Supplementary Information

Following is the main pseudocode in this article, which includes three parts: "self-organization effect of the knowledge interaction stage in inter-firm cooperation", "the evolutionary dynamics of Inter-cooperation System in different scenarios" and "comparative figures for the simulation in different parameter setting". All the algorithm are conducted in Matlab 2014.

1.Pseudocode for the Self-organized effect of the Inter-cooperation System in knowledge interaction stage with different parameters of Potential and Beta. While, parameter 'Potential' and 'Beta' should be both endowed with 0.8, 1.0, and 1.3 respectively to check the status.

```
phi=0.2;
chi=0.7;
theta=1-phi-chi;
beta_min=-1;
beta_max=1;
gamma_min=-1;
gamma_max=1;
h=figure('color',[1,1,1]);
ax = axes('Parent',h);
set(gcf,'outerposition',get(0,'screensize'));
ezmesh(['-',num2str(chi),'*beta-',num2str(phi),'/',num2str(theta)
,'*gamma*beta^3'],[beta_min,beta_max],[gamma_min,gamma_max],100); %
The value of the parameter can be endowed with differently.
xlabel('$\beta$','Fontsize',15,'Fontname','times new
roman','Interpreter','latex');
ylabel('$\gamma$','Fontsize',15,'Fontname','times new
roman','Interpreter','latex');
zlabel('$\dot{\beta}$','Fontsize',15,'Fontname','times new
roman','Interpreter','latex');
set(gca,'Color','w','linewidth',0.5,'fontsize',15,'fontname','tim
es new
roman','xtick',[beta_min:0.2:beta_max],'ytick',[gamma_min:0.2:gam
ma_max]);
delete(get(gca,'title'));
colormap('cool');
shading interp;
view(-37,18);%
```

2. Pseudocode for the evolutionary dynamics of Inter-cooperation System in different scenarios: 'different knowledge Potential between firms' and 'with seeking behavior within firms or not'.

```
t=0:0.005:15;     % Fix time range [0, 15], with each time steps t-0.005
m=0.1;          % quality parameter
k=0.16*(pi).^2;   % strength parameter
xi=0.025;        % 'damping coefficient', can be endowed with
different value.
e=exp(1);        % 'exponent parameter'
omega=sqrt(k/m);  % 'Fix frequency Omega'(k/m)^0.5
omega_n=omega.*sqrt(1-xi.^2);% calculate the frequency with damping
coefficient
p=0.5;           % Exciting force amplitude within [0, 1]
yst=p/k;         % Static amplitude yst=p/k
beta=1./(2.*xi);  % Dynamic coefficient
A=beta.*yst;     % Dynamic range
y=A.*(e.^(-xi.*omega.*t).*(xi.*omega./omega_n.*sin(omega_n.*t)+co
s(omega_n.*t))-cos(omega.*t));
y1=-A.*(e.^(-xi.*omega.*t).*sqrt((xi.*omega./omega_n).^2+1)-1);
y2=A.*(e.^(-xi.*omega.*t).*sqrt((xi.*omega./omega_n).^2+1)-1);
figure;                % for blank figures
subplot(3,2,1);
plot(t,y,'LineWidth',1);  % plot figure
hold on;                                          % hold on
plot(t,y1,'LineWidth',1,'LineStyle','--','color','r');%
hold on;                                          % hold on
plot(t,y2,'LineWidth',1,'LineStyle','--','color','m');%
hold on;
xlim([0,t(end)]);
ylim([-A-5,A+5]);
ylabel('$f$','Interpreter','latex','fontname','times new roman');
xlabel({sprintf('$t$');'$(a)$'},'Interpreter','latex','fontname',
'times new roman');
set(gca,'linewidth',1,'fontsize',10,'fontname','times new roman');
h=legend(['$\xi=$',num2str(xi),'$,p=$',num2str(p)],'Location','No
rthEast');
set(h,'interpreter','latex','FontName','times new
roman','FontSize',8);
-----------------------------------------------------------------
t=0:0.005:15;     % Fix time range [0, 15], with each time steps t-0.005
m=0.1;          % quality parameter
k=0.16*(pi).^2;   % strength parameter
```

```
xi=0.1;        % 'damping coefficient', can be endowed with different
value.
e=exp(1);        % 'exponent parameter'
omega=sqrt(k/m);  % 'Fix frequency Omega'(k/m)^0.5
omega_n=omega.*sqrt(1-xi.^2);% calculate the frequency with damping
coefficient
p=0.5;           % Exciting force amplitude within [0, 1]
yst=p/k;         % Static amplitude yst=p/k
beta=1./(2.*xi);  % Dynamic coefficient
A=beta.*yst;     % Dynamic range
y=A.*(e.^(-xi.*omega.*t).*(xi.*omega./omega_n.*sin(omega_n.*t)+co
s(omega_n.*t))-cos(omega.*t));
y1=-A.*(e.^(-xi.*omega.*t).*sqrt((xi.*omega./omega_n).^2+1)-1);
y2=A.*(e.^(-xi.*omega.*t).*sqrt((xi.*omega./omega_n).^2+1)-1);
subplot(3,2,2);
plot(t,y,'LineWidth',1);
hold on;                                          % hold on
plot(t,y1,'LineWidth',1,'LineStyle','--','color','r');
hold on;                                          % hold on
plot(t,y2,'LineWidth',1,'LineStyle','--','color','m');
hold on;
xlim([0,t(end)]);
ylim([-A-3,A+3]);
ylabel('$f$','Interpreter','latex','Fontname','times new roman');
xlabel({sprintf('$t$');'$(b)$'},'Interpreter','latex','fontname',
'times new roman');
set(gca,'linewidth',1,'fontsize',10,'fontname','times new roman');
h=legend(['$\xi=$',num2str(xi),'$,p=$',num2str(p)],'Location','No
rthEast');
set(h,'interpreter','latex','FontName','times new
roman','FontSize',10);%
-----------------------------------------------------------------
t=0:0.005:15;     % Fix time range [0, 15], with each time steps t-0.005
m=0.1;          % quality parameter
k=0.16*(pi).^2;   % strength parameter
xi=0.1;        % 'damping coefficient', can be endowed with different
value.
e=exp(1);        % 'exponent parameter'
omega=sqrt(k/m);  % 'Fix frequency Omega'(k/m)^0.5
omega_n=omega.*sqrt(1-xi.^2);% calculate the frequency with damping
coefficient
p=0.5;           % Exciting force amplitude within [0, 1]
yst=p/k;         % Static amplitude yst=p/k
beta=1./(2.*xi);  % Dynamic coefficient
```

```
A=beta.*yst;     % Dynamic range
y=A.*(e.^(-xi.*omega.*t).*(xi.*omega./omega_n.*sin(omega_n.*t)+co
s(omega_n.*t))-cos(omega.*t));
y1=-A.*(e.^(-xi.*omega.*t).*sqrt((xi.*omega./omega_n).^2+1)-1);
y2=A.*(e.^(-xi.*omega.*t).*sqrt((xi.*omega./omega_n).^2+1)-1);
subplot(3,2,3);
plot(t,y,'LineWidth',1);
hold on;                                          % hold on
plot(t,y1,'LineWidth',1,'LineStyle','--','color','r');%
hold on;                                          % hold on
plot(t,y2,'LineWidth',1,'LineStyle','--','color','m');%
hold on;
xlim([0,t(end)]);
ylim([-A-4,A+4]);
ylabel('$f$','Interpreter','latex','fontname','times new roman');
xlabel({sprintf('$t$');'$(c)$'},'Interpreter','latex','fontname',
'times new roman');
set(gca,'linewidth',1,'fontsize',10,'fontname','times new roman');
h=legend(['$\xi=$',num2str(xi),'$,p=$',num2str(p)],'Location','No
rthEast');
set(h,'interpreter','latex','FontName','times new
roman','FontSize',10);
-----------------------------------------------------------------
t=0:0.005:15;
m=0.1;
k=0.16*(pi).^2;
xi=0.1;
e=exp(1);
omega=sqrt(k/m);
omega_n=omega.*sqrt(1-xi.^2);
p=0.3;
yst=p/k;
beta=1./(2.*xi);
A=beta.*yst;
y=A.*(e.^(-xi.*omega.*t).*(xi.*omega./omega_n.*sin(omega_n.*t)+co
s(omega_n.*t))-cos(omega.*t));
y1=-A.*(e.^(-xi.*omega.*t).*sqrt((xi.*omega./omega_n).^2+1)-1);
y2=A.*(e.^(-xi.*omega.*t).*sqrt((xi.*omega./omega_n).^2+1)-1);
subplot(3,2,4);
plot(t,y,'LineWidth',1);
hold on;
plot(t,y1,'LineWidth',1,'LineStyle','--','color','r');
hold on;
plot(t,y2,'LineWidth',1,'LineStyle','--','color','m');
```

```
hold on;
xlim([0,t(end)]);
ylim([-A-2,A+2]);
ylabel('$f$','Interpreter','latex','fontname','times new roman');
xlabel({sprintf('$t$');'$(d)$'},'Interpreter','latex','fontname',
'times new roman');
set(gca,'linewidth',1,'fontsize',10,'fontname','times new roman');
h=legend(['$\xi=$',num2str(xi),'$,p=$',num2str(p)],'Location','No
rthEast');
set(h,'interpreter','latex','FontName','times new
roman','FontSize',10);
----------------------------------------------------------------
t=0:0.005:8;
m=0.1;
k=0.16*(pi).^2;
xi=0.5;
e=exp(1);
omega=sqrt(k/m);
omega_n=omega.*sqrt(1-xi.^2);
p=0.5;
yst=p/k;
beta=1./(2.*xi);
A=beta.*yst;
y=A.*(e.^(-xi.*omega.*t).*(xi.*omega./omega_n.*sin(omega_n.*t)+co
s(omega_n.*t))-cos(omega.*t));
y1=-A.*(e.^(-xi.*omega.*t).*sqrt((xi.*omega./omega_n).^2+1)-1);
y2=A.*(e.^(-xi.*omega.*t).*sqrt((xi.*omega./omega_n).^2+1)-1);
subplot(3,2,5);
plot(t,y,'LineWidth',1);
hold on;
plot(t,y1,'LineWidth',1,'LineStyle','--','color','r');
hold on;
plot(t,y2,'LineWidth',1,'LineStyle','--','color','m');
hold on;
xlim([0,t(end)]);
ylim([-A-1,A+1]);
ylabel('$f$','Interpreter','latex','fontname','times new roman');
xlabel({sprintf('$t$');'$(e)$'},'Interpreter','latex','fontname',
'times new roman');
set(gca,'linewidth',1,'fontsize',10,'fontname','times new roman');
h=legend(['$\xi=$',num2str(xi),'$,p=$',num2str(p)],'Location','No
rthEast');
set(h,'interpreter','latex','FontName','times new
roman','FontSize',10);
```

```
-----------------------------------------------------------------
t=0:0.005:8;
m=0.1;
k=0.16*(pi).^2;
xi=0.8;
e=exp(1);
omega=sqrt(k/m);
omega_n=omega.*sqrt(1-xi.^2);
p=0.5;
yst=p/k;
beta=1./(2.*xi);
A=beta.*yst;
y=A.*(e.^(-xi.*omega.*t).*(xi.*omega./omega_n.*sin(omega_n.*t)+co
s(omega_n.*t))-cos(omega.*t));
y1=-A.*(e.^(-xi.*omega.*t).*sqrt((xi.*omega./omega_n).^2+1)-1);
y2=A.*(e.^(-xi.*omega.*t).*sqrt((xi.*omega./omega_n).^2+1)-1);
subplot(3,2,6);
plot(t,y,'LineWidth',1);
hold on;                                          % hold on
plot(t,y1,'LineWidth',1,'LineStyle','--','color','r');
hold on;                                          % hold on
plot(t,y2,'LineWidth',1,'LineStyle','--','color','m');
hold on;
xlim([0,t(end)]);
ylim([-A-0.5,A+0.5]);
ylabel('$f$','Interpreter','latex','fontname','times new roman');
xlabel({sprintf('$t$');'$(f)$'},'Interpreter','latex','fontname',
'times new roman');
set(gca,'linewidth',1,'fontsize',10,'fontname','times new roman');
h=legend(['$\xi=$',num2str(xi),'$,p=$',num2str(p)],'Location','No
rthEast');
set(h,'interpreter','latex','FontName','times new
roman','FontSize',10);%
```

3. Pseudocode of the figures in simulation experiment for different scenarios in different parameter setting.

```
t=0:0.004:8;    % Time rang [0, 8] with each time step 0.004
xi=2;          % High critical damping
omega=2.*pi;    % Frequency Omega
f0=1;          % Original value of y0
df0=[25,30,0,-25,-40]; % Original value of Derivative of y0
```

```
e=exp(1);       % Exponent coefficient
figure;         % figure for blank
for i=1:5       %  For three times loop with different original value
setup of derivation y0
    omega_n=omega.*sqrt(xi.^2-1);  % Calculation for Damping
frequency
    c1=0.5.*(f0+(df0(i)+xi.*omega.*f0)/(omega.*sqrt(xi.^2-1)));  %
    c2=0.5.*(f0-(df0(i)+xi.*omega.*f0)/(omega.*sqrt(xi.^2-1)));  %
y=c1.*e.^(-xi.*omega.*t+omega_n.*t)+c2.*e.^(-xi.*omega.*t-omega_n
.*t); % Calculation effect of the mechanics between firms
    subplot(2,2,1);
    plot(t,y,'LineWidth',1);
    hold on;
end;
line([0,100],[0,0],'LineWidth',1,'LineStyle','--','Color','k');
ylim([-1,2]);
xlim([0,3.5]);
ylabel('$f$','Interpreter','latex','fontname','times new roman');
xlabel({sprintf('$t$');'$(a)$'},'Interpreter','latex','fontname',
'times new roman');
set(gca,'LineWidth',1,'Fontsize',13,'Fontname','times new roman');
m=legend(['$\xi=$',num2str(xi),'$\dot
f_{0}=$',num2str(df0(1))],['$\xi=$',num2str(xi),'$\dot
f_{0}=$',num2str(df0(2))],['$\xi=$',num2str(xi),'$\dot
f_{0}=$',num2str(df0(3))],['$\xi=$',num2str(xi),'$\dot
f_{0}=$',num2str(df0(4))],['$\xi=$',num2str(xi),'$\dot
f_{0}=$',num2str(df0(5))],'Location','NorthEast');
set(m,'interpreter','latex','FontName','times new
roman','FontSize',10);

% figure 2
t=0:0.004:8;
xi=3;
omega=2.*pi;
f0=1;
df0=[25,30,0,-25,-40];
e=exp(1);
for i=1:5
    omega_n=omega.*sqrt(xi.^2-1);
    c1=0.5.*(f0+(df0(i)+xi.*omega.*f0)/(omega.*sqrt(xi.^2-1)));
    c2=0.5.*(f0-(df0(i)+xi.*omega.*f0)/(omega.*sqrt(xi.^2-1)));

y=c1.*e.^(-xi.*omega.*t+omega_n.*t)+c2.*e.^(-xi.*omega.*t-omega_n
.*t);    subplot(2,2,2);
```

```
    plot(t,y,'LineWidth',1);
    hold on;
end;
line([0,100],[0,0],'LineWidth',1,'LineStyle','--','Color','k');
ylim([-1,2]);
xlim([0,3.5]);
ylabel('$f$','Interpreter','latex','fontname','times new roman');
xlabel({'$t$';'$(b)$'},'Interpreter','latex','fontname','times new
roman');
set(gca,'LineWidth',1,'Fontsize',13,'Fontname','times new roman');
m=legend(['$\xi=$',num2str(xi),'$\dot
f_{0}=$',num2str(df0(1))],['$\xi=$',num2str(xi),'$\dot
f_{0}=$',num2str(df0(2))],['$\xi=$',num2str(xi),'$\dot
f_{0}=$',num2str(df0(3))],['$\xi=$',num2str(xi),'$\dot
f_{0}=$',num2str(df0(4))],['$\xi=$',num2str(xi),'$\dot
f_{0}=$',num2str(df0(5))],'Location','NorthEast');
set(m,'interpreter','latex','FontName','times new
roman','FontSize',10);

% figure 3
t=0:0.004:8;
xi=5;
omega=2.*pi;
f0=1;
df0=[25,30,0,-25,-40];
e=exp(1);
for i=1:5
    omega_n=omega.*sqrt(xi.^2-1);
    c1=0.5.*(f0+(df0(i)+xi.*omega.*f0)/(omega.*sqrt(xi.^2-1)));  %
    c2=0.5.*(f0-(df0(i)+xi.*omega.*f0)/(omega.*sqrt(xi.^2-1)));  %

y=c1.*e.^(-xi.*omega.*t+omega_n.*t)+c2.*e.^(-xi.*omega.*t-omega_n
.*t);
    subplot(2,2,3);
    plot(t,y,'LineWidth',1);
    hold on;
end;
line([0,100],[0,0],'LineWidth',1,'LineStyle','--','Color','k');
ylim([-1,2]);
xlim([0,3.5]);
ylabel('$f$','Interpreter','latex','fontname','times new roman');
xlabel({'$t$';'$(c)$'},'Interpreter','latex','fontname','times new
roman');
set(gca,'LineWidth',1,'Fontsize',13,'Fontname','times new roman');
```

```
m=legend(['$\xi=$',num2str(xi),'$\dot
f_{0}=$',num2str(df0(1))],['$\xi=$',num2str(xi),'$\dot
f_{0}=$',num2str(df0(2))],['$\xi=$',num2str(xi),'$\dot
f_{0}=$',num2str(df0(3))],['$\xi=$',num2str(xi),'$\dot
f_{0}=$',num2str(df0(4))],['$\xi=$',num2str(xi),'$\dot
f_{0}=$',num2str(df0(5))],'Location','NorthEast');
set(m,'interpreter','latex','FontName','times new
roman','FontSize',8);

% figure 4
t=0:0.004:8;
xi=7;
omega=2.*pi;
f0=1;
df0=[25,30,0,-25,-40];
e=exp(1);
for i=1:5
    omega_n=omega.*sqrt(xi.^2-1);
    c1=0.5.*(f0+(df0(i)+xi.*omega.*f0)/(omega.*sqrt(xi.^2-1)));
    c2=0.5.*(f0-(df0(i)+xi.*omega.*f0)/(omega.*sqrt(xi.^2-1)));

y=c1.*e.^(-xi.*omega.*t+omega_n.*t)+c2.*e.^(-xi.*omega.*t-omega_n
.*t);
    subplot(2,2,4);
    plot(t,y,'LineWidth',1);
    hold on;
end;
line([0,100],[0,0],'LineWidth',1,'LineStyle','--','Color','k');
ylim([-1,2]);
xlim([0,3.5]);
ylabel('$f$','Interpreter','latex','fontname','times new roman');
xlabel({'$t$';'$(d)$'},'Interpreter','latex','fontname','times new
roman');
set(gca,'LineWidth',1,'Fontsize',13,'Fontname','times new roman');
m=legend(['$\xi=$',num2str(xi),'$\dot
f_{0}=$',num2str(df0(1))],['$\xi=$',num2str(xi),'$\dot
f_{0}=$',num2str(df0(2))],['$\xi=$',num2str(xi),'$\dot
f_{0}=$',num2str(df0(3))],['$\xi=$',num2str(xi),'$\dot
f_{0}=$',num2str(df0(4))],['$\xi=$',num2str(xi),'$\dot
f_{0}=$',num2str(df0(5))],'Location','NorthEast');
set(m,'interpreter','latex','FontName','times new
roman','FontSize',8);
```