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EU Contract Networks

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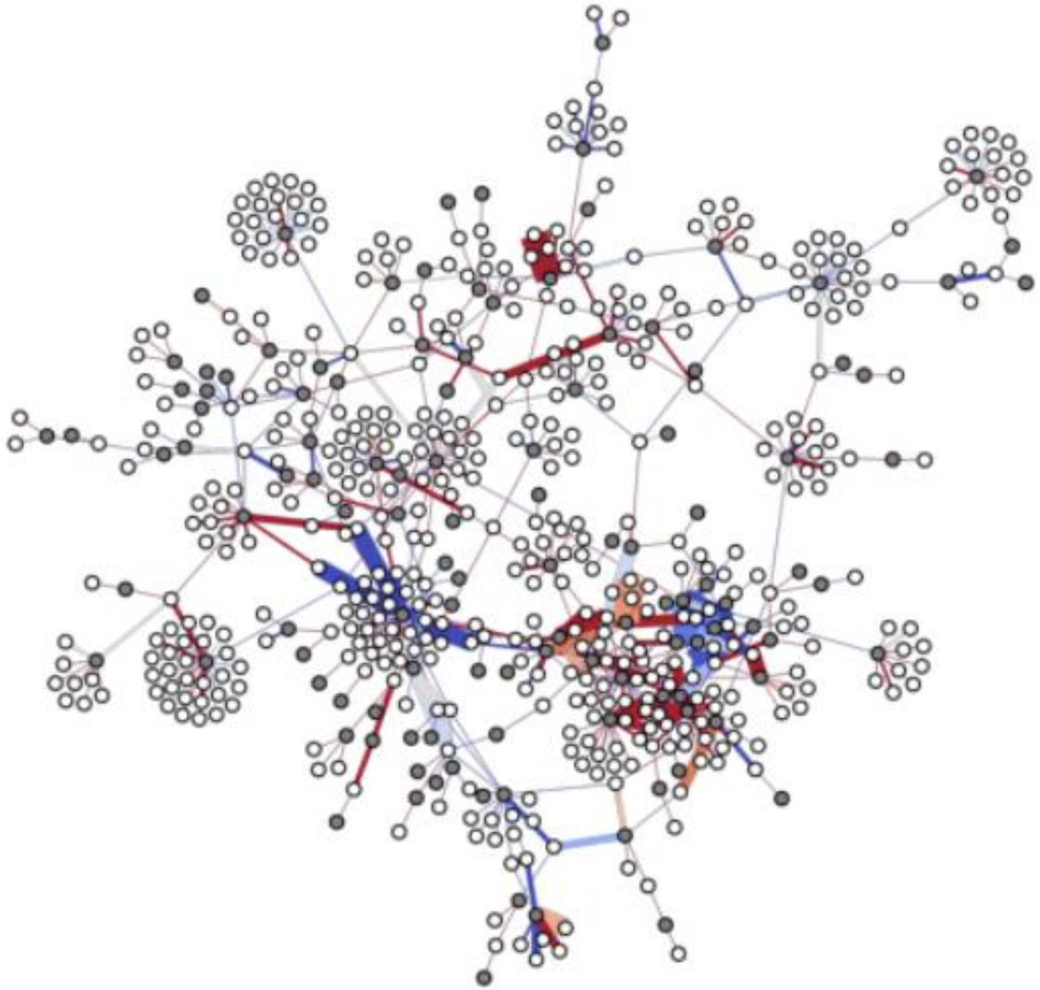
Agenda

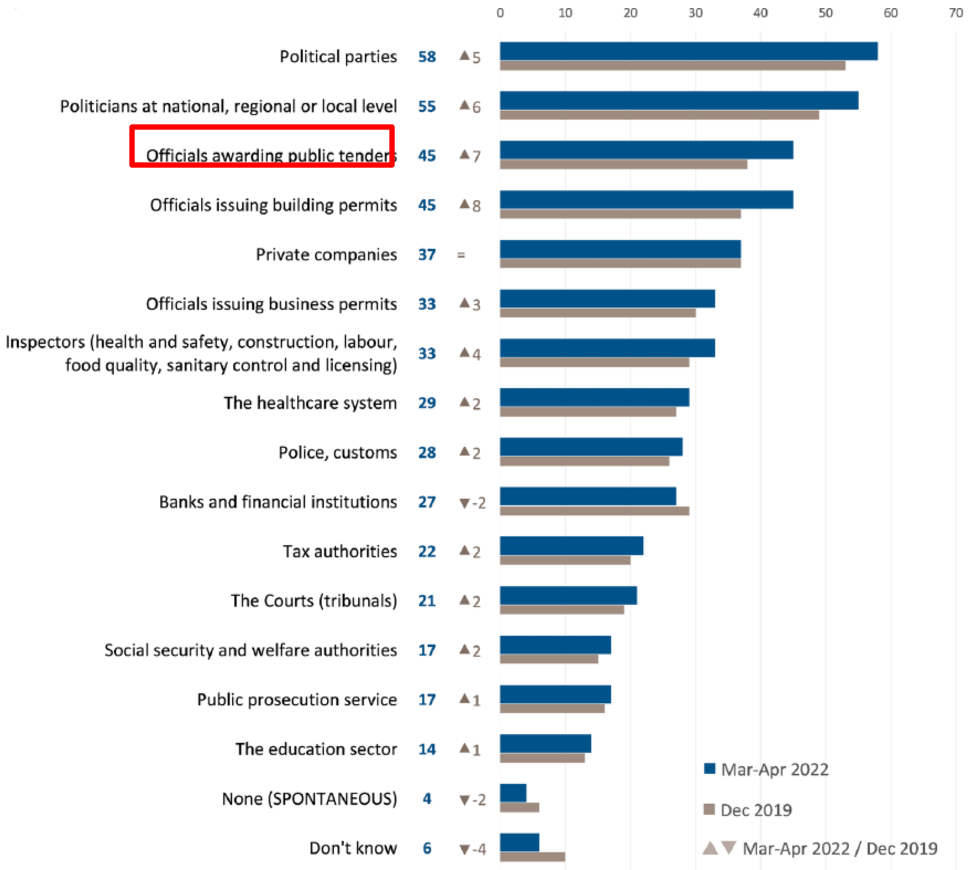
1. *Background*
2. *Dataset*
3. *Networks Over Time*
4. *Comparison with Empirical Models*
5. *Link Prediction*
6. *Conclusion*



Background

Corruption in public procurement

- ***Corruption*** *= "deliberate restriction of open and fair access to public resources for the benefit of connected actors" (Wachs, Fazekas and Kertesz, 2019, p. 45)*



Source: European Comission (2022), European Council (2022)

Corruption risk in contracting markets: a network science perspective by Wachs, Fazekas and Kertesz

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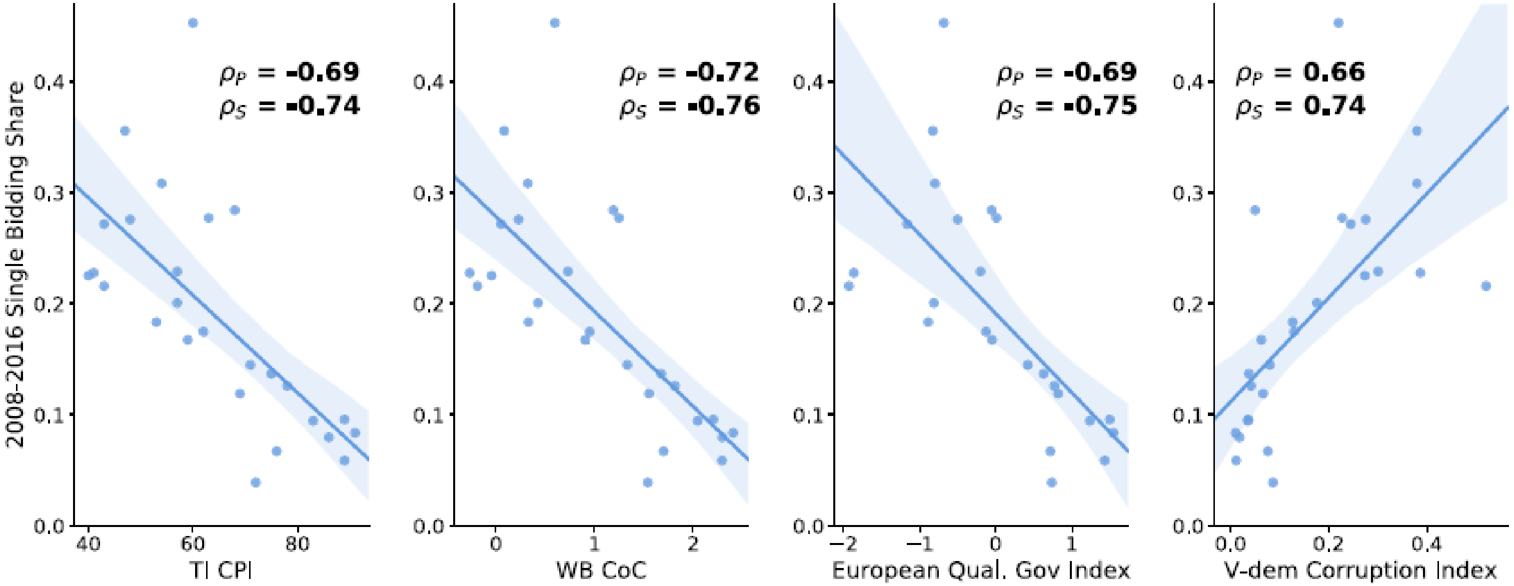
TRANSPARENCY INTERNATIONAL
the global coalition against corruption

THE WORLD BANK

V-Dem INSTITUTE

- *Corruption is traditionally measured via surveys (often flawed)*
- *For each contract, use single bidding rate as proxy for corruption risk*
  - *0 if there was competition*
  - *1 if there was no competition*

Single bidding rate correlated with survey-based measures of corruption



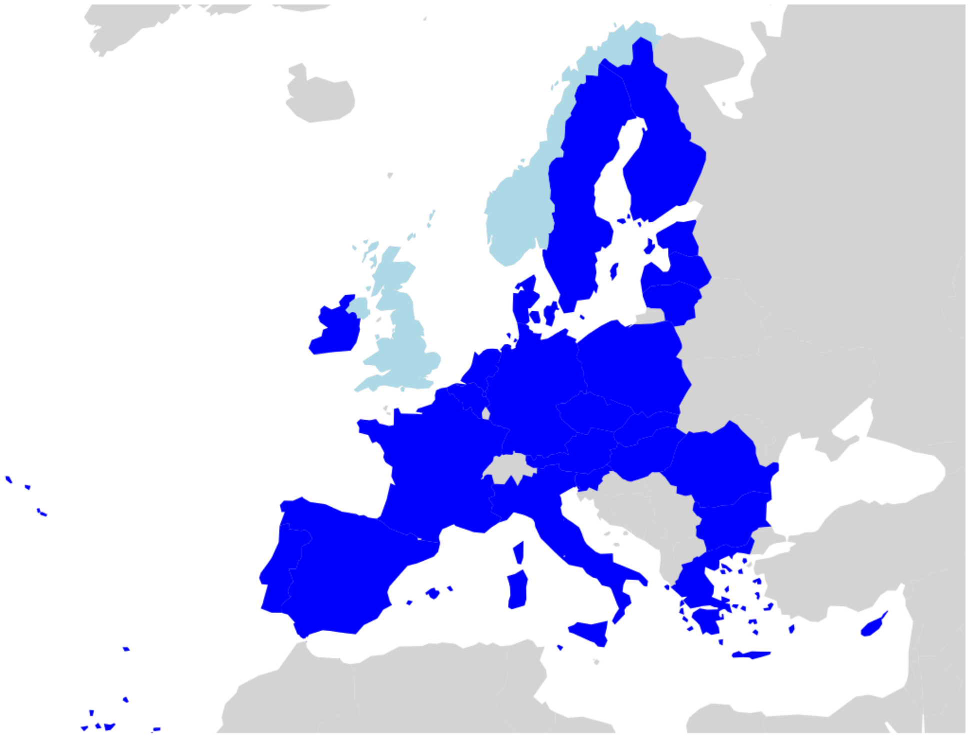
Note: TI CPI stands for Transparency International's Corruption Perception Index, WB CoC stands for World Bank's Control of Corruption Index, European Qual. Gov Index stands for the Quality of Government Institute's European Quality of Governance Index and V-dem Corruption Index stands for Varieties of Democracy's Corruption Index.
Source: Wachs, Fazekas and Kertesz (2019)

Dataset

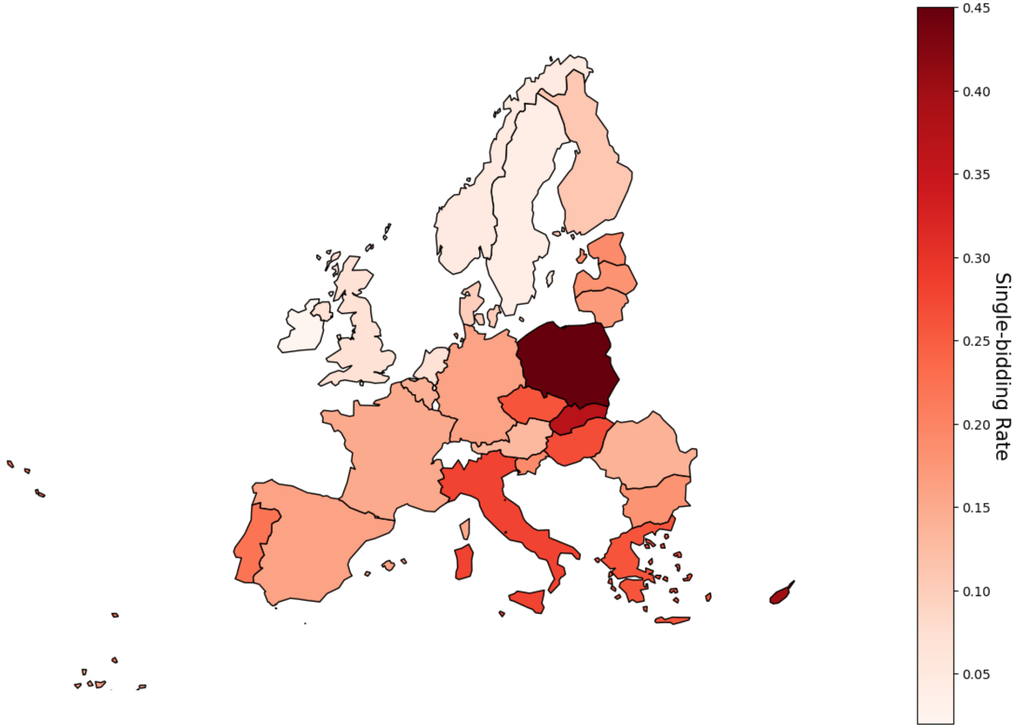
Dataset: EU procurement contract networks (2008-2016)

- *4M+ public contracts (2008-2016)*
- *Bipartite networks of public institutions ("buyers/issuers") and firms ("suppliers/winners")*

26 EU countries (excl. LU, MT, HR) + UK + NO



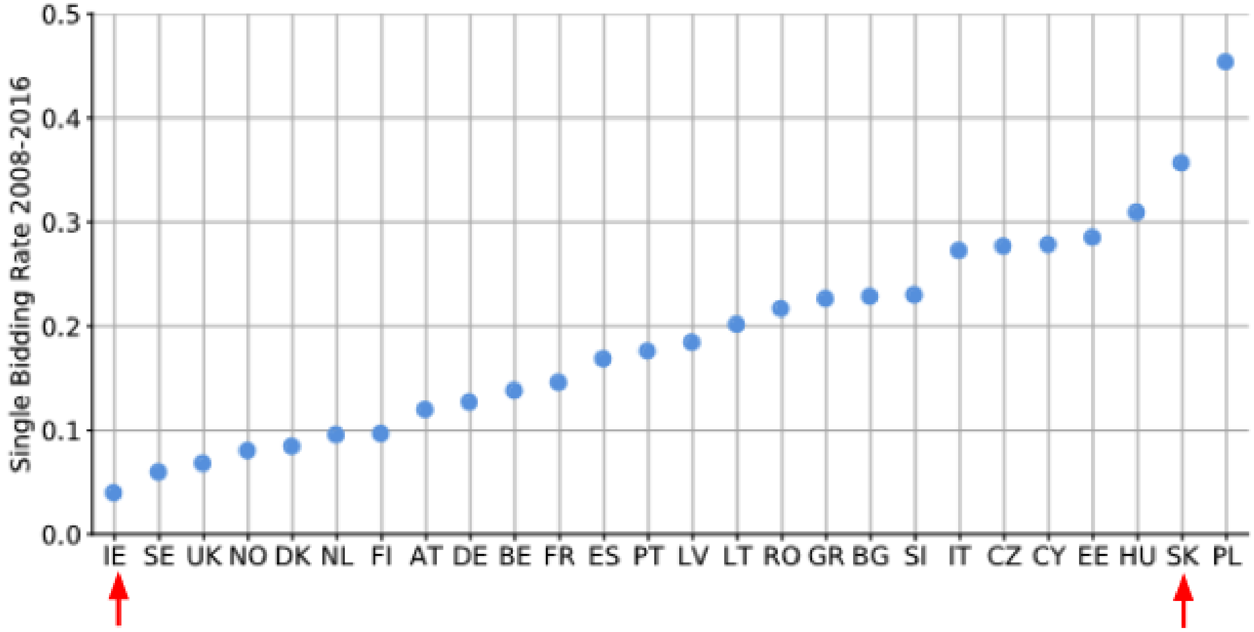
Single-bid rates used as a proxy for corruption

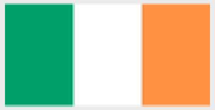


Source: Eurostat (2020), Wachs, Fazekas and Kertesz (2019)

Case Studies: Ireland & Slovakia

- *Ireland and Slovakia*
  - *Similar population sizes (IE – 4.6M, SK- 5.4M in 2012)*
- *2012 – Year Selection*
  - *Middle of dataset (2008-2016)*
- *Significant difference in single-bidder rates*
- *Closeness of CPI scores from Transparency International*



2012	Country	CPI Score	SB Rank
	Ireland	69	1
	Slovakia	46	25

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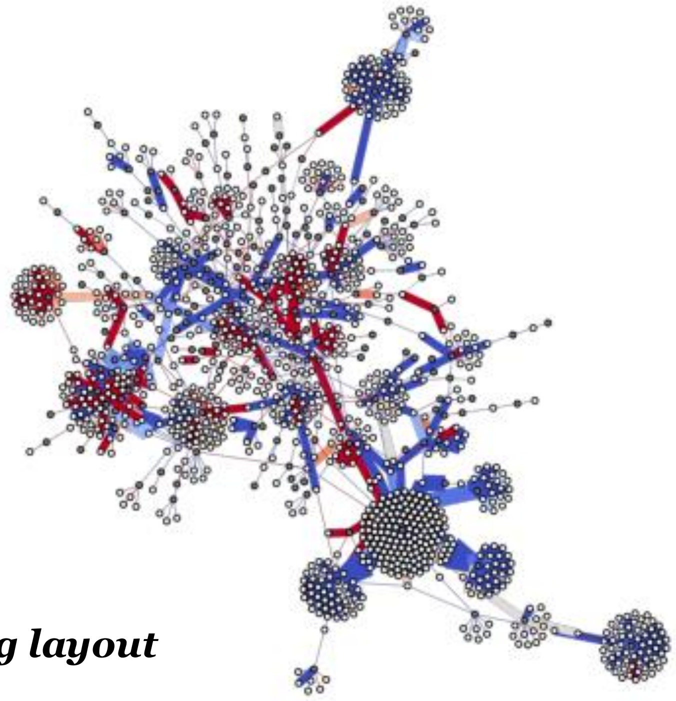
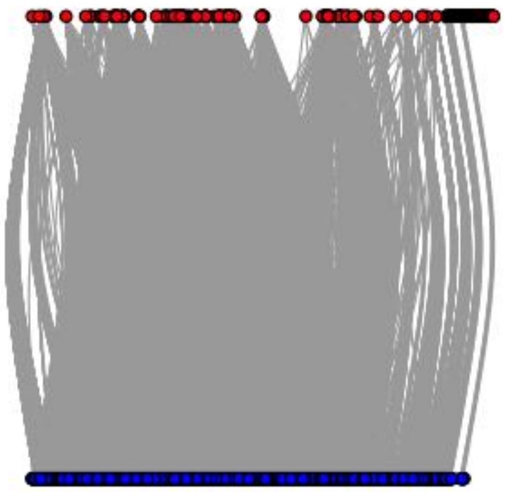
Summary Statistics

Country	# Contracts	# Winners	# Issuers	<K> Winners	<K> Issuers
Ireland	2,713	1,587	208	1.7	13.1
Slovakia	2,654	1,068	344	2.4	8.1

- *While Ireland and Slovakia have a similar number of contracts, Slovakia has 33% fewers winners despite having 65% more public institutions.*
- *Additionally, the average degree for firms is lower in Ireland than in Slovakia, and the average degree for public institutions is higher in Ireland than in Slovakia.*

Network Properties





On the Left: Bipartite network structure Ireland 2012

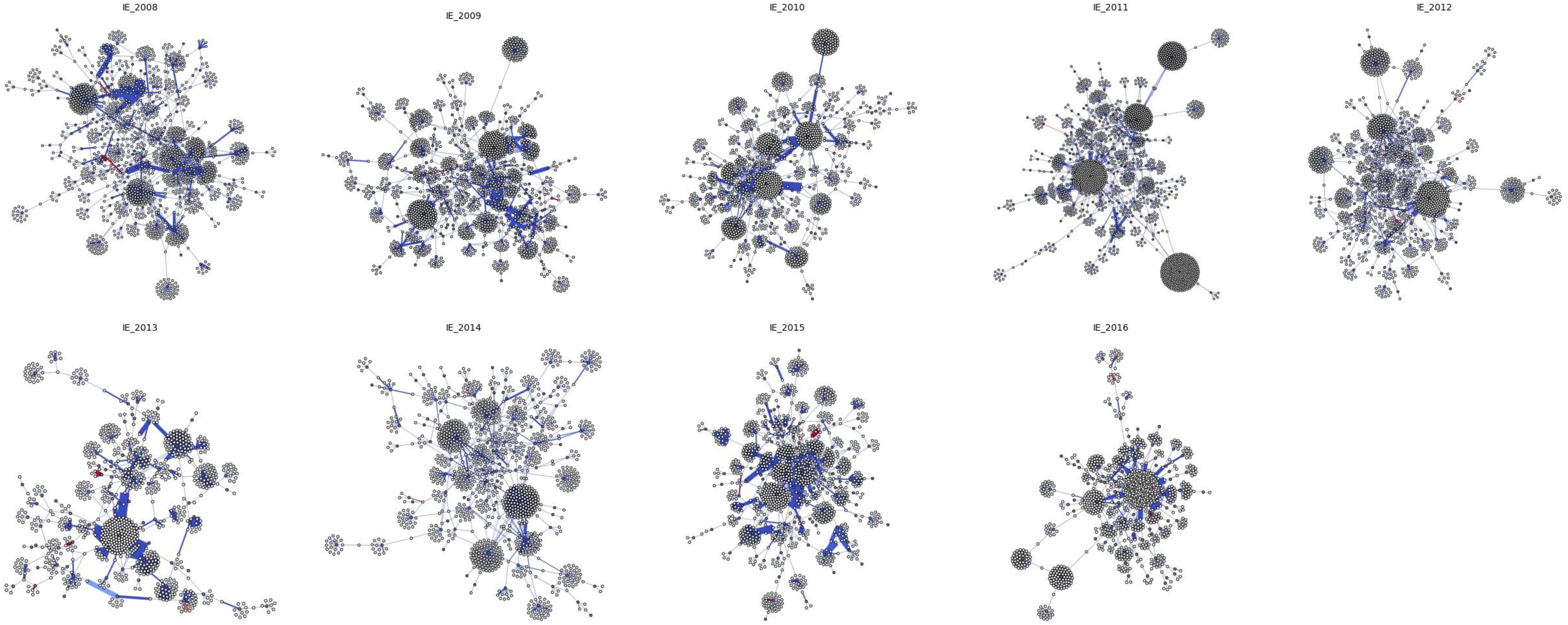
- *Red nodes – issuers of contracts*
- *Blue nodes – winners of contracts*

On the Right: Slovakia 2012 in spring layout

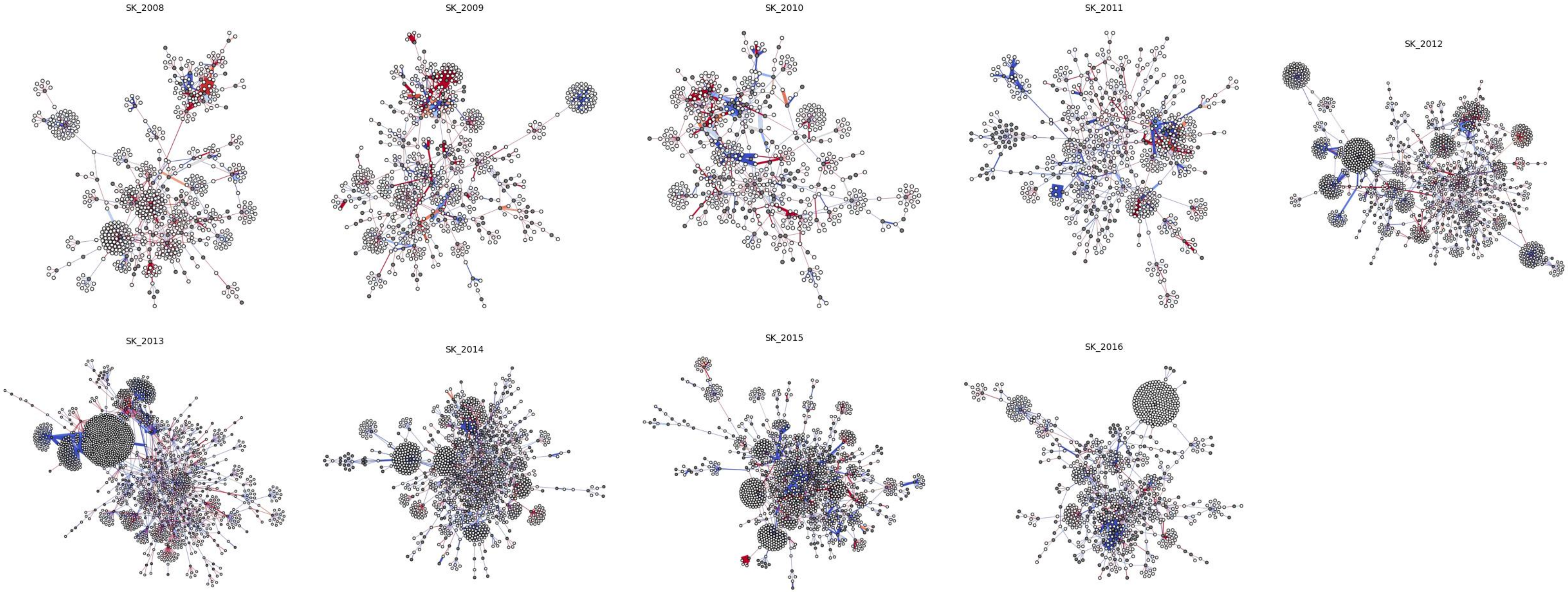
- *Gray nodes are issuers of contracts.*
- *White nodes are winners of contracts.*
- *The weight of the edges (thickness) indicates the log count of contracts between the issuers and winners.*
- *The color of the edges represents the share of single-bid contracts among these connections; the more red an edge is, the higher the proportion of single-bid contracts.*

Networks Over Time

Ireland


IE_2008
IE_2009
IE_2010
IE_2011
IE_2012
IE_2013
IE_2014
IE_2015
IE_2016

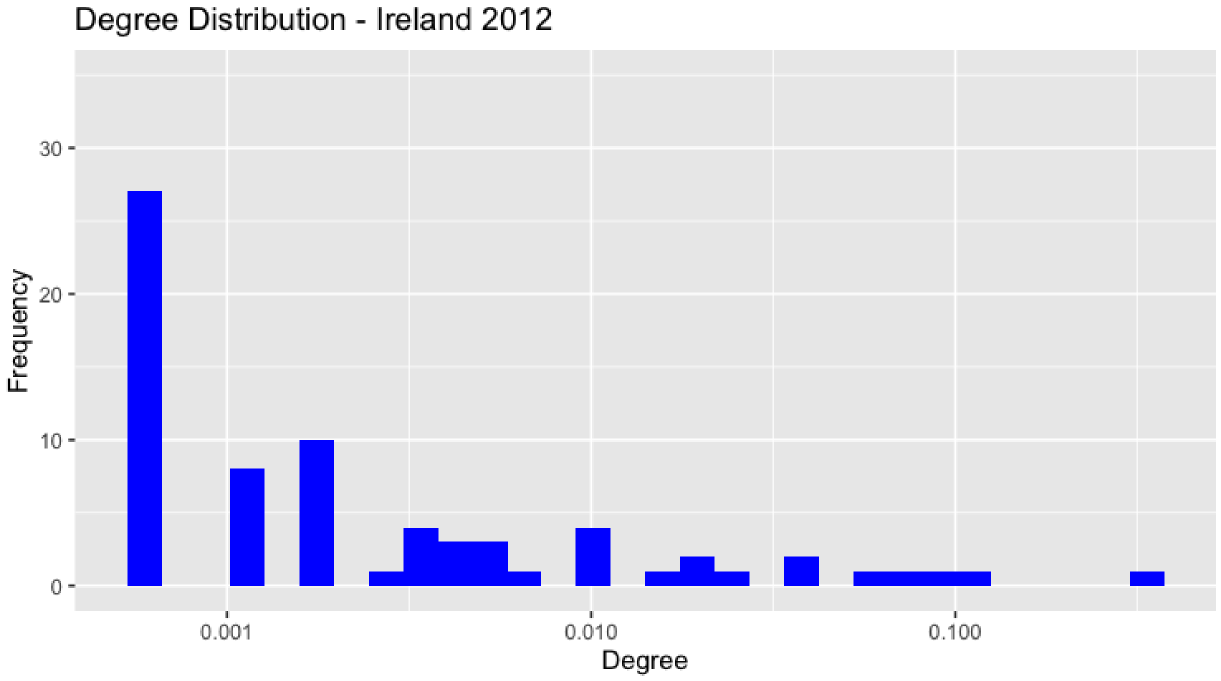
Slovakia

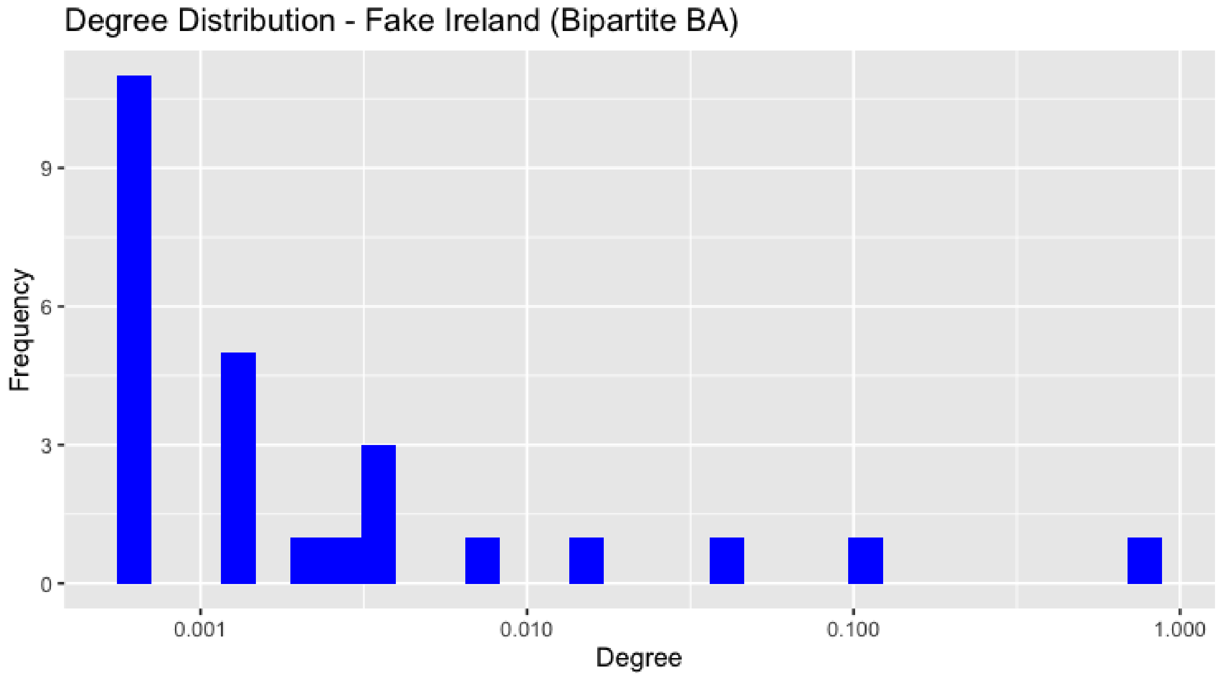

SK_2008
SK_2009
SK_2010
SK_2011
SK_2012
SK_2013
SK_2014
SK_2015
SK_2016

Comparison with Empirical Models

Degree Distributions

Comparing our degree distribution to the degree distribution of the Barabási–Albert model

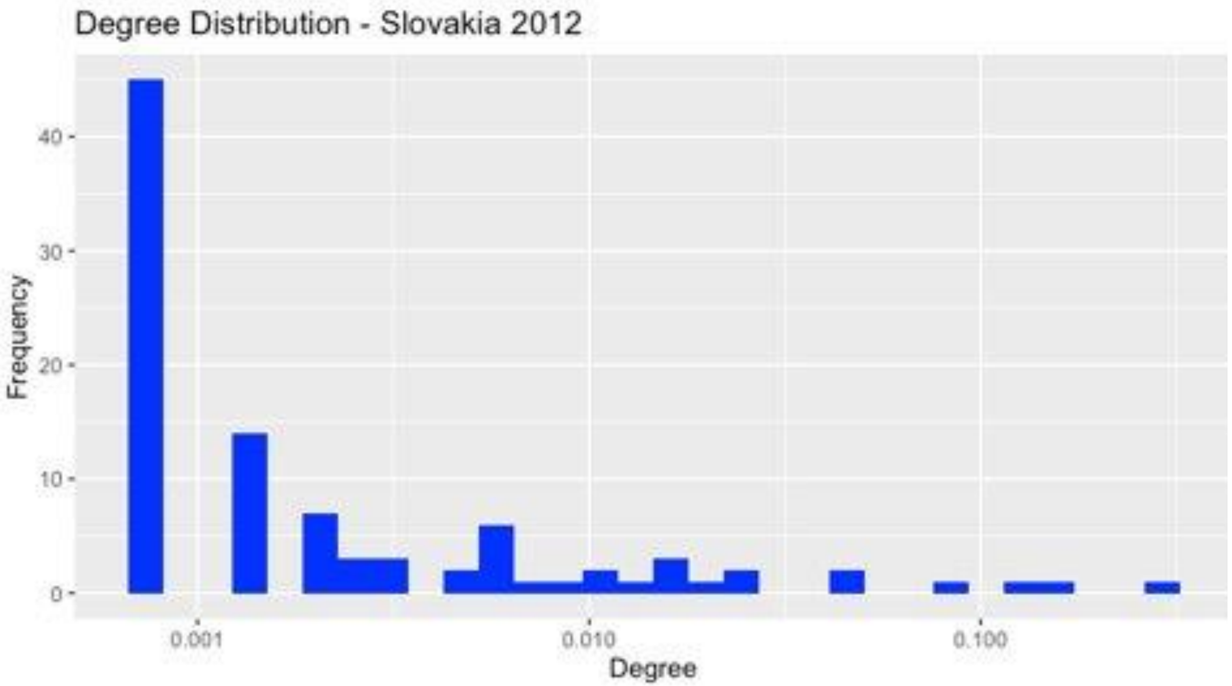


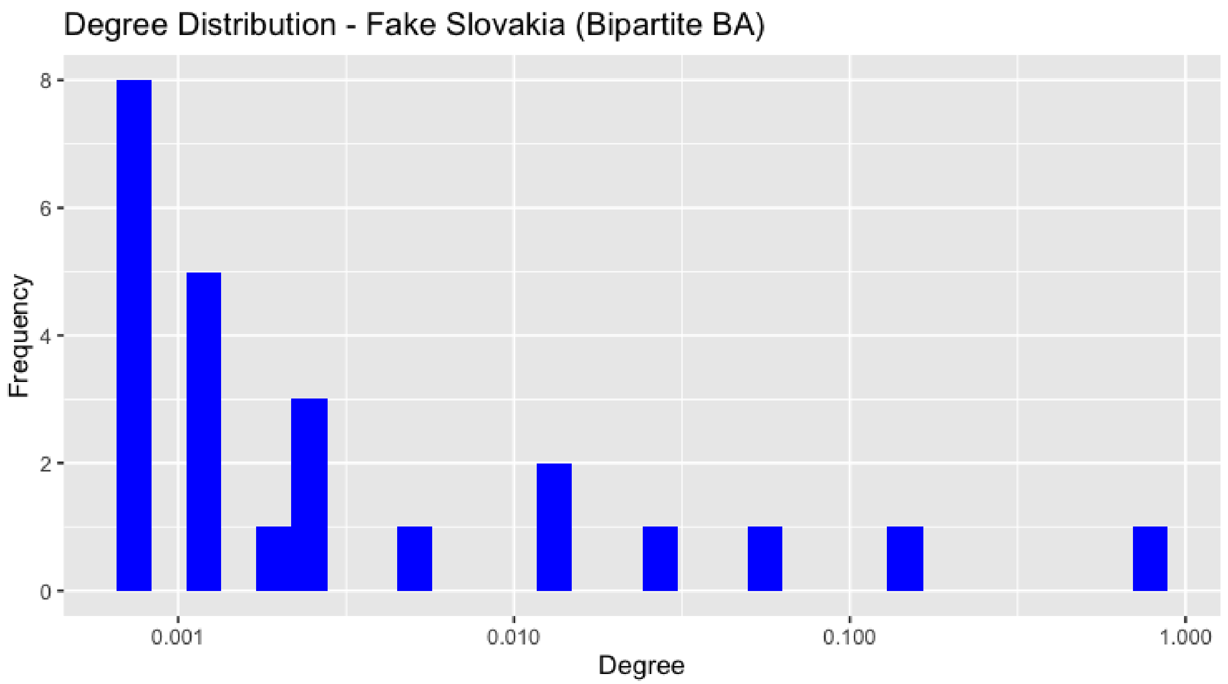


- *Both networks are scale-free*
- *Similar distribution, but greater range on x-axis*
    - *All winners can work with all issuers in simulation… no specialization*

Degree Distributions

Comparing our degree distribution to the degree distribution of the Barabási–Albert model

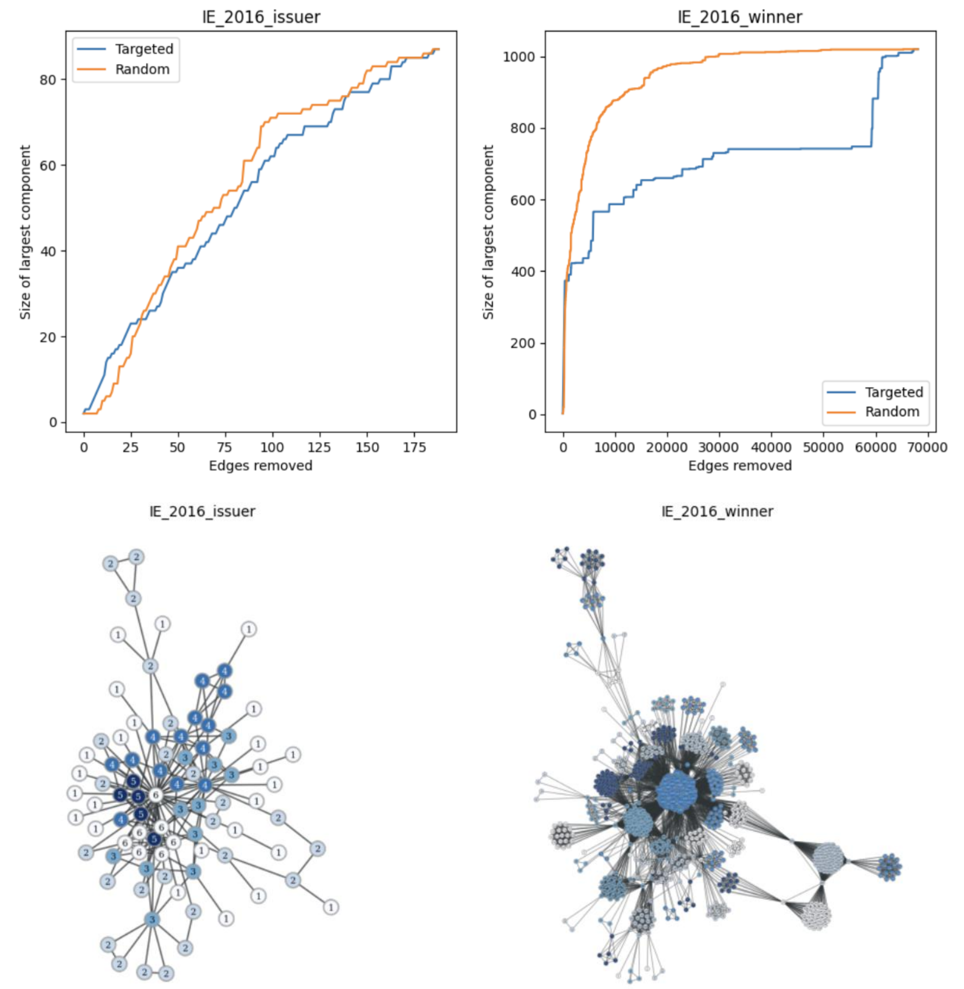




Inverse Percolations

Comparing inverse percolations in the EU Network with the Albert Barabasi Model

- *Assessing the robustness of the Network*
- *Random Networks:*
  - *A randomly picked node is likely to have an average degree of the network <k>*
  - *Doesn’t matter which edge you remove first*
  - *There’s a finite fraction of nodes at which we lose the Giant Component*
- *Scale Free (AB) Network:*
  - *No <k>*
  - *Large # of Nodes with small k*
  - *Small # of Nodes with large k (Hubs)*
  - *A randomly removed edge is more likely to be a node with smaller k*
  - *More robust against random failures but are not tolerant to a coordinated attack*



Inverse Percolations

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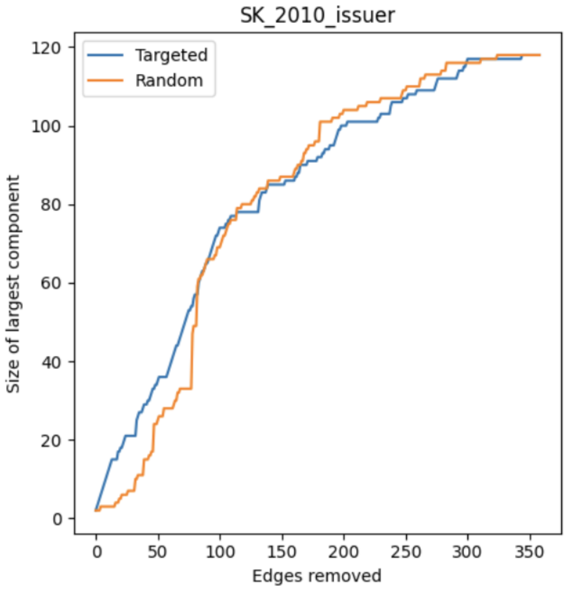
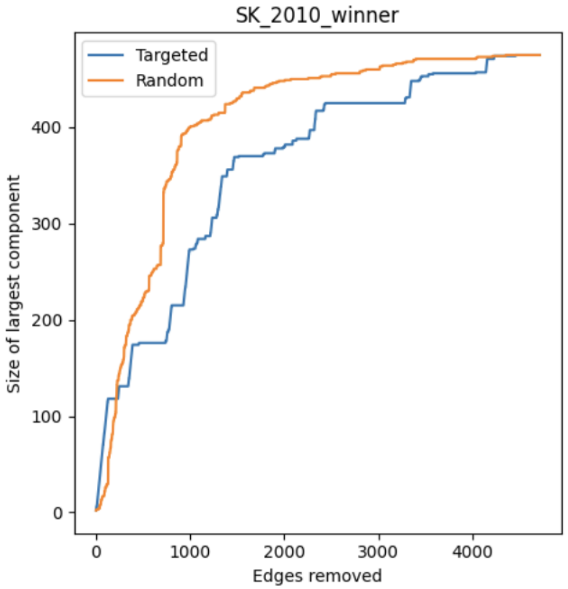
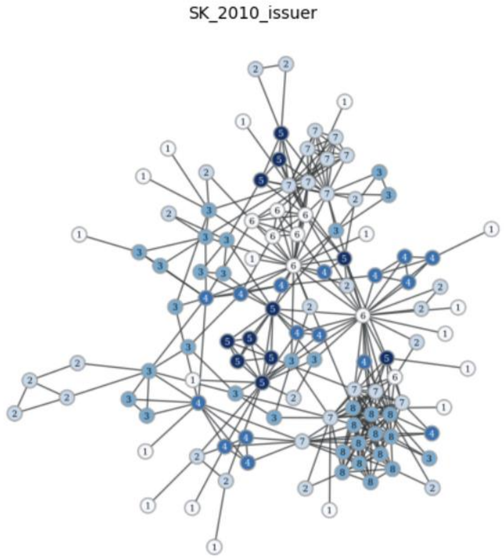
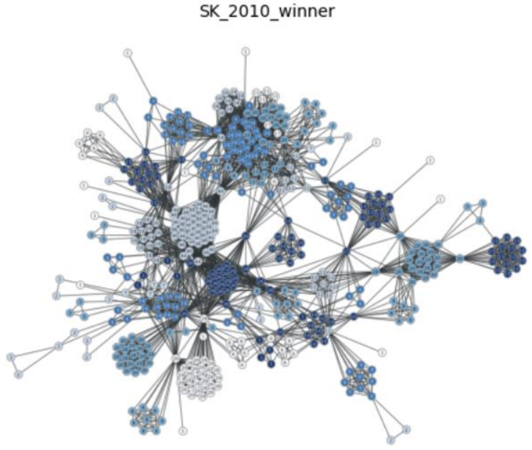


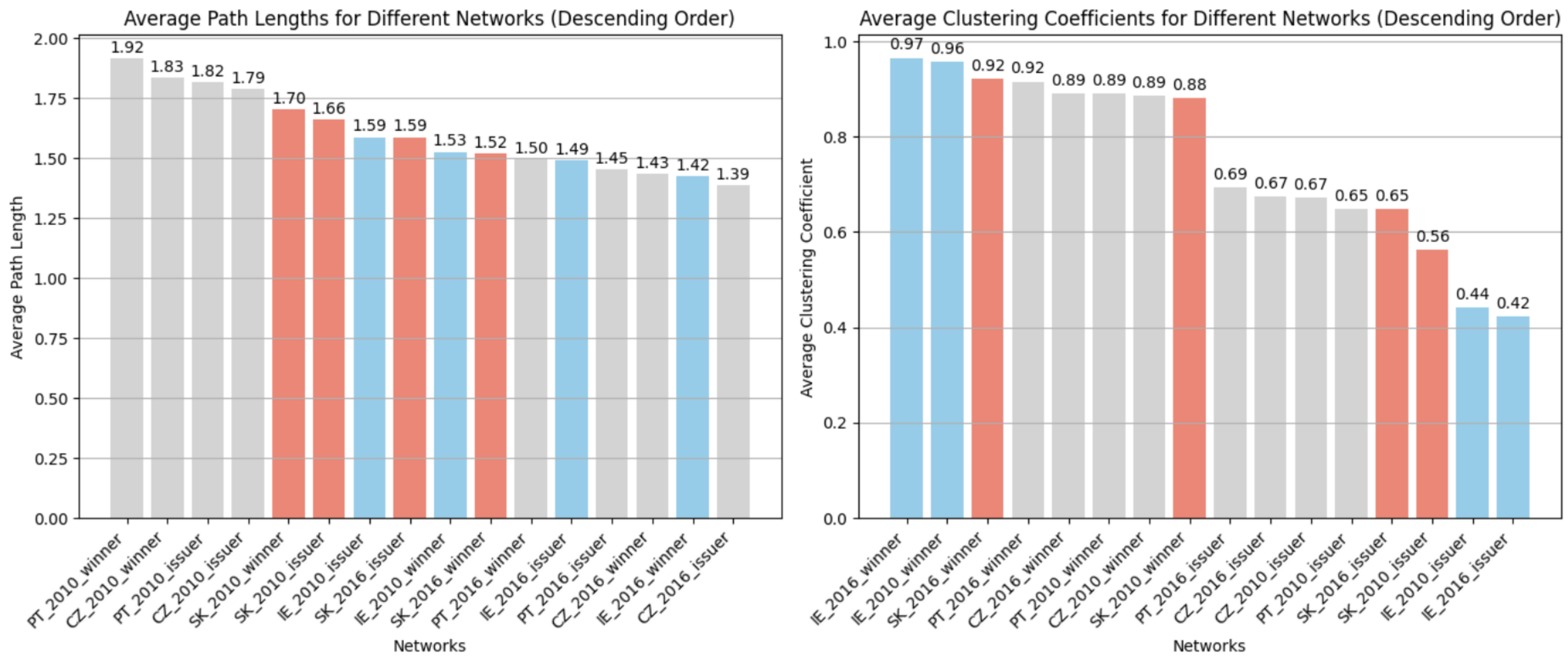






Similar results seen for Slovakia in 2010 as well

Average Path lengths and Clustering Coefficients

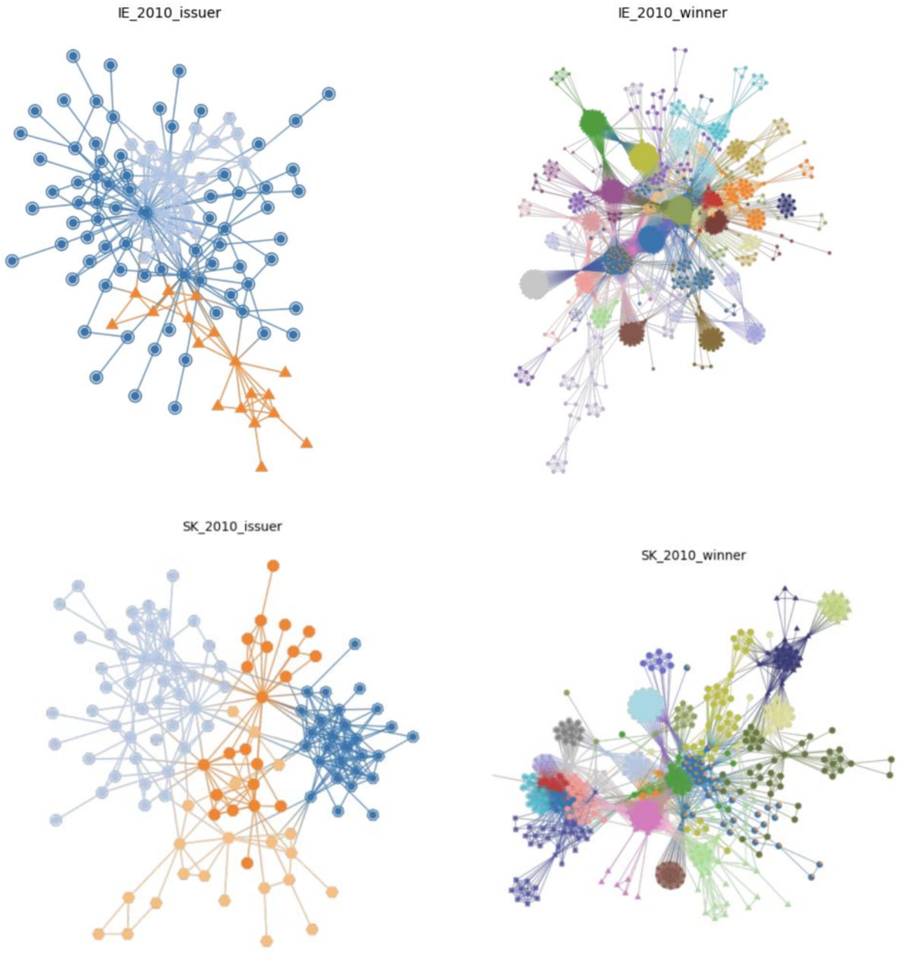


- *Small number of Avg. path length signifies a more interconnected network. It takes a smaller number of 'hops' on average to reach from one node to another*
- *Lower Clustering Coefficient signifies nodes are connected to the overall network rather than being more connected to their own clusters*

Block Models

Limitations of the Albert Barabasi model and the use of Stochastic Block Model

- *As we know, the Albert Barabasi model does a good job in reproducing percolations, small world, short paths and hubs but not a great job at identifying assortative behaviour (communities)*
- *We therefore look at the Stochastic Block model*
- *On the Right:*
  - *Each color corresponds to a different block or community identified by the blockmodel algorithm.*
  - *Nodes with the same color belong to the same block*
  - *Winners have a greater number of communities in general*
- *More of an inferential/descriptive model rather than an explanatory one.*



A more explanatory community detection

Hungarian procurement market

- *The 2014 Hungarian procurement market. Plotted the largest connected component of the network,*
- *Filtering out nodes involved in less than three contracts for the sake of visualization.*
- *Nodes are buyers and suppliers of contracts*
- *Each edge represents that the buyers and suppliers have a contract.*
- *Edges are colored red if the single-bidding rate on the edge exceeds the average rate of single bidding that year.*
- *Single bidding is significantly overrepresented among the edges in the top left cluster.*

Link Prediction

Link Prediction

- *Given that a firm wins a contract from two public institutions AND another firm wins a contract from one of those two public institutions, what is the probability that the second firm will also win a contract from the other public institution?*
- *Robins-Alexander clustering coefficient provides an answer by measuring the tendency for local clustering in bipartite networks.*
- *The greater the Robins-Alexander clustering coefficient, the more local correlations in a market.*
- *R-A clustering coefficients:*
  - *Ireland: 0.03*
  - *Slovakia: 0.09*

Conclusion

Conclusion

- *Public procurement markets are scale-free networks*
- *However, Albert-Barabasi model may not be the best fit*
- *Limitations*
  - *Analysis is not industry-specific*
  - *Do not account for contract value*
  - *Haven't accounted for spillover effect between countries*
  - *Seasonality not captured in annual data*
  - *Single-bidding rate is not a flawless method*

- *Network science does not replace traditional survey methods, but supplements them*

References

References

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