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Still in the shadow of the wall? The case of the Berlin biotechnology cluster

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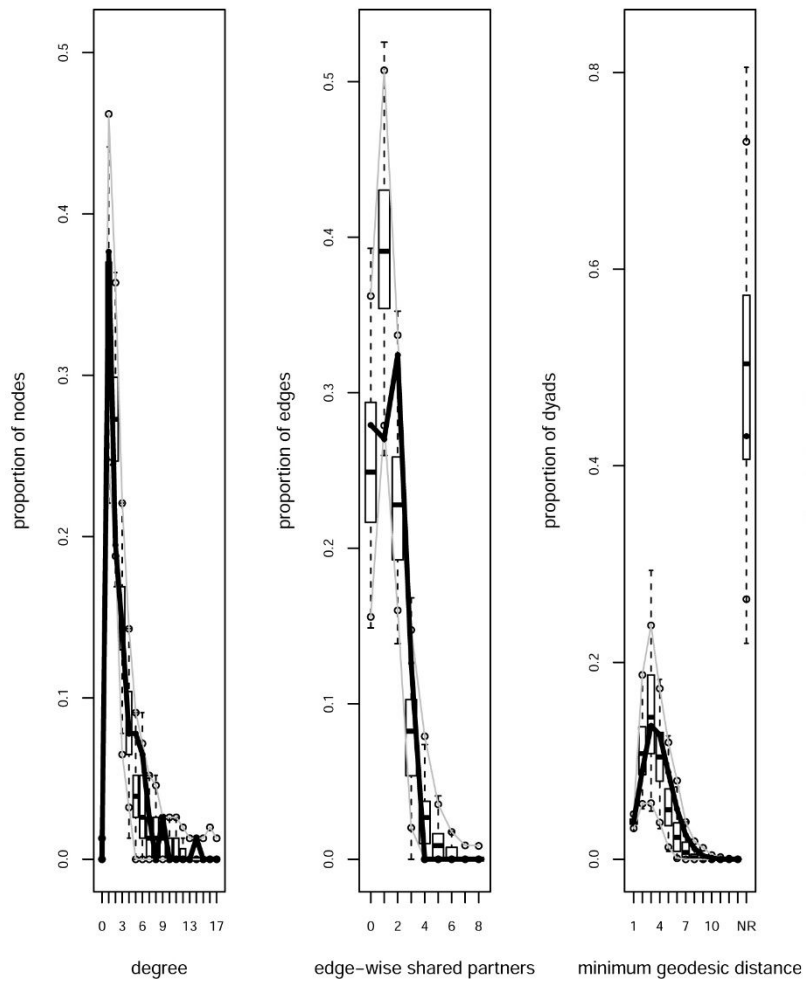
Appendix 1. A technical overview of STERGM

The statistical modelling of the evolution of networks does not follow the logic of standard econometric methods because complex dependency relations characterize such data (Broekel et al. 2014). Exponential random graph models (ERG models, also known as p^* models) use Markov random graph theory to approach the problem of interdependence (Broekel et al, 2014; Robins et al, 2007). Elaborating on the concept of exponential graph, an ERG model in its basic form is defined as (Robins et al, 2007):

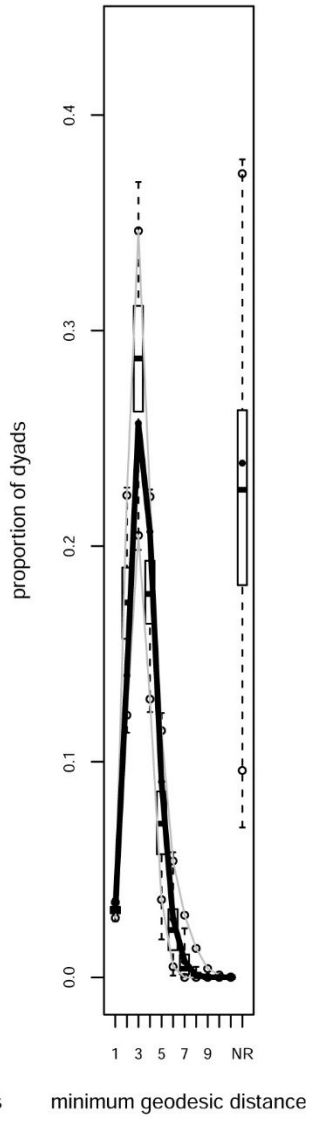
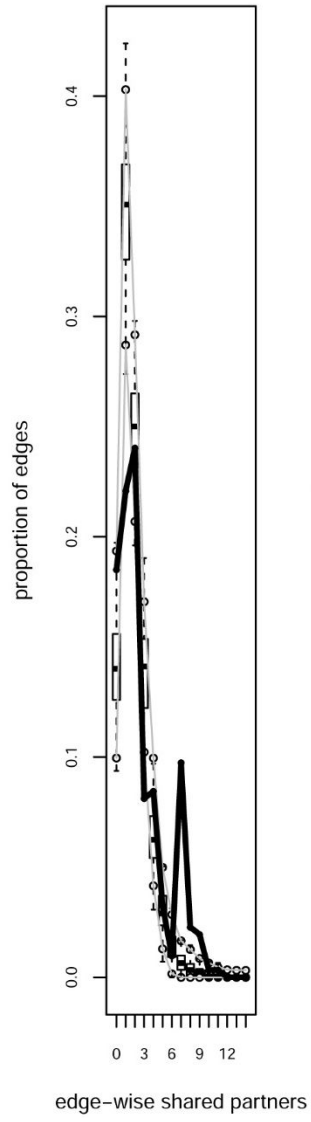
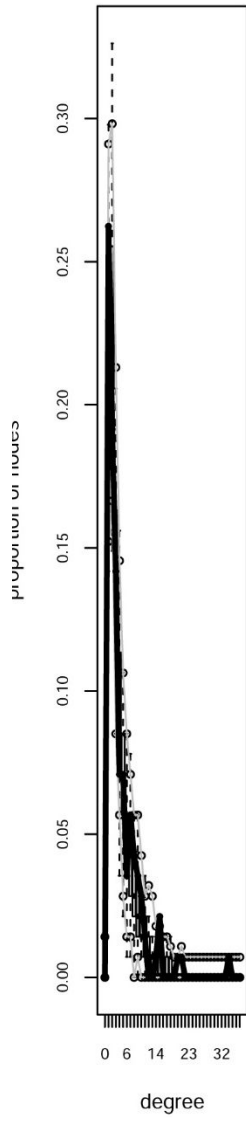
$$\Pr(X = x) = \frac{1}{Z} \exp\left\{\sum_A (\eta_A g_A(x))\right\} \quad (1)$$

$\Pr(X = x)$ is the probability of the network (X), which is constructed through the exponential random graph modelling, being equal to the observed network (x). η_A represents network configurations A at the node, dyad and network levels. $g_A(x)$ corresponds to the network statistics. We used Markov chain Monte Carlo maximum likelihood to fit the model. As basic ERG models are designed for cross-sectional networks, Hanneke and Xing (2007) adapted this approach to the modelling of dynamic networks, creating so-called temporal ERG models. Later, Krivitsky and Handcock (2016) extended this to separable temporal ERG models (STERGM). STERGM enable researchers to tackle questions regarding network evolution. As a discrete-time model of evolving networks, it formulates sets of separate parameters for tie formation and tie dissolution, which are independent in each time step and dependent across time steps (Krivitsky and Goodreau, 2016). The model then analyses both processes (formation and dissolution) collectively and calculates the final coefficients (Krivitsky and Goodreau, 2014). Separating the formation and dissolution processes is useful because, in real-world networks, nodes (e.g. organizations) form and dissolve ties for different reasons. Hence, this model enables researchers to test the relative importance of factors driving the evolution of networks for each process independently.

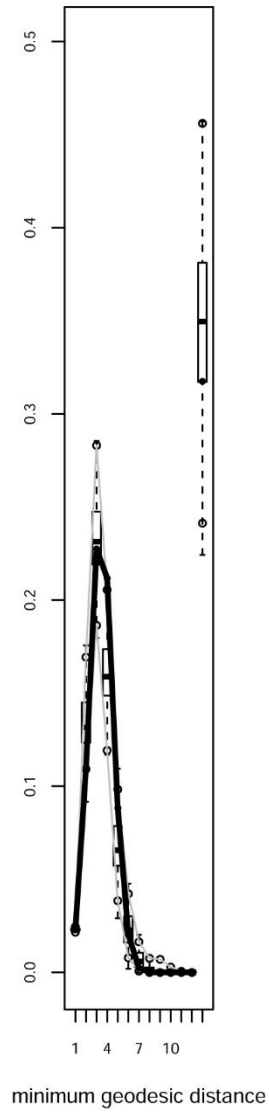
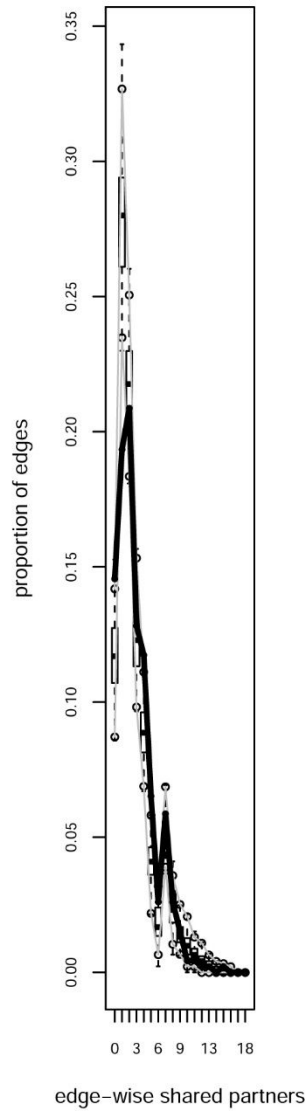
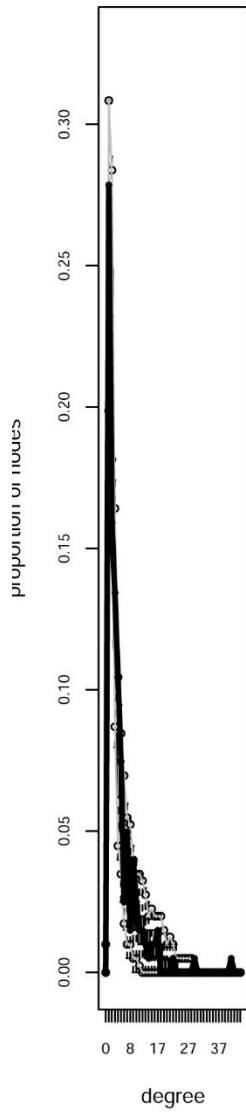
Appendix 2. The goodness of fits
 The formation part
 Model (1)



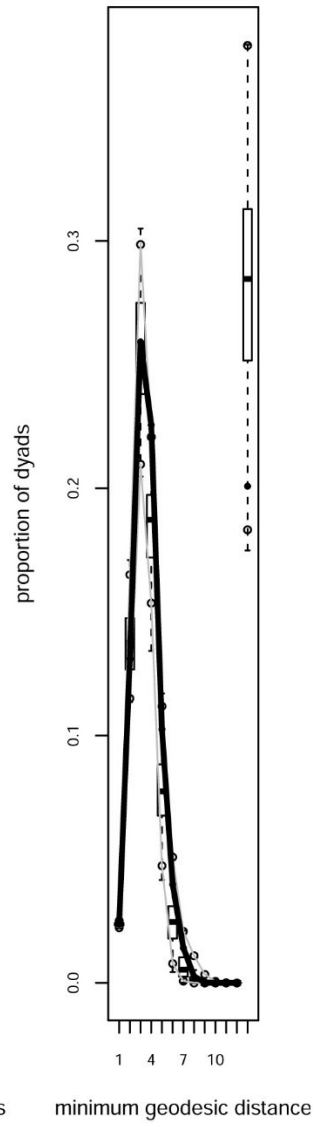
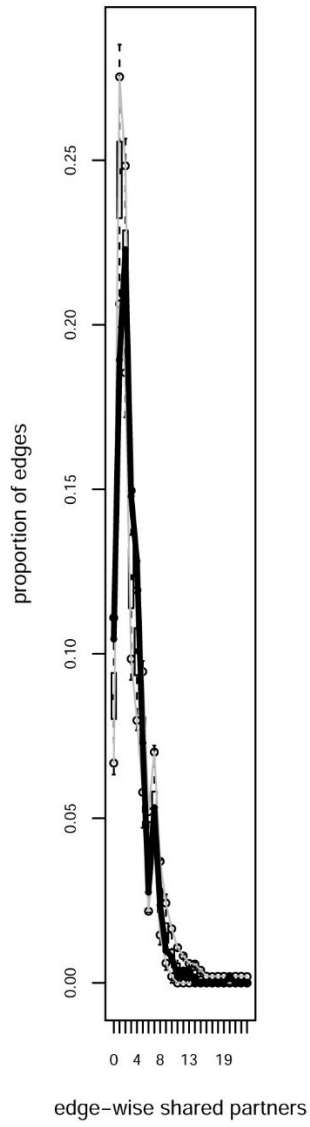
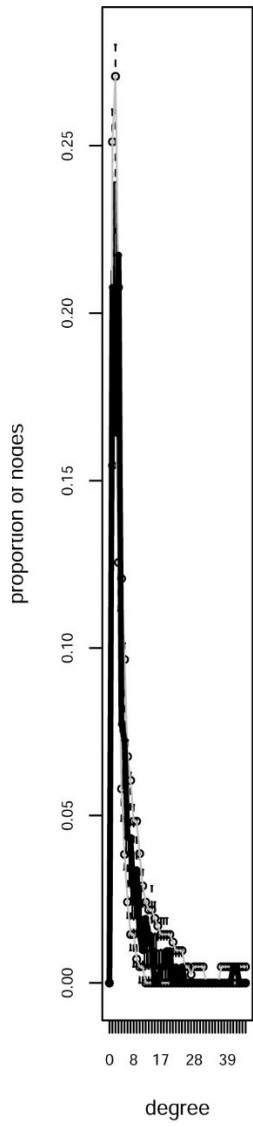
Model (2)



Model (3)

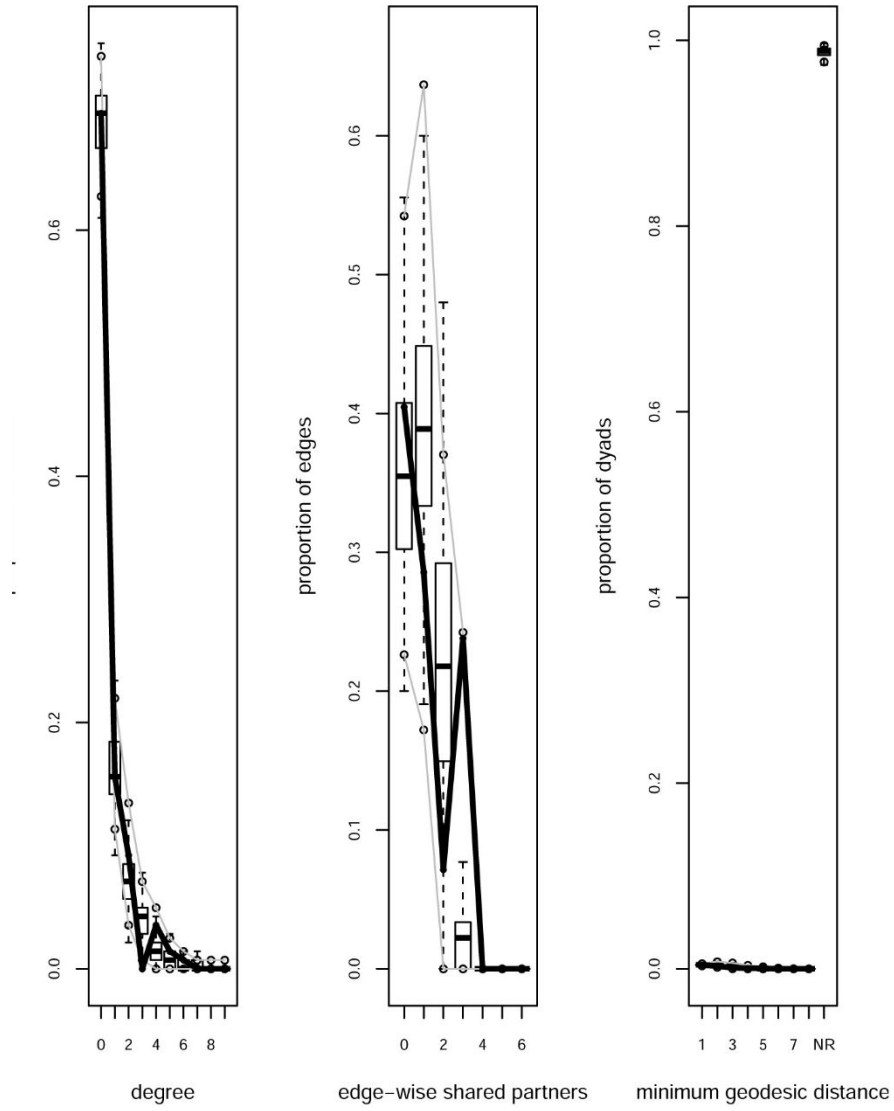


Model (4)

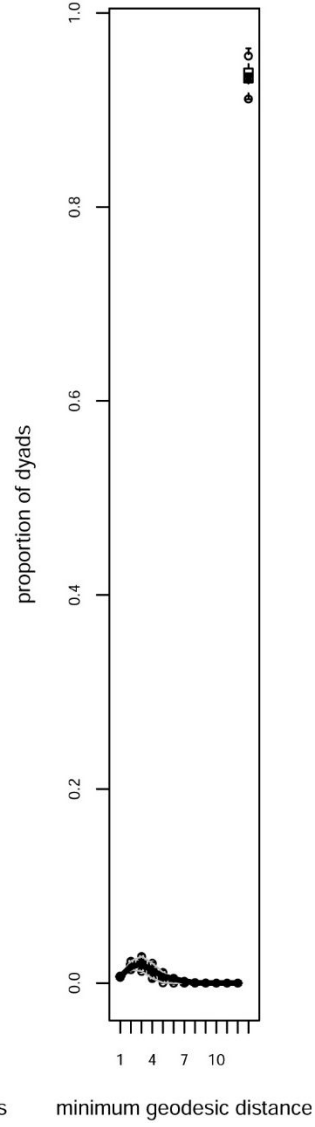
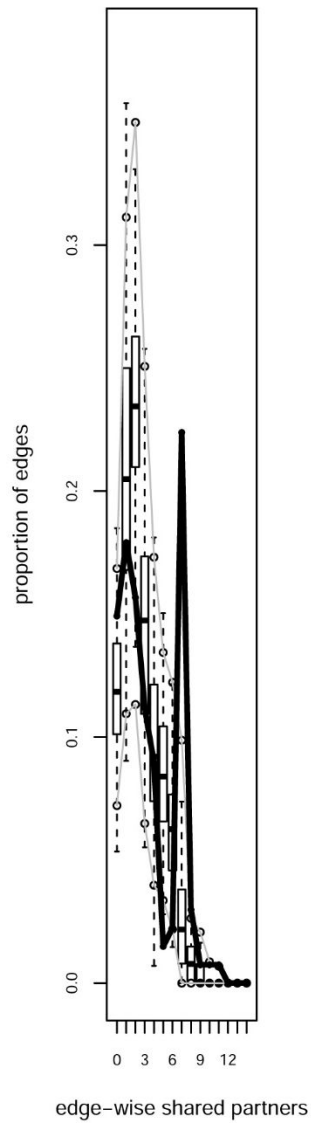
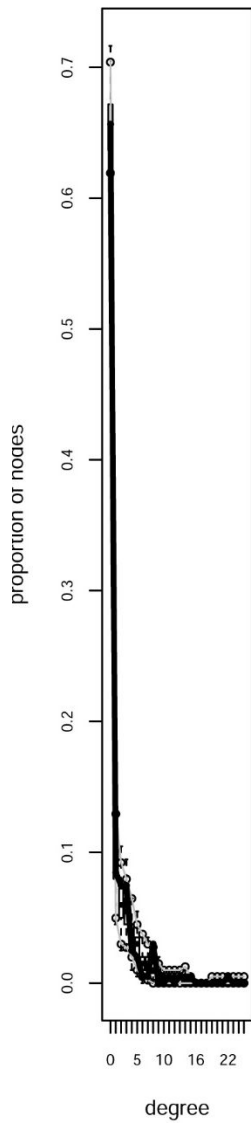


The persistence part

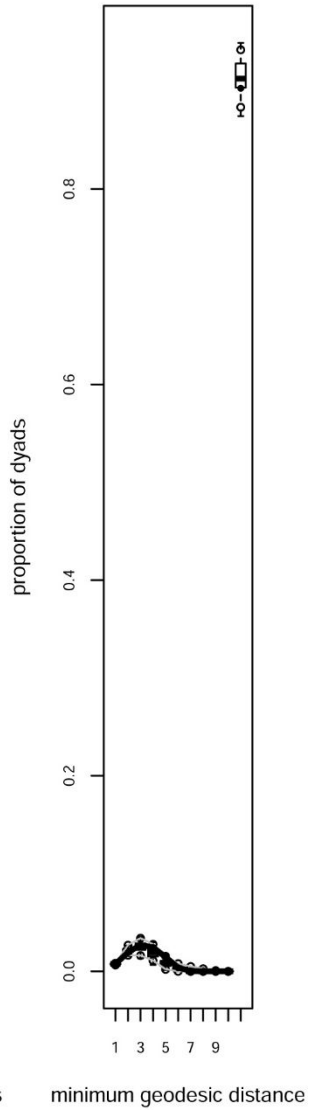
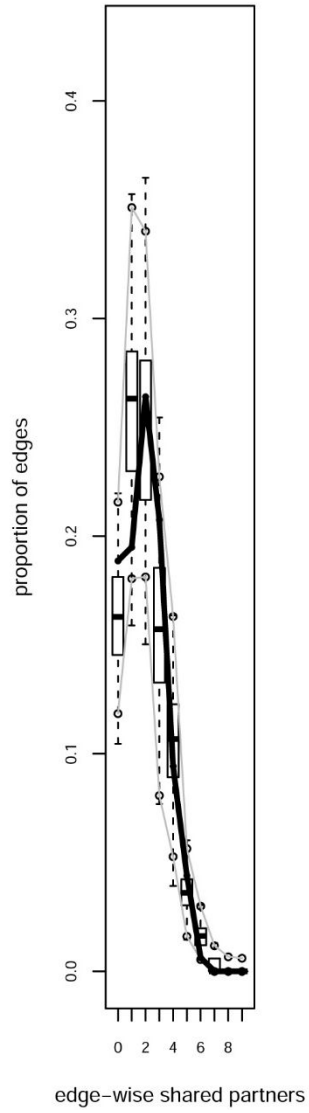
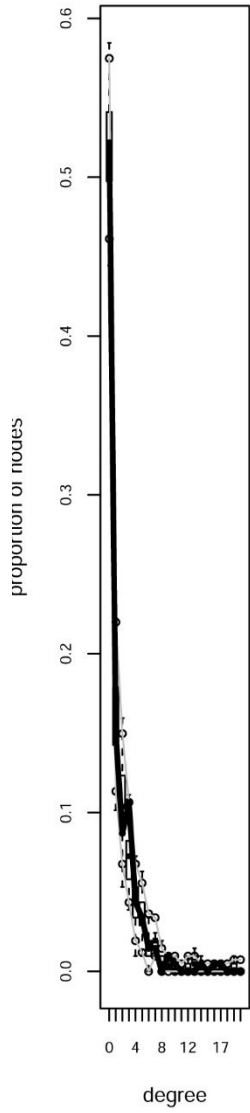
Model (2)



Model (3)



Model (4)



Appendix 3. STERGM results (robustness check).

	Formation				Persistence		
	(1)	(2)	(3)	(4)	(2)	(3)	(4)
Network level							
EDGES	-10.003*** (1.173)	-6.981*** (0.566)	-7.200*** (0.541)	-8.756*** (0.718)	-2.044 (2.184)	1.201 (1.777)	2.013 (1.356)
GWESP	1.970*** (0.239)	1.878*** (0.164)	2.431*** (0.159)	2.464*** (0.181)	1.924*** (0.444)	1.516*** (0.299)	1.640*** (0.262)
GWDEG	8.043*** (2.755)	5.892*** (1.411)	6.521*** (1.393)	8.141*** (2.073)	1.380** (0.661)	0.348 (0.492)	0.940** (0.419)
Dyad level							
GEO	0.103* (0.058)	0.162*** (0.032)	0.153*** (0.027)	0.112*** (0.037)	0.013 (0.100)	0.262*** (0.090)	0.073 (0.061)
INST	-0.396 (0.253)	0.016 (0.172)	0.263* (0.158)	0.422** (0.198)	-0.214 (0.515)	0.176 (0.381)	-0.309 (0.325)
BERLIN	0.837 (0.514)	-0.005 (0.246)	-0.604*** (0.172)	-0.443** (0.209)	-1.099 (0.971)	0.293 (0.652)	-2.049*** (0.492)
SAME	0.446** (0.223)	-0.245 (0.154)	0.100 (0.149)	0.561*** (0.175)	-0.429 (0.565)	-0.639* (0.365)	0.260 (0.330)
Node level							
SIZE.2	0.320 (0.263)	0.195 (0.126)	0.141 (0.109)	-0.380** (0.181)	-0.336 (0.456)	0.406 (0.381)	-0.192 (0.216)
SIZE.3	-0.076 (0.234)	0.216* (0.119)	-0.125 (0.124)	0.102 (0.143)	0.309 (0.461)	0.312 (0.278)	-0.259 (0.252)
PROJ	1.296*** (0.245)	0.671*** (0.097)	0.592*** (0.083)	0.645*** (0.091)	0.218 (0.273)	0.126 (0.180)	0.071 (0.147)
AGE	0.199* (0.106)	-0.117 (0.071)	-0.100 (0.078)	-0.087 (0.094)	-0.179 (0.264)	-0.574** (0.237)	-0.522*** (0.181)
Leibniz	0.481 (0.432)	0.587*** (0.173)	-0.462 (0.301)	0.310 (0.205)	-0.464 (0.901)	-0.597 (0.537)	-0.109 (0.428)
MaxPlanck	-0.984** (0.466)	0.108 (0.191)	-0.709*** (0.224)	-0.014 (0.255)	1.539* (0.919)	0.370 (0.493)	0.104 (0.363)
Charite	0.276 (0.267)	0.785*** (0.128)	0.158 (0.137)	0.302* (0.170)	0.388 (0.435)	0.796** (0.335)	-0.184 (0.252)
Akaike Inf. Crit.	571.584	1,395.292	1,733.806	1,287.158	131.667	234.346	341.375
Bayesian Inf. Crit.	655.189	1,495.894	1,844.353	1,398.470	169.726	283.307	395.426

Note:

*p<0.1; **p<0.05; ***p<0.01