

Forum users and threads 2011: a fishing expedition

Mini project involving a bipartite network model and a
multiplex networks implementation of a valued ties model

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Definitions

- <http://www.ford-team.si/forum>
- **Population:** car enthusiasts
- **Data from:** sep. 2003 to feb. 2011
- **2456 forum users**
- **10410 forum threads**
- With todays computers that could mean a bit of waiting.

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What constitutes a tie

- **Posting in the thread** is a proxy of the user's interest in the post's topic.
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Part of the matrix

Table: Data with structural zeros.

...
...	0	0	0	10	0	10	0	0	10	0	...
...	0	0	0	10	0	10	0	0	10	0	...
...	1	1	1	10	1	10	1	1	10	1	...
...	0	0	0	10	0	10	0	0	10	0	...
...	0	0	0	10	1	10	0	0	10	0	...
...	0	1	0	10	0	10	0	0	10	0	...
...	0	0	0	10	0	10	0	0	10	0	...
...	0	0	0	10	0	10	0	0	10	0	...
...	0	0	0	10	0	10	0	0	10	0	...
...	0	0	0	10	0	10	0	0	10	0	...
...	0	0	0	10	0	10	1	0	10	1	...
...	0	0	0	10	0	10	0	0	10	0	...
...	1	0	0	10	0	10	0	0	10	0	...
...	10	10	10	10	10	10	10	10	10	10	...
...	10	10	10	10	10	10	10	10	10	10	...
...	0	1	1	10	1	10	0	1	10	0	...
...

Part of the matrix

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...	0	0	0	10	0	10	0	0	10	0	...
...	0	0	0	10	0	10	0	0	10	0	...
...	1	1	1	10	1	10	1	1	10	1	...
...	0	0	0	10	0	10	0	0	10	0	...
...	0	0	0	10	1	10	0	0	10	0	...
...	0	1	0	10	0	10	0	0	10	0	...
...	0	0	0	10	0	10	0	0	10	0	...
...	0	0	0	10	0	10	0	0	10	0	...
...	0	0	0	10	0	10	0	0	10	0	...
...	0	0	0	10	0	10	0	0	10	0	...
...	0	0	0	10	0	10	0	0	10	0	...
...	0	0	0	10	0	10	1	0	10	1	...
...	0	0	0	10	0	10	0	0	10	0	...
...	1	0	0	10	0	10	0	0	10	0	...
...	10	10	10	10	10	10	10	10	10	10	...
...	10	10	10	10	10	10	10	10	10	10	...
...	0	1	1	10	1	10	0	1	10	0	...
...

Missing column: at this point in time the corresponding thread has not been started yet, but its place in the matrix is reserved.

Part of the matrix

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...
...	0	0	0	10	0	10	0	0	10	0	...
...	0	0	0	10	0	10	0	0	10	0	...
...	1	1	1	10	1	10	1	1	10	1	...
...	0	0	0	10	0	10	0	0	10	0	...
...	0	0	0	10	1	10	0	0	10	0	...
...	0	1	0	10	0	10	0	0	10	0	...
...	0	0	0	10	0	10	0	0	10	0	...
...	0	0	0	10	0	10	0	0	10	0	...
...	0	0	0	10	0	10	0	0	10	0	...
...	0	0	0	10	0	10	0	0	10	0	...
...	0	0	0	10	0	10	1	0	10	1	...
...	0	0	0	10	0	10	0	0	10	0	...
...	1	0	0	10	0	10	0	0	10	0	...
...	10	10	10	10	10	10	10	10	10	10	...
...	10	10	10	10	10	10	10	10	10	10	...
...	0	1	1	10	1	10	0	1	10	0	...
...

Missing column: the user had at this time-point not yet joined the forum.

Reduce number of users and threads

- Select only those users who posted **at least 50 posts** in the period of interest (2006 — 2010). There were **238** such **users**
- Two criteria for selection of threads:
 - number of posts in the period of interest is at least 30,
 - the user who posted the first post in the period of interest is among the 238 users.
- We have **65 threads** that satisfy both criteria.

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Choose a narrower time period

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- **Time intervals** equidistantly: several interval widths were considered.
- Decision made on the basis of the **Jaccard coefficient**: its value should be **above .3**

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How many intervals?

Table: Jaccard coefficients for different partitionings of the 2006-2010 period.

							1 ==>	2	0.133									
							2 ==>	3	0.195									
							1 ==>	2	0.209									
						2 ==>	3	0.225	3 ==>	4	0.167							
						1 ==>	2	0.239	4 ==>	5	0.217							
			1 ==>	2	0.174	2 ==>	3	0.180	3 ==>	4	0.198	5 ==>	6	0.192				
	1 ==>	2	0.157	2 ==>	3	0.222	3 ==>	4	0.239	4 ==>	5	0.209	5 ==>	6	0.229	6 ==>	7	0.304
	2 ==>	3	0.231	3 ==>	4	0.257	4 ==>	5	0.264	5 ==>	6	0.229	6 ==>	7	0.256	7 ==>	8	0.253
	3 ==>	4	0.190	4 ==>	5	0.232	5 ==>	6	0.260	6 ==>	7	0.256	7 ==>	8	0.330	8 ==>	9	0.240
				5 ==>	6	0.159	6 ==>	7	0.238	7 ==>	8	0.330	8 ==>	9	0.187	9 ==>	10	0.307
							7 ==>	8	0.179	8 ==>	9	0.187	9 ==>	10	0.152	10 ==>	11	0.249
										9 ==>	10	0.152	10 ==>	11	0.152	11 ==>	12	0.205
										10 ==>	11	0.161	11 ==>	12	0.152	12 ==>	13	0.149
										11 ==>	12	0.143	12 ==>	13	0.161	13 ==>	14	0.223
																14 ==>	15	0.104
																15 ==>	16	0.061

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	1 ==> 2 0.239	3 ==> 4 0.198		5 ==> 6 0.192
1 ==> 2 0.174	2 ==> 3 0.180	4 ==> 5 0.209		6 ==> 7 0.304
2 ==> 3 0.231	3 ==> 4 0.239	5 ==> 6 0.229		7 ==> 8 0.253
3 ==> 4 0.190	4 ==> 5 0.264	6 ==> 7 0.256		8 ==> 9 0.240
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				14 ==> 15 0.104
				15 ==> 16 0.061

Eight 6-month time periods

Table: Measures of change for each transition.

periods	0 => 0	0 => 1	1 => 0	1 => 1	Distance	Jaccard	Missing
1 ==> 2	14858	277	189	146	342	0.239	0 (0%)
2 ==> 3	14433	614	236	187	470	0.180	0 (0%)
3 ==> 4	14281	388	517	284	745	0.239	0 (0%)
4 ==> 5	14438	360	400	272	610	0.264	0 (0%)
5 ==> 6	14654	184	420	212	593	0.260	0 (0%)
6 ==> 7	14831	243	244	152	464	0.238	0 (0%)
7 ==> 8	14950	125	302	93	424	0.179	0 (0%)

The network in six time intervals

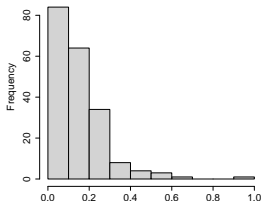
Covariates

Table: Covariates and their type

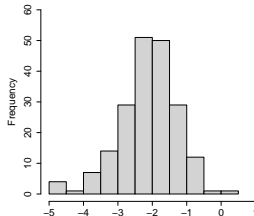
Covariate	no. vars	time
duration of user's membership	monadic	time varying
thread age	monadic	time varying
thread "ownership"	dyadic	constant
tendency to use quotes	monadic	constant
tendency to use links	monadic	constant
thread topic category:	monadic	constant
<i>general</i>		
<i>technical</i>		
baseline: <i>photo gallery + vehicles</i>		

Tendency to use quotes and links

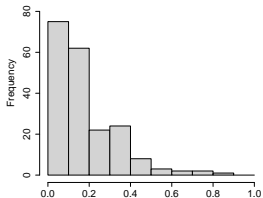
Proportion of links



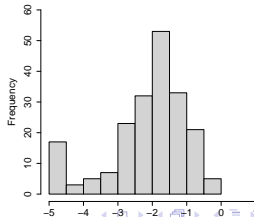
$\log(\text{proportion of links} + 0.01)$



Proportion of quotes

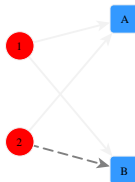


$\log(\text{proportion of quotes} + 0.01)$



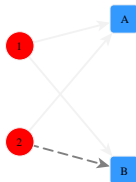
Proto-hypotheses

- Thread activity eventually subsides i.e. threads die over time.
- The user who initiated the discussion feels responsible for the creation of the thread and is more likely to keep posting in it.
- Transitivity: if user 1 and user 2 partake in the discussion in thread **A**, and user 1 also has a tie to thread **B**, then user 2 is also more likely to have a tie to thread **B**.



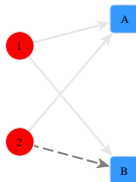
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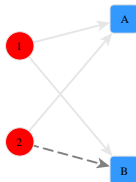
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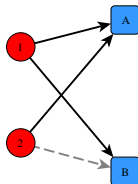
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Siena models

Dichotomous tie bipartite models

Model 1: All possible structural effects

		est.	s.e.	t
Rate	parameters:			
0.1	Rate parameter period 1	152.023	(18248)	
0.2	Rate parameter period 2	219.318	(31199)	
0.3	Rate parameter period 3	142.924	(17152)	
0.4	Rate parameter period 4	97.383	(0.8325)	
0.5	Rate parameter period 5	84.138	(0.7676)	
0.6	Rate parameter period 6	80.523	(0.9482)	
0.7	Rate parameter period 7	56.516	(0.5763)	
Other	parameters:			
1.	eval outdegree (density)	-41.070	(0.1172)	0.8708
2.	eval 4-cycles	0.0118	(0.0020)	-0.0048
3.	eval indegree - popularity (\surd)	0.4529	(0.0421)	-0.2841
4.	eval outdegree - activity (\surd)	0.5310	(0.0790)	-0.1346
5.	eval out-in degree (\surd) assortativity	-0.1049	(0.0287)	-0.2566

Estimation time (Intel Core2duo 2GHz, both cores): **18 min**

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Model 1: Correlations between parameter estimates

	1.	2.	3.	4.	5.
1. eval outdegree (density)	0.014	0.000	-0.004	-0.008	0.003
2. eval 4-cycles	-0.601	0.000	0.000	0.000	0.000
3. eval indegree - popularity (✓)	-0.910	0.837	0.002	0.003	-0.001
4. eval outdegree - activity (✓)	-0.889	0.838	0.970	0.006	-0.002
5. eval out-in degree(✓) assortativity	0.806	-0.926	-0.965	-0.976	0.001

Fishing for many effects at once



Model 2: Many possible effects

		est.	s.e.	t
Rate	parameters:			
0.1	Rate parameter period 1	112.828	(11914)	
0.2	Rate parameter period 2	138.626	(14735)	
0.3	Rate parameter period 3	161.780	(16799)	
0.4	Rate parameter period 4	91.506	(0.6602)	
0.5	Rate parameter period 5	80.563	(0.5877)	
0.6	Rate parameter period 6	65.946	(0.6227)	
0.7	Rate parameter period 7	52.820	(0.4628)	
Other	parameters:			
1.	eval outdegree (density)	-23.098	(0.0266)	0.1409
2.	eval 4-cycles	0.0152	(0.0005)	0.1223
3.	eval ownrship	0.9933	(0.1446)	0.0411
4.	eval log.quotes ego	0.0959	(0.0234)	0.1299
5.	eval log.links ego	0.2137	(0.0280)	0.0175
6.	eval mubr.duration ego	-0.1735	(0.0543)	0.1829
7.	eval mubr.duration.sq ego	0.0278	(0.0118)	-0.1524
8.	eval thrd.age alter	0.0326	(0.0589)	-0.1305
9.	eval thrd.age.sq alter	-0.0485	(0.0152)	-0.0900

Estimation time (Intel Core2duo 2GHz, both cores): **20 min**

Model 2: Correlations between parameter estimates

	1.	2.	3.	4.	5.	6.	7.	8.	9.
1. eval outdegree (density)	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2. eval 4-cycles	-0.428	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3. eval ownrship	-0.106	0.088	0.021	0.000	0.000	0.000	0.000	0.000	0.000
4. eval log.quotes ego	-0.177	-0.044	-0.005	0.001	0.000	0.000	0.000	0.000	0.000
5. eval log.links ego	-0.309	0.039	-0.097	-0.141	0.001	0.000	0.000	0.000	0.000
6. eval mubr.duration ego	0.109	-0.172	0.022	0.047	-0.057	0.003	-0.001	0.000	0.000
7. eval mubr.duration.sq ego	-0.075	0.147	-0.044	-0.088	0.099	-0.954	0.000	0.000	0.000
8. eval thrd.age alter	-0.016	0.076	0.028	0.025	-0.064	-0.016	-0.004	0.003	-0.001
9. eval thrd.age.sq alter	0.059	-0.016	-0.029	-0.024	0.053	-0.002	0.012	-0.948	0.000

Model 3: added topic category as covariate

		est.	s.e.	t
Rate	parameters:			
0.1	Rate parameter period	113.826	(12147)	
0.2	Rate parameter period	138.118	(14703)	
0.3	Rate parameter period	159.646	(16142)	
0.4	Rate parameter period	93.067	(0.7001)	
0.5	Rate parameter period	81.324	(0.6020)	
0.6	Rate parameter period	67.827	(0.6089)	
0.7	Rate parameter period	53.671	(0.4986)	
Other	parameters:			
1.	eval outdegree (density)	-23.252	(0.0244)	0.0240
2.	eval 4-cycles	0.0149	(0.0006)	0.0228
3.	eval ownrship	0.9678	(0.1416)	0.0291
4.	eval log.quotes ego	0.0965	(0.0249)	0.0028
5.	eval log.links ego	0.2103	(0.0287)	0.0023
6.	eval cat.general alter	-0.1292	(0.0419)	0.0345
7.	eval cat.technical alter	-0.3465	(0.0446)	-0.0208
8.	eval mubr.duration ego	-0.0426	(0.0166)	-0.0285
9.	eval thrd.age alter	-0.1425	(0.0187)	-0.0613

Estimation time (Intel Core2duo 2GHz, both cores): **19 min**

Model 3: Time test results

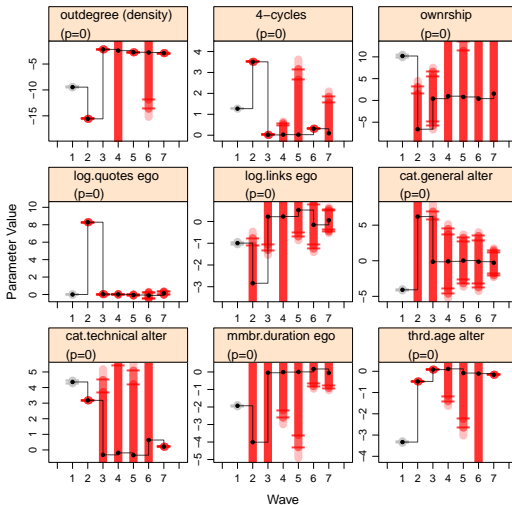
Table: Parameter-wise joint significance tests (i.e. each parameter across all dummies)

	p-Val
outdegree (density)	0
4-cycles	0
ownership	0
log.quotes ego	0
log.links ego	0
cat.general alter	0
cat.technical alter	0
mubr.duration ego	0
thrd.age alter	0

Joint significance test of the dummy parameters: **p-Val = 0**

Where H_0 : all dummy parameters for time-periods are zero.

Model 3: Time test results



Model 4: narrower time period (2007—2010)

Users: 199 Threads: 67

Rate	parameters:			
0.1	Rate parameter period 1	199.537	(19230)	
0.2	Rate parameter period 2	122.401	(0.8366)	
0.3	Rate parameter period 3	103.681	(0.7852)	
0.4	Rate parameter period 4	93.488	(0.8189)	
0.5	Rate parameter period 5	69.679	(0.5741)	
Other	parameters:			
1.	eval outdegree (density)	-22.802	(0.0301)	0.1306
2.	eval 4-cycles	0.0142	(0.0006)	-0.0019
3.	eval ownrship	0.7874	(0.1715)	-0.0145
4.	eval log.quotes ego	0.0532	(0.0277)	0.0586
5.	eval log.links ego	0.2314	(0.0323)	-0.0597
6.	eval cat.general alter	-0.0287	(0.0466)	0.0739
7.	eval cat.technical alter	-0.2431	(0.0519)	-0.0745
8.	eval mubr.duration ego	0.0141	(0.0192)	-0.0527
9.	eval thrd.age alter	0.0033	(0.0193)	-0.0935

Estimation time (Intel Core2duo 2GHz, both cores): **19 + 20 min**

Model 4: Time test results

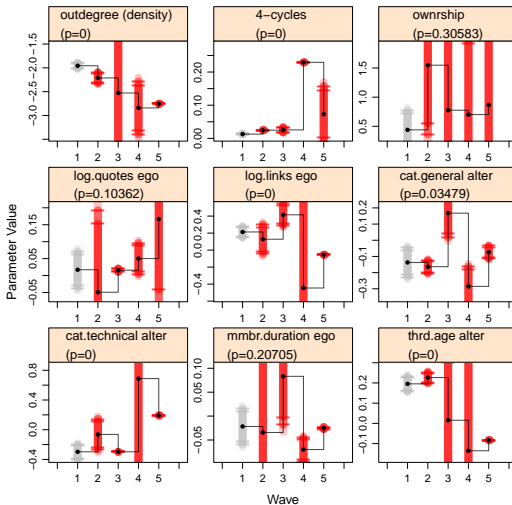
Table: Parameter-wise joint significance tests (i.e. each parameter across all dummies)

	p-Val
outdegree (density)	0.00000
4-cycles	0.00000
ownership	0.30583
log.quotes ego	0.10362
log.links ego	0.00000
cat.general alter	0.03479
cat.technical alter	0.00000
mubr.duration ego	0.20705
thrd.age alter	0.00000

Joint significance test of the dummy parameters: **p-Val = 0**

Where H_0 : all dummy parameters for time-periods are zero.

Model 3: Time test results



Siena models

Valued-tie bipartite model

Model 4: multiplex network

Table: multiplex network; network1 - one post or more; network2 - three posts or more

	est.	s.e.	t
1. rate constant biPart1more rate (period 1)	264.917	(55040)	-0.4847
2. rate constant biPart1more rate (period 2)	173.436	(21200)	-0.1637
3. rate constant biPart1more rate (period 3)	152.764	(28871)	0.0343
4. rate constant biPart1more rate (period 4)	135.216	(27270)	-0.0241
5. rate constant biPart1more rate (period 5)	103.926	(19657)	-0.0717
6. eval biPart1more: outdegree (density)	-28.127	(0.1437)	0.9687
7. eval biPart1more: 4-cycles	0.0097	(0.0012)	-0.2140
8. eval biPart1more: indegree - popularity (sqrt)	0.1652	(0.0318)	-0.5348
9. eval biPart1more: ownrship	0.8013	(0.2805)	0.0670
10. eval biPart1more: outdegree ^{1/2} biPart3more activity	0.3652	(0.0641)	0.1118
11. eval Dummy4:biPart1more ego	NA	(NA)	0.0684
12. eval int. Dummy4:biPart1more ego x 4-cycles	0.0170	(0.0021)	0.1217
13. rate constant biPart3more rate (period 1)	219.846	(35837)	-0.3674
14. rate constant biPart3more rate (period 2)	183.270	(58634)	0.0098
15. rate constant biPart3more rate (period 3)	164.464	(40343)	0.0210
16. rate constant biPart3more rate (period 4)	478.536	(397009)	-0.7074
17. rate constant biPart3more rate (period 5)	177.996	(42765)	-0.3652
18. eval biPart3more: outdegree (density)	-23.588	(0.1396)	0.1150
19. eval biPart3more: 4-cycles	-0.0096	(0.0074)	-0.6286
20. eval biPart3more: indegree - popularity (sqrt)	0.5333	(0.0407)	0.0845
21. eval biPart3more: ownrship	0.4204	(0.2483)	0.1870
22. eval biPart3more: cat.general alter	-0.1798	(0.0887)	0.1513
23. eval biPart3more: thrd.age alter	0.0756	(0.0373)	-0.0606
24. eval biPart3more: outdegree ^{1/2} biPart1more activity	0.3127	(0.0591)	0.2993
25. eval Dummy4:biPart3more ego	NA	(NA)	-0.5431
26. eval int. Dummy4:biPart3more ego x 4-cycles	0.0006	(0.0433)	0.0185

Estimation time (Intel Core2duo 2GHz, both cores): **46 min, didn't converge**

Conclusions

- For the few effects that we were able to include, the results make sense.
- Repeat the exercise on a dataset with better covariates.

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Thanks for listening!