**4. Game theory**

**Nash equilibrium**

Let us modify bioekonomia.m file for two competing fishing nations. The purpose is to compute a Nash-equilibrium numerically.

We need optimisation files for both players, and a run-file that switches between optimisation files of the players. Nash- equilibrium is hence found iteratively.

player1.m

R=.8; K=100;

x(1)=20;

for e1=1:10

E1=e1/10;

h1(1)=E1\*x(1);

p=1; c=7; r=0.1;

P1(1)=p\*h1(1)-c\*E1;

for t=2:20

x(t)=x(t-1)+R\*x(t-1)\*(1-x(t-1)/K)-h1(t-1)-E2\*x(t-1);

h1(t)=E1\*x(t);

P1(t)=(p\*h1(t)-c\*E1)/((1+r)^(t-1));

end

Nykyarvo1=sum(P1);

voitot1(e1)=Nykyarvo1;

end

[NPVstar1 Estar1]=max(voitot1);

E1=Estar1/10

player2.m

R=.8; K=100;

x(1)=20;

for e2=1:10

E2=e2/10;

h2(1)=E2\*x(1);

p=1; c=7; r=0.1;

P2(1)=p\*h2(1)-c\*E2;

for t=2:20

x(t)=x(t-1)+R\*x(t-1)\*(1-x(t-1)/K)-h2(t-1)-E1\*x(t-1);

h2(t)=E2\*x(t);

P2(t)=(p\*h2(t)-c\*E2)/((1+r)^(t-1));

end

Nykyarvo2=sum(P2);

voitot2(e2)=Nykyarvo2;

end

[NPVstar2 Estar2]=max(voitot2);

E2=Estar2/10

peli.m

E2=0;

for game=1:5

player1

player2

end

**Partition function game – stability analysis**

We analyses stability of grand coalition in a 3-player symmetric game. For this we need two values.

1. grand coalition NPV bioekonomiaopt = NPV(G)
2. free-rider NPV bioekonomiagame = NPV(i)

Grand coalition is stable if NPV(G) > 3\*NPV(i)

meaning that each player receives more benefits by staying in grand coalition compared to leaving

Stability could also be computed for two-player coalitions (partial cooperation).

For an asymmetric game, see Pintassilgo et al. 2010 ERE for results.

**bioekonomiagame.m**

R=0.8; K=100;

x(1)=20;

T=20;

E=E2; %change compared to bioekonomia.m

h(1)=E\*x(1);

p=1; c=7; r=0.1;

P(1)=p\*h(1)-c\*E;

for t=2:T

x(t)=x(t-1)+R\*x(t-1)\*(1-x(t-1)/K)-2\*h(t-1); %other player influence accounted for here

h(t)=E\*x(t);

P(t)=(p\*h(t)-c\*E)/((1+r)^(t-1));

end

NPV=sum(P)