



How to do cross-sectional network analyses?

A **6,5-minute tutorial** of Pnet, utilizing
 Exponential Random Graph Models (ERGMs, p^*)

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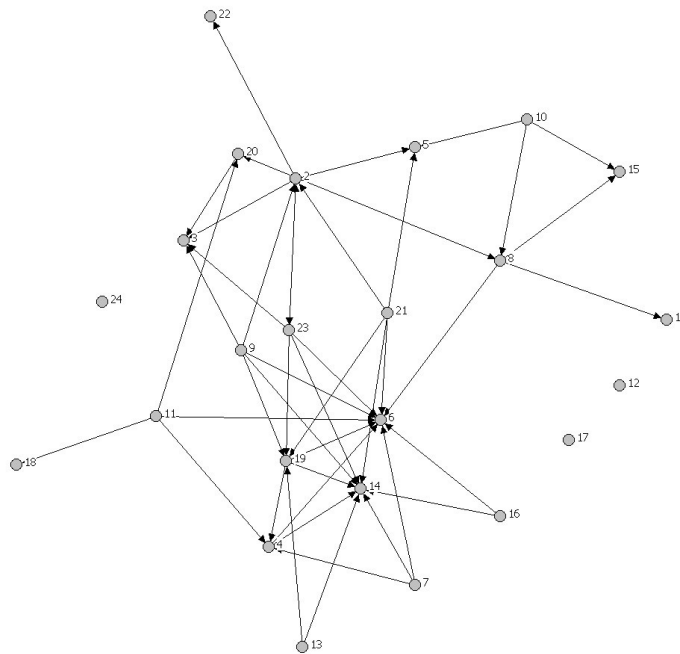
Exponential Random Graph Models

- › Analyze complete networks
- › They include random effects, capturing the *irregularity* of everyday life
- › Tie formation is assumed to depend on others.
 - For example, sharing many friends makes the establishment of a friendship more likely
- › Homogeneity is assumed, which means that network parameters are the same for all actors in the network.

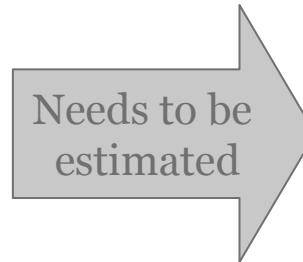


Network Analyses = Modeling networks

Observed network



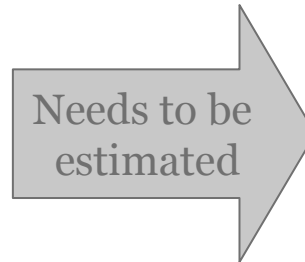
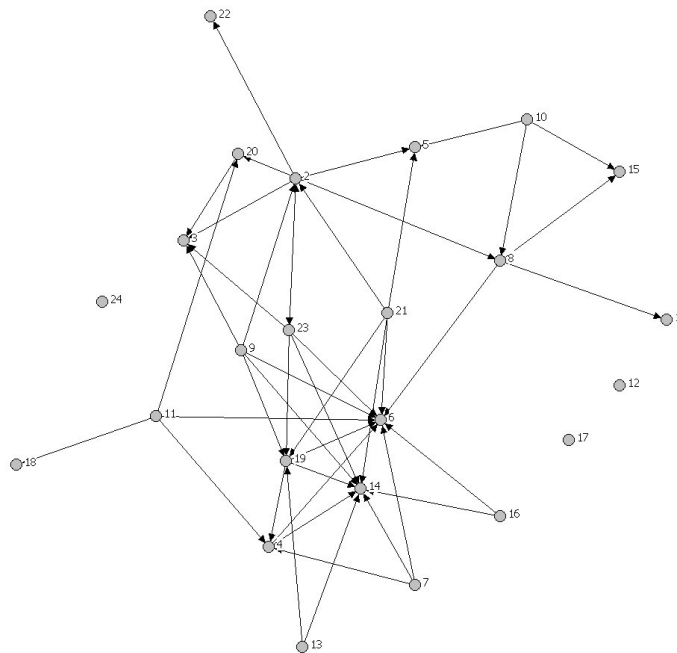
Estimated network





Network Analyses = Modeling networks

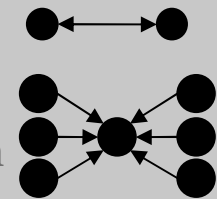
Observed network



Estimated network

By means of **configurations**:
These are subsets of actors and ties between them:

- e.g.,
- Reciprocity
- Indegree distribution





- › Download the program Pnet
- › sna.unimelb.edu.au/

The screenshot shows the PNet website interface. At the top, there is a navigation bar with tabs for Home, Events, People, Projects, p* Models, PNet, Publications, Network Gallery, Useful Links, and Mailing List. The 'PNet' tab is highlighted with a red box. Below the navigation bar, the main content area is titled 'PNet'. On the left side, there is a sidebar with a 'Downloads' section containing links for Introduction, Simulation, Estimation, and Goodness of Fit. The main content area contains the following text:

PNet is a program for the simulation and estimation of Exponential Random Graph (p*) Models.

- **Simulation:**
Simulate Exponential Random Graph distributions with given parameters.
- **Estimation:**
Approximate specified network effects or parameters for a given network.
- **Goodness of Fit:**
Test parameter estimates of a model against important features of the observed network.

Available Downloads

Required Environment

- [Java Runtime Environment \(JRE\) 6.0](#)
- [Microsoft .NET Framework Version 1.1 Redistributable Package](#).
(Not required, if the C/C++ standard library is installed on your computer.)

PNet for Single Networks
Click on File Names to download
(last update 16/02/2010)

Update log	update.txt
Readme	readme.txt
PNet Java GUI	PNet.jar
PNet DLL	pnet.dll
User Manual	PNetManual.pdf
"PNet for Dummies" by Nicholas Harrigan	



- › Open the program!

The screenshot shows the PNet software interface. The window title is "PNet". The menu bar includes "File" and "Help". Below the menu bar, there are input fields for "Session Name:" and "Session Folder:" with a "Browse..." button. The main area is divided into several sections:

- Simulation** (selected tab):
 - Number of Actors: 0
 - Starting Graph Density (0.0-1.0): 0
 - Select Network Type:
 - Non-directed Network
 - Directed Network
 - Maximum Degree for Each Actor: 0
 - Maximum Out Degree for Each Actor: 0
 - Select Structural Parameters:
 - Structural Parameters
 - Select Parameters...
 - Select Dyadic Attribute Parameters:
 - Dyadic Attributes
 - Number of attributes: 1
 - Select Parameters...
 - Select Actor Attribute Parameters:
 - Actor Attribute Parameters
 - Binary Attributes: Number of attributes: 1, Select Parameters...
 - Continuous Attributes: Number of attributes: 1, Select Parameters...
 - Categorical Attributes: Number of attributes: 1, Select Parameters...
- Simulation Options** (right panel):
 - No conditions
 - Fix out-degree distribution
 - Fix graph density
 - Structural "0" File: [] Browse...
 - Pick up sample graph files.
 - Pick up sample degree distribution.
 - Pick up sample geodesic distribution.
 - Pick up sample clustering coefficient.
 - Burn in: 100000
 - Number of Iterations: 1000000
 - Number of samples to pick up: 1000
 - Start!



- › Provide session name and select folder with the data

The screenshot shows the PNet software interface. At the top, there is a menu bar with 'File' and 'Help'. Below the menu bar, there are two input fields: 'Session Name: Labsession_SRCD' and 'Session folder: D:_SRCD'. A 'Browse...' button is located to the right of the 'Session folder' field. These three elements are highlighted with a red rectangular box. Below the session information, there are several tabs: 'Simulation', 'Estimation', 'Goodness of fit', and 'Bayes goodness of fit'. The 'Simulation' tab is selected. Under the 'Simulation' tab, there are several sections: 'Number of Actors: 0' and 'Starting Graph Density (0.0-1.0): 0'. 'Select Network Type' includes 'Non-directed Network' (selected) and 'Directed Network'. 'Select Structural Parameters' has a 'Structural Parameters' checkbox and a 'Select Parameters...' button. 'Select Dyadic Attribute Parameters' has a 'Dyadic Attributes' checkbox, 'Number of attributes: 1', and a 'Select Parameters...' button. 'Select Actor Attribute Parameters' has an 'Actor Attribute Parameters' checkbox and three sub-sections: 'Binary Attributes' (Number of attributes: 1), 'Continuous Attributes' (Number of attributes: 1), and 'Categorical Attributes' (Number of attributes: 1), each with a 'Select Parameters...' button. On the right side, there is a 'Simulation Options' section with radio buttons for 'No conditions' (selected), 'Fix out-degree distribution', and 'Fix graph density'. There are checkboxes for 'Structural "0" File: D:_SRCD', 'Pick up sample graph files.', 'Pick up sample degree distribution.', 'Pick up sample geodesic distribution.', and 'Pick up sample clustering coefficient.'. Below these are input fields for 'Burn in: 100000', 'Number of Iterations: 1000000', and 'Number of samples to pick up: 1000'. At the bottom right, there is a 'Start!' button.



- › Press estimation, provide number of children in the classroom, and select the network file

The screenshot shows the PNet software interface. The 'Estimation' tab is selected. The 'Number of Actors' is set to 23, and the 'Network File' is D:_SRCD\like_least.txt. The 'Estimation Options' section includes 'No conditions', 'Fix out-degree distribution', and 'Fix graph density'. The 'Start!' button is visible.



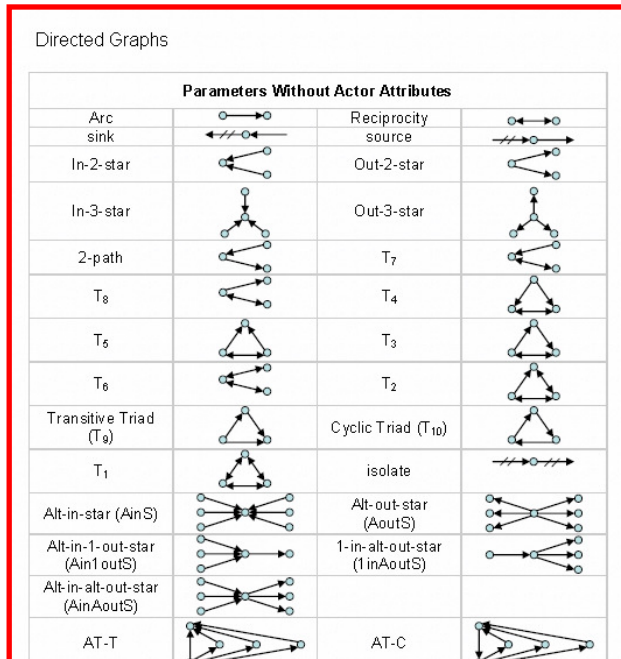
- > A matrix with rows and columns equal to the number of children in the classrooms
- > “1” indicate a tie, “0” indicate no tie.
- > For example, child 2 nominates child 4

```
like_least.txt - Notepad
File Edit Format View Help
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 1 0 0 0 0 1 0 0 0 1 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0
0 1 0 0 0 0 0 0 0 1 0 0 0 0 1 0 1 1 1 0
1 1 0 1 0 0 1 0 0 1 0 0 0 0 0 0 0 1 1 0
0 0 0 0 1 0 1 0 0 1 0 0 0 1 0 0 0 1 1 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 1 0
0 0 0 1 1 0 0 0 0 1 0 0 0 0 0 0 0 1 0 1
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0
0 0 1 1 1 0 1 0 0 1 0 0 0 1 0 0 0 0 1 0
1 0 0 0 1 0 1 0 1 1 0 0 0 1 0 0 1 1 1 0
0 0 0 1 0 0 1 0 0 0 0 0 0 0 0 0 0 1 0 0
0 0 1 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0
1 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 1 0 1 0
1 0 0 1 1 0 1 0 1 0 1 0 1 1 1 1 0 0 1 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 1 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0
1 1 0 1 0 0 1 0 0 1 0 1 0 0 0 0 0 1 1 0
```



- › Select the structural parameters

The screenshot shows the PNet software interface. The 'Simulation' tab is active. The 'Select Structural Parameters' section is highlighted with a red box. In this section, the checkbox for 'Structural Parameters' is checked, and the 'Select Parameters...' button is visible. Other sections include 'Select Network Type' (Directed Network selected), 'Select Dyadic Attribute Parameters' (Dyadic Attributes, 1 attribute), 'Select Actor Attribute Parameters' (Actor Attribute Parameters, Binary Attributes, Continuous Attributes, Categorical Attributes, each with 1 attribute), and 'Estimation Options' (No conditions selected, 5 subphases, 0.01 gaining factor, 10 multiplication factor, 500 iterations in phase 3, 1 max. number of estimation runs, Do GOF @ model convergence unchecked). The 'Start!' and 'Update!' buttons are at the bottom right.



Structural Parameter Selection

Markov Parameters	High-Order Parameters
<input type="checkbox"/> Arc [0]	<input type="checkbox"/> AinS [0] lambda: [2]
<input type="checkbox"/> Reciprocity [0]	<input type="checkbox"/> AoutS [0] lambda: [2]
<input type="checkbox"/> In-2-star [0]	<input type="checkbox"/> AinS-2nd [0] lambda: [2]
<input type="checkbox"/> Out-2-star [0]	<input type="checkbox"/> AoutS-2nd [0] lambda: [2]
<input type="checkbox"/> In-3-star [0]	<input type="checkbox"/> AinAoutS [0] lambda: [2]
<input type="checkbox"/> Out-3-star [0]	<input type="checkbox"/> Ain1outS [0] lambda: [2]
<input type="checkbox"/> 2-path [0]	<input type="checkbox"/> 1inAoutS [0] lambda: [2]
<input type="checkbox"/> Transitive-Triad [0]	<input type="checkbox"/> AT-T [0] lambda: [2]
<input type="checkbox"/> Cyclic-Triad [0]	<input type="checkbox"/> AT-C [0] lambda: [2]
<input type="checkbox"/> T1 [0]	<input type="checkbox"/> AT-D [0] lambda: [2]
<input type="checkbox"/> T2 [0]	<input type="checkbox"/> AT-U [0] lambda: [2]
<input type="checkbox"/> T3 [0]	<input type="checkbox"/> AT-TD [0] lambda: [2]
<input type="checkbox"/> T4 [0]	<input type="checkbox"/> AT-TU [0] lambda: [2]
<input type="checkbox"/> T5 [0]	<input type="checkbox"/> AT-DU [0] lambda: [2]
<input type="checkbox"/> T6 [0]	<input type="checkbox"/> AT-TDU [0] lambda: [2]
<input type="checkbox"/> T7 [0]	<input type="checkbox"/> A2P-T [0] lambda: [2]
<input type="checkbox"/> T8 [0]	<input type="checkbox"/> A2P-D [0] lambda: [2]
<input type="checkbox"/> Sink [0]	<input type="checkbox"/> A2P-U [0] lambda: [2]
<input type="checkbox"/> Source [0]	<input type="checkbox"/> A2P-TD [0] lambda: [2]
<input type="checkbox"/> Isolates [0]	<input type="checkbox"/> A2P-TU [0] lambda: [2]
	<input type="checkbox"/> A2P-DU [0] lambda: [2]
	<input type="checkbox"/> A2P-TDU [0] lambda: [2]

Clear All Select All OK

Explanations of the meaning of the parameters can be found in the PNet-manual (see PNet-website)



- › Fix the graph density, increase the multiplication factor (>50), and set the estimation runs to 10

The screenshot shows the PNet software interface with the following configuration details:

- Session Name:** Labsession_SRCD
- Session Folder:** D:_SRCD
- Simulation Tab:** Selected
- Number of Actors:** 23
- Network File:** D:_SRCD\like_least.txt
- Select Network Type:** Directed Network (selected)
- Select Structural Parameters:** Structural Parameters (checked)
- Select Dyadic Attribute Parameters:** Dyadic Attributes (unchecked), Number of attributes: 1
- Select Actor Attribute Parameters:** Actor Attribute Parameters (unchecked), Binary Attributes (unchecked), Continuous Attributes (unchecked), Categorical Attributes (unchecked), all with 1 attribute.
- Estimation Options:** Fix graph density (selected)
- Structural "0" File:** D:_SRCD
- Number of Subphases:** 5
- Gaining Factor (a-value):** 0.01
- Multiplication Factor:** 75
- Number of Iterations in Phase 3:** 500
- Max. Number of Estimation Runs:** 10
- Do GOF @ model convergence:** (unchecked)
- Buttons:** Start! and Update!



> Request a GoF (Goodness of Fit)

The image shows the PNet software interface. The window title is "PNet". The menu bar includes "File" and "Help".

Session Name: Session Folder:

Simulation | Estimation | **Goodness of fit** | Bayes goodness of fit

Number of Actors: Network File:

Select Network Type

Non-directed Network Maximum Degree for Each Actor:

Directed Network Maximum Out Degree for Each Actor:

Select Structural Parameters

Structural Parameters

Select Dyadic Attribute Parameters

Dyadic Attributes Number of attributes:

Select Actor Attribute Parameters

Actor Attribute Parameters

Binary Attributes Number of attributes:

Continuous Attributes Number of attributes:

Categorical Attributes Number of attributes:

Estimation Options

No conditions

Fix out-degree distribution Fix graph density

Structural "0" File:

Number of Subphases:

Gaining Factor (a-value):

Multiplication Factor:

Number of Iterations in Phase 3:

Max. Number of Estimation Runs:

Do GOF @ model convergence



Goodness of fit

- › Compares parameters of observed networks with estimated parameters
- › Convergence t-ratio =

$$\frac{(\text{Observed network} - \text{Mean simulated networks})}{\text{Standard error simulated networks}}$$

The smaller the ratio, the less difference between estimated and observed parameters!

Estimated (<0.10) & unestimated (<2.00) parameters



> Press Start!

The screenshot shows the PNet software interface with the following settings:

- Session Name: Labsession_SRCD
- Session Folder: D:_SRCD
- Simulation tab selected
- Number of Actors: 23
- Network File: D:_SRCD\like_least.txt
- Select Network Type: Directed Network (selected)
- Select Structural Parameters: Structural Parameters (checked)
- Select Dyadic Attribute Parameters: Dyadic Attributes (unchecked), Number of attributes: 1
- Select Actor Attribute Parameters: Actor Attribute Parameters (unchecked), Binary Attributes (unchecked), Continuous Attributes (unchecked), Categorical Attributes (unchecked), all with 1 attribute
- Estimation Options: Fix graph density (selected)
- Structural "0" File: D:_SRCD
- Number of Subphases: 5
- Gaining Factor (a-value): 0.01
- Multiplication Factor: 75
- Number of Iterations in Phase 3: 500
- Max. Number of Estimation Runs: 10
- Do GOF @ model convergence (unchecked)

The "Start!" button is highlighted with a red border.



- › Inspect your results
- › T-ratios smaller than 0.10 reflect good model convergence.

```

estimation_Labsession_SRCD.txt - Notepad
File Edit Format View Help
STOCHASTIC ESTIMATION FOR NETWORK Labsession_SRCD
ESTIMATION SETTINGS
Number of sub-phases in estimation (phase 2) = 5
starting a-value in estimation (phase 2) = 0.010000
Multiplication factor for estimation (phase 2) = 75
Number of steps in final simulation (phase 3) = 500
Number of estimation runs = 10

STOCHASTIC APPROXIMATION RUN 1
original statistics:13.000000  115.798828
starting parameters:0.000000  0.000000
Phase1 started with the following setup:
a = 0.010000
num of steps = 13
num of iterations in each step = 5951.807851
*****
mean statistics in phase1:7.384615  105.405048
END PHASE1 parameter:0.000000  0.000000
Phase 2 started
num of iterations in each step = 5951.807851
*****
mean statistics in phase3:12.976000  115.648438

Estimation Result for Network SUMMARY (parameter, standard error, t-statistics)
NOTE: t-statistics = (observation - sample mean)/standard error
effects estimates      stderr  t-ratio
reciprocity           0.680335  0.30431  0.00921 *
Ains(2.00)            1.298692  0.28083  0.04216 *

Subphase 2 has gone up to 65 steps
Parameter after Subphase 2: 0.63490  1.28492

Subphase 3 started with a valued 0.002500
Subphase 3 has gone up to 344 steps
Parameter after Subphase 3: 0.67043  1.31073

Subphase 4 started with a valued 0.001250
Subphase 4 has gone up to 563 steps
Parameter after Subphase 4: 0.68033  1.29869
END PHASE2 parameter:0.680335  1.298692
Phase3 started with the following setup:
num of steps = 500
num of iterations in each step = 5951.807851
*****
mean statistics in phase3:12.976000  115.648438

Estimation Result for Network SUMMARY (parameter, standard error, t-statistics)
NOTE: t-statistics = (observation - sample mean)/standard error
effects estimates      stderr  t-ratio
reciprocity           0.680335  0.30431  0.00921 *
Ains(2.00)            1.298692  0.28083  0.04216 *

Estimated Covariance Matrix
0.147694  0.006536
0.006536  0.078866

```

- › In this classroom, there was a significant number of reciprocal nominations
- › Some children attracted many nominations (alternating-in-star)



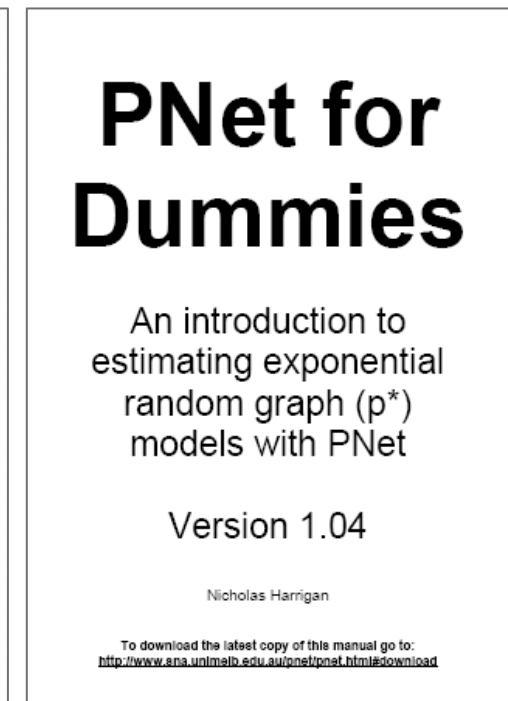
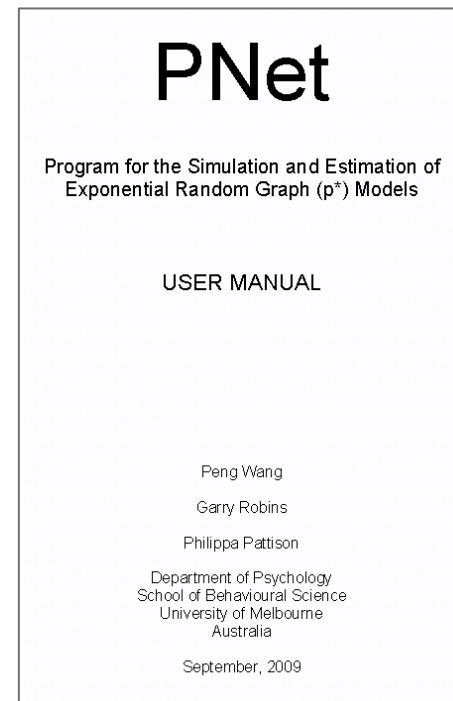
- › Inspect model convergence
- › All t-ratios should be smaller than 2 to reflect good model convergence.
- › This model is not good, many parameters are under- or overestimated
- › The solution would be to include more parameters

```
gof_Labsession_SRC.D.txt - Notepad
File Edit Format View Help
t-statistics = (observation - sample mean)/standard deviation
effects observed mean stddev t-ratio
arc 93 93.000 0.000 -1.#IO
reciprocity 13 13.171 2.634 -0.065
2-in-star 251 226.418 19.506 1.260
2-out-star 285 176.287 10.393 10.460
3-in-star 494 366.067 77.187 1.657
3-out-star 654 208.319 37.985 11.733
path2 318 361.838 21.181 -2.070
T1 0 0.457 0.723 -0.632
T2 7 8.044 5.699 -0.183
T3 26 23.525 8.773 0.282
T4 13 14.407 5.196 -0.271
T5 26 11.792 4.685 3.033
T6 24 17.471 7.960 0.820
T7 121 126.320 27.901 -0.191
T8 154 100.992 24.138 2.196
T9(030T) 117 83.306 12.687 2.656
T10(030C) 19 22.664 5.485 -0.668
sink 5 0.181 0.415 11.606
2-in-star 251 226.418 19.506 1.260
2-out-star 285 176.287 10.393 10.460
3-in-star 494 366.067 77.187 1.657
3-out-star 654 208.319 37.985 11.733
path2 318 361.838 21.181 -2.070
T1 0 0.457 0.723 -0.632
T2 7 8.044 5.699 -0.183
T3 26 23.525 8.773 0.282
T4 13 14.407 5.196 -0.271
T5 26 11.792 4.685 3.033
T6 24 17.471 7.960 0.820
T7 121 126.320 27.901 -0.191
T8 154 100.992 24.138 2.196
T9(030T) 117 83.306 12.687 2.656
T10(030C) 19 22.664 5.485 -0.668
A2P-DU(2.00) 176.176 161.620 5.146 2.829
A2P-TDU(2.00) 200.706 206.536 5.892 -0.990
Std Dev in-degree dist 3.155 2.760 0.320 1.235
Skew in-degree dist 0.535 0.090 0.272 1.634
Std Dev out-degree dist 3.612 1.758 0.264 7.013
Skew out-degree dist 0.670 0.234 0.399 1.092
CorrCoef in-out-degree dists -0.122 0.106 0.201 -1.138
Global Clustering Cto 0.205 0.236 0.033 -0.934
Global Clustering Cti 0.233 0.184 0.023 2.145
Global Clustering Ctm 0.368 0.230 0.031 4.442
Global Clustering Ccm 0.179 0.186 0.037 -0.193
Global Clustering AKC-T 0.332 0.228 0.027 3.795
Global Clustering AKC-D 0.213 0.234 0.029 -0.720
Global Clustering AKC-U 0.214 0.184 0.019 1.566
Global Clustering AKC-C 0.183 0.187 0.032 -0.114
ACCEPTANCE RATE: 0.6517
SAMPLE GEODESIC DISTRIBUTION
```



Need help??

- › See: sna.unimelb.edu.au/
- › See the PNet manual,
or the PNet for Dummies
guide
- › Or contact us:
g.e.huitsing@rug.nl





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