

Social Networks: Assignment #1

Due on Monday, December 15, 2025

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Question 1

Structural Analysis of Political Power In this assignment, you will analyze the interaction network (mutual likes) of 5,768 politicians worldwide on Facebook. This network is an Induced Subgraph containing exclusively political nodes. You must transition univariate statistical analysis to deep structural analysis to demonstrate how a politician's topological position determines their real-world role.

(a) *Power Geometry (Quantity, Quality, and Access)*

Power in networks manifests in three forms: the volume of connections (Quantity), the importance of connections (Quality), and the speed of access to the entire network (Access).

1. Centrality Calculations: Calculate Normalized Degree , Eigenvector Centrality , and Closeness Centrality for all. Extract and report the top 10 nodes for each metric.

We computed the *Normalized Degree Centrality*, *Eigenvector Centrality*, and *Closeness Centrality* for all nodes in the network. The top 10 nodes for each metric are reported below.

- **Top 10 by Normalized Degree Centrality:**

- (a) Manfred Weber
- (b) Joachim Herrmann
- (c) Katarina Barley
- (d) Arno Klare MdB
- (e) Katja Mast
- (f) Barack Obama
- (g) Angela Merkel
- (h) Niels Annen
- (i) Martin Schulz
- (j) Sir Peter Bottomley MP

- **Top 10 by Eigenvector Centrality:**

- (a) Katarina Barley
- (b) Arno Klare MdB
- (c) Katja Mast
- (d) Christian Petry
- (e) Heike Baehrens
- (f) Klaus Mindrup
- (g) Michelle Müntefering
- (h) Niels Annen
- (i) Johannes Schrap
- (j) Sigmar Gabriel

- **Top 10 by Closeness Centrality:**

- (a) Barack Obama
- (b) Michael Roth
- (c) Niels Annen
- (d) Tanja Fajon
- (e) Malcolm Turnbull
- (f) Mariano Rajoy Brey
- (g) Achim Post
- (h) Peter Tauber
- (i) Dietmar Nietan
- (j) Hillary Clinton

2. Gap Analysis: Generate a Scatter Plot with Degree on the X-axis and Eigenvector on the Y-axis. Identify nodes that deviate significantly positively from the correlation line (Low Degree but High Eigenvector).

We performed a gap analysis by generating a scatter plot shown in Figure 1 with *Normalized Degree Centrality* on the X-axis and *Eigenvector Centrality* on the Y-axis. A linear regression line was fitted to capture the overall correlation between quantity of connections (degree) and quality of connections (eigenvector).

Nodes that lie significantly *above* the regression line exhibit **high eigenvector centrality despite relatively low degree**, indicating disproportionate structural influence or *power efficiency*. These nodes are identified via large positive residuals from the regression.

The top 10 positive deviants (low degree / high eigenvector) are:

- (a) Christian Petry
- (b) Heike Baehrens
- (c) Katarina Barley
- (d) Klaus Mindrup
- (e) Arno Klare MdB
- (f) Michelle Müntefering
- (g) Katja Mast
- (h) Sigmar Gabriel
- (i) Johannes Schrappe
- (j) Wolfgang Hellmich

These actors occupy strategically influential positions by being strongly connected to highly central nodes rather than maintaining a large number of connections. This highlights a distinction between *connection volume* and *connection quality*, which is not captured by degree centrality alone.

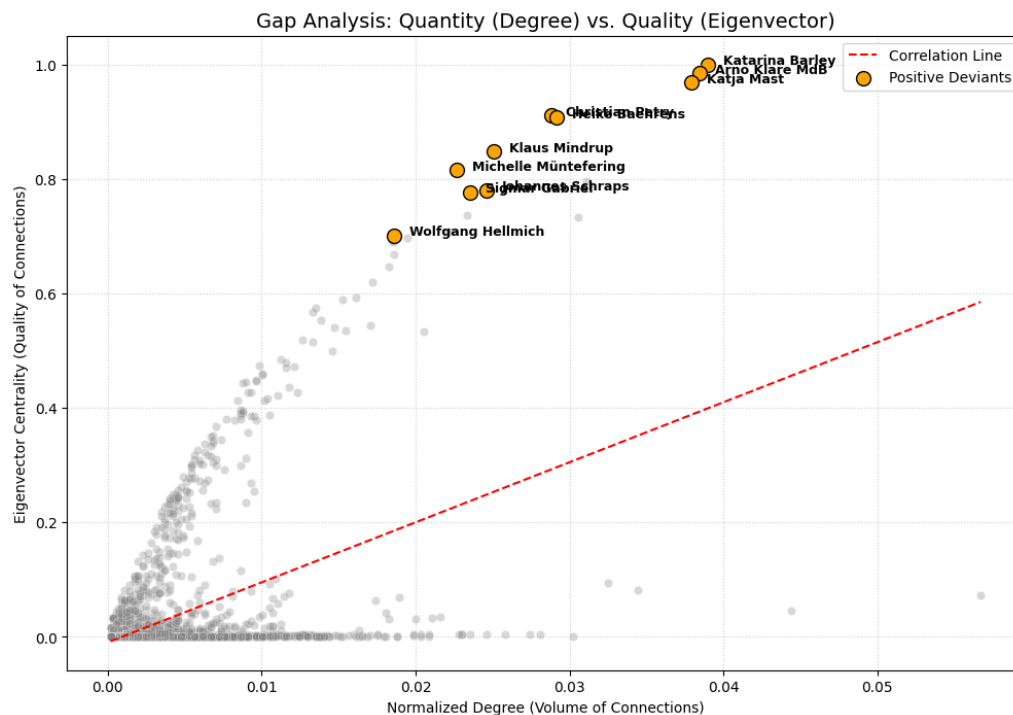


Figure 1: scatter plot *Normalized Degree Centrality vs Eigenvector Centrality* showing positive deviants.

3. Three-Way Case Study: Select three politicians who exhibit Low Degree (ranked outside the top 100) but High Eigenvector (ranked within the top 50). Closeness Analysis: Examine the Closeness rank of these three individuals Role Analysis: Investigate the real-world names and positions of these selected individuals. Does the mathematical analysis corroborate their actual roles (e.g., Chief of Staff, Executive Secretary, or Senior Advisor)?

To connect structural metrics with real-world roles, we selected three politicians who exhibit *Low Degree Centrality* (ranked outside the top 100) but *High Eigenvector Centrality* (ranked within the top 50). This combination highlights actors who are not broadly connected, yet are embedded within highly influential neighborhoods of the network.

Interpretive Framework (Closeness Centrality):

- **High Closeness:** The individual resides in the *geometric heart* of the network, acting with relative independence and direct access to many parts of the graph.
- **Low Closeness:** The individual is *structurally dependent* on powerful neighbors, indicating a marginal attachment to the core and influence mediated through elite ties.

- (a) **Carsten Schneider** (Degree Rank = 228.5, Eigenvector Rank = 43, Closeness Rank = 29) Schneider's high closeness places him near the geometric center of the network, suggesting operational independence despite a limited number of direct connections. This aligns with his real-world role as a senior parliamentary coordinator in the German Bundestag, where influence stems from central positioning rather than high interaction volume.

- (b) **Bernd Lange** (Degree Rank = 118, Eigenvector Rank = 44, Closeness Rank = 14) Lange exhibits both high eigenvector and very high closeness, indicating strong central embeddedness and autonomy. This corroborates his role as Chair of the European Parliament's Committee on International Trade, a position that naturally situates him at the network's core with direct access to multiple influential actors.
- (c) **Barbara Hendricks** (Degree Rank = 130.5, Eigenvector Rank = 33, Closeness Rank = 283.5) In contrast, Hendricks shows low closeness despite high eigenvector centrality. This pattern indicates reliance on a small set of powerful neighbors rather than broad network accessibility. Such a structure is consistent with her status as a former Federal Minister, where residual influence is maintained through elite, high-impact ties rather than central operational presence.

Conclusion: Incorporating closeness centrality sharpens the interpretation of influence. High eigenvector centrality alone captures *who one is connected to*, while closeness reveals *how independently* that influence is exercised. The three cases demonstrate two distinct modes of power: centrally embedded autonomous actors versus peripheral elites whose influence is mediated through powerful neighbors—both of which are accurately reflected by the network metrics.

(b) *Information Bottlenecks*

Identify actors who are not necessarily the most famous, but who control the vital arteries of connection within the network.

1. Calculations & Ranking: Calculate Betweenness Centrality for the entire network. Extract the top 10 nodes and report their corresponding Degree Rank alongside their names.

We computed the *Betweenness Centrality* for all nodes in the network, capturing the extent to which a node lies on the shortest paths between others and thus acts as a broker or bridge. The top 10 nodes based on betweenness centrality, along with their corresponding degree ranks, are reported below.

- (a) Barack Obama (Betweenness Rank = 1, Degree Rank = 6)
- (b) Hillary Clinton (Betweenness Rank = 2, Degree Rank = 145.5)
- (c) Angela Merkel (Betweenness Rank = 3, Degree Rank = 7)
- (d) Justin Trudeau (Betweenness Rank = 4, Degree Rank = 27)
- (e) Malcolm Turnbull (Betweenness Rank = 5, Degree Rank = 35.5)
- (f) Manfred Weber (Betweenness Rank = 6, Degree Rank = 1)
- (g) Peter Tauber (Betweenness Rank = 7, Degree Rank = 38)
- (h) Betinho Gomes (Betweenness Rank = 8, Degree Rank = 122)
- (i) Niels Annen (Betweenness Rank = 9, Degree Rank = 8)
- (j) Boris Johnson (Betweenness Rank = 10, Degree Rank = 679.5)

2. Rank Gap Analysis: Examine the table for individuals with Top-Tier Betweenness (Top 10) but Lower Degree. These individuals are mathematical Bridges. Explain the structural difference between their position and that of Hubs.

We examined nodes with *Top-Tier Betweenness Centrality* (top 10) but comparatively lower *Degree Centrality*. These individuals act as **mathematical bridges** in the network—nodes that connect otherwise distant parts of the graph without necessarily having many direct connections themselves.

Observation from the Top 10 Betweenness Table:

- Nodes such as **Hillary Clinton** (Degree Rank = 145.5) and **Boris Johnson** (Degree Rank = 679.5) exemplify this phenomenon. Despite having moderate or low degree, they appear in the top 10 for betweenness because they lie on many shortest paths that connect different clusters.
- In contrast, traditional **hubs** like **Manfred Weber** (Degree Rank = 1) or **Angela Merkel** (Degree Rank = 7) are highly connected nodes that accumulate influence through sheer volume of ties rather than strategic positioning.

Structural Difference:

- **Bridges:** Moderate or low degree, strategically positioned on key paths, critical for network connectivity between clusters, often controlling information or influence flow.
- **Hubs:** High degree, central in local neighborhoods, influence derived from extensive direct connections rather than bridging disparate regions.

Conclusion: Betweenness highlights nodes that maintain *structural control* over the network, whereas degree identifies nodes with *volumetric influence*. Bridges and hubs represent complementary forms of power: one by connecting clusters, the other by commanding a dense local neighborhood.

3. Contextual Role Analysis: Select three mediators from the list above. Using reliable sources, identify their real-world positions. Explain which countries, parties, or international organizations they bridge. (Reference the diversity of their Facebook friends' nationalities as evidence).

We selected three individuals from the betweenness centrality ranking—**Malcolm Turnbull**, **Hillary Clinton**, and **Betinho Gomes**—to analyze whether their roles as mathematical bridges correspond to real-world bridging positions across countries, parties, or international networks.

- (a) **Malcolm Turnbull Real-World Position:** Former Prime Minister of Australia (2015–2018), leader of the Liberal Party of Australia, and long-standing Member of Parliament. **Bridging Role:** As Prime Minister, Turnbull acted as a key interlocutor between Australia and major global partners including the United States, United Kingdom, and Asia-Pacific nations. His high betweenness likely reflects cross-regional links—politically between differing factions within the Commonwealth and economically between advanced and emerging markets. Turnbull's public profile and leadership

in major trilateral and multilateral forums suggest social media ties that span diverse nationalities and political milieus, consistent with structural bridging.

- (b) **Hillary Clinton Real-World Position:** Former United States Secretary of State (2009–2013), U.S. Senator, and presidential candidate. Clinton has extensive diplomatic experience across Europe, Asia, the Middle East, and Africa.
Bridging Role: Clinton's role as Secretary of State placed her at the center of U.S. foreign policy and major international negotiations (e.g., United Nations engagements, NATO diplomacy). Her network position as a bridge likely captures ties not only to U.S. political elites but also to foreign governments, international NGOs, and global civil society – reflecting heterogeneous nationalities in her extended professional and public networks. High betweenness despite moderate degree suggests influence through strategic elite connections rather than broad grassroots ties.
- (c) **Betinho Gomes Real-World Position:** Brazilian politician; former member of the Chamber of Deputies representing Pernambuco, affiliated with the Brazilian Social Democracy Party. He served in both state and federal legislatures (2003–2006, 2011–2019).
Bridging Role: Gomes occupies a different scale of bridging: within Brazilian domestic politics, he connects regional actors (Pernambuco political circles) to the national legislature and party coalitions. His betweenness suggests that, although not a global political figure like Clinton or Turnbull, he functions as a connector across factions or legislative blocs within Brazil's party system and between urban/rural constituencies. In network terms this reflects bridging across sub-communities rather than international political blocs.

for facebook connection only the following section was analyzed and it goes like:

- (a) Malcolm Turnbull's Facebook connections demonstrate his structural role as a bridge across diverse media, political, and institutional networks. His friends and pages include national media outlets (e.g., ABC News, Media Watch, The Chaser, The Age), political figures and organizations (Liberal Party of Australia, Young Liberal Movement, Tony Abbott, Scott Morrison, Josh Frydenberg), international leaders (Barack Obama, David Cameron, Narendra Modi, Christine Lagarde), and civic and cultural institutions (CSIRO, Australian Red Cross Lifeblood, Woollahra Council, Penrith Panthers). This diversity reflects both domestic and international reach, spanning party lines, governmental agencies, media, and global networks, which supports his mathematical position as a high-betweenness node: Turnbull connects otherwise separate clusters, mediating information and influence across multiple communities.
- (b) Hillary Clinton's Facebook connections highlight her bridging role across political, educational, and advocacy networks. Her connections include key political figures (President Bill Clinton, Kamala Harris, Joe Biden), family and legacy links (Chelsea Clinton), and institutions promoting education and women's rights (Wellesley College, Women's Suffrage National Monument Foundation). This network reflects both domestic and international influence, spanning U.S. federal politics, gender equality advocacy, and educational leadership, reinforcing

her high-betweenness position: she connects otherwise distinct clusters of political, familial, and institutional networks, mediating influence across multiple spheres.

- (c) Betinho Gomes' Facebook connections illustrate his role as a political and regional bridge within Brazil. His network includes local and state-level actors (e.g., Regivaldo Antonio, Raul Henry, Armando Monteiro, Fernando Bezerra Coelho), government institutions and programs (Ministério da Integração e do Desenvolvimento Regional, Programa Cidades Sustentáveis, Governo de Pernambuco), party affiliations (PSDB, Roberto Freire, Luciana Santos), and regional media and cultural organizations (Diário de Pernambuco, Cultura PE, Porta dos Fundos). Additionally, he connects to national political figures and media outlets (Lula, Dilma Rousseff, Aécio Neves, Época, VEJA). This diversity reflects his structural position as a high-betweenness node: despite a moderate number of direct connections, he links regional, state, and national political and civic clusters, effectively mediating influence across multiple communities within Brazil.