

Beyond Hierarchy: Network Architecture and Gender Neutrality in Ecuadorian Government Auditing

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Abstract

This study examines the manifestation of female technical leadership within the management network of Ecuador's Supreme Audit Institution through the lens of complex network theory. The research responds to the growing need to understand how relational dynamics of leadership and cooperation operate within public institutions from a perspective distinct from econometric approaches. The article seeks to identify patterns of female leadership within the operational structure of the Ecuadorian audit network, considering the functional roles and gender of each auditor involved in government auditing.

The study adopts a quantitative approach based on complex network analysis applied to an anonymized institutional database. Drawing on these data, the researchers constructed a collaboration network comprising 2,442 nodes and 22,565 ties, to which they applied centrality, density, and assortativity metrics, together with non-parametric statistical tests, to assess structural differences. The empirical data reveal a low-density network in which highly connected nodes tend to collaborate with one another. The analysis also identifies a significant presence of women within the technical supervision core, alongside relevant functional brokerage performed by support roles.

The findings indicate that brokerage varies unevenly across functional roles but not across genders, suggesting that the institution operates predominantly through a gender-neutral and technically oriented structure. Nevertheless, the gender gap in brokerage widened over the period under analysis. Female leadership primarily manifests itself through women's structural integration into the network's technical coordination spaces.

Keywords: Leadership; gender; auditing; complex networks; governance; public administration.

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Introduction

The debate surrounding female leadership, as in private-sector management, has gained increasing relevance within the field of public management, particularly in institutions characterized by hierarchical structures, rigid regulations, and a historical masculinization of positions of power. At the international level, external oversight bodies, such as Supreme Audit Institutions (SAIs), have not remained unaffected by this dynamic and face the challenge of incorporating gender equity and inclusive leadership approaches into contexts shaped by traditional bureaucratic logics (Gilas, 2024; INTOSAI, 2025). In this regard, analyzing female leadership in the management of such organizations constitutes not only a matter of equity but also a strategic factor for improving the effectiveness, legitimacy, and quality of government oversight (Castillo y Maribel, 2022).

The Office of the Comptroller General of the State (CGE), as Ecuador's Supreme Audit Institution, plays a fundamental role in overseeing and auditing the proper use of public resources and strengthening transparency and accountability (Redroban-Ortiz, Matute-Petroche, et al., 2025). Its operational structure primarily comprises processes that require high levels of technical expertise, decision-making capacity, and legal responsibility, distributed across clearly differentiated functional roles among auditors, including supervisor, team leader, operational auditor, and support staff. Within this organizational framework, leadership does not emerge solely through formal positions; rather, it also manifests through patterns of interaction, influence, and technical collaboration that can be examined from a relational perspective rather than exclusively through conventional econometric models.

Despite regulatory advances in gender equity within Ecuador's public sector, empirical evidence regarding how female leadership manifests itself in oversight institutions remains limited. Most existing research focuses on descriptive variables without examining in depth the internal dynamics of technical and collaborative leadership that emerge during the day-to-day development of organizational processes (Bodla et al., 2023). This gap becomes particularly

relevant given that effective leadership in key oversight institutions such as SAIs depends not exclusively on formal authority but also on the ability to coordinate work teams in fulfilling their government oversight mission, mediate among stakeholders, and ensure the technical and legal quality of audit reports.

Within this context, complex network analysis emerges as an innovative and relevant methodological approach for examining female leadership from a different perspective. By modeling workplace interactions as networks, researchers can identify performance patterns through centrality, density, and correlation metrics, thereby providing insight into how influence and collaboration become distributed across different organizational roles. This approach has been successfully applied in studies of leadership, governance, and organizational performance, offering a robust alternative to traditional approaches that rely exclusively on formal hierarchies (Bodla et al., 2023; Borgatti y Everett, 2000).

Theoretical Foundations of Female Leadership in Public Organizations

The literature on female technical leadership has evolved from classical approaches focused on merely comparing leadership styles between men and women toward more complex perspectives that acknowledge the influence of organizational context, power structures, and relational dynamics among actors. Some studies suggest that women tend to adopt more collaborative, participatory, and people-oriented leadership styles, characteristics that prove particularly valuable in knowledge-intensive organizations such as audit institutions (Lee, 2024; White et al., 2016).

Within the field of public management, female leadership commonly correlates with improvements in transparency, organizational ethics, and public trust. Comparative studies of European and Latin American public administrations show that greater female representation in key positions strongly correlates with more inclusive governance practices and a stronger orientation toward the public interest (Hancu-Budui & Zorio-Grima, 2023; Meng & Neill, 2021; Rudiana et al., 2025; Stephenson, 2017). Nevertheless, these studies generally focus on macro-level patterns, leaving aside the micro-level analysis of the everyday interactions that sustain institutional functioning.

From an organizational perspective, leadership can emerge as a phenomenon constructed through social relationships and information flows (Jogulu & Wood, 2006). In this regard, network theory provides a robust conceptual framework for examining how individuals occupy strategic positions that enable them to influence others, coordinate actions, and facilitate cooperation toward the achievement of institutional objectives (Freeman, 1977; Gómez, 2019). It should be noted, however, that centrality metrics constitute structural proxies of relational position, including connectivity, brokerage capacity, and proximity to highly influential nodes, rather than direct measures of leadership behavior. This study assumes that occupying structurally advantageous positions increases an actor's potential for influence and coordination, without necessarily implying the observed exercise of leadership practices, whose behavioral assessment falls beyond the scope of network analysis.

Leadership, Gender, and Complex Networks: Empirical Evidence

The application of complex network analysis to the study of leadership and gender has grown steadily in recent years. Empirical studies have shown that women's structural positions within organizational networks correlate positively with managerial performance, team coordination, and decision-making effectiveness (Bodla et al., 2023; Buss et al., 2025). In particular, degree centrality has emerged as a robust indicator of active and operational leadership, as it reflects the level of direct interaction maintained by an actor within the network.

A substantial body of literature combines gender, leadership, and network analysis to explain not only who leads organizations but also how leadership operates. The analytical focus shifts from formal positions to structural positions, including centrality, density, and assortativity, closely aligning with evidence concerning the relational advantages associated with female leadership. Other studies have shown that women in leadership positions tend to build broader and more diverse networks, thereby increasing their functional visibility and coordination capacity (Cárdenas et al., 2015; Paustian-Underdahl et al., 2014). This pattern proves particularly relevant in knowledge-intensive public organizations, where leadership operates through the continuous coordination of organizations, actors, and tasks.

Complementing these findings, other studies have demonstrated that betweenness centrality can capture collaborative leadership, understood as the capacity to connect subgroups, mediate across areas of expertise, and facilitate information flows. Recent evidence suggests that women more frequently occupy strategic brokerage positions, acting as bridge nodes that foster cooperation and reduce organizational fragmentation (White et al., 2016). This perspective forms part of a broader body of research linking transformational leadership, work engagement, and public service motivation in government organizations (Alamri, 2023). Such relational leadership has been associated with more inclusive organizational climates and improved collective outcomes.

Integrative reviews of the leadership literature emphasize the need to incorporate complex methodological approaches that move beyond traditional hierarchical perspectives by incorporating structural and relational analyses to understand more precisely how female leadership operates within formal organizational contexts (Buss et al., 2025). Research conducted in public and private organizations has shown that, even when women hold fewer hierarchical positions, they often perform key roles as facilitators of collaboration and occupy positions characterized by high levels of brokerage within organizations (Paustian-Underdahl et al., 2014).

Likewise, the literature on complex network analysis indicates that greater network density generally correlates with increased collaboration, coordination, and collective learning, although important contextual differences may arise. Denser networks tend to facilitate coordination and collective learning, conditions that can support inclusive and participatory leadership styles. Within this context, gender assortativity allows researchers to examine whether interactions tend to concentrate among actors of the same gender or, conversely, whether patterns of cross-gender integration and collaboration emerge. This distinction proves fundamental for assessing organizational equity and cohesion (Baumann et al., 2024; Newman, 2002; Ulibarri & Scott, 2017).

In the Latin American context, researchers have begun to examine female leadership in public organizations through more empirical and relational approaches, although this line of inquiry remains incipient. Studies have shown that the presence of women in technical leadership positions correlates with higher levels of collaboration, organizational innovation, and orientation toward the public interest (Carrera & Mareque, 2023; Naranjo Bautista et al., 2022; Vega Osuna et al., 2023). However, these studies also emphasize that the effects associated with female leadership depend to a considerable extent on the relational structure within which women leaders operate.

In Ecuador, an empirical gap persists in this area. Few studies have measured female leadership through network metrics in the public sector, despite international evidence highlighting the relevance of such approaches. Available research generally falls into three main categories: (1) normative approaches and descriptive participation (Almeida-Guzmán & Barroso-González, 2020; Sacoto & Osuna, 2018); (2) leadership styles and gender without network structures (Boada et al., 2023; Malean Romero et al., 2023); and (3) female leadership and innovation (Bown & McClellan, 2017; Chávez-Rivera et al., 2024).

None of the cited Ecuadorian studies applies metrics derived from complex network theory, such as centrality, density, or assortativity, to assess female leadership in public oversight institutions or other public organizations. This evidence therefore remains largely limited to quotas, formal positions, and self-reported leadership styles. These findings reinforce the need to examine not only women's presence in technical positions but also their structural positions within work networks in key organizations such as public oversight institutions.

Purpose, Objectives, and Hypotheses

Based on the gaps identified in the literature, this study aims to analyze female leadership in the technical management of the Contraloría General del Estado, Ecuador's Supreme Audit Institution (SAI), from a complex network perspective, with particular emphasis on workplace interactions arising from government auditing processes and functional roles. The study seeks to move beyond traditional approaches based on formal hierarchies by proposing a relational analysis capable of identifying patterns of technical leadership within the management of the oversight institution.

The general objective of the study involves analyzing how female technical leadership manifests within the audit network. Accordingly, the following general research question guides the study:

How does female leadership manifest within the audit network of Ecuador's Contraloría General del Estado, considering functional roles and complex network metrics?

Based on this research question, the study proposes the following research hypotheses:

H1: The gender gap in brokerage within the management of the Contraloría General del Estado decreased between 2018 and 2022, reflecting a process of structural convergence at the upper hierarchical levels (Supervisor and Team Leader) that would have reduced gender-differentiated control over information.

H2: Specialized technical brokerage centrality concentrates in support roles that function as fundamental articulating nodes in the validation of audit processes, regardless of gender and administrative hierarchy.

H3: The management network of Ecuador's SAI exhibits low structural density, a stratified core-periphery architecture, and a positive degree-assortativity pattern, forming a technical coordination core in which highly connected nodes preferentially interact with one another and where women hold a significant presence in structural articulation positions.

H4: Gender assortativity within the management network of Ecuador's SAI remains low or negative, indicating interaction patterns that favor integration based on technical profiles and reduce cross-gender segregation in audit processes.

Materials and Methods

This study employed a quantitative research design with an exploratory and descriptive scope, based on a complex network analysis approach applied to the organizational structure of the Contraloría General del Estado, Ecuador's Supreme Audit Institution (SAI). This approach enabled the modeling of institutional interactions as a management network in which auditors represent the nodes and collaborative relationships reflected in audit reports represent the ties.

The methodological approach drew primarily on the principles of complex network science developed by Albert-László Barabási and the formal methods of structural network analysis proposed by Mark Newman, two leading scholars in the field of network science whose concepts have been widely applied to the study of complex organizational systems and interaction patterns within social and professional networks.

The study examined the collaboration structure of audit teams within Ecuador's SAI by considering interactions generated when two or more auditors jointly participated in the preparation of government audit reports while performing different roles. Based on these interactions, the researchers constructed a co-participation network (Fig. 1) to assess the structural properties of the organization's management network and test the hypotheses presented in the previous section.

Data Source

The data used in this study came from an institutional database containing audit reports produced by Ecuador's SAI between 2018 and 2022. The database includes chronological and documentary records of the oversight institution's activities, the composition of audit teams, the

roles performed by team members, the operational management of the different audit phases, and the gender of each auditor.

Based on these records, the study identified instances of co-participation among auditors within the same audit report, thereby establishing the ties that structure the organizational network under analysis. The resulting network comprised 2,442 nodes (auditors) and 22,565 collaborative ties, forming a large-scale institutional network of professional interactions.

Network Topology

The complex network presented in Figure 1 was constructed using a co-participation network approach, in which two auditors become connected when they jointly participate in the preparation of the same audit report while performing different roles. This procedure generated an undirected network in which each tie represents a professional interaction within a work team. The network structure was modeled in Python using the NetworkX library, which enabled the calculation of various structural graph metrics for subsequent testing of each research hypothesis.

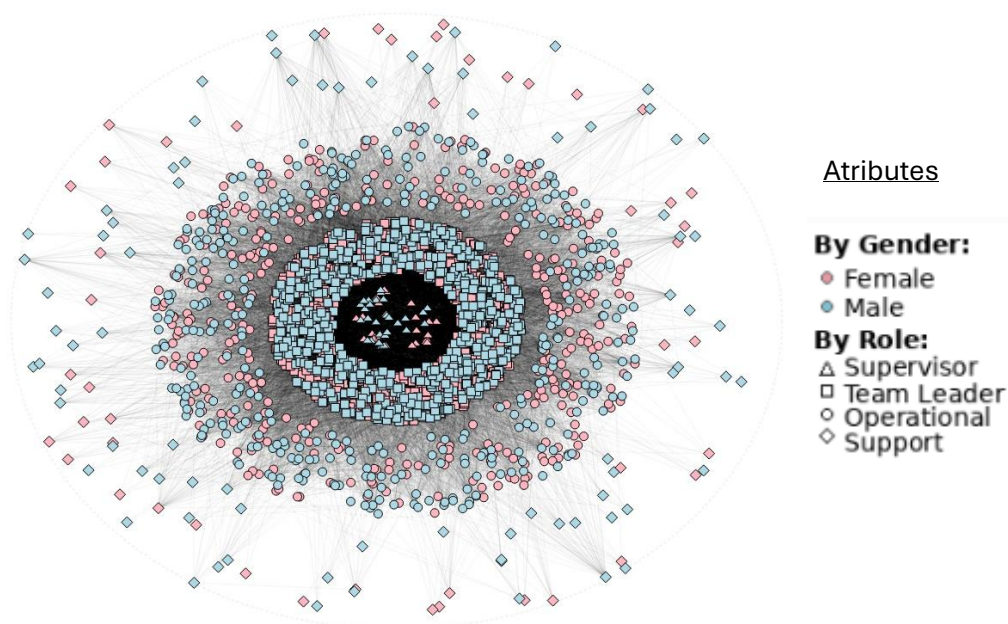


Figure 1. Hierarchical and Gender Architecture of the Ecuadorian SAI Management Network

Organizational Stratification

To analyze the hierarchical structure of the organization, the nodes were classified according to the institutional role performed within the audit process. For analytical purposes, four hierarchical levels established by Ecuador's Supreme Audit Institution (SAI) were defined: supervisor, team leader, operational auditor, and support auditor. The analysis also incorporated the gender of each auditor. This classification allowed the network to be structured into

organizational strata, thereby facilitating the identification of interaction patterns across hierarchical levels and the detection of potential core–periphery structural configurations within the institutional network. These results were subsequently complemented with centrality metrics to identify the relative importance of each node within the network.

Assortativity and Network Structure

Following the theoretical foundations of complex network science, particularly the developments proposed by Barabási and Albert (2015), the degree assortativity coefficient was assessed to determine whether nodes with a higher number of connections tend to preferentially interact with one another. This indicator made it possible to identify whether the network exhibits patterns of hierarchical organization or the formation of highly connected cores, characteristics frequently observed in organizational networks where certain actors concentrate coordination and supervisory functions.

Additionally, average-degree correlation matrices were generated and represented as heat maps, which allowed the intensity of interactions among the different organizational groups under analysis to be examined.

Nonparametric Statistics

To assess potential structural differences among network groups, nonparametric statistical tests applicable to complex network methodology were performed. Network metrics, such as node degree, often exhibit highly asymmetric or heavy-tailed distributions, thereby limiting the applicability of traditional parametric methods.

Specifically, the following tests were applied in this study:

Mann–Whitney U Test

The Mann–Whitney U test, proposed by Henry Mann and Donald Whitney (1947), was used to compare the distributions of network metrics, such as node degree and centrality, between two independent groups, particularly auditors classified by gender. This test allowed us to determine whether statistically significant differences existed between the medians of the two groups without assuming normally distributed data.

Because the number of active auditors varies from year to year and the same professional may participate in the network during more than one annual period, the unit of analysis used for both this test and the Kruskal–Wallis test consisted of auditor–year observations. The dataset comprised approximately 4,500 to 5,000 records for the 2018–2022 period, with observations distributed relatively evenly across genders, rather than the 2,442 unique nodes described in Section 2.1. This distinction is necessary for correctly interpreting the magnitude of the U and H statistics reported in the Results section.

Kruskal–Wallis Test

To compare network metrics across more than two organizational groups, the Kruskal–Wallis test, developed by William Kruskal and W. Allen Wallis (1952), was applied. This test constitutes a nonparametric extension of analysis of variance (ANOVA) and allows researchers to assess whether significant differences exist in the distributions of network metrics across the organizational roles defined in the study: supervisor, team leader, operational auditor, and support staff.

Visualization of the Network Structure

The network was visualized using the Fruchterman–Reingold algorithm, which relies on a physical force model involving attraction and repulsion to position nodes within the graphical space, thereby facilitating the visual identification of clustering and centrality patterns (Fruchterman & Reingold, 1991). In addition, two-dimensional visualizations and interaction matrices were generated to examine the organizational structure of the network from different analytical perspectives.

Information Confidentiality

The use of institutional data strictly adhered to the principles of confidentiality, institutional secrecy, and personal data protection, in accordance with the legal obligations governing information management within Ecuador’s Supreme Audit Institution (SAI). To safeguard the identities of the officials involved, the data used in the analysis underwent anonymization and masking procedures, through which personal identifiers were removed or replaced. Consequently, the study does not disclose names, surnames, personal identification numbers, or other sensitive information. Instead, it uses only coded identifiers that allow the structural characteristics of the network to be analyzed without compromising individual privacy.

Results and Analysis

The analysis of the collaboration network constructed from the institutional records of Ecuador’s Supreme Audit Institution (SAI) for the 2018–2022 period revealed relevant structural patterns within a network characterized by low overall density but, nonetheless, a dense core of technical coordination. The results are presented according to the four hypotheses formulated in the study.

Regarding Hypothesis 1, Table 1 presents the results for degree, betweenness, closeness, and eigenvector centrality for each year, disaggregated by auditor gender.

Table 1. Centrality Analysis by Gender, 2018–2022

Year	Gender	Centrality Values			
		Degree	Betweenness	Closeness	Eigenvector
2018	Female	0.002775	0.000741	0.040734	0.004517
	Male	0.003050	0.001139	0.042540	0.005069
2019	Female	0.004673	0.001122	0.095554	0.004943
	Male	0.005013	0.001296	0.098343	0.003894
2020	Female	0.004449	0.001224	0.078698	0.006683
	Male	0.004759	0.002066	0.080401	0.006241
2021	Female	0.005660	0.001157	0.109949	0.005990
	Male	0.006187	0.002271	0.118490	0.007626
2022	Female	0.005029	0.001342	0.076420	0.005596
	Male	0.005486	0.002524	0.075332	0.007566

To further clarify the evolution of the gender gap in betweenness centrality, the difference between men and women was calculated for each year of the analyzed period using the values reported in Table 1. The absolute gap, calculated as male betweenness centrality minus female betweenness centrality, decreased from 0.000398 in 2018 to 0.000174 in 2019, widened to 0.000842 in 2020, continued to increase to 0.001114 in 2021, and reached 0.001182 in 2022, a value close to three times that recorded at the beginning of the period. In relative terms, the ratio of male to female betweenness increased from 1.54 in 2018 to 1.88 in 2022, indicating that the proportional advantage of male auditors also increased. These findings run counter to the original formulation of H1: rather than showing convergence that would reduce the betweenness gap between 2018 and 2022, the data reveal a sustained widening of this gap in both absolute and relative terms. Therefore, the hypothesis, as initially formulated, lacks empirical support and is rejected.

Figure 2 illustrates the evolution of auditor performance according to the centrality metrics. When Figure 1 is examined alongside the betweenness and eigenvector centrality values reported in Table 1, a structural paradox emerges. At the center of the network (Figure 1), the architecture shows the Supervisor level as the organizational core. Visually, female nodes, represented in pink, appear in large numbers within this core. However, the data indicate that occupying the center does not necessarily translate into control. Despite this structural centrality, male auditors exhibit higher betweenness centrality (0.00252 vs. 0.00134 in 2022). This finding suggests that, while women function as the “engine” that holds the technical core together through supervision, men act as the “bridges” connecting this core with external decision-making structures, particularly team leadership positions.

In Figure 1, the nodes belonging to the outer strata (Operational and Support) appear radially connected to the center. However, Figure 2 shows that female leadership, as reflected in eigenvector centrality measures, remained influential through 2020, indicating that women succeeded in establishing connections with the most important nodes in the network.

Nevertheless, the decline observed by 2022 suggests that social capital has become re-centralized among male auditors, who not only have more contacts (degree) but also maintain connections with one another in positions of greater hierarchical authority.

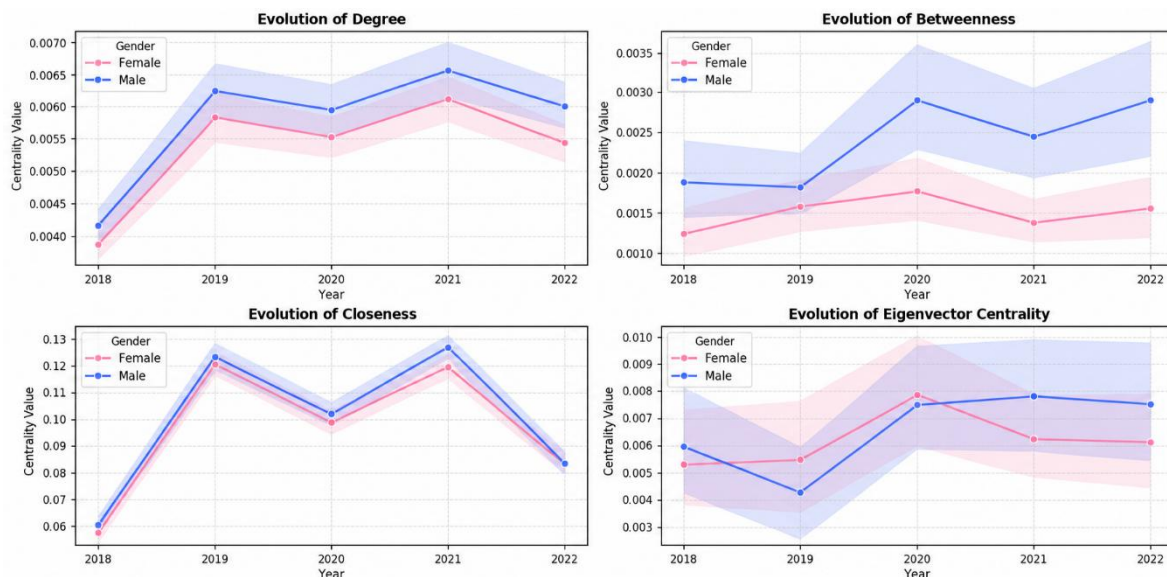


Figure 2. Gender-Based Performance According to Centrality Measures

According to executives of Ecuador's Supreme Audit Institution (SAI), this pattern reflects a post-pandemic effect that affected women more strongly than men. Although this factor warrants further investigation, it does not alter the decision to reject H1 under its original formulation.

Regarding Hypothesis 2, the following section presents the betweenness centrality results, complemented by the nonparametric Mann–Whitney U test and the Kruskal–Wallis test.

Average Betweenness Centrality by Gender:

Female	0.001339
Male	0.001613

Average Betweenness Centrality by Organizational Role:

Support	0.002021
Team Leader	0.001327
Operational	0.001409
Supervisor	0.000609

Average Betweenness Centrality by Role and Gender:

Support - Female	0.001925
Support - Male	0.002097
Team Leader Female	0.001220
Team Leader - Male	0.001454
Operational - Female	0.001276

Operational - Male	0.001559
Supervisor - Female	0.000711
Supervisor - Male	0.000506

Mann-Whitney U Test (F vs M)

U statistic:	2548917.5
p-value:	0.5647450270239114

Kruskal-Wallis Test (por Rol)

H statistic:	51.29199792777587
p-value:	4.2391751837241505e-11

Betweenness centrality measures a node's ability to act as a bridge in information flows, making it a particularly relevant indicator for analyzing structural control within the technical coordination core described in H1. It should be noted that the overall network exhibits low global density (0.0076); therefore, this analysis focuses on how such control is distributed within a predominantly dispersed system rather than within a generally dense network of ties.

Regarding betweenness centrality by gender (Female: 0.001339; Male: 0.001613), although male auditors exhibit a slightly higher mean betweenness centrality descriptively, the nonparametric Mann–Whitney U test yielded $U = 2,548,917.5$ and $p = 0.5647$. Because $p > 0.05$, the test does not allow rejection of the null hypothesis of equal distributions between male and female auditors. The corresponding effect size, calculated using the rank-biserial correlation ($r = 1 - 2U/n_1n_2$), approaches zero, further supporting the interpretation that, in addition to lacking statistical significance, the observed difference has little practical relevance.

From the perspective of complex network methodology, this finding warrants cautious interpretation. The absence of statistical significance does not demonstrate the absence of a difference between genders; rather, it indicates that the test did not detect a difference distinguishable from random variation under the employed analytical framework. Nevertheless, the virtually null effect size, together with the substantial sample size, makes a substantively meaningful undetected gap less plausible.

Accordingly, the data remain consistent with a relatively equitable relational configuration regarding structural opportunities for betweenness among male and female auditors. A stronger conclusion concerning statistical equivalence, however, would require an equivalence test, such as the two one-sided tests (TOST), with an a priori defined equivalence margin, which could constitute a direction for future research.

This distinction matters because, even within hierarchical structures, the network does not reveal a statistically significant gender bias in strategic brokerage positions. This finding remains compatible with the predominance of relational and technical criteria over gender in shaping access to intermediary positions within the network.

Regarding betweenness centrality by organizational role, based on the mean values (SUPPORT: 0.002021; OPERATIONAL: 0.001409; TEAM LEADER: 0.001327; and SUPERVISOR:

0.000609), as well as the results of the Kruskal–Wallis test ($H = 51.29$; $p = 4.23 \times 10^{-11}$), the p -value < 0.001 indicates highly significant differences across roles. This constitutes an omnibus test and, by itself, does not identify the specific pairs of roles in which the differences are concentrated; nevertheless, the descriptive comparison of the means remains consistent with the magnitude of the test statistic. The most relevant finding concerns the SUPPORT role, which exhibits the highest mean betweenness centrality, even exceeding that of higher-ranking hierarchical levels.

This result indicates that: (1) support nodes act as key structural bridges, connecting different areas and hierarchical levels; (2) supervisors exhibit the lowest betweenness centrality, suggesting a more vertical rather than transversal function; and (3) team leaders and operational auditors maintain intermediate levels of betweenness centrality.

From the perspective of complex network methodology, these findings demonstrate that structural power does not necessarily coincide with formal hierarchy, that actors occupying lower hierarchical positions may possess greater structural centrality, and that the network reveals a possible organizational structure characterized by functional rather than strictly hierarchical brokerage. This finding aligns theoretically with studies showing that administrative or support roles frequently connect multiple subnetworks.

Regarding the Role $\times$ Gender interaction, the results show that men exhibit slightly higher values in almost all roles, except for the supervisory role. However, because the overall gender test did not reach statistical significance, these differences should be interpreted as descriptive variations rather than structurally determining effects. The SUPPORT role maintains the highest betweenness centrality for both genders, further indicating that the primary explanatory factor involves the technical role rather than gender.

Regarding Hypothesis 3, the results yielded a network density of 0.0076 and an assortativity coefficient (r) of 0.341. From a core–periphery network architecture perspective, these values show that the network core, in terms of collaboration density, contains a dense cluster in which nodes are highly interconnected (hubs). Empirically, this cluster corresponds to the technical supervision core identified in H1. The presence of pink (female) and blue (male) nodes of similar size in this area indicates that leadership and decision-making involve both genders, with active female participation in highly connected roles, as demonstrated in H2.

Regarding the periphery, the outer ring represents auditors with limited connections. According to executives of Ecuador's SAI, these patterns reflect the formation of teams assigned to specific reports, involving professionals who perform temporary functions as specialized auditors in particular subject areas and specific control activities. They also reflect the disengagement or resignation of auditors who did not participate in additional control activities during the period under analysis.

The fact that the central hubs connect with peripheral nodes confirms the network's stratification and the technical functioning of the audit process. In other words, the network contains a coordinated core with specific expertise, comprising Supervisors and Team Leaders, who extend their influence and knowledge to auditors performing complementary roles, namely Operational and Support auditors.

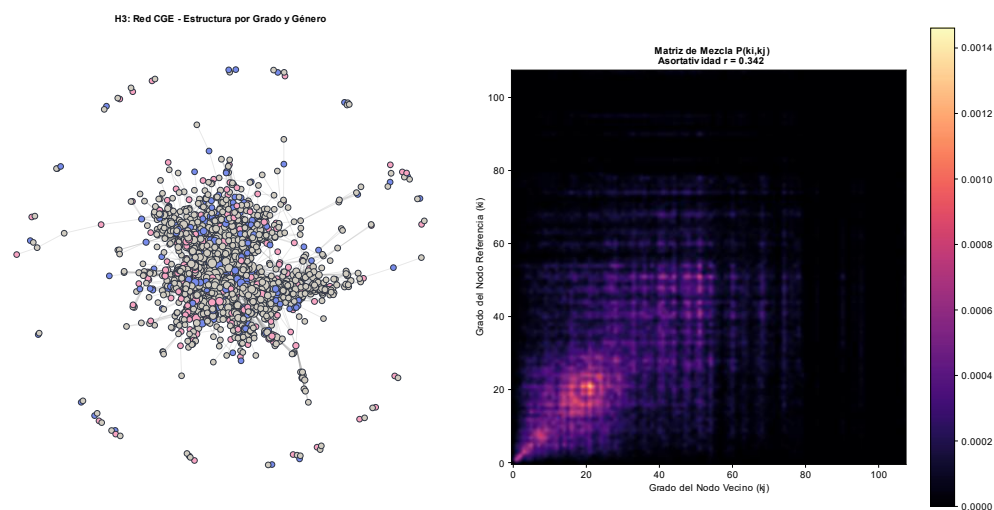


Figure 3. Assortativity Analysis of the Ecuadorian SAI Management Network

Figure 3 presents a heat map visualization of the degree mixing matrix $P(k_i, k_j)$, which allows the distribution of connections among nodes with different levels of connectivity to be identified. The results show a significant concentration of probabilities along the diagonal of the matrix, particularly within intermediate degree ranges. This pattern indicates that nodes tend to connect with other nodes exhibiting similar levels of connectivity.

From the perspective of the complex network theory developed by Albert-László Barabási, this behavior characterizes assortative networks, in which highly connected nodes tend to form interaction cores with structurally similar counterparts. This pattern carries important implications for the organizational dynamics of the Ecuadorian SAI network. First, it suggests the existence of coordination structures among actors with comparable levels of responsibility or experience based on their assigned roles, thereby facilitating the consolidation of specialized technical collaboration spaces. Second, the presence of these structural concentrations indicates that the network does not follow a completely hierarchical or centralized organization. Instead, it contains collaborative cores in which multiple actors share articulation functions within the system. Third, this pattern reinforces the interpretation that the Ecuadorian SAI organizational system operates through relational coordination mechanisms, whereby interactions among actors with similar capabilities strengthen institutional processes during government audits.

Finally, regarding Hypothesis 4, the results yielded a gender assortativity coefficient of -0.0147 , with a slope of 0.0627 and a 95% confidence interval (CI). As shown in Figure 4, these values indicate that audit teams tend to comprise both men and women rather than segregating members by gender.



Figure 4. Confidence Analysis of Intergender Integration in the Management of the Ecuadorian SAI

The statistical test preliminarily suggests that the Ecuadorian SAI may operate as an institution in which gender plays a limited role in team composition, consistent with propositions concerning relational neutrality in network theory (Barabási, 2015; Newman, 2002). This would imply that the network does not exhibit “attraction forces” that systematically lead women to work only with women or men only with men. The slope value (0.0627), which approaches zero, indicates that the gender of the “Reference Auditor” provides little predictive information regarding the gender of their “Colleague.” Given the nearly flat slope, the 95% confidence interval (CI), and the distribution across quadrants, the data remain consistent with the interpretation that the probability of forming a mixed-gender work team during an audit activity within the Ecuadorian SAI does not substantially depend on the gender of its members, with team composition primarily reflecting the technical profiles required.

In summary, the findings remain consistent with H4: the data suggest that the audit network does not exhibit a meaningful pattern of gender segregation, thereby supporting a collaborative culture based primarily on the technical profiles of its members. Consequently, the structure of the Contraloría General del Estado may be interpreted as approaching a “gender-blind” and “technically profile-oriented” model, with this characterization understood as an interpretive synthesis of the findings across the four hypotheses rather than as the outcome of a single confirmatory statistical test.

Discussion

The findings reveal a relational architecture within Ecuador's Supreme Audit Institution (SAI) characterized by positive degree assortativity ($r = 0.341$), confirming the existence of a "core of experts," which Barabási (2015) describes as a "rich-club." This finding challenges the traditional model of disassortative bureaucratic networks and aligns with recent studies suggesting that, in knowledge-intensive organizations such as SAIs, leaders tend to collaborate preferentially with one another to ensure the technical quality of their outputs (Bodla et al., 2023; Buss et al., 2025; Eagly & Johnson, 1990; Gartzia & Pizarro, 2025).

Within this context, the manifestation of female technical leadership in the Ecuadorian SAI appears particularly noteworthy and strategically relevant. Whereas classical literature associates women with peripheral or support positions, our data reveal a substantial presence of female nodes within the network's dense core (Supervision). Closeness and eigenvector centrality suggest that women exercise a cohesive form of leadership, functioning as the technical "glue" that stabilizes audit processes. A similar phenomenon has emerged in SAIs across the region, where female social capital contributes to institutional resilience as a result of gender inclusion and equity policies (INTOSAI, 2022; Redroban-Ortiz, Torres Maldonado, et al., 2025).

A particularly noteworthy finding concerns the gender-neutral pattern of assortativity ($r = -0.0147$) and the nearly zero slope (0.0627) observed in the intergender integration analysis. These results remain consistent with the interpretation that, in its operational processes, the Ecuadorian SAI functions as an institution relatively unaffected by gender and oriented toward "technical profiles." This interpretation aligns with network theory approaches to organizational leadership, which suggest that operational efficiency can increase when networks exhibit competence-based assortative patterns integrated with a relatively gender-neutral identity (White et al., 2016), within an institutional context in which broader gender-equity challenges persist across Latin American public governance (Gilas, 2024).

Finally, the paradox of higher male betweenness centrality suggests that, although the network exhibits relatively equitable structural access, a functional division may persist in the control of strategic flows. However, female "technical support leadership" contributes to internal operational stability while potentially requiring greater representation in external brokerage roles to achieve greater parity in overall network influence, consistent with the objectives pursued by gender-equity policies (Lee, 2024; Naranjo Bautista et al., 2022).

Conclusions

This study analyzed the relational structure of the management network of Ecuador's Supreme Audit Institution (SAI) by applying tools derived from complex network theory. The analysis involved a network comprising 2,442 nodes (auditors) and 22,565 professional collaboration ties (role-based participation in audit reports). The analysis identified structural patterns that organize interactions within the government auditing process in Ecuador, as well as the ways in which female technical leadership integrates into this relational architecture.

In response to the research question, the findings show that female leadership manifests primarily through its structural presence within the network's technical supervision core, with women actively participating in areas characterized by greater relational density and professional technical collaboration. This leadership does not necessarily manifest through higher betweenness centrality but rather through mechanisms of technical cohesion, professional collaboration, and institutional articulation. These findings suggest a leadership model based on technical integration within densely connected coordination cores that emerge within an overall low-density network.

Regarding H1, the data do not support the strategic convergence originally proposed. The betweenness centrality gap between men and women widened between 2018 and 2022, both in absolute and relative terms; therefore, the hypothesis is rejected under its initial formulation. Nevertheless, this finding provides valuable insight: female leadership manifests more clearly through participation in technical coordination structures and the cohesion of the supervision core than through the concentration of relational power associated with betweenness centrality. This pattern opens a specific line of inquiry into why the increase in female betweenness centrality did not narrow the gap relative to male auditors.

Regarding H2, the analysis detected no statistically significant differences in betweenness centrality between men and women, with a virtually null effect size. This finding remains compatible with a relatively equitable configuration across key network positions, although formally establishing statistical equivalence would require additional tests, such as TOST. By contrast, the Kruskal–Wallis test revealed statistically significant differences across organizational roles ($H = 51.29$, $p < .001$), indicating that the primary explanatory factor for betweenness centrality involves the technical role performed rather than auditor gender.

Regarding H3, the analysis indicates that nodes with a greater number of connections tend to collaborate preferentially with one another, forming a highly interconnected technical supervision core that articulates institutional coordination dynamics. The network visualization confirms this structure, showing a compact core surrounded by a more dispersed periphery corresponding to operational levels. The substantial presence of female nodes within this core indicates that female technical leadership actively participates in areas of greater structural centrality within the organization.

Finally, the analysis associated with H4 provides insight into the nature of social interactions within this hierarchical structure. Whereas H3 identified a collaboration core among technical hubs, H4 examined whether these interactions followed patterns of gender segregation. The findings provide no evidence of structural gender segregation within the network, indicating that professional relationships primarily follow technical and functional criteria rather than gender-based divisions.

Taken together, the findings indicate that the Ecuadorian SAI audit network exhibits a complex organizational architecture in which hierarchical structures of technical supervision coexist with inclusive relational dynamics. Female leadership actively integrates into institutional coordination cores, although such leadership does not necessarily manifest through dominant control over betweenness flows. Instead, it emerges through structural participation in technical coordination

and professional cohesion spaces, thereby contributing to the stability and articulation of the audit system.

From a practical perspective, the findings suggest that network analysis constitutes a strategic tool for strengthening institutional control systems because it allows organizations to identify critical brokerage nodes, key actors involved in information flows, and collaboration structures that sustain organizational coordination. In particular, recognizing the structural role played by auditors according to their organizational positions may contribute to the design of knowledge-management strategies, organizational risk analysis, and stronger audit processes within Ecuadorian government oversight institutions.

The study presents several limitations that open avenues for future research. Characterizing the Ecuadorian SAI as a “gender-blind” institution represents an interpretation derived from the convergence of several descriptive and inferential findings rather than the outcome of a single confirmatory statistical test. Future studies should therefore compare the gender assortativity coefficient against a null model based on label permutations that preserves team size and role composition, while also calculating its confidence interval through bootstrapping.

Furthermore, the analysis of the gender gap in betweenness centrality aggregated observations by year. The availability of more granular microdata would allow future research to disaggregate betweenness centrality by gender within each hierarchical level (role $\times$ gender $\times$ year) and apply trend tests to characterize more precisely the trajectory documented under H1. Finally, because centrality metrics constitute structural proxies of relational position rather than direct measures of leadership behavior, the findings should be interpreted as evidence of the positions occupied by women and men within the network, rather than as a behavioral measure of leadership itself.

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