Contents

FIGURE 7 – BACCALA ET AL. (2016) DTF: UNIFIED ASYMPTOTIC THEORY

DESCRIPTION:

Routine **figure7_example2_dtf_qqplots_ns500_2000.m** publish

Linear bivariate VAR(2) model

LA Baccala, DY Takahashi, K Sameshima (2016) Directed Transfer Function: Unified Asymptotic Theory and Some of its Implications. *IEEE Transactions on Biomedical Engineering* **PP**.

```
http://dx.doi.org/10.1109/TBME.2016.2550199
```

Example 1: Simple example VAR(2) without feedback

Contents

- Function for quantile plots
- Generate Fig. 7a+7b quantile plots
- Figure 7 from article, Baccala et al (2016)

Function for quantile plots

```
function [] = figure7_example2_idtf_qqplots_ns500_2000(m, ns, nDiscard, metric,
    pairs, connectivity);
```

```
% Example 2 - Generate quantile plots from idtf estimate.
%
% function [res, resa] = example2_dtf_qqplots(m, ns, nDiscard, metric, pairs,
   connectivity);
%
% input: m - number of simulation
%        ns - data length
%        nDiscard - initial discarded points
%        metric - DTF type metric
%        pairs - pair of variables
%        connectivity - 0: not connected; and 1: connected
%
% output:  res       - results of simulation
%          resa      -
```

Generate Fig. 7a+7b quantile plots

```
format compact
if nargin < 1 || ~exist('m','var') || isempty(m), m = 2000; end;
if nargin < 2, nd = [500 2000]; end;
if nargin < 3, nDiscard = 5000; end;
if nargin < 5 pairs = [[2,1]; [2,3]]; end;
```

```
if nargin < 6,
   connectivity = [1 0]; % 0 = not connected; 1 = connected.
end;

metric = 'info';

kFreq = 6; % Take the third frequency ==> $\lambda = 0.25$
strFreq = '0.25';

k = length(nd); if k > 2, nd=nd(1:2); end;

for ns = nd,
```

```
   disp(' ');
   disp(['m = ' int2str(m) '; ns = ' int2str(ns) '; nDiscard = ' ...
      int2str(nDiscard) '; metric = ' metric '.'])

   % Performing m Monte Carlo simulations
   [res, resa] = example2_dtf_monte_carlo(m,ns,nDiscard,metric);

   [h] = qqplots2(res,resa,pairs,connectivity,'iDTF',kFreq,strFreq);

   set(h,'Name', ['[Asymptotic DTF] Fig 7. Example 2 - iDTF Q-Q plots, ' ...
                  'ns = ' int2str(ns)])

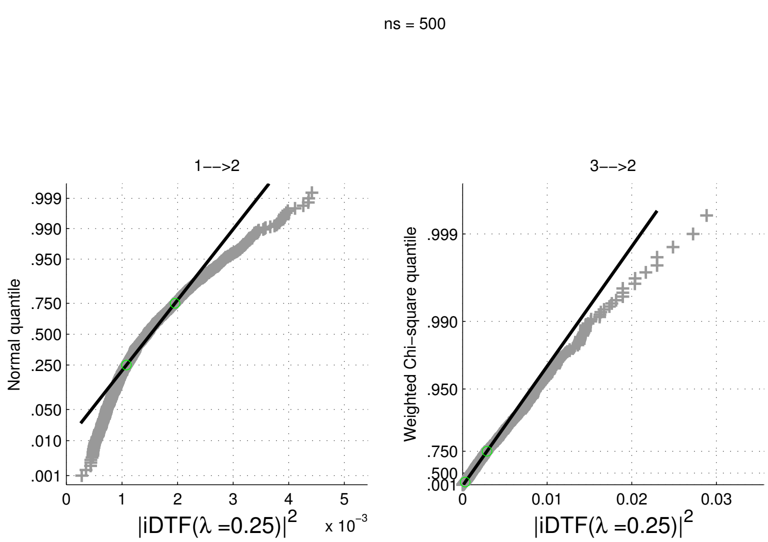
   [ax,h1] = suplabel(['ns = ' int2str(ns)]  ,'t');

   if ~is_octave, snapnow; end;
```

```
m = 2000; ns = 500; nDiscard = 5000; metric = info.
```

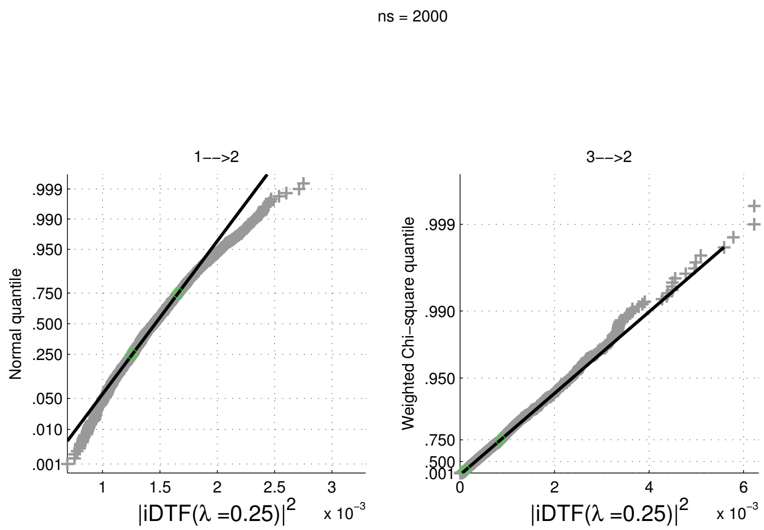
```
m = 2000; ns = 2000; nDiscard = 5000; metric = info.
pr_ =
    metric: 'info'
      fixp: 1.00
      maxp: 2.00
        ss: 0
        nf: 10.00
         v: 0
R =
  Columns 1 through 5
         64.52         59.98         33.00         51.63         58.32
         59.98        194.82         96.92         62.25        127.40
         33.00         96.92        131.87         43.48        146.36
         51.63         62.25         43.48         64.52         59.98
         58.32        127.40        146.36         59.98        194.82
         51.25         64.96         30.99         33.00         96.92
  Column 6
         51.25
         64.96
         30.99
         33.00
         96.92
        131.87
Ao(:,:,1) =
```

```
          1.34              0           0.35
          0.50           0.50              0
             0           1.00          -0.50
Ao(:,:,2) =
         -0.90              0              0
             0              0              0
             0              0              0
iter  100
iter  200
iter  300
iter  400
iter  500
iter  600
iter  700
iter  800
iter  900
iter 1000
iter 1100
iter 1200
iter 1300
iter 1400
iter 1500
iter 1600
iter 1700
iter 1800
iter 1900
iter 2000
----------------------------------------------------------------------
             Information DTF and asymptotic statistics
======================================================================
qqnorm
qqChi2
```



Uncomment the command line bellow to generate an eps output file

```
%eval(['print -depsc2 -painters Fig7_example2_idtf_qqplots_ns' int2str(ns) '.
   eps'])
```




```
end
```

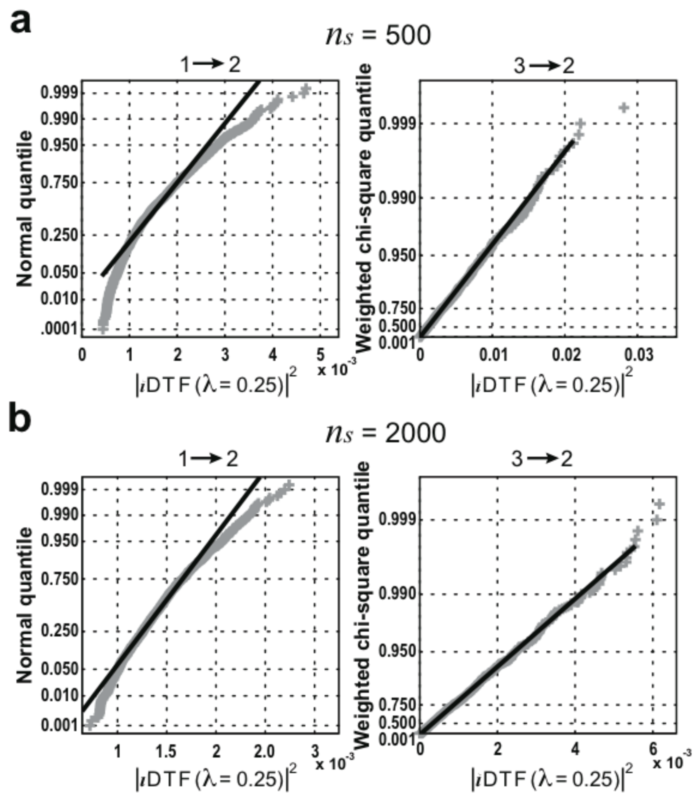
Figure 7 from article, Baccala et al (2016)

Figure 7, from article.

```
function [res, resa] = example2_dtf_monte_carlo(m, ns, nDiscard, metric, nf)
%Perform Monte Carlo simulation.
%
%function [res, resa] = example1_monte_carlo(m = 10000, ns = 20000,
%                         nDiscard = 2000, metric = 'euc')
%
% input: m - number of simulation
%        ns - data length
%        nDiscard - initial discarded points
%        metric - type PDC or DTF
%        nf - number of frequency
%
% output:  res       - results used by qqplots.m
%          resa      -

if nargin == 0,
   m=2000
   ns = 2000
   nDiscard = 2000;
   metric = 'euc';
   nf = 10;
end;
global pr_

pr_.metric = metric    % Asymptotic statistics metric
pr_.fixp = 1;          % True
pr_.maxp = 2;   IP = 2;% max IP
pr_.ss = 0;            % False
pr_.nf = 10;           % Number of frequency points.
pr_.v = 0;             % False
```




```
n = 3;                    % Number of variables?
if nargin < 3,
   nDiscard = 2000;
end;
[Ao, eo] = model2();
R = auto_theo(Ao,eo)
sumA = 0;
sume = 0;
Ao
res = zeros(m,n,n,pr_.nf);
flgRandomize = 1;
for i = 1:m,            % m simulations

   if mod(i,100) == 0, fprintf('iter %4.0f\n', i); end;

   % Generate data sample.
   data = fbaccala2016_example2( ns, nDiscard, flgRandomize );
   % of the VAR model
   % MVAR estimation:
   [du,e,A,pb,B,ef,eb,vaic,Vaicv] = mvar(data,IP,1,5);
   %     alg=1;        Nutall-Strand
   %     criterion=5;  Fixed IP
   %     maxIP = IP;   IP value itself
   res(i,:,:,:) = abs(dtf_alg_A(A, e, pr_.nf,pr_.metric));

   sumA = sumA + A;
   sume = sume + e;
```

```
   pr_.v = 0; %False;

end;

% Average A & e
Am = sumA/m;
em = sume/m;

resa = zeros(4,n,n,pr_.nf);

data = ar_data_example2(Ao, eo, ns, nDiscard);
alpha = 0.05;

c = asymp_dtf_theo(data, Am, em, pr_.nf,pr_.metric,alpha);
%c = asymp_dtf_theo(data, Ao, eo, pr_.nf,pr_.metric,alpha);

resa(1,:,:,:) = c.dtf;              % pdc
resa(2,:,:,:) = sqrt(c.varass1);   % r[1] == th
resa(3,:,:,:) = c.patden*ns;       % r[6] == patden
resa(4,:,:,:) = c.patdf;           % r[5] == patdf

% eval(['save fig7_monte_carlo_example2_ns' int2str(ns) '_m' int2str(m) '_'
   date])

%%============================================================================
function [A,e]= model2(dummy)
% Adapted from Baccala & Sameshima 2001
e = [1 5 .30;5 100 2;.30 2 1];
A = zeros(3,3,2);
A(1,1,1) = 2*0.95*cos(pi/4);
A(1,1,2) = -(0.95)^2;
A(2,1,1) = 0.5;
A(2,2,1) = 0.5;
A(3,2,1) = 1.0;
A(1,3,1) = 0.35;
A(3,3,1) = -0.5;

%%============================================================================
function c = ar_data_example2(A, er, m, nDiscard)
% function c = ar_data(A, er, m, nDiscard)
%    Simulate ar-model from A matrix
%
%       Input:
%         A(n, n, p) - AR model (n - number of signals, p - model order)
%         er(n) - variance of innovations
%         m - length of simulated time-series
%
%       Output:
%         data(n, m) - simulated time-series
%

if ndims(A) == 2,
   [n,du]=size(A);
   p=1;
elseif ndims(A) == 3,
   [n du p] = size(A);
```

```
else
   error('A matrix dimension > 3.');
end;

randn('state', sum(100*clock))

N=m+nDiscard+p;
x1=zeros(1,N); x2=zeros(1,N);x3=zeros(1,N);
SZ=[1 5 .30;5 100 2;.30 2 1];SZ=chol(SZ);
ei=randn(3,N);
ei=SZ'*ei;

for t=1:2,
   x1(t)=randn(1); x2(t)=randn(1);x3(t)=randn(1);
end;

for t=3:N,
   x1(t) = 2*0.95*cos(pi/4)*x1(t-1) - 0.9025*x1(t-2) + 0.35*x3(t-1)+ ei(1,t);
   x2(t) = .5*x1(t-1)+.5*x2(t-1) + ei(2,t);
   x3(t) = -.5*x3(t-1) + x2(t-1)+ ei(3,t);
end;

y=[x1' x2' x3']; % data must be organized column-wise
c=y(nDiscard+1:nDiscard+m,:)';
```

```
        pr_ =
    metric: 'info'
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  Columns 1 through 5
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