

Table of Content

1	Introduction	1
1.1	Topic and contents of this thesis	1
1.2	The complex network approach to network societies	3
1.3	QuickCent model	4
1.4	Food-sharing model	5
2	The complex networks approach to network societies	8
2.1	Introduction	10
2.2	Basic Concepts	10
2.2.1	Features and relevance of complex networks	11
2.2.2	Random network model	12
2.2.3	Power-law distribution	13
2.2.4	Scale-free distribution	14
2.2.5	Moments of the power-law	15
2.3	Contemporary network science models	16
2.3.1	First models	16
2.3.2	Conceptual critiques to the first models	19
2.3.3	Critiques in fitting real-world networks	20
2.3.4	Preferential attachment growth	22
2.3.5	Posterior models of complex networks	23
2.3.6	Social networks are only weakly scale-free	26

2.4	Models of communities in networks	27
2.4.1	Complementarity	27
2.4.2	Social sanctioning	28
2.4.3	Risk-sharing	28
2.4.4	Homophily	29
2.5	Concluding remarks	29
3	QuickCent: a fast and frugal heuristic for harmonic centrality estimation on scale-free graphs	31
3.1	Introduction	32
3.2	The QuickCent Heuristic	34
3.3	A QuickCent implementation	36
3.3.1	Using the in-degree for the clues	37
3.3.2	Computing the summary statistic via a power-law distribution assumption	37
3.3.3	Putting all the pieces together	38
3.4	Results	40
3.4.1	Comparison with other methods	41
3.4.2	Time measurements	44
3.4.3	Networks defying QuickCent assumptions	45
3.4.4	Experiments with empirical networks	48
3.5	Discussion and future work	51
3.6	Conclusion	54
4	Modularity of food-sharing networks minimises the risk for individual and group starvation in hunter-gatherer societies	55
4.1	Introduction	56
4.2	Materials and methods	60
4.2.1	Food-sharing protocol and assumptions	60
4.2.2	Probability of eating	61

4.2.3	Optimizing criteria	62
4.2.4	Model solution	63
4.2.5	Pipeline of analysis	66
4.3	Results	68
4.3.1	Welfare optima	68
4.3.2	Reduction of variability optima	70
4.3.3	Multi-objective optima	76
4.4	Discussion	80
4.5	Conclusion	84
4.6	Acknowledgements	85
5	Conclusion	86
6	Declarations	88
6.1	Funding.	88
6.2	Competing interests.	88
6.3	Data availability Statement.	88
6.4	Author contributions.	89
	Bibliography	109
	Annex A Fragmentation threshold under random removal	110
	Annex B Supplementary Information for “QuickCent: a fast and frugal heuristic for harmonic centrality estimation on scale-free networks”	113
B.1	Practical procedure to estimate the lower limit of the power-law distribution	114
B.2	Synthetic networks setting and assumptions verification	115
B.3	Robustness of estimates	118
B.4	Assumption verification experiments on randomized networks	120
B.5	Sensitivity to connection probability and assumptions verification on Erdős-Rényi digraphs and control networks	121

B.6	Assumptions verification on empirical networks	123
Annex C Food sharing gave birth to social networks		125
Annex D Supplementary Information for “Modularity of food-sharing networks minimises the risk for individual and group starvation in hunter-gatherer societies”		128
D.1	Estimate of probability of eating	129
D.2	Structure of simulation and sampling of model variables	130
D.3	Sizes of tables of networks and features	132
D.4	Domain of optimization model and evolutionary algorithm implementation details	133
D.5	Choice of tSNE hyperparameters and heuristics to set OPTICS hyperparameters	134
D.6	Analytical argument for the inclusion of additional features in the construction of decision trees	136
D.7	Implementation details of decision trees	136
D.8	Decision trees for Pareto optimal networks	137
Annex E Are food-sharing networks scale-free?		141
E.1	Introduction	142
E.2	Methods	142
E.3	Limitations	143
E.4	Results	143
E.5	Conclusions	145
E.6	Other analyses	147
E.7	Data availability	147