Report 4

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0.1   5.28. Farmers, Bandits And Soldiers

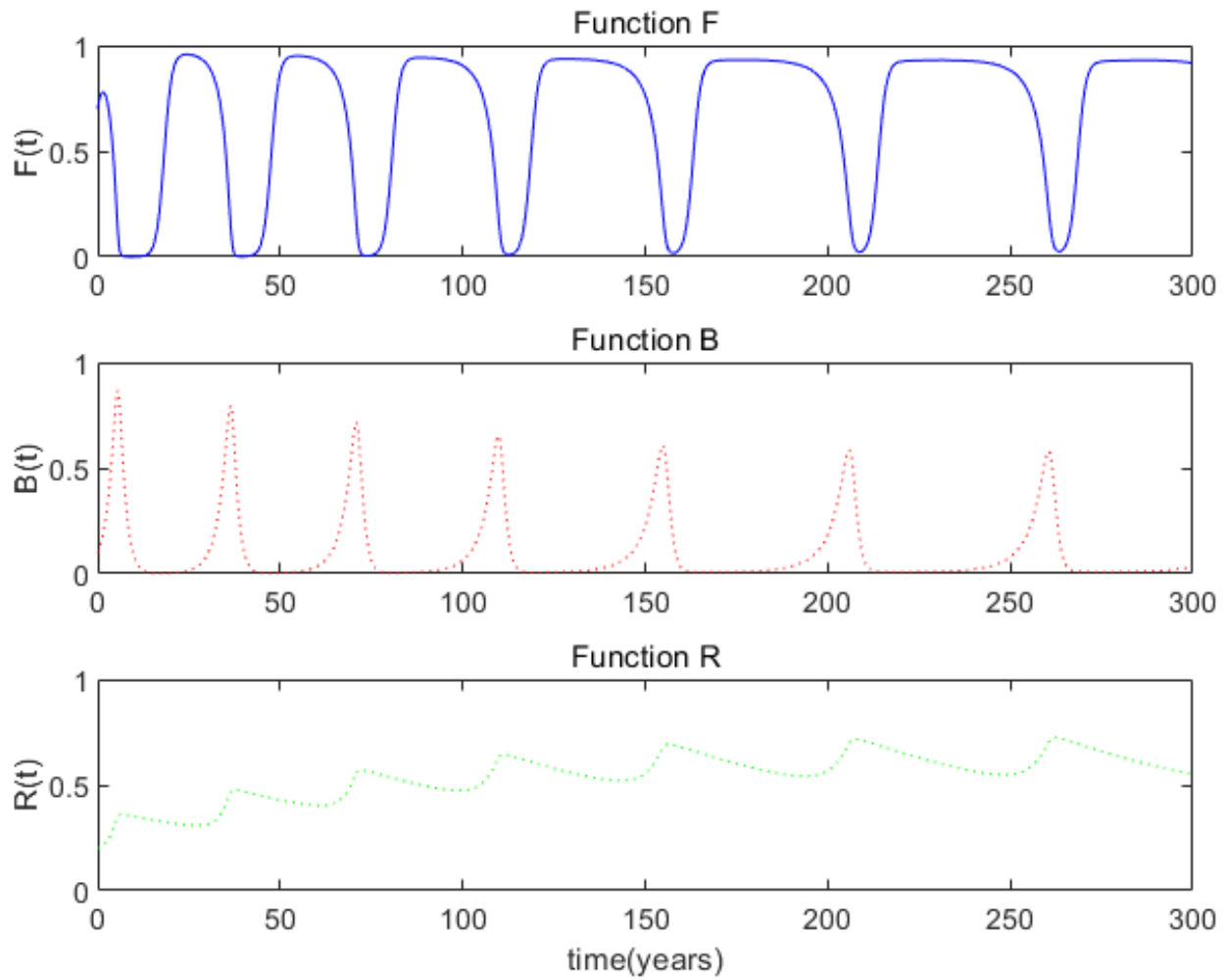## 0.1.1   reproduce the graph in Figure 5.18

Figure 1: Numerical simulation of the farmer-bandit-rulers model for the rise and fall of dynasties in ancient China

The code is written below:

```
global r b m g K h c e a d f;
r = 1;
b = 0.17;
m=0.4;
g=0.009;
K=1;
h=0.1;
c=0.4;
e=1.2;
a=1;
d=0.42;
f=0.1;
tend = 300;
```

```
u0 = [0.7; 0.1;0.2];
[tsol, usol] = ode45(@rhs, [0, tend], u0);
Fsol = usol(:,1);
Bsol = usol(:,2);
Rsol = usol(:,3);
subplot(3,1,1);
plot(tsol, Fsol, 'b'); hold on;
title('Function F');
ylabel('F(t)');
subplot(3,1,2);
plot(tsol, Bsol, 'r:');
title('Function B');
ylabel('B(t)');
subplot(3,1,3);
plot(tsol, Rsol, 'g:');
title('Function R');
axis([0, tend, 0, 1]);
xlabel('time(years)');
ylabel('R(t)');
function udot = rhs(t, u)
global r b m g K h c e a d f;
F = u(1); B = u(2); R=u(3);
Fdot = r*F*(1-F/K)-a*F*B/(b+F)-h*F*R;
Bdot = e*a*F*B/(b+F)-m*B-c*B*R/(d+B);
Rdot = f*a*F*B/(b+F)-g*R
udot = [Fdot; Bdot; Rdot];
end
```

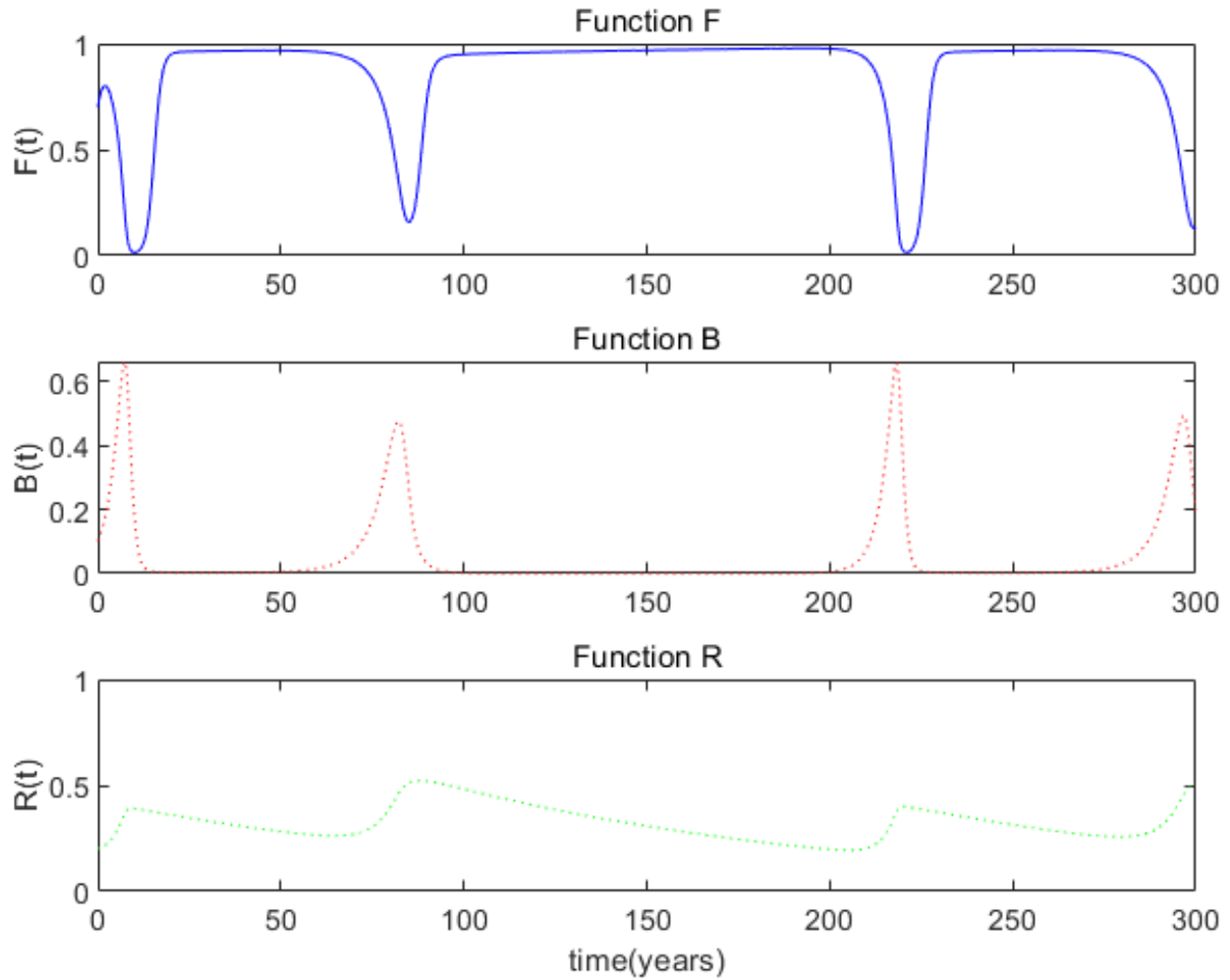## 0.1.2 Change parameter c from 0.4 to 0.8

Plot the graph:

Figure 2: Numerical simulation of the farmer-bandit-rulers model for the rise and fall of dynasties in ancient China

The code is written below:

```
global r b m g K h c e a d f;
r = 1;
b = 0.17;
m=0.4;
g=0.009;
K=1;
h=0.1;
c=0.8;
e=1.2;
a=1;
d=0.42;
f=0.1;
tend = 300;
```

```
u0 = [0.7; 0.1;0.2];
[tsol, usol] = ode45(@rhs, [0, tend], u0);
Fsol = usol(:,1);
Bsol = usol(:,2);
Rsol = usol(:,3);
subplot(3,1,1);
plot(tsol, Fsol, 'b'); hold on;
title('Function F');
ylabel('F(t)');
subplot(3,1,2);
plot(tsol, Bsol, 'r:');
title('Function B');
ylabel('B(t)');
subplot(3,1,3);
plot(tsol, Rsol, 'g:');
title('Function R');
axis([0, tend, 0, 1]);
xlabel('time(years)');
ylabel('R(t)');
function udot = rhs(t, u)
global r b m g K h c e a d f;
F = u(1); B = u(2); R=u(3);
Fdot = r*F*(1-F/K)-a*F*B/(b+F)-h*F*R;
Bdot = e*a*F*B/(b+F)-m*B-c*B*R/(d+B);
Rdot = f*a*F*B/(b+F)-g*R
udot = [Fdot; Bdot; Rdot];
end
```

Describe the changes and interpret

We note that the change causes longer periods between periods of anarchy for F(t), B(t), R(t), it also due to the decline of maxima value of both B(t) and R(t).

The extend of peace time is because the increase in bandit mortality caused by soldiers fighting bandits has slowed the growth rate of bandits. This makes it take longer for the number of bandits to reach its peak as it grows; since the peak in banditry coincides with the trough in peasantry, the later the number of bandits reaches its peak, the longer the period of peace can be prolonged.