Lineup Cohesion

A Network-Based Approach to Starting Eleven Optimization

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Bundesliga 2023/24 · IMPECT Open Data · 306 Matches

Research Question

Can we quantify team cohesion from passing networks to predict match outcomes and optimize lineups?

Stakeholder Value

Coaches need objective metrics beyond intuition for lineup decisions

Network Science

Passing patterns encode team chemistry that box scores miss

Actionable Insight

Identify key hubs, optimal pairings, and substitution strategies

Cohesion Metric: Four Components

$$\text{Cohesion} = 0.50 \cdot \text{Connectivity} + 0.25 \cdot \text{Chemistry} + 0.15 \cdot \text{Hub} + 0.10 \cdot \text{Progression}$$

Connectivity — 50%

Network density + clustering coefficient

$r = +0.785^{***}$

Chemistry — 25%

Strength of midfield→attack connections

$r = +0.448^{*}$

Hub Dependence — 15%

Gini coefficient (star-player reliance)

$r = +0.714^{***}$

Progression — 10%

Pre-shot pass ratio in network edges

$r = +0.133$

Weights empirically optimized from correlation with season points (n=18 teams)

Key Insight: The Hub Dependence Paradox

Initial Expectation

Balanced teams (equal pass distribution) should perform better.

Actual Finding

Star-dependent networks win more. Elite teams funnel play through hub players (Xhaka, Kimmich).

Original 'Balance' showed r = -0.714 with points.

After inverting → Hub Dependence r = +0.714***

Metric Improvement

Before (equal weights)

r = 0.314

p = 0.204 (not significant)

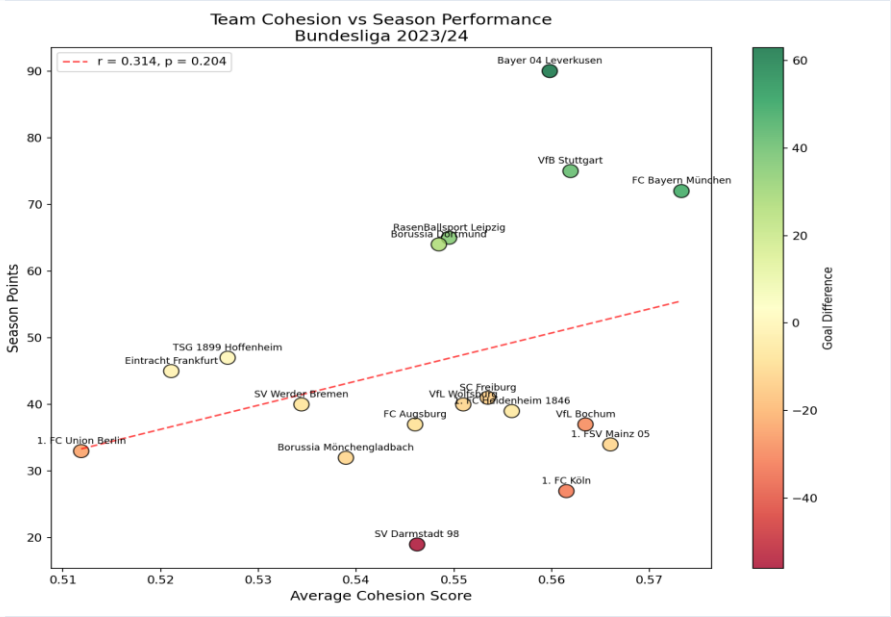
After (optimized weights)

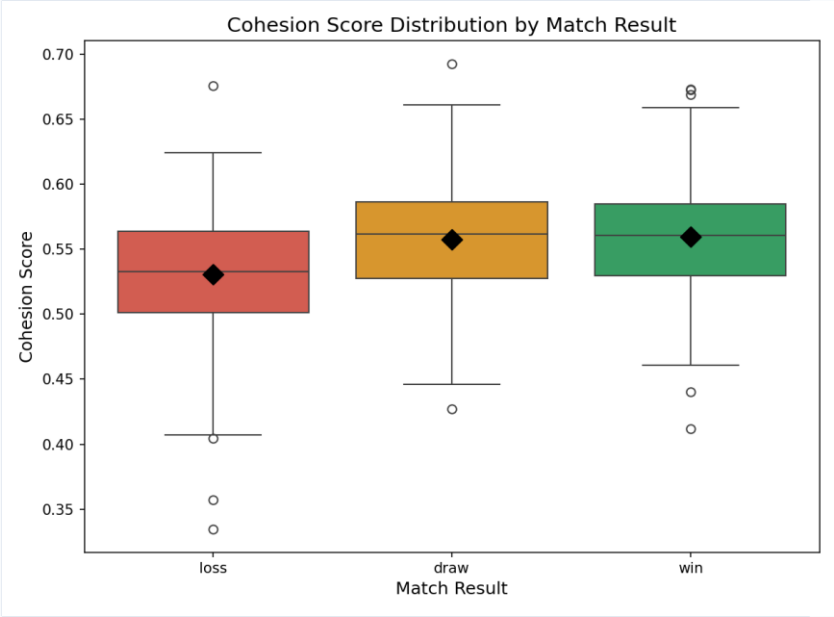
r = 0.728

p = 0.0006*** (highly significant)

+132% improvement in predictive power

Validation: Season & Match Level





Season Level: Cohesion vs Points

Match Level: Cohesion by Result

ANOVA: F = 36.64, p < 0.0001 — Significant difference between Win/Draw/Loss

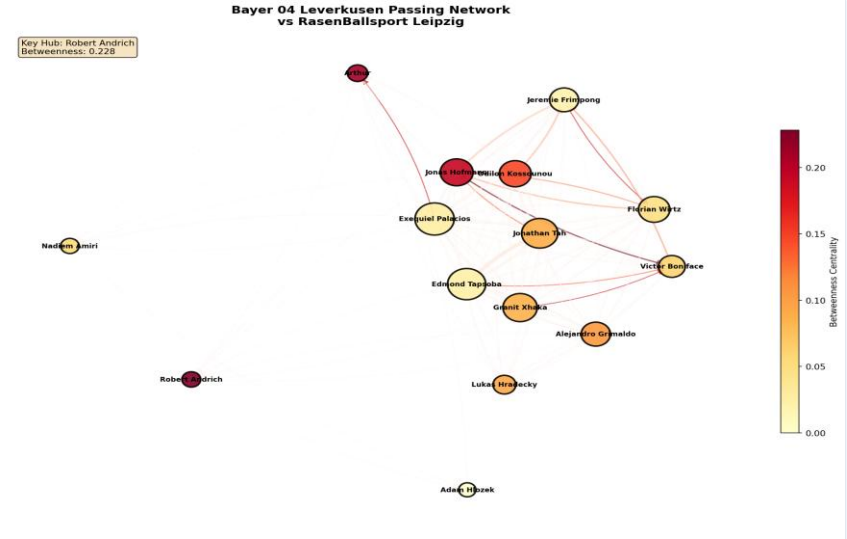
Case Study: Leverkusen's Undefeated Season

28W	6D	0L	90 pts	87 GF	24 GA

Two Hub Types Discovered

Granit Xhaka
Volume Hub — 558 passes with Palacios alone
Recycles possession, dictates tempo

Florian Wirtz
Attack Hub — Highest max betweenness (0.448)
Wirtz→Boniface: 22 pre-shot passes (23.4%)



The Killer Chain: Xhaka → Wirtz → Boniface → GOAL

Application: Lineup Optimization

Starting XI Selection

Score candidate lineups by predicted cohesion. Select players who maximize connectivity with existing starters.

Substitution Strategy

Identify which subs preserve hub structure vs. which disrupt it. Avoid removing high-betweenness players.

Transfer Targets

Project how a new signing integrates: simulate their historical passing patterns into the team's network.

Opponent Analysis

Identify opponent's hub players to mark/isolate. Disrupting their Xhaka-equivalent drops cohesion.

Conclusions

1. Network cohesion predicts season performance
r = 0.728 (p < 0.001) — explains 53% of variance in points

2. Hub dependence > balance for elite teams
Star-player reliance is a feature, not a bug

3. Different hub types serve different functions
Xhaka (volume) vs Wirtz (attack) — both essential

Limitations

- Single season (n=18 teams)
- ~24% passes lack receiver ID
- Position data from metadata only
- No tracking data (spatial context)

Future: Multi-season validation, player-level predictions

GitHub: https://github.com/amin8448/lineup-cohesion-hackathon | Contact: aminnabavi@cmail.Carleton.ca, amin8448@gmail.com

AI Disclosure: Claude assisted with code development and slide formatting