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# TEAM EFFICIENCY AND NETWORK STRUCTURE: THE CASE OF PROFESSIONAL LEAGUE OF LEGENDS

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# TABLE OF CONTENT

➤ **Introduction**

➤ **Hypothesis**

➤ **Measures**

➤ **Method**

➤ **Results**

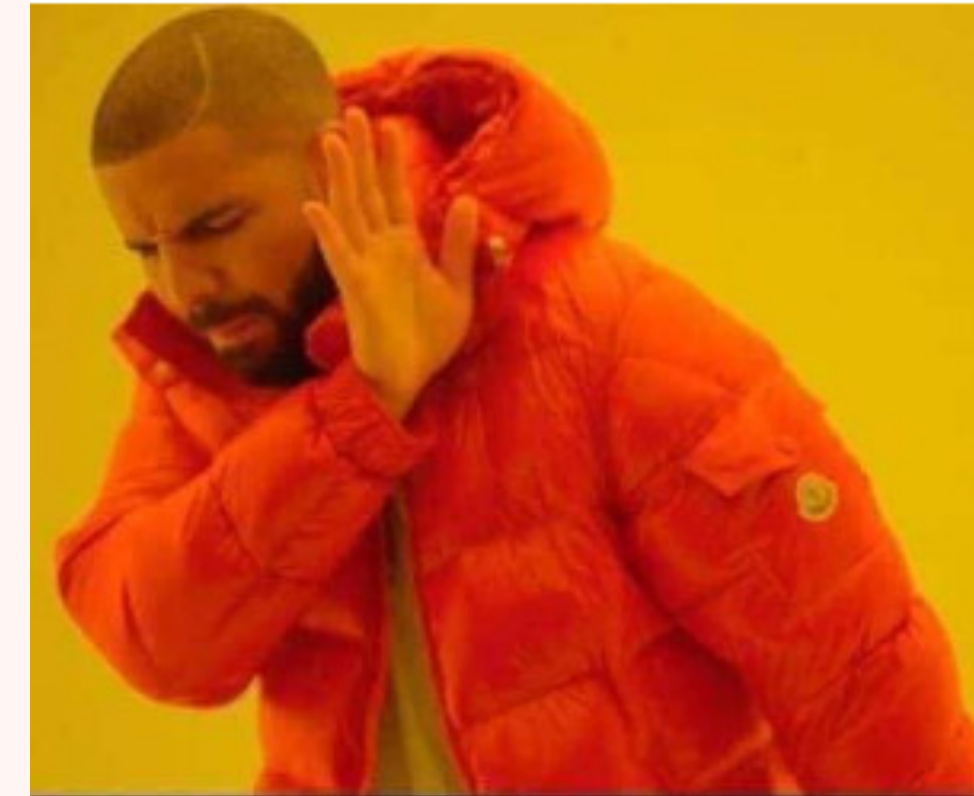
➤ **Conclusion**

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# INTRODUCTION

## What Makes Teams Efficient?

### 英雄聯盟的召喚峽谷日常



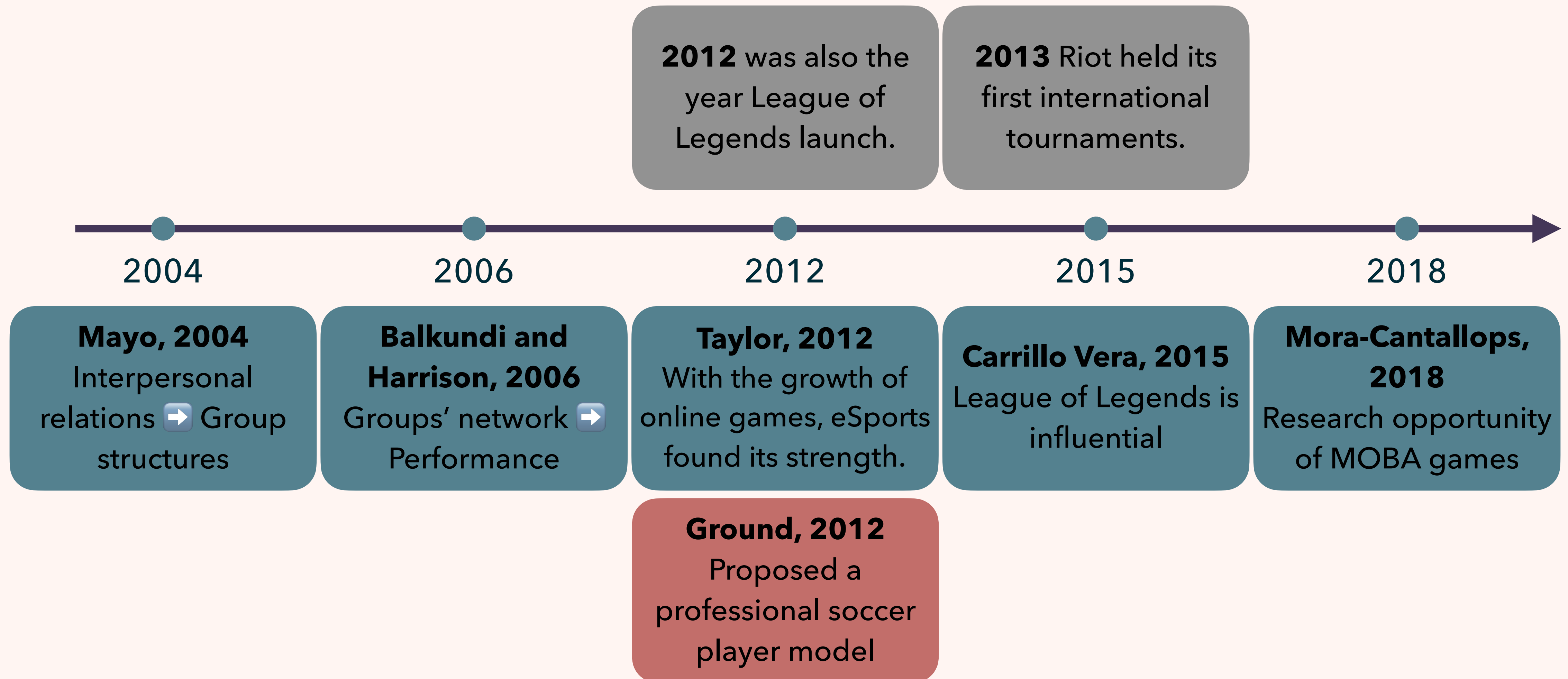
團隊合作 取得勝利



開局就送 不爽中離

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# INTRODUCTION



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# HYPOTHESIS

- **Hypothesis 1.** Increased interaction intensity within the team is associated with a higher team performance and efficiency.
  - **Hypothesis 2.** Increased centralization of (higher individualization) of interaction affect team performance negatively.
  - **Hypothesis 3.** Efficiency network structures in *League of Legends* are independent of their region, year and season.
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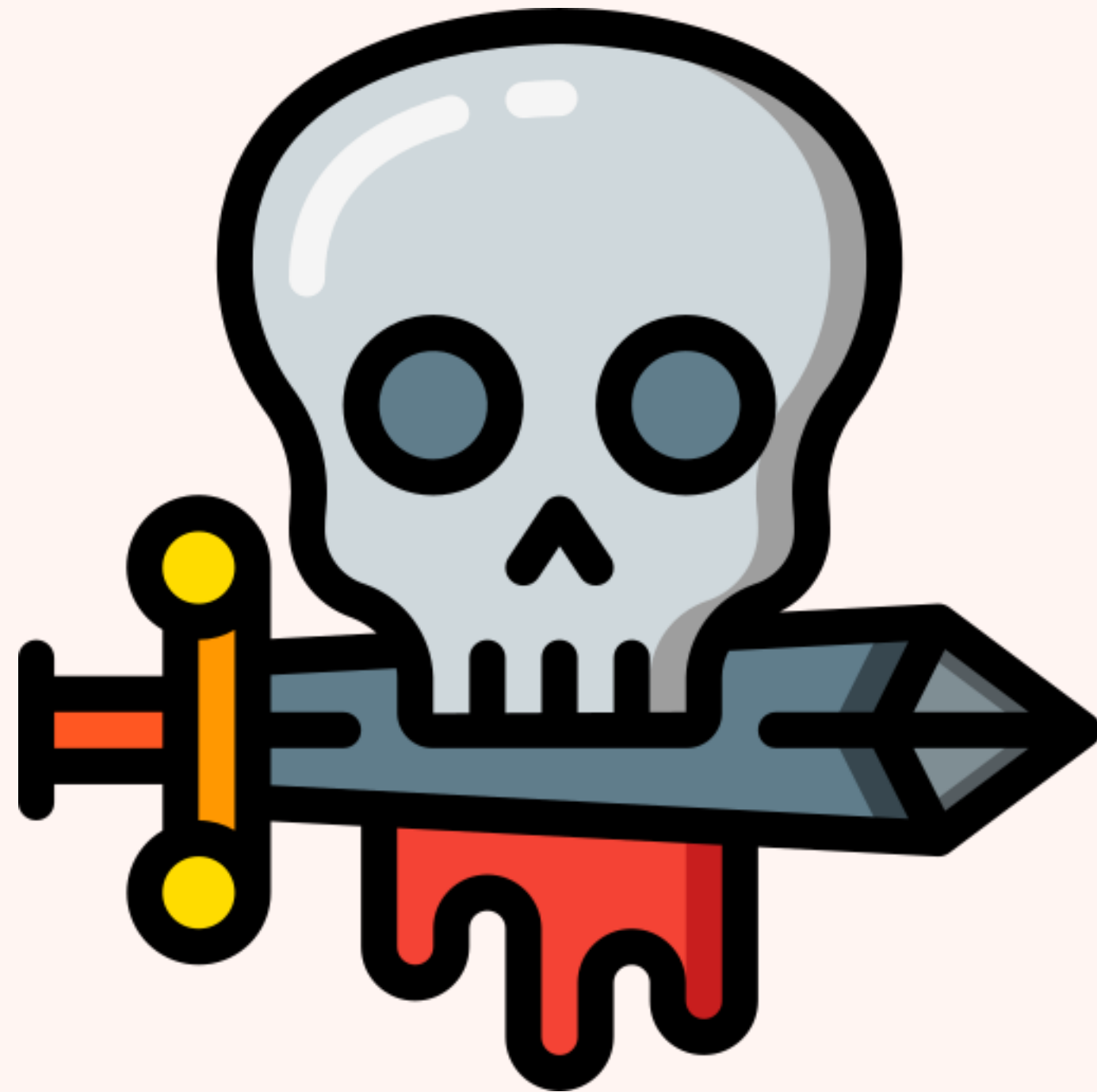
# MEASURES

- **Dataset: Professional games data from 2014 to 2018 including 244 teams, 7582 games, 190060 kills, 453386 assists.**



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# MEASURES-PERFORMANCE VARIABLE



# MEASURES-NETWORK STRUCTURE AND CENTRALITY

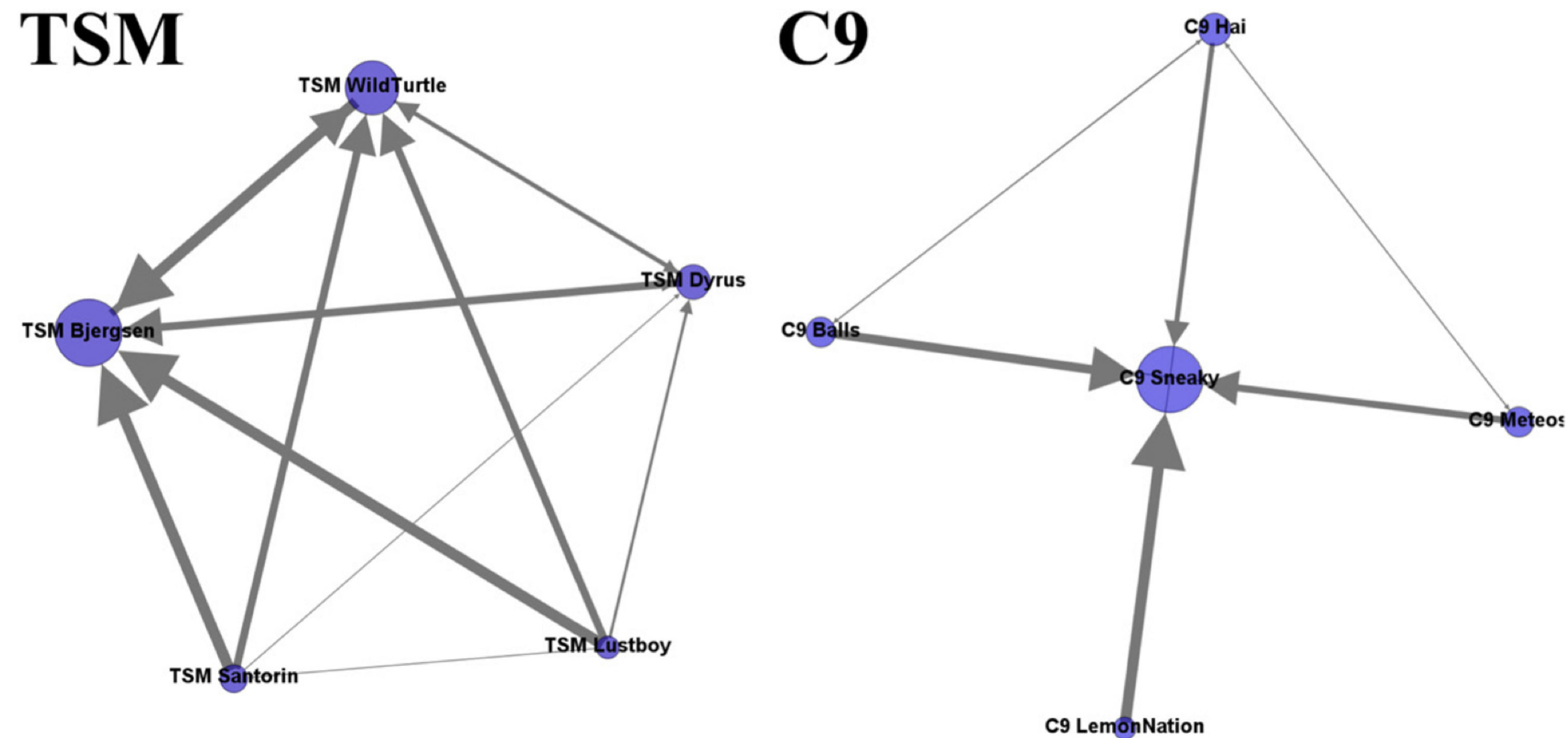


Fig. 3. Network patterns of TSM against C9; January 24, 2015.



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# MEASURES-NETWORK INTENSITY

$$C_{\text{OD}}(i) = \sum_{j=1}^N w_{ij}$$

Out-degree of  $i$

$$C_{\text{ID}}(i) = \sum_{j=1}^N w_{ji}$$

In-degree of  $i$

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# MEASURES-WEIGHT CENTRALIZATION

$$C_w = \frac{\sum_{i=1}^N \sum_{j=1}^N (w^{\max} - w_{ij})}{(N^2 - N - 1)A}$$

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# MEASURES-NODE CENTRALIZATION

$$C_I = \frac{\sum_{i=1}^N (C_{ID}^{\max} - C_{ID}(i))}{(N - 1)A}$$

$$C_O = \frac{\sum_{i=1}^N (C_{OD}^{\max} - C_{OD}(i))}{(N - 1)A}$$

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# MEASURES-DESCRIPTIVE STATISTIC

**Table 2**

Descriptive statistics.

	Mean	Std dev	Min	Max	Obs
(1) $A$ /min: assists per minute	0.82	0.50	0	3.57	15,164
(2) $K$ /min: kills per minute	0.35	0.20	0	1.87	15,164
<b>Network intensity</b>					
(3) $AR$ : assist ratio	2.33	0.59	0.00	4.00	15,164
<b>Network centralization</b>					
(4) $C_w$ : weight centralization	0.13	0.10	0.00	1.00	15,164
(5) $C_I$ : indegree centralization	0.35	0.20	0.00	1.00	15,164
(6) $C_O$ : outdegree centralization	0.14	0.10	0.00	1.00	15,164
<b>Team performance</b>					
(7) Gold per minute	1684.70	192.30	1083.70	2310.03	15,164

# METHOD-DIMENSIONALITY REDUCTION

**Table 3**  
VIF iterative selection.

	(1)	(2)	(3)
$A/\text{min}$	18.04	Drop	Drop
$K/\text{min}$	15.59	1.20	1.20
Intensity	2.97	1.30	1.21
$C_w$	6.50	6.37	Drop
$C_I$	3.08	2.97	1.39
$C_O$	3.37	3.36	1.48

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# METHOD-MULTI-LEVEL REGRESSION

$$y_{mi} = \beta_0 + \beta_1 K_{mi} + \beta_2 I_{mi} + \beta_3 C_{Imi} + \beta_4 C_{Omi} + \zeta_{1i} + \varepsilon_{mi}$$



# RESULTS

**Table 4**  
Multilevel regression results for gold per minute.

	Hypothesis	Linear	(1)	(2)	(3)	(4)
<b>Fixed part</b>						
Kills/min	–	658.69 <sup>**</sup> (0.000)	665.80 <sup>**</sup> (0.000)	661.58 <sup>**</sup> (0.000)	663.84 <sup>**</sup> (0.000)	687.87 <sup>**</sup> (0.000)
Intensity (AR)	> 0	27.82 <sup>**</sup> (0.000)	27.38 <sup>**</sup> (0.000)	26.00 <sup>**</sup> (0.000)	25.63 <sup>**</sup> (0.000)	24.44 <sup>**</sup> (0.000)
Indegree centralization	< 0	– 49.02 <sup>**</sup> (0.000)	– 43.90 <sup>**</sup> (0.000)	– 43.69 <sup>**</sup> (0.000)	– 43.88 <sup>**</sup> (0.000)	– 45.39 <sup>**</sup> (0.000)
Outdegree centralization	< 0	– 27.40 <sup>*</sup> (0.031)	– 21.48 (0.057)	– 20.60 (0.052)	– 20.09 (0.058)	– 15.77 (0.099)
<b>Random part</b>						
$\sqrt{\psi_1}$ (Team)		–	97.67	82.62	83.60	48.06
$\sqrt{\psi_2}$ (Opponent)		–	–	68.07	66.15	31.60
$\sqrt{\psi_3}$ (Region)		–	–	–	30.71	17.05
$\sqrt{\psi_4}$ (Year/Season)		–	–	–	–	123.61/9.09
Team effects		No	Yes	Yes	Yes	Yes
Opponent effects		No	No	Yes	Yes	Yes
Region effects		No	No	No	Yes	Yes
Year/Season effects		No	No	No	No	Yes
Observations		15,164	15,164	15,164	15,164	15,164
Log likelihood		–	– 93,944.6	– 93,220.2	– 93,180.5	– 91,460.3

*p*-Values in parentheses.

\*  $p < 0.05$ .

\*\*  $p \ll 0.001$ .

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# CONCLUSION

- **Interaction among players is crucial.**
  - **Exhibit similar properties with traditional sports in team performance.**
  - **Network intensity is predictor of performance and efficiency.**
  - **Centralization is a negative influence.**
  - **eSports have more advantage for research.**
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# CONCLUSION

- **Roles and tactical setups have not been taken into account.**
  - **Only consider the network at the end of the game but time is not.**
  - **Model is purely quantitative data based.**
  - **The attribute and other network around players need to be study.**
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**THANKS FOR YOUR LISTENING!**

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