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FIGURE 12 – BACCALA ET AL. (2016) DTF: UNIFIED ASYMPTOTIC THEORY

DESCRIPTION:

Routine **figure12_example4_dtf_qqplots_ns50_500.m** publish

Linear trivariate VAR(1) 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 4: Reachability model VAR(1)

Contents

- Function for quantile plots
- Generate Figure 4 quantile plots
- Firgure 12 from article, Baccala et al (2016)

Function for quantile plots

```
function [] = figure12_example4_dtf_qqplots_ns50_500(m, nd, nDiscard, metric,
   pairs, connectivity);
```

```
% Example 4 - Generate quantile plots from dtf estimate.
%
% function [res, resa] = example3_dtf_qqplots(m, nd, nDiscard, metric, pairs,
   connectivity);
%
% input: m - number of simulation
%        nd - data lengths
%        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 Figure 4 quantile plots

```
if nargin < 1 || ~exist('m','var') || isempty(m), m = 2000; end;
if nargin < 2, nd = [50 500]; end;
if nargin < 3, nDiscard = 2000; end;
if nargin < 4, metric = 'info'; end;
```

```
if nargin < 5 pairs = [[3,1]; [1,3]]; end;
if nargin < 6,
   connectivity = [1 0]; % 0 = not connected; 1 = connected.
end;

metric = 'euc';
kFreq = 3; % Take the second frequency.
strFreq = '0.1';
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 '.'])

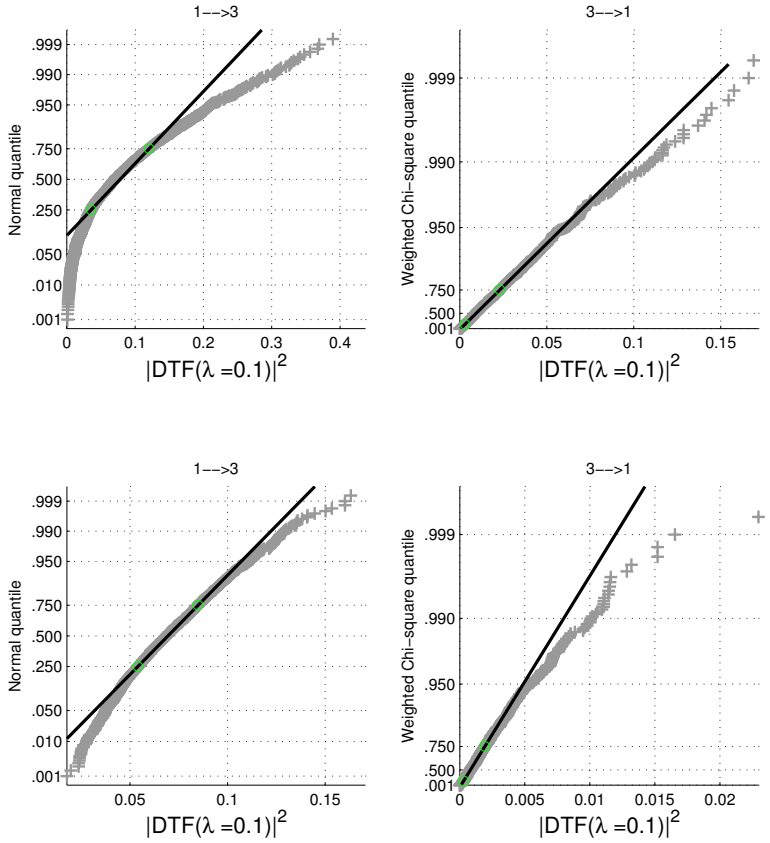
   % Performing m Monte Carlo simulations
   [res, resa] = example4_dtf_monte_carlo(m,ns,nDiscard,metric,kFreq);

   [h] = qqplots2(res,resa,pairs,connectivity,'DTF',kFreq,strFreq);
   set(h,'Name', ['[Asymptotic DTF] Fig 12. Example 4 DTF Q-Q plots, ' ...
                  'ns = ' int2str(ns)])
   if ~is_octave, snapnow; end;
```

```
m = 2000; ns = 50; nDiscard = 2000; metric = euc.
```

```
m = 2000; ns = 500; nDiscard = 2000; metric = euc.
pr_ =
    metric: 'euc'
      fixp: 1.00
      maxp: 1.00
        ss: 0
        nf: 10.00
         v: 0
R =
          1.33          0.00          0.24
          0.00          1.33          0.24
          0.24          0.24          1.33
Ao =
          0.35          0.35             0
         -0.35          0.35             0
             0          0.50             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
------------------------------------------------------------------------
               Original DTF and asymptotic statistics
========================================================================
qqnorm
qqChi2
```



Uncomment the command line bellow to generate an eps output file

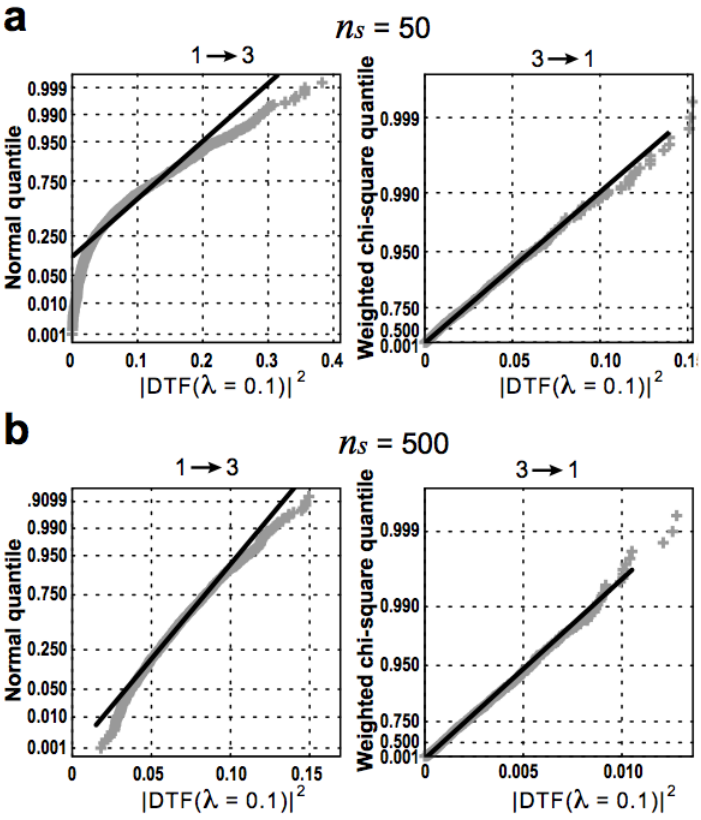
```
  eval(['print -depsc2 -painters Fig12_example4_dtf_qqplots_ns' ...
        int2str(ns) '.eps'])
```

```
end;
```

Firgure 12 from article, Baccala et al (2016)

Figure 12, from article.

```
function [res, resa] = example4_dtf_monte_carlo(m, ns, nDiscard, metric, nf)
%Perform Monte Carlo simulation.
%
```




```
%function [res, resa] = example6_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 = 50
   nDiscard = 2000;
   metric = 'info';
   nf = 5;
end;
global pr_

pr_.metric = metric   % Asymptotic statistics metric
pr_.fixp = 1;         % True
pr_.maxp = 1;  IP = 1;% 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_example4(ns, nDiscard, flgRandomize); % Ao & eo are
      truth values
   % 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_example6(Ao, eo, ns, nDiscard);
alpha = 0.05;

%c = asymp_dtf3_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 fig12_monte_carlo_example4_' date])

%%=========================================================================
function [A,e]= model2(dummy)
```

```
% Adapted from Baccala & Sameshima 2001
e = eye(3);
A = zeros(3,3,1);
A(1,1,1) = 0.25*sqrt(2);
A(1,2,1) = 0.25*sqrt(2);
A(2,1,1) = -0.25*sqrt(2);
A(2,2,1) = 0.25*sqrt(2);
A(3,2,1) = 0.5;

%%=========================================================================
function c = ar_data_example6(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=2:N,
   x1(t) = 0.25*sqrt(2)*x1(t-1) + 0.25*sqrt(2)*x2(t-1) + ei(1,t);
   x2(t) = -0.25*sqrt(2)*x1(t-1) + 0.25*sqrt(2)*x2(t-1) + ei(2,t);
   x3(t) = 0.5*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: 'euc'
      fixp: 1.00
      maxp: 2.00
```

```
        ss: 0
        nf: 10.00
         v: 0
R =
          1.33          0.00          0.24
          0.00          1.33          0.24
          0.24          0.24          1.33
Ao =
          0.35          0.35             0
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             0          0.50             0
iter  100
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qqnorm
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