SUNBELT 2005

Who passed to Whom: *Analysis of Optimal Network Structure in Soccer Matches*

Lee[1], Borgatti[1], Molina[2] & Guervos[3]

[1] Boston College
[2] Universitat Autònoma de Barcelona, Spain
[3] Escuela Técnica Superior de Ingenería Informática, Spain

February 19th, 2005 Redondo Beach, CA

Research Issues

Puzzle:

"EURO 2004 presented us with perhaps the biggest upset in modern football, with the Greek outsiders stunning the favourites en route to lifting the trophy" (Andreas Werz, FIFA magazine)

"What Greece have achieved is a sporting miracle" (Otto Rehagel, Head Coach for Greek team)

- Unexpected performances by Greek Team
  - Never won in international matches before
  - Ranked 34th by FIFA (13th among 16 teams)
- Then, what were successful factors for Greek team?

Research Issues

Focus:

- the passing patterns (network structures of passing)

    1. Passing – keeping possession of the ball – is a critical mean for success (goals) in soccer games
    2. Passing is a good way to move a ball quickly and to be kept it away from the other team
    3. Passing is like communication to achieve a goal
    4. Passing is a group level measurement rather than a individual level measurement

Research Issues

Proposition:

- The structure of passing network influences team performances

Research Questions:

- If the network structures of passing in a team influence its performance, how?

    1. What is the impact from the passing structure of a team on its performance?
    2. Can a weak team's passing structure predict its extraordinary achievement?

Research Issues

(1) ***Centralization***:

1) the group-level quality
2) how variable or heterogeneous the actor centralities are (variability, dispersion or spread)
3) The big centralization value implies that a single player passes with most other players, but that the remaining players are considerably not passing with each other

cf. Actor Centrality:

1) how central an actor is in a certain network
2) degree central: an actor is active, having many ties
3) betweenness central: ‘an actor is in the middle ‘

Research Issues

(2) ***Core/Periphery Structure***:

1) A dense, cohesive core and a sparse, unconnected periphery (Borgatti & Everett, 1999)

2) actors in cohesive center are connected with each other; however, actors in periphery are not connected with each other, and are mostly connected to actors in cohesive center (Laumann & Pappi, 1976; Pattison, 1993)

3) Hierarchy in passing – two classes of players: one class is well-connected, and the other class is rarely connected

Research Methods

Variables of Interests:

- The difference in performance between 2 teams would be influenced by …

1) the difference in the variation of in-passing among players (measured by in-degree centralization)
2) the difference in the variation of out-passing among players (measured by out-degree centralization)
3) the difference in the variation of passing-brokerage (measured by Freeman flow-betweenness centralization)
4) the difference in dominance of passing (measured by Core/Periphery concentration ratio)

… between 2 teams

Research Methods

Data / Sample:

- Passing patterns among players of each team in each match from UEFA EURO 2004
- 16 teams in 31 matches (sample size = 28)
- Unit of analysis – team (not ego)

Dependent Variables

- Difference in Performance between 2 teams

1) Difference in number of goals (study 1)
2) Difference in FIFA ranks weighted by difference in number of goals (study 2)

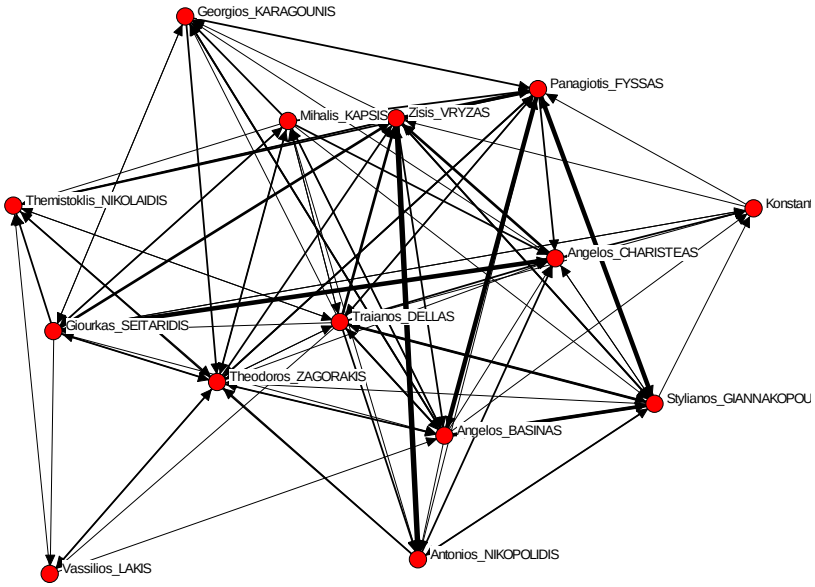
***Statistical Method*:** Conventional OLS Regression

Study 1: Number of Goals

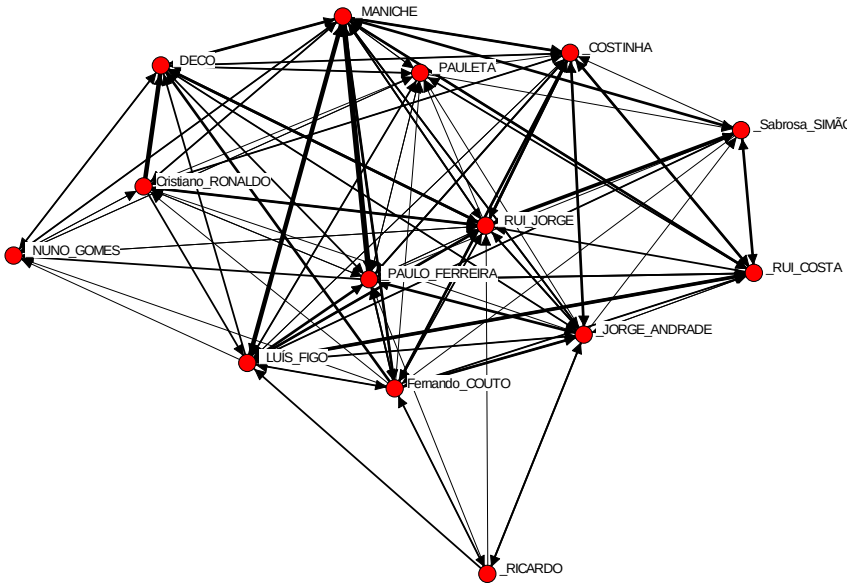
- DV – difference in number of goals
- Control Variable – difference in FIFA rankings
- IVs – differences in …
  1) In-degree / Out-degree Centralization (valued digraph)
  2) Flow-Betweenness Centralization (valued digraph)
  3) Core/Periphery Concentration Ratio

$$\begin{aligned}&[\text{team 1's number of goals}]-[\text{team 2's number of goals}]\\&=\alpha+\beta\cdot[(\text{team 1's flow btwnness})-(\text{team2's flow btwnness})]\\&\ldots\ldots+\gamma\cdot[(\text{team 1's FIFA rank})-(\text{team2's FIFA rank})]\end{aligned}$$

Study 1: *Who would win?*
(Out-degree Centralization)



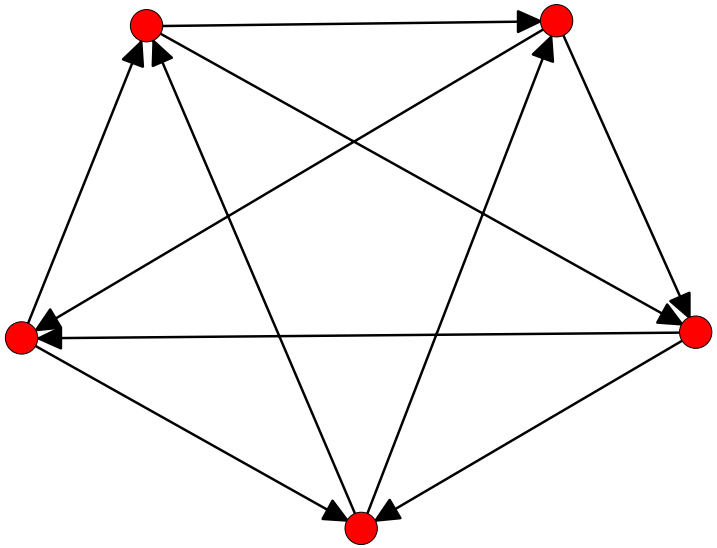
Greece (vs Portugal); ODC = 71.01



Portugal (vs Greece); ODC = 237.87

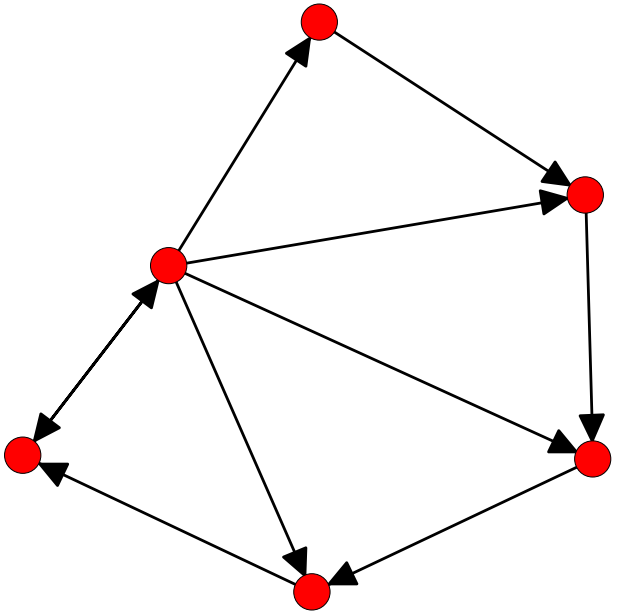
Greece 2 : 1 Portugal

Study 1: *Who would win?*
(Out-degree Centralization)



ODC = 0.00

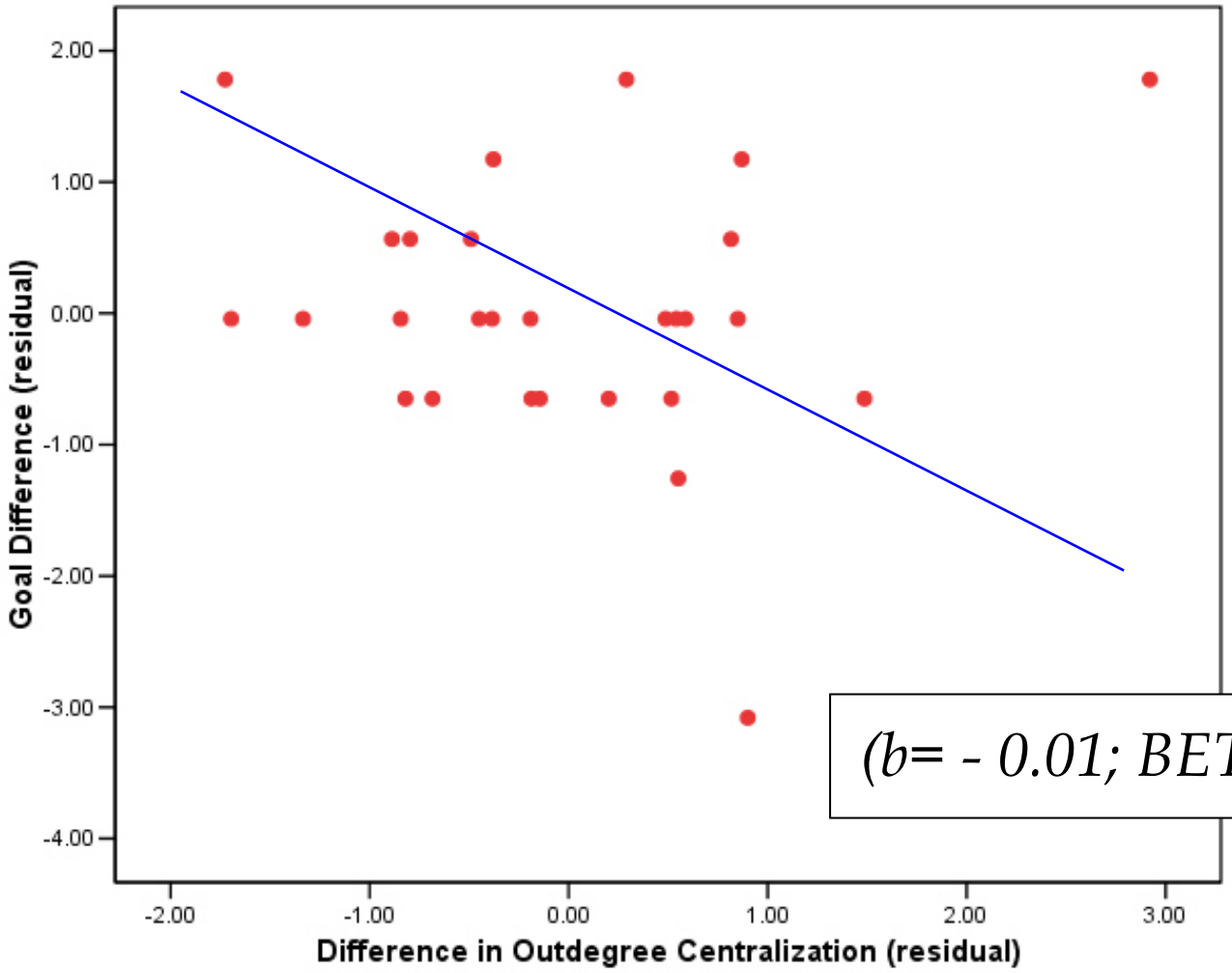
Each node has 2 out degree



ODC = 0.80

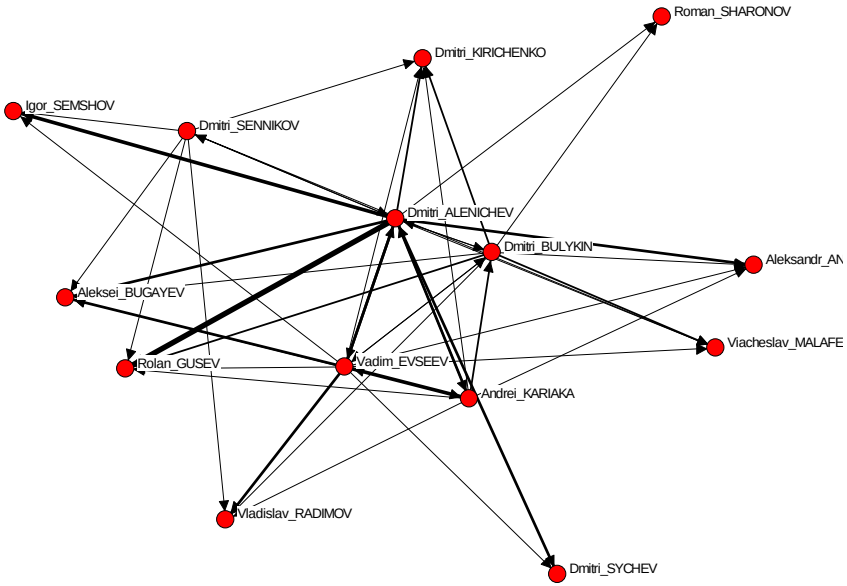
A node has 5 out degree, and all other nodes have 1 out degree

Study 1: *Out Degree Centralization*

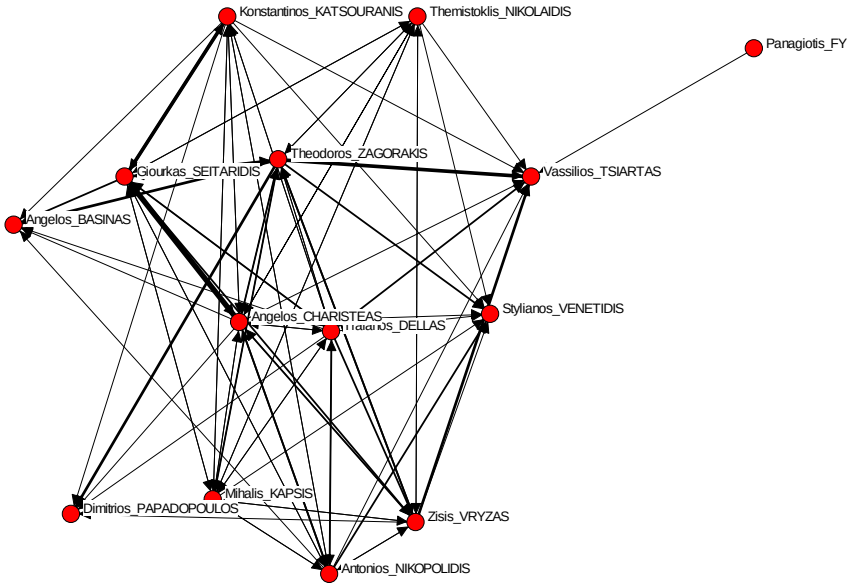


(b= - 0.01; BETA= - 0.47)

Study 1: *Who would win?*
(Flow Betweenness)



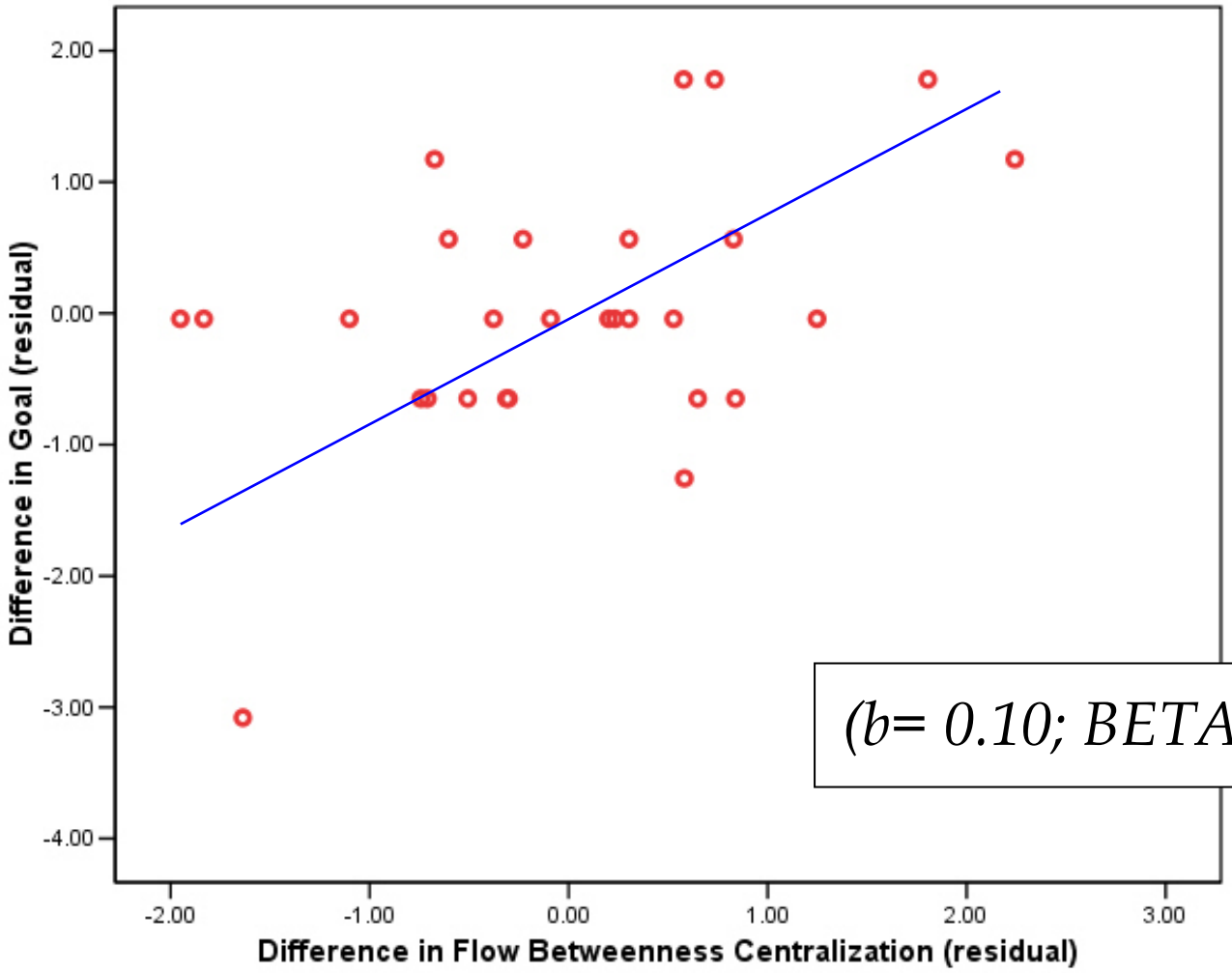
Russia (vs Greece); FBC = 12.17



Greece (vs Russia); FBC = 7.39

Russia 2 : 1 Greece

Study 1: *Flow Betweenness*



(b= 0.10; BETA= 0.33)

Study 1: Statistical Results

	Model 1	Model 2
Predictors		
In-degree centralization		0.03 (0.90)
Out-degree centralization		**- 0.47 (0.04)**
Flow-btwn centralization		0.33 (0.10)
C/P concentration ratio		0.04 (0.80)
Control		
FIFA rank (team1 / team2)	–0.75 (0.00)	–0.62 (0.01)
Model Fit Index		
F (significance)	4.741 (0.01)	3.547 (0.02)
R^2	0.372	0.446
Adjusted R^2	0.294	0.320

Standardized Coefficients;
Number in parentheses are significance level

Study 1: *Research Summary*

- Out degree centralization (ODC)
  - significant + negative coefficient
  - the higher a difference in ODC, the less goal difference
  - in order to win, try **lower ODC** than the enemy has
- Flow betweenness centralization (FBC)
  - moderately significant + positive coefficient
  - the higher a difference in FBC, the more goal difference
  - in order to win, try **higher FBC** than the enemy has
- In UEFA 2004, in order to win, a team must have kept lower out-degree centralization (and higher flow betweenness centralization) than the opponent team did

Study 2: *Extraordinary Outcome*

- DV – Ratio of FIFA ranking weighted by goal difference

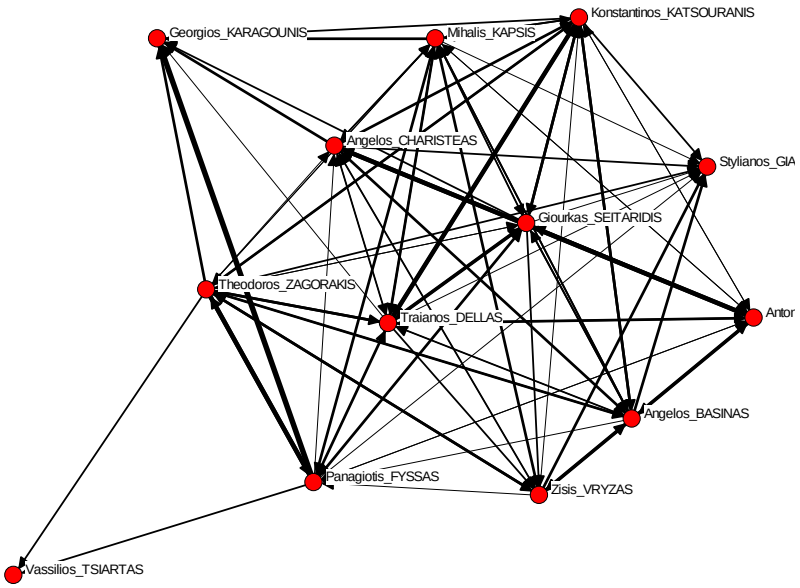
$$\left(\frac{\text{Winner's } \textit{FIFA} \text{ ranking}}{\text{Loser's } \textit{FIFA} \text{ ranking}}\right) \times \left(\text{Winner's } \#\text{of goals} - \text{Loser's } \#\text{of goals}\right)$$

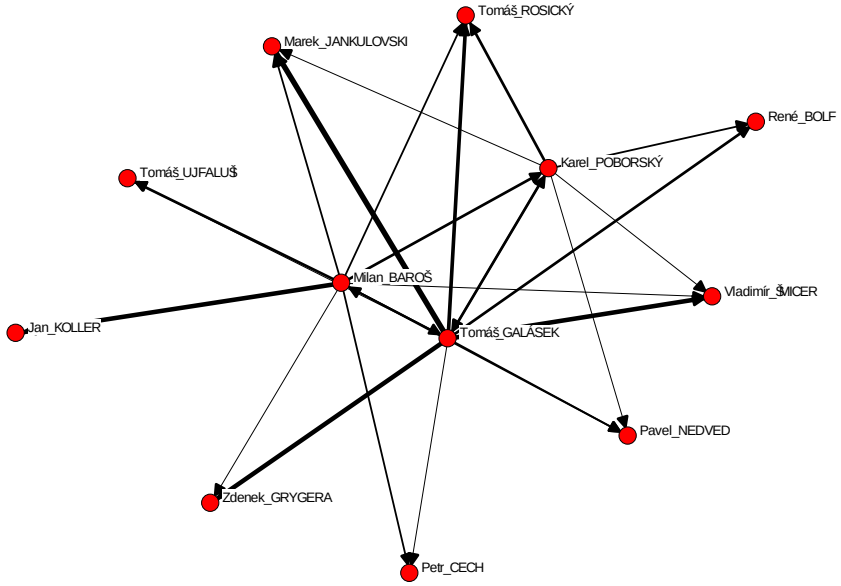
- If a winner's FIFA ranking is much lower than a loser's, the value will be larger; however, if a winner's FIFA ranking is much higher than a loser's, the value will be much smaller, approach to 0

Ex. Greece (34th) 1 vs 0 Czech (10th) → (34/10) × (1 – 0) = 3.4

Ex. France (2nd) vs Swiss (47th) → (2/47) × (3 – 1) = 0.04 × 2 = 0.08

Study 2: *Who would win?*
(Core/Periphery Concentration Ratio)



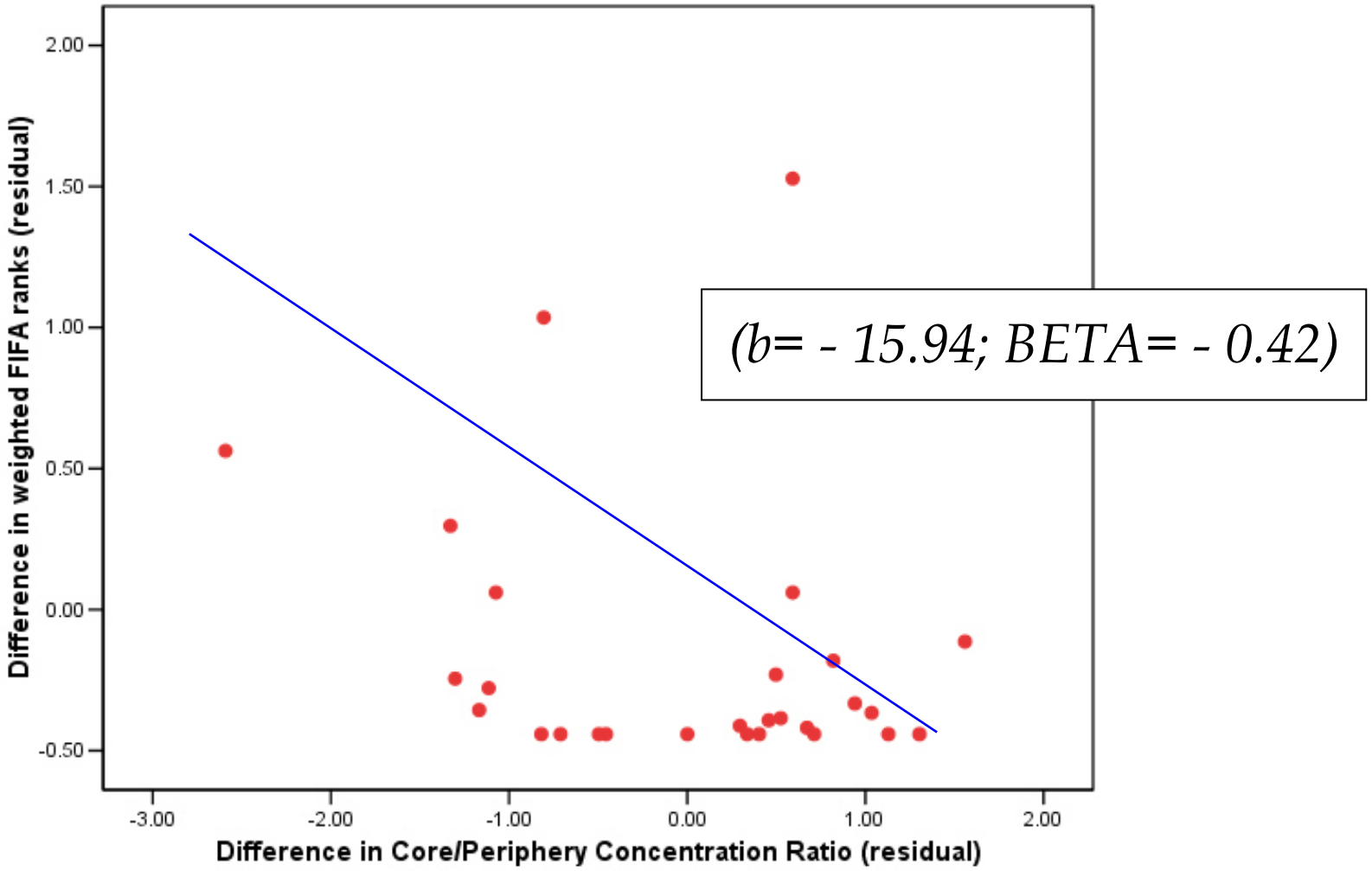


Greece (vs Czech); CPCR = 0.816

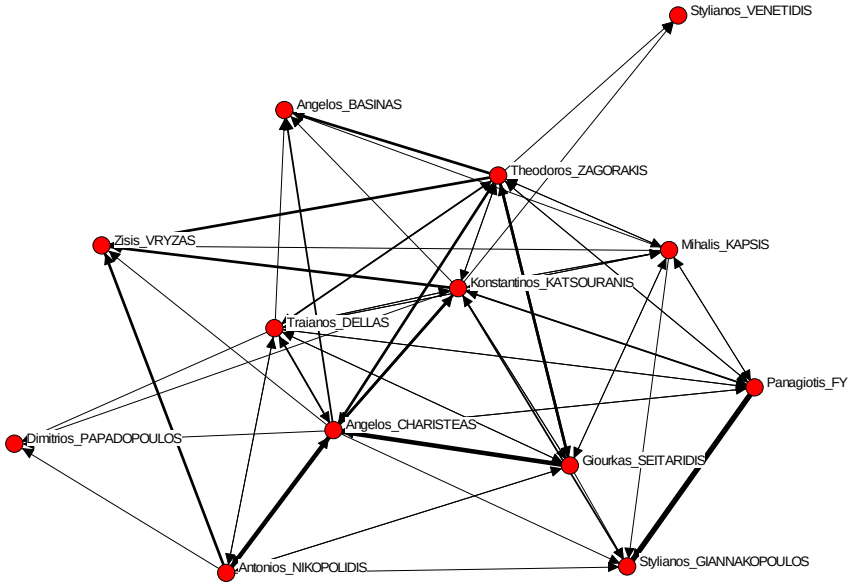
Czech (vs Greece); CPCR = 1.000

Greece 1 : 0 Czech

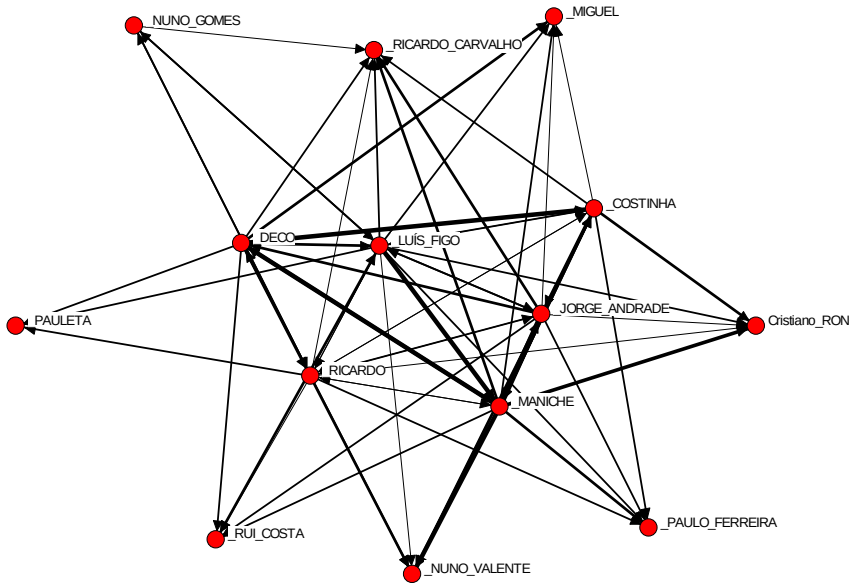
Study 2 *- C/P Concentration Ratio*



Study 2: *Who would win?*
(Out-degree Centralization)



Greece (vs Portugal); ODC = 111.81

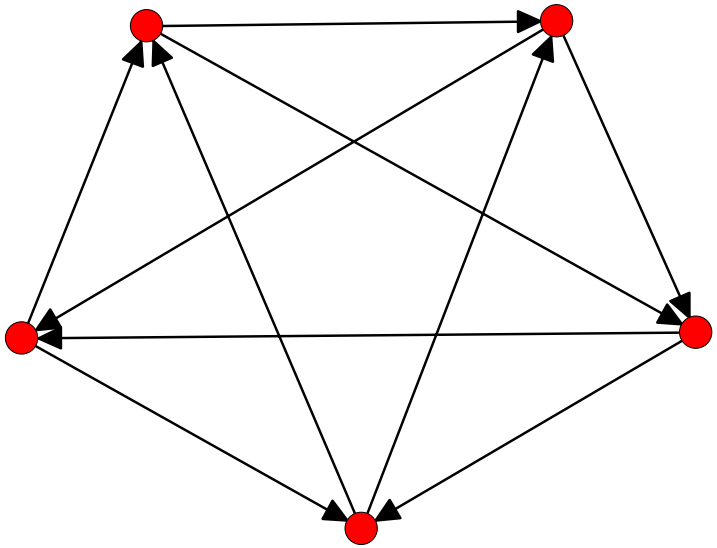


Portugal (vs Greece); ODC = 262.72

Greece 1 : 0 Portugal

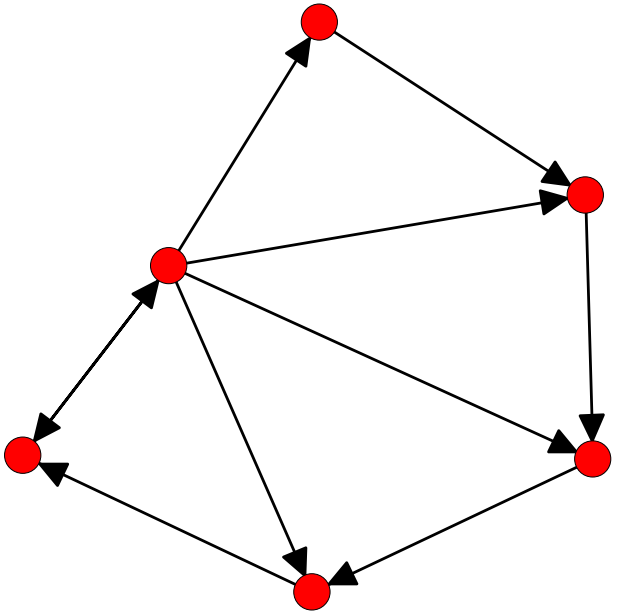
(Final Match)

Study 1: *Who would win?*
(Out-degree Centralization)



ODC = 0.00

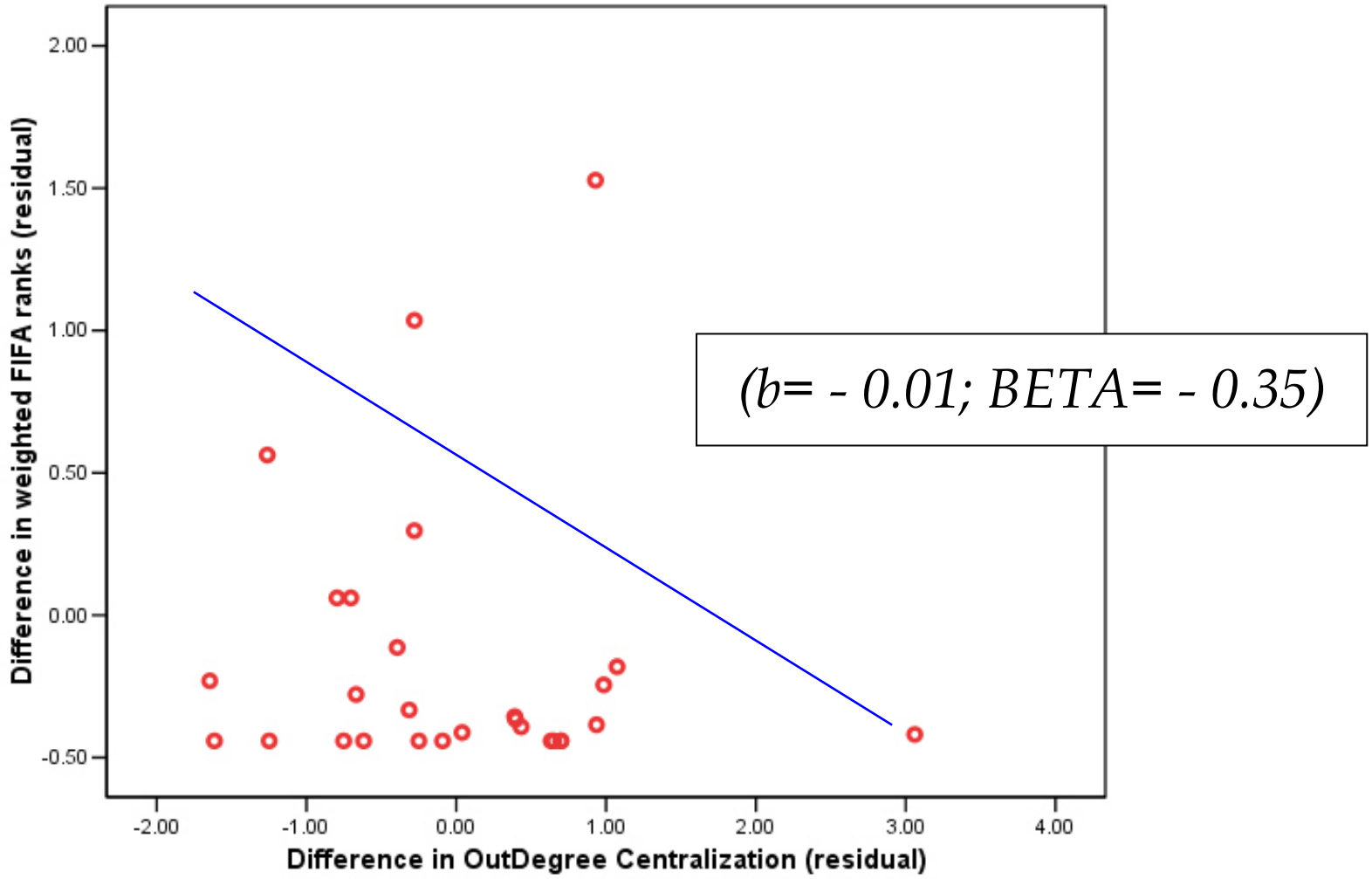
Each node has 2 out degree



ODC = 0.80

A node has 5 out degree, and all other nodes have 1 out degree

Study 2: *Out Degree Centralization*



(b= - 0.01; BETA= - 0.35)

Study 2: *Extraordinary Outcome*

	Model 1
Predictors	
In-degree centralization	0.32 (0.14)
Out-degree centralization	- 0.35 (0.10)
Flow-btwn centralization	0.14 (0.48)
C/P concentration ratio	**- 0.42 (0.02)**
Model Fit Index	
F (significance)	2.616 (0.06)
R^2	0.313
Adjusted R^2	0.193

Standardized Coefficients;
Number in parentheses are significance level

Study 2: *Extraordinary Outcome*

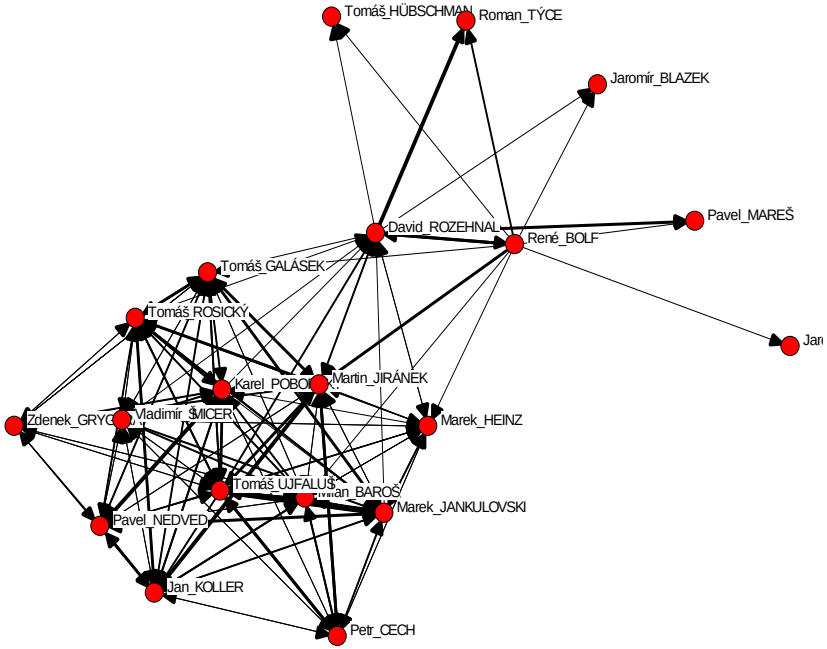
- C/P concentration ratio (CPCR)
  - the most important IV & negative relationship
  - the **lower CPCR** a team has, the more likely it achieves an extraordinary result
- Out degree centralization (ODC)
  - moderately significant / negative relationship
  - the **lower ODC** a team has, the more likely it achieves an extraordinary result
- In UEFA 2004, for a lower ranked team to achieve extraordinary results, it must have kept lower concentration ratio (and lower out-degree centralization) than the opponent team did

Summary & Conclusion

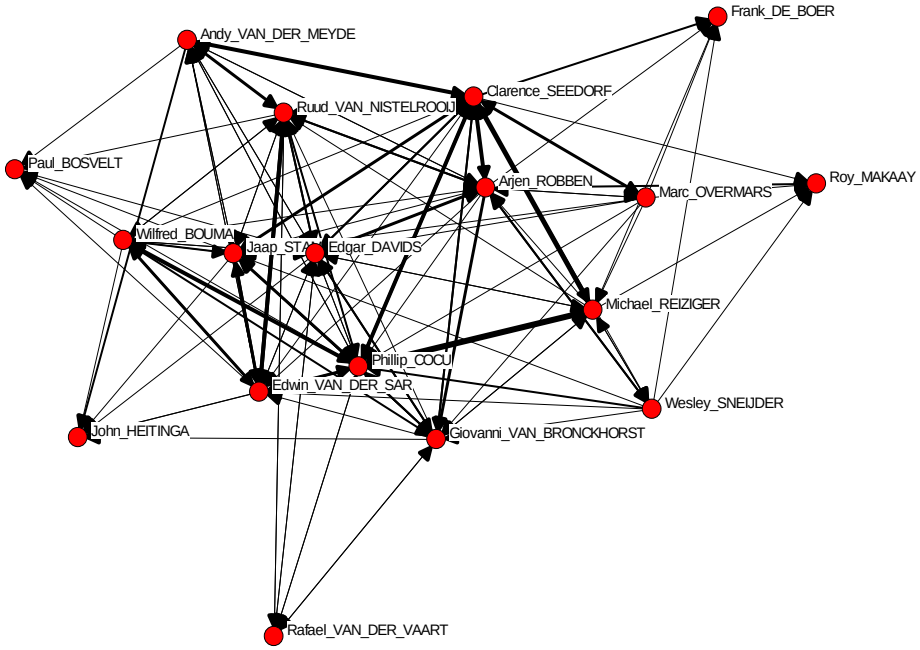
Research Limitations

- Data from one big event (UEFA 2004) – limitations for generalization of results
- No further information about passes between two teams (turnover or intercepts)
- Passes are flow; however, missing information about passing-timing (e.g. A passed to B, then B passed to C, then C passed to A, then …)
- Data are incorrect for some teams; for example, 18 players are found in a few matches

Strange number of players



Czech (vs Holland); FBC = 21.34



Holland (vs Czech); FBC = 9.40

Czech 3 : 1 Holland

Summary & Conclusion

In general

- The lower Out Degree Centralization, compared to the opponent team, is advantageous
- A successful team distributed out-passes more evenly among all players (no passing coordinator) than the opponent did

For Weaker Teams, in particular

- The more likely Core/Periphery structure a team has, the less advantageous it would be
- A weak team must maintain less-concentrated pass structures than its opponent team has, in order to achieve extraordinary performances