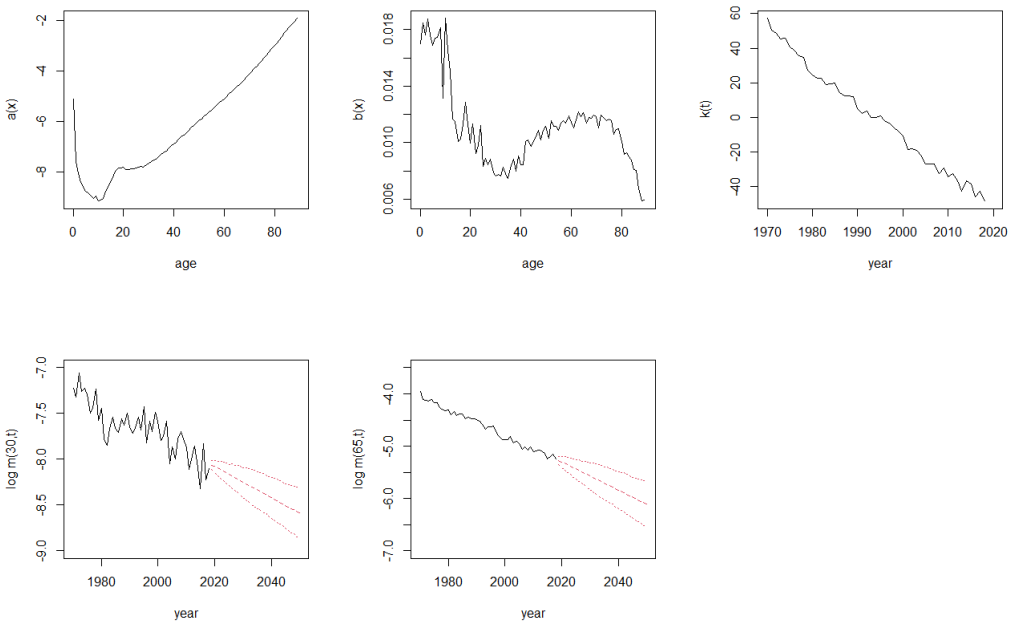
Tutorial 9

9.1

```
raw<-read.table("Australia Data.txt",header=TRUE)
age=90; year=49

d<-array(NA,c(age,year))
e<-array(NA,c(age,year))
m<-array(NA,c(age,year+32))
h=1
for (t in 1:year) {
for (x in 1:age) {
d[x,t]=raw$dxFemale[h]
e[x,t]=raw$exFemale[h]
m[x,t]=d[x,t]/e[x,t]
h=h+1 }
h=h+21 }
```

Then adopt the codes in the lecture slides

```
plot(c(0:89),a,xlab="age",ylab="a(x)",xlim=c(0,90),type="l")
plot(c(0:89),b,xlab="age",ylab="b(x)",xlim=c(0,90),type="l")
plot(c(1970:2018),k[1:year],xlab="year",ylab="k(t)",xlim=c(1970,2020),type="l")

plot(c(1970:2018),log(m[31,1:year]),xlab="year",ylab="log
m(30,t)",xlim=c(1970,2050),type="l",ylim=c(-9,-7))
lines(c(2019:2050),log(m[31,(year+1):(year+32)]),lty=2,col=2)
lines(c(2019:2050),log(upper),lty=3,col=2)
lines(c(2019:2050),log(lower),lty=3,col=2)

plot(c(1970:2018),log(m[66,1:year]),xlab="year",ylab="log
m(65,t)",xlim=c(1970,2050),type="l",ylim=c(-7,-3.5))
lines(c(2019:2050),log(m[66,(year+1):(year+32)]),lty=2,col=2)
lines(c(2019:2050),log(upper),lty=3,col=2)
lines(c(2019:2050),log(lower),lty=3,col=2)
```



9.2 raw<-read.table("Australia Data.txt",header=TRUE)

age=30; year=49

```
d<-array(NA,c(age,year))
e<-array(NA,c(age,year))
m<-array(NA,c(age,year))
q<-array(NA,c(age,year+32))
h=61
for (t in 1:year) {
for (x in 1:age) {
d[x,t]=raw$dxMale[h]
e[x,t]=raw$exMale[h]
m[x,t]=d[x,t]/e[x,t]
q[x,t]=1-exp(-m[x,t])
h=h+1 }
h=h+81 }
```

Then use the codes in the lecture slides

```
mu1=(k1[year]-k1[1])/(year-1)
mu2=(k2[year]-k2[1])/(year-1)

for (t in 1:32) {
k1[year+t]=k1[year+t-1]+mu1
k2[year+t]=k2[year+t-1]+mu2
for (x in 1:age) {
temp=exp(k1[year+t]+k2[year+t]*(x+59-xbar))
q[x,year+t]=temp/(1+temp)
}}

sigma1=sd(k1[2:year]-k1[1:(year-1)])
sigma2=sd(k2[2:year]-k2[1:(year-1)])
sigma12=cor(k1[2:year]-k1[1:(year-1)],k2[2:year]-k2[1:(year-1)])

qf<-array(NA,c(age,year+32,1000))
k1f<-array(NA,c(year+32,1000))
k2f<-array(NA,c(year+32,1000))
for (z in 1:1000) {
qf[1:age,1:year,z]=q[1:age,1:year]
k1f[1:year,z]=k1[1:year]
k2f[1:year,z]=k2[1:year]
for (t in 1:32) {
z1=rnorm(1)
z2=sigma12*z1+sqrt(1-sigma12^2)*rnorm(1)
k1f[year+t,z]=k1f[year+t-1,z]+mu1+sigma1*z1
k2f[year+t,z]=k2f[year+t-1,z]+mu2+sigma2*z2
for (x in 1:age) {
temp=exp(k1f[year+t,z]+k2f[year+t,z]*(x+59-xbar))
qf[x,year+t,z]=temp/(1+temp)
}}}
```

```
upper<-numeric()
lower<-numeric()
for (t in 1:32) {
upper[t]=quantile(qf[6,year+t,1:1000],0.95)
lower[t]=quantile(qf[6,year+t,1:1000],0.05)
}

plot(c(1970:2018),k1[1:year],xlab="year",ylab="k1(t)",xlim=c(1970,2020),type="l")
plot(c(1970:2018),k2[1:year],xlab="year",ylab="k2(t)",xlim=c(1970,2020),type="l")

plot(c(1970:2018),log(q[6,1:year]),xlab="year",ylab="log
q(65,t)",xlim=c(1970,2050),type="l",ylim=c(-6.5,-3))
lines(c(2019:2050),log(q[6,(year+1):(year+32)]),lty=2,col=2)
lines(c(2019:2050),log(upper),lty=3,col=2)
lines(c(2019:2050),log(lower),lty=3,col=2)
```