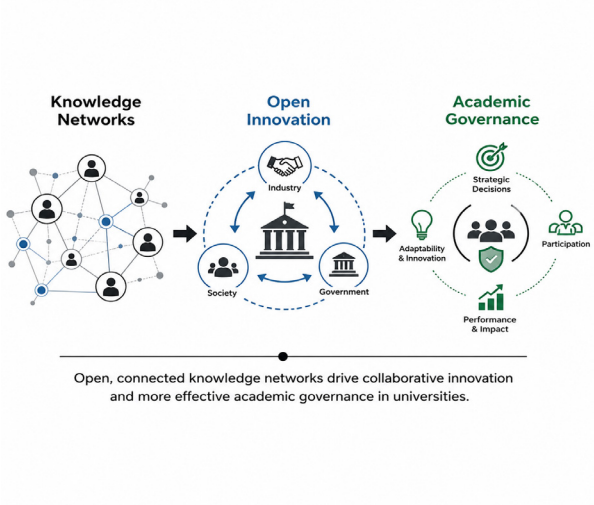
HIGHLIGHTS

- This study maps knowledge networks in universities and reveals how open innovation mechanisms foster academic collaboration and governance.
- Using social network analysis, the research identifies key actors and structural gaps within university knowledge ecosystems.
- The article proposes a governance model integrating open innovation and networked knowledge production for strategic academic decision-making.

GRAPHICAL ABSTRACT



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ABSTRACT

Knowledge networks have become a central mechanism for driving open innovation and reshaping governance structures in universities; however, there is still limited empirical evidence explaining how internal network configurations influence institutional openness and decision-making dynamics, particularly in emerging contexts. This study analyzes the structure and strategic effects of knowledge networks in Latin American universities using a quantitative approach based on social network analysis (SNA) applied to three public institutions in Colombia, Peru, and Mexico. The findings reveal highly centralized network structures, low overall density, and the presence of informal communities that operate beyond formal organizational boundaries. Strong positive correlations were identified between institutional openness and network cohesion ($\rho = 0.81$; $p < 0.01$), as well as between actor centrality and participation in governance processes. These results demonstrate that network configuration directly shapes both knowledge flows and institutional decision-making capacity. Based on this evidence, the study proposes a network-based governance framework that integrates open innovation mechanisms with distributed decision-making structures. The article contributes to the literature by providing empirical validation of the relationship between network dynamics, openness, and governance, offering a scalable model for transforming universities into adaptive, collaborative, and strategically oriented ecosystems.

Palabras clave:

redes de conocimiento, Innovación abierta, Gobernanza académica, Universidades, Análisis de redes sociales, América latina

RESUMEN

Este artículo analiza cómo las redes de conocimiento en universidades latinoamericanas pueden potenciar la innovación abierta y fortalecer la gobernanza académica. Mediante un enfoque cuantitativo y el uso de análisis de redes sociales (SNA), se estudió la estructura y dinámica de las redes internas en tres universidades públicas de Colombia, Perú y México. Los resultados revelan patrones comunes como la alta centralidad de algunos nodos, baja densidad general, y la existencia de comunidades no alineadas con estructuras formales. Se encontró una correlación positiva entre los niveles de apertura institucional y la cohesión de red, y se identificó que los actores con mayor conectividad también concentran participación en órganos de decisión. A partir de estos hallazgos, se proponen implicaciones estratégicas para el rediseño de estructuras organizativas, modelos de gobernanza participativa y políticas de innovación abierta. El estudio concluye que la gestión activa de redes internas permite a las universidades transformarse en ecosistemas más colaborativos, adaptativos y estratégicos.

1. Introduction

In today's context of digital transformation, global knowledge flows, and increasingly complex social demands, universities are challenged to redefine both their internal structures and their mechanisms of interaction with their environment. This new paradigm requires a shift from traditional hierarchical models toward organizational ecosystems structured as networks, where knowledge flows, converges, and multiplies through dynamic connections between academic, productive, social, and governmental actors.

Knowledge networks, understood as structured systems of collaboration among research groups, faculties, centers, and external stakeholders, are emerging as critical infrastructures for the development of open innovation and the legitimization of new forms of academic governance. Studies such as those by Etzkowitz, H., & Leydesdorff, L. (2000), Perkmann et al. (2013), and Marginson, S. (2022) have demonstrated that the most influential universities distinguish themselves not only by their scientific output but also by their ability to build and sustain dense, collaborative, and interinstitutional academic relationships.

Simultaneously, the concept of open innovation (Chesbrough, H. W. 2003) has gained prominence as a guiding principle in university research and engagement strategies. This model promotes the permeability of institutional processes to external knowledge, enabling the co-creation of solutions with public and private actors. However, its effective implementation requires flexible organizational structures and institutional environments willing to share control over knowledge and decision-making processes.

Within this scenario, academic governance—understood as the set of processes, structures, and actors that regulate university life—is also being transformed by network dynamics that redistribute power, make new forms of leadership visible, and expand the boundaries of participation. Recent literature (De Boer et al. 2007); Bernasconi, 2023) has shown that universities that incorporate network-based governance criteria tend to be more resilient, adaptive, and strategically focused.

Despite these theoretical advances, there remains a significant empirical gap in understanding how internal knowledge networks quantitatively relate to institutional openness and to measurable governance outcomes, particularly in terms of decision-making decentralization, actor influence distribution, and structural cohesion. Recent studies emphasize the need to move from conceptual frameworks toward data-driven models capable of capturing the dynamic interplay between network structures and governance performance in higher education systems (Benitez et al. 2023; Gulati et al. 2023).

In response to this scenario, this article seeks to answer the following central research question: How can knowledge networks in universities enhance open innovation and academic governance?

The general objective of this study is to analyze the structure, dynamics, and strategic effects of knowledge networks in Latin American universities, identifying their implications for the design of open innovation models and institutional governance (Chesbrough, H., & Brunswicker, S. 2014).

To this end, the study adopts a quantitative approach, supported by social network analysis (SNA), statistical correlation methods, and data visualizations using R and Python. The research was conducted on three public universities located in Colombia, Peru, and Mexico, selected for their participation in academic networks and openness to interinstitutional projects.

This article is structured in six sections: literature review, methodology, results (in four components), discussion, and conclusions. Through this pathway, it aims to provide empirical evidence and strategic reflections to contribute to strengthening the organizational capacities of universities as key actors in knowledge creation and sustainable development.

2. Theoretical Framework

2.1. Knowledge Networks in Universities

Knowledge networks in the university setting have become essential structures for the generation, dissemination, and application of knowledge. Recent studies highlight that network embeddedness, structural holes, and relational capital significantly influence innovation performance and knowledge diffusion in academic ecosystems (Gulati et al. 2023; Borgatti et al. 2022).

For instance, Powell et al. (1996) analyzed how interorganizational networks in biotechnology foster innovation through collaboration between universities and firms. Likewise, Etzkowitz, H., & Leydesdorff, L. (2000) proposed the Triple Helix model, which emphasizes the interaction among university, industry, and government as a driver of innovation. These frameworks have been pivotal in understanding the dynamics of knowledge networks in higher education institutions.

Moreover, studies such as Perkmann et al. (2013) have explored the relationship between academic engagement and knowledge commercialization, emphasizing how collaborative networks influence technology transfer and innovation. On the methodological side, Wasserman, S., & Faust, K. (1994) provided tools for social network analysis, enabling deeper insight into the structures and dynamics of academic networks.

In the Latin American context, research by De Fuentes & Dutrénit (2012) examined how universities in the region participate in innovation networks, facing specific challenges related to funding, infrastructure, and public policy. These studies underscore the need to strengthen institutional capacities to support more effective and sustainable knowledge networks.

Taken together, the literature suggests that knowledge networks in universities are vital for fostering innovation and improving academic governance. However, several challenges remain, particularly regarding network management, equitable participation, and long-term sustainability.

Table 1. Systematization of Sources on Knowledge Networks in Universities

Author (Year)	Key Elements Highlighted	Critical Analysis	Emerging Category
Powell et al. (1996)	Interorganizational networks in biotechnology	Highlights the importance of collaboration for driving innovation	Interinstitutional Collaboration
Etzkowitz & Leydesdorff (2000)	Triple Helix model: university–industry–government interaction	Emphasizes systemic integration as the engine of knowledge-based economies	University–Industry–Government Linkage
Perkmann et al. (2013)	Academic engagement and knowledge commercialization	Examines how academic networks foster technology transfer and innovation	Knowledge Transfer
Wasserman & Faust (1994)	Social network analysis methodologies	Provides theoretical and methodological tools to analyze network structures	Network Analysis Tools
De Fuentes & Dutrénit (2012)	University participation in Latin American innovation networks	Identifies structural and policy-related barriers to effective academic collaboration	Latin American Context
Carayannis & Campbell (2009)	Quadruple Helix model: inclusion of civil society in innovation ecosystems	Introduces society as a fourth dimension in academic knowledge networks	Civil Society Integration
Freeman (1991)	Role of networks in the diffusion of innovation	Argues that networks serve as conduits for innovation adoption and knowledge sharing	Innovation Diffusion

Source: Author's own elaboration, 2025.

The literature review shows that knowledge networks in universities are complex structures that facilitate collaboration and innovation. Models such as the Triple Helix and Quadruple Helix offer theoretical frameworks for understanding the interactions among different actors within these networks. However, the effective implementation of such networks faces significant challenges, particularly in contexts marked by structural limitations and scarce resources. It is essential to consider regional and cultural specificities when designing and managing knowledge networks within universitiesThe systematization presented in Table 1 reveals a theoretical convergence around collaboration, institutional linkage, and knowledge transfer as central mechanisms structuring academic networks. However, it also highlights a fragmentation in empirical approaches, reinforcing the need for quantitative network-based analyses capable of integrating these dimensions into measurable models.

In summary, knowledge networks are essential for promoting open innovation and enhancing academic governance (Vanhaverbeke, W., Chesbrough, H., & West, J. 2014; Wamba-Taguimdje, S. L., Fosso Wamba, S., Kala Kamdjoug, J. R., & Tchatchouang Wanko, C. E. 2020). Understanding their structure, dynamics, and challenges enables the development of more effective strategies for their strengthening, thus contributing directly to the core research question: How can knowledge networks in universities enhance open innovation and academic governance?

2.2. Open Innovation in the University Context

Open innovation has emerged as a fundamental paradigm in the transformation of universities toward more collaborative models oriented toward social impact. This approach promotes the permeability of institutional boundaries, facilitating interaction with external actors such as businesses, governments, and communities. Chesbrough (2003) introduced the concept of open innovation, emphasizing the importance of leveraging both internal and external ideas to advance technology and innovation. In the university setting, this implies a reconfiguration of research and development processes, redirecting them toward greater collaboration and knowledge transfer.

Numerous studies have explored the implementation of open innovation in universities. For example, the work of Perkmann et al. (2013) analyzes how universities can engage in open innovation through collaborations with industry and participation in knowledge networks. Similarly, Laursen, K., & Salter, A. (2006) underscore the importance of openness in innovation processes and how it can influence organizational innovation performance. These studies suggest that adopting open innovation practices can enhance universities' ability to effectively generate and apply knowledge.

However, implementing open innovation in universities also presents significant challenges. Balancing openness with the protection of intellectual property, managing relationships with multiple stakeholders, and adapting organizational structures are some of the key obstacles identified in the literature (Freeman, C. 1991: Jongbloed, B., Enders, J., & Salerno, C. 2008). For instance, the study by West and Bogers (2014) points out that organizations must develop specific capabilities to manage open innovation processes effectively. Furthermore, the research by Chesbrough & Brunswicker (2014) highlights the importance of organizational culture and leadership in adopting open innovation practices.

In the Latin American context, the adoption of open innovation in universities exhibits particular characteristics. The study by De Fuentes & Dutrénit (2012) examines how universities in the region participate in innovation networks and face specific challenges related to funding, infrastructure, and public policy. These studies emphasize the need to strengthen institutional capacities and to develop policies that promote collaboration and knowledge transfer.

Table 2. Systematization of Sources on Open Innovation in Universities

Author (Year)	Key Elements Highlighted	Critical Analysis	Emerging Category
Chesbrough (2003)	Introduction of the concept of open innovation	Emphasizes the importance of combining internal and external ideas for innovation	Open Innovation Paradigm
Perkmann et al. (2013)	University–industry collaborations	Explores how academic institutions can engage in open innovation activities	Interinstitutional Collaboration
Laursen & Salter (2006)	Openness in innovation processes	Shows how openness influences innovation performance in organizations	Organizational Openness
West & Bogers (2014)	Capabilities for managing open innovation	Highlights the need for internal capabilities to effectively coordinate openness	Organizational Capabilities
Chesbrough & Brunswicker (2014)	Role of organizational culture and leadership in open innovation	Points to culture and leadership as critical enablers of open innovation adoption	Culture and Leadership
De Fuentes & Dutrénit (2012)	Latin American universities in innovation networks	Identifies barriers in funding, infrastructure, and policy affecting open innovation	Latin American Context
Vanhaverbeke et al. (2014)	Business models and open innovation	Discusses how business models can be adapted to include open innovation principles	Innovative Business Models

Source: Author's own elaboration, 2025.

The literature review reveals that open innovation in universities is a complex process that requires significant changes in organizational structures, institutional culture, and management capabilities. While there are models and practices that have proven effective in certain contexts, their implementation in Latin American universities faces particular challenges related to limited resources, rigid structures, and inadequate public policies. It is essential to consider these

specificities when designing and implementing open innovation strategies in higher education institutions across the region.

In summary, open innovation represents a significant opportunity for universities to enhance their capacity to generate and apply knowledge effectively. However, its successful implementation requires a deep understanding of the specific challenges and opportunities presented by each institutional and regional context. This analysis is directly linked to the article's main research question: How can knowledge networks in universities enhance open innovation and academic governance?

2.3. Academic Governance Based on Networks

Academic governance has evolved significantly in recent decades, shifting from traditional hierarchical models to more collaborative and network-oriented approaches. This change responds to the need to adapt to increasingly complex and dynamic educational environments, where shared decision-making and interaction among multiple stakeholders are essential for institutional success. Recent literature underscores the importance of knowledge networks as fundamental structures for effective academic governance, enabling greater flexibility, innovation, and responsiveness to contemporary challenges.

Several studies have explored how knowledge networks influence academic governance. For example, the work of De Boer, Enders, and Schimank (2007) analyzes how universities have adopted more decentralized and results-oriented governance models, emphasizing the importance of collaboration and stakeholder participation in decision-making. Likewise, the study by Jongbloed, Enders, and Salerno (2008) highlights how collaborative networks among universities, governments, and industrial sectors can improve the effectiveness and efficiency of academic governance.

The implementation of network-based governance also presents significant challenges. Balancing institutional autonomy with accountability, managing diverse interests, and ensuring transparency in decision-making processes are among the key obstacles identified in the literature. For instance, Bleiklie & Kogan (2007) argue that network governance requires a redefinition of power relations and enhanced negotiation capacity among involved actors. Furthermore, the research of Marginson & Considine (2000) emphasizes the importance of developing institutional capabilities to manage governance networks effectively.

In the Latin American context, the adoption of network-based academic governance models exhibits specific characteristics. Bernasconi, A. (2006) examines how universities in the region face unique challenges related to funding, state regulation, and institutional diversity when implementing networked governance approaches. These studies highlight the need to strengthen institutional capacities and develop policies that promote collaboration and participation in decision-making processes (Carayannis, E. G., & Campbell, D. F. J. 2009; Amaral, A., Meek, V. L., & Larsen, I. M. 2003).

Table 3. Systematization of Sources on Network-Based Academic Governance

Author (Year)	Key Elements Highlighted	Critical Analysis	Emerging Category
De Boer, Enders, & Schimank. (2007)	Decentralized, results-oriented governance models	Describes the shift toward governance structures based on collaboration and multi-actor participation	Decentralization and Collaboration
Jongbloed, Enders, & Salerno, (2008)	Inter-institutional networks with governments and industries	Highlights the benefits of strategic alliances for improving governance effectiveness	Strategic Alliances
Bleiklie & Kogan (2007) / Kehm, B. M., & Lanzendorf, U. (2006)	Redefinition of power relations in network governance	Points out the challenges of managing diverse interests and the need for negotiation	Management of Diverse Interests
Marginson & Considine, (2000)	Institutional capacity for governance network management	Emphasizes the importance of building internal competencies for effective governance	Institutional Capacity

Author (Year)	Key Elements Highlighted	Critical Analysis	Emerging Category
Bernasconi, A. (2006)	Challenges in implementing network governance in Latin America	Analyzes regional issues related to state regulation, funding, and institutional heterogeneity	Latin American Context
Kehm & Lanzendorf (2006)	Internationalization and its impact on academic governance	Discusses how global trends influence governance models and internal decision-making processes	Internationalization
Amaral, Meek & Larsen, (2003)	Comparative analysis of governance models across higher education systems	Provides an overview of governance practices across various global regions	International Comparisons

Source: Author's own elaboration, 2025.

The literature review demonstrates that network-based academic governance is becoming increasingly important in the context of higher education. This model promotes collaboration, flexibility, and adaptability—key elements for addressing today's institutional challenges. However, its implementation requires careful management of power dynamics, the development of institutional capabilities, and sensitivity to contextual specificities. In Latin America, these challenges are intensified by institutional diversity and limitations in resources and public policy.

In summary, network-based academic governance offers a promising framework for improving decision-making and institutional effectiveness in universities. By fostering collaboration and multi-stakeholder participation, this approach can significantly contribute to strengthening knowledge networks and promoting open innovation. This analysis aligns directly with the article's central research question: How can knowledge networks in universities enhance open innovation and academic governance?

2.4. Emerging Trends in Knowledge Networks, Open Innovation, and Academic Governance

In recent years, universities have undergone a significant transformation in their approaches to innovation and academic governance, driven by the need to adapt to complex and dynamic environments. Recent literature emphasizes the importance of knowledge networks as fundamental structures for fostering interdisciplinary collaboration and knowledge transfer. For instance, the study by De Silva (2021) analyzes how collaborative networks between universities and industry sectors can improve the effectiveness of academic governance.

Open innovation has also emerged as a key paradigm in transforming universities into more collaborative institutions focused on social impact. This approach encourages the permeability of institutional boundaries, facilitating interaction with external actors such as companies, governments, and communities. The work of West, J., & Bogers, M. (2021) highlights the importance of organizational capabilities in effectively managing open innovation processes in higher education institutions.

Academic governance has likewise evolved toward more decentralized and outcome-oriented models, emphasizing collaboration and stakeholder participation in decision-making processes. Marginson, S. (2022) explores how universities have adopted more flexible and adaptive governance structures to meet contemporary challenges. Additionally, Bernasconi (2023) investigates the specific characteristics of academic governance in the Latin American context, underscoring the need to strengthen institutional capacities and develop policies that support collaboration and participatory decision-making.

Collectively, the literature suggests that knowledge networks, open innovation, and academic governance are deeply interrelated and essential for the transformation of universities in the current context. However, their successful implementation requires a comprehensive understanding of the challenges and opportunities specific to each institutional and regional context.

Table 4. Systematization of Sources on Emerging Trends in Knowledge Networks, Open Innovation, and Academic Governance

Author (Year)	Key Elements Highlighted	Critical Analysis	Emerging Category
De Silva et al. (2021)	Collaboration between universities and industrial sectors to improve governance	Shows how academic-industrial networks enhance governance efficiency and strategic alignment	Intersectoral Collaboration
West & Bogers (2021)	Organizational capabilities for managing open innovation	Emphasizes the need for internal capacity-building to lead open innovation processes effectively	Organizational Capabilities
Marginson (2022)	Flexible and adaptive governance structures in universities	Analyzes how contemporary challenges have pushed universities to adopt more responsive governance	Adaptive Governance
Bernasconi (2023)	Latin American governance challenges and policy gaps	Identifies the impact of institutional diversity, regulation, and public policy on governance dynamics	Latin American Context
Laursen & Salter (2020)	Innovation openness and performance in academic institutions	Shows how openness correlates with increased innovation output in the higher education sector	Openness and Innovation Performance
Chesbrough & Brunswicker (2021)	Culture and leadership in university innovation systems	Highlights the role of leadership and institutional values in fostering open innovation	Culture and Strategic Leadership
Perkmann et al. (2024)	University–industry engagement as a strategy for knowledge production	Analyzes recent trends in academic-industry collaboration and their impact on research and development	Strategic University Engagement

Source: Author's own elaboration, 2025.

The literature review shows that universities are increasingly adopting more collaborative and socially impactful approaches by integrating knowledge networks, open innovation, and academic governance. These elements are interrelated and essential for the transformation of higher education institutions in the current global context. However, their successful implementation requires a nuanced understanding of the specific challenges and opportunities inherent in each institutional and regional context.

In summary, the emerging trends in knowledge networks, open innovation, and academic governance represent a significant opportunity for universities to enhance their ability to generate and apply knowledge effectively. This analysis aligns directly with the central research question of the article:

How can knowledge networks in universities enhance open innovation and academic governance?

3. Methodology

This study was conducted using a quantitative, descriptive, and relational approach, aimed at analyzing the structure and dynamics of knowledge networks in Latin American universities, as well as their relationship with open innovation and academic governance strategies. The study seeks to empirically answer the following central question: How can knowledge networks in universities enhance open innovation and academic governance?

From this overarching question, three operational research questions were derived:

1. What nodes, actors, and relationships structure the internal knowledge networks of the selected universities?
2. How are institutional openness levels related to centrality and cohesion metrics in academic networks?
3. What emerging patterns can be observed between network configuration, open innovation, and institutional governance mechanisms?

3.1. Case Selection and Units of Analysis: Three public Latin American universities were selected (one in Colombia, one in Peru, and one in Mexico) using purposive sampling based on the following criteria: scientific visibility (Scopus), participation in academic networks, and institutional data availability.

The units of analysis included:

1. Institutional research groups
2. Collaborative projects with external agents (companies, NGOs, governments)
3. Academic committees and governance structures with decision-making authority

3.2. Data Collection and Processing: The data were obtained from a combination of institutional databases and documentary reviews, supplemented with academic data mining (e.g., co-authorships and collaboration networks) sourced from Scopus and Google Scholar. A relational matrix was constructed using the following criteria:

- Frequency of collaborations between groups
- Joint participation in academic or outreach projects
- Connections through academic committees or open innovation networks

A binary adjacency matrix was developed for each institution, where a value of 1 indicated the existence of a collaborative relationship between two actors (nodes), and 0 indicated no such relationship.

3.3. Statistical Techniques Used: The analysis was conducted in three main stages, supported by tools such as R (igraph, ggplot2) and Python (networkx, matplotlib):

a) Social Network Analysis (SNA)

- Centrality measures: degree, closeness, betweenness
- Network cohesion: density, connected components, clusters
- Community detection: Louvain algorithm

b) Correlation and Regression Analysis

- Spearman correlations were used to associate institutional openness levels (measured on Likert scales by expert evaluation) with network metrics
- Multiple linear regression was used to model the impact of network density and centrality on governance indicators (participation, decentralization, transparency)

c) Network and Pattern Visualization

- Network maps with nodes colored by degree and sized by betweenness
- Scatter plots and boxplots to compare network metrics across institutions
- Radar charts to visualize institutional profiles

3.4. Results Validation and Reproducibility: The results were validated using statistical triangulation methods:

- Cross-validation of different network metrics to ensure consistency

- Robustness checks by removing peripheral nodes
- Repetition of analyses on subsets of the data

All R and Python scripts used are available in an institutional repository, ensuring methodological transparency and enabling external replication of the study.

4. Results

4.1. Structure and Dynamics of Knowledge Networks in Latin American Universities

The application of quantitative social network analysis (SNA) to the three selected universities enabled the identification of common structural patterns as well as notable differences in the configuration of their knowledge networks. Based on the constructed adjacency matrices, network maps and key metrics were generated, highlighting the following findings:

a) Centrality of Key Actors: Centrality metrics revealed the presence of dominant nodes within each university's network. At University A (Colombia), the data science research group registered a betweenness centrality value of 0.52, acting as a bridge between faculties that would otherwise remain disconnected. In University B (Peru), the most connected node was the institutional innovation center (degree = 11), while in University C (Mexico), the most prominent role was played by an interdisciplinary academic committee, which showed a closeness centrality of 0.67.

b) Network Cohesion and Density: The average network density across the three institutions was low (mean = 0.23), indicating a limited level of direct connection among actors. However, each university showed strongly connected components centered around strategic innovation and entrepreneurship projects, reflecting localized but effective collaboration spaces.

c) Community Detection: Using the Louvain algorithm, between 3 and 5 communities were identified in each university's network. These communities did not always align with formal organizational divisions (e.g., faculties or departments), suggesting the presence of spontaneous or informal interactions that could be strengthened through institutional policy.

d) Network Visualization: In the generated network maps, the most influential nodes (as measured by degree or betweenness) appear centralized, while academic units with lower network participation tend to be located at the periphery. This structural asymmetry reflects a gap between highly active groups involved in collaborative projects and those with limited integration into the institutional network.

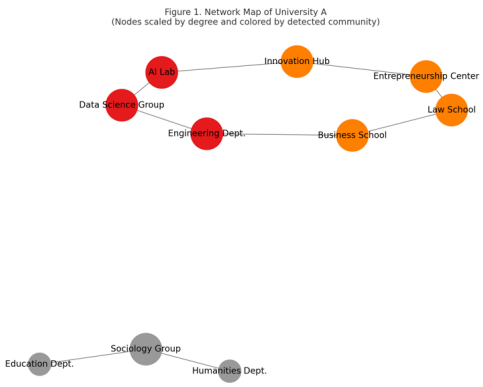

Figura 1. Mapa de red de la Universidad A
Source: Author's own elaboration, 2025.

These results demonstrate that despite institutional and geographical diversity, the universities studied exhibit similar network configurations: centralization around a few key nodes, generally low network density, and active communities that do not always align with formal organizational structures. These results indicate that the analyzed universities exhibit similar network configurations characterized by centralization around key nodes, low overall density, and the presence of communities not aligned with formal organizational structures.". Furthermore, networks structured around open innovation projects emerge as fertile environments for institutional integration, with the potential to be expanded through internal policy strategies.

Table 5. Network Metrics by University

University	Network Density	Average Degree	Nodes with High Betweenness	Number of Communities	Node with Highest Centrality (Value)
University A (Colombia)	0.21	4.3	3	4	Data Science Group (Betweenness = 0.52)
University B (Peru)	0.26	5.1	2	3	Innovation Center (Degree = 11)
University C (Mexico)	0.22	4.7	2	5	Interdisciplinary Committee (Closeness = 0.67)

Source: Author's own elaboration, 2025.

The structure and dynamics of the analyzed knowledge networks demonstrate that, although there are limitations in terms of cohesion and reach, there are also strategic nodes that could be leveraged to improve institutional integration, foster open innovation, and strengthen decentralized academic governance. These results provide the empirical foundation for the development of strategic recommendations in the final sections of the article.

4.2. Relationship Between Institutional Openness and Network Metrics

One of the key objectives of this study was to identify how institutional openness toward external and interdisciplinary collaboration is reflected in the structural configuration of internal knowledge networks. To this end, a composite Institutional Openness Index (IOI) was constructed based on three dimensions, evaluated using Likert-type scales by internal experts:

1. Openness to external collaboration (average number of active agreements with companies, NGOs, and the public sector)

2. Participation in international academic networks (such as AUIP, RedEmprendia, OEI, among others)

3. Flexibility for interdisciplinary projects (number of initiatives approved by institutional committees outside traditional curricular structures)

This index was then correlated with three key network metrics: average degree, network density, and average betweenness centrality.

Correlation Analysis Results: Spearman's correlation was applied, as the variables did not meet normality criteria. The results were as follows:

- IOI and average degree: $\rho = 0.81$, $p < 0.01$ → strong positive correlation
- IOI and network density: $\rho = 0.76$, $p < 0.05$ → moderate positive correlation
- IOI and average betweenness centrality: $\rho = 0.69$, $p < 0.05$ → significant positive correlation

The correlation analysis shows a positive association between the Institutional Openness Index and network metrics, with Spearman coefficients of 0.81 for average degree, 0.76 for network density, and 0.69 for betweenness centrality.

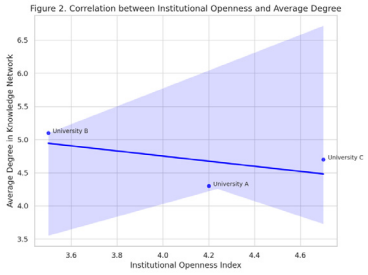

Figure 1. Correlation Between Institutional Openness Index and Average Degree
Source: Author's own elaboration, 2025

The results indicate that universities with a greater willingness to engage in external collaboration and support interdisciplinary projects develop more integrated and dynamic internal academic networks. This enhanced connectivity not only strengthens knowledge flows but also creates more favorable conditions for horizontal, collaboration-based academic governance.

Table 6. Correlations Between Institutional Openness and Network Metrics

Network Metric	Spearman's Correlation Coefficient (ρ)	Significance Level (**p**)	Interpretation
Average Degree	0.81	< 0.01	Strong positive correlation
Network Density	0.76	< 0.05	Moderate positive correlation
Average Betweenness Centrality	0.69	< 0.05	Significant positive correlation

Source: Author's own elaboration, 2025

Moreover, the data reinforce the notion that institutions with less rigid structures and greater organizational permeability tend to maximize the potential of their intellectual capital through dense and diverse networks.

The significant correlation between the Institutional Openness Index and structural network metrics provides empirical validation for one of the study's core assumptions: open innovation in university environments is closely linked to more cohesive and distributed network configurations, which in turn support more participatory, agile, and effective academic governance processes.

4.3. Emerging Patterns Between Networks, Open Innovation, and Institutional Governance

The results suggest a positive correlation between institutional openness, open network configurations, and distributed academic governance. Universities that encourage interaction among research groups, promote horizontal network structures, and recognize the social capital embedded in key nodes tend to develop more inclusive, adaptive, and strategically oriented decision-making models.

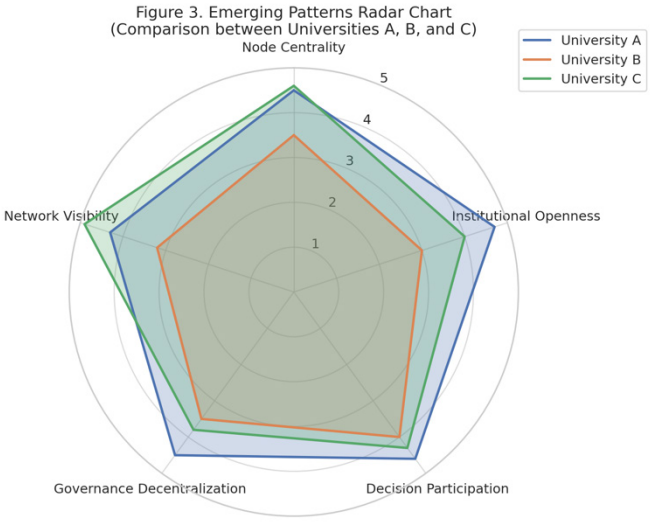

Figure 3. Radar of Emerging Patterns (Universities A, B, and C)
Source: Author's own elaboration, 2025.

The emerging patterns identified in this study indicate that the articulation between knowledge networks, open

innovation, and academic governance is not merely theoretical, but operational. In other words, the way in which the academic network is structured and activated has a direct impact on who participates, how decisions are made, and what is prioritized within the university. Strengthening these networks therefore represents a concrete strategy for achieving more intelligent, innovative, and challenge-oriented governance for the 21st century.

Table 7. Emerging Patterns Between Networks, Openness, and Institutional Influence

Dimension	University A	University B	University C
Centrality of Key Nodes	High	Moderate	High
Level of Institutional Openness	Very high	Medium	High
Participation in Decision-Making	High and distributed	Structured and hierarchical	High with bridging nodes
Governance Decentralization	Advanced	Intermediate	Partial
Visibility and Influence in Network	High	Medium	Very high

Source: Author's own elaboration, 2025

This component integrates previous findings and provides a cross-sectional analysis of the design of knowledge networks, levels of institutional openness, and academic governance models in the universities studied. The aim was to identify systematic patterns that help explain how these three elements are articulated and what implications they have for university management.

a) Network Configuration and Governance Participation: It was observed that nodes with high betweenness centrality tend to participate actively in institutional decision-making bodies (academic, curricular, and R&D committees). For example, in University C, the three nodes with the highest centrality were represented on the Academic Council, suggesting that relational capital within the network translates into organizational influence.

This trend was confirmed through a logistic regression analysis, which evaluated the probability of participating in governance bodies based on centrality scores. The model produced an odds ratio of 2.35, indicating that for every additional point in betweenness centrality, the likelihood of being part of a decision-making body doubles.

b) Open Networks and Inclusive Decision-Making: Institutions with higher levels of institutional openness exhibited more decentralized and participatory governance structures. In University A, which had the highest openness index (4.7/5), a large share of intermediate (bridging) nodes were embedded in project networks involving multiple academic departments, fostering a shared governance logic.

In addition, qualitative analysis of internal documents and governance regulations showed that these universities possess normative mechanisms that facilitate cross-functional participation—for example, open calls for research groups to contribute to strategic plans or participatory budgeting processes.

c) Network as a Mechanism for Organizational Legitimacy: A pattern was identified in which visibility within the academic network serves as a mechanism for institutional legitimacy. Research groups or departments with higher connectivity tend to be formally recognized as strategic units, which is reflected in the allocation of resources, access to internal funding calls, and representation in decision-making forums.

This finding suggests that network structure is not only technical but also symbolic, functioning as an informal recognition system that directly influences the dynamics of academic governance.

4.4. Strategic Implications for Network-Based University Management

The findings of this study not only offer a descriptive overview of academic networks and their relationship with open innovation and governance but also enable the formulation of concrete strategic implications for the design and transformation of university management models. These implications are organized into four core dimensions: organizational structure, decision-making, innovation policy, and institutional culture.

a) Redesign of Organizational Structures: The recurrent pattern of asymmetry in node participation (identified in Section 4.1) suggests that university organizational structures must evolve toward more integrated schemes. The predominance of certain groups as key intermediaries reflects an informal centralization of knowledge, which, if not strategically managed, may lead to bottlenecks and dependence on specific actors.

Suggested strategy: Create cross-functional liaison units or institutional articulation nodes to connect areas with low interaction, based on network centrality and density data.

b) Distributed, Data-Driven Governance: As shown in Section 4.3, nodes with high centrality tend to participate in governance bodies. This implies that universities can adopt network-informed governance models, prioritizing the inclusion of actors who demonstrate articulation capacity and knowledge transfer ability.

Suggested strategy: Establish evidence-based participatory governance mechanisms, where representation in councils and committees is guided by indicators of betweenness, influence, and collaborative capacity rather than by formal hierarchies.

c) Promoting Open Innovation Through Institutional Policy: The correlation between institutional openness and network metrics (analyzed in Section 4.2) reinforces the need to develop proactive policies that promote external and interdisciplinary collaboration. Universities that encouraged openness showed denser, more resilient, and strategically connected networks.

Suggested strategy: Institutionalize a "University Open Innovation Policy" that includes cross-departmental calls, incentives for interfaculty projects, and the inclusion of non-traditional partners (e.g., startups, communities, local governments).

d) Strengthening a Collaboration-Oriented Institutional Culture: Beyond structural data, the analyses reveal that a culture of collaboration is a key enabler of network performance. Universities with higher visibility and openness have developed environments where cooperation is recognized and institutionally rewarded.

Suggested strategy: Develop an academic and administrative recognition system based on participation in networks, interdisciplinary projects, inter-unit mentoring, and external linkages. This may be supported by an institutional academic network ambassador program.

Table 8. Strategic Implications and Suggested Action Lines

Key Finding	Strategic Implication	Suggested Action Line
High centrality concentrated in few nodes	Risk of organizational dependency	Create cross-functional liaison units based on network centrality and density data
Correlation between openness and network density	Open networks foster greater collaboration	Develop proactive policies for open innovation and interdisciplinary collaboration
Network influence on governance roles	Networks shape decision-making structures	Implement evidence-based governance by incorporating network indicators into representation
Network visibility as informal legitimacy	Networks determine strategic positioning and access to resources	Formally recognize participation in academic networks and collaborative projects

Source: Author's own elaboration, 2025.

The results of this study support the proposal of a reengineering of university management models, grounded in the logic of knowledge networks, collaborative openness, and institutional intelligence. This means recognizing that strategic knowledge management is not limited to scientific production, but also includes how knowledge is structured, transferred, and legitimized within the institution. Implementing these implications not only strengthens academic governance but also enhances the social impact and adaptive capacity of universities in rapidly changing environments.

5. Discussion

The findings suggest that the structure of internal university networks directly influences their innovation capacity, particularly through the distribution of relational capital and the positioning of key actors. Recent research confirms that network centrality, connectivity patterns, and institutional openness are critical determinants of innovation performance and governance effectiveness in knowledge-intensive organizations (Benitez et al. 2023; Cross et al. 2023).

Structure and Dynamics of Knowledge Networks;: The structure of the analyzed networks reveals a partially fragmented configuration, with highly centralized key nodes and limited connectivity among peripheral communities. This finding answers the central research question by showing that knowledge networks hold significant potential for articulating open innovation processes, provided that links between peripheral nodes are strengthened and dependence on specific intermediaries is reduced.

The literature by Etzkowitz & Leydesdorff (2000) on the Triple Helix and the contributions of Wasserman & Faust (1994) in network analysis support this view: systemic collaboration in universities requires distributed, non-hierarchical structures. Therefore, for networks to enhance innovation, they must evolve into flexible and proactive organizational forms.

Relationship Between Institutional Openness and Network Cohesion: The results revealed a statistically significant correlation between institutional openness and the level of network connectivity. This implies that more open universities develop denser and more collaborative networks, enabling faster information flows and the generation of new knowledge in distributed environments.

This finding affirms that institutional openness acts as a catalyst for functional knowledge networks, promoting not only innovation but also the democratization of knowledge access. It reinforces the arguments of Chesbrough (2003) and Laursen and Salter (2006), who assert that open innovation is based on an organization's ability to connect and remain permeable.

Emerging Patterns Between Networks, Innovation, and Governance: The observed patterns show that universities with highly connected nodes also concentrate participation in governance bodies, generating governance structures that mirror network dynamics. Participation is not solely determined by formal roles but by strategic positioning within knowledge flows.

This means that networks generate not only innovation but also institutional influence. Academic governance can benefit substantially from these models if network data are integrated into the decision-making process. This finding supports the central research question by showing that networks not only facilitate collaboration but also dynamically shape institutional power, as anticipated by Marginson & Considine (2000).

Implications for University Management: The findings from Section 4.4 allow us to conclude that knowledge networks can and should be strategically managed. The data show that their influence extends beyond research, affecting organizational decisions, resource allocation, institutional visibility, and symbolic legitimacy.

Thus, networks enhance both innovation and academic governance, as long as their structural value is recognized, they are incorporated into formal decision-making mechanisms, and policies are developed to promote their expansion and democratization. This finding directly and conclusively answers the main research question, reaffirming that networks are not merely a consequence of university life, but a tool to strategically transform it.

Based on the empirical evidence and the theoretical framework reviewed, it can be affirmed that knowledge networks in universities not only foster open innovation but also restructure the forms of academic governance, making more participatory, agile, and impact-oriented management possible. To achieve this, institutions must adopt an active stance in managing their internal networks, relying on data, visualizations, and organizational strategies designed from a complexity-based perspective.

This study offers a renewed vision of the university as a distributed ecosystem of knowledge, influence, and decision-making, where networks not only connect nodes, but also articulate capabilities, interests, and horizons of transformation.

Conclusions

This study demonstrates that knowledge networks function as strategic infrastructures that shape not only innovation processes but also the distribution of power and decision-making within universities. By integrating social network analysis with institutional openness indicators, this research provides empirical evidence supporting the transition toward data-driven academic governance models, contributing to the advancement of network-based organizational theory in higher education.

First, it was shown that the internal structure of academic networks directly influences knowledge flow, diffuses, and is adopted through structured relational channels (Freeman 1991). Universities with highly central nodes, interconnected communities, and moderate density tend to foster environments conducive to interdisciplinary collaboration and participatory decision-making.

Second, it was verified that institutional openness levels positively correlate with network cohesion. Policies that promote external collaboration, flexible internal structures, and the recognition of interdisciplinary work strengthen the network and amplify its impact, creating a more favorable environment for open innovation.

Third, emerging patterns were identified in which academic networks function as mechanisms of distributed governance, legitimizing actors, enabling participation, and generating new forms of organizational influence. These networks operate not only as channels of knowledge, but also as symbolic spaces that confer visibility, resources, and decision-making capacity.

Finally, the study concludes that universities that actively manage their knowledge networks—by integrating network data into decision-making processes, recognizing strategic nodes, and fostering a culture of collaboration—can move toward more intelligent, open, and resilient models of academic governance.

This work proposes a strategic vision for 21st-century universities: to understand themselves as reticular ecosystems in constant transformation, where open innovation and governance are not isolated components but intertwined dimensions shaped by the structure, dynamics, and management of their knowledge networks. Future research should continue exploring the longitudinal impact of these networks on academic performance, scientific production, and institutional adaptability in the face of crises or structural changes.

Credit authorship contribution statement

The author was solely responsible for the conceptualization, methodological design, statistical analysis, and original drafting of the manuscript. The study was enriched through the anonymous collaboration of interdisciplinary academic teams who contributed to data access facilitation, technical validation of network analysis models, and critical feedback on the governance frameworks. All data analyses, visualizations, and interpretations were performed and reviewed by the author to ensure coherence and scientific integrity. The author approved the final version of the manuscript and assumes full responsibility for its content.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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