

The third homework

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Abstract

Use **bookdown** or **rmarkdown** to produce a report for the following task. It should contain at least one math equation, one table, one figure, and one chunk of R code.

Keywords:

Rmarkdown, Monte Carlo method

Introduction

This report uses **bookdown** or **rmarkdown** to produce a report for considering approximation of the distribution function of $N(0, 1)$ by the Monte Carlo methods, and do a Experiment with the approximation at $n \in \{10^2, 10^3, 10^4\}$ at $t \in \{0.0, 0.67, 0.84, 1.28, 1.65, 2.32, 2.58, 3.09, 3.72\}$ to form a table. And Draw box plots of the 100 approximation errors at each t using **ggplot2** [R-ggplot2] for each n .

Math Equations

Consider approximation of the distribution function of $N(0, 1)$,

$$\Phi(t) = \int_{-\infty}^t \frac{1}{\sqrt{2\pi}} e^{-y^2/2} dy, (\#eq : cdf) \quad (1)$$

by the Monte Carlo methods:

$$\hat{\Phi}(t) = \frac{1}{n} \sum_{i=1}^n I(X_i \leq t), \quad (2)$$

where X_i 's are a random sample from $N(0, 1)$, and $I(\cdot)$ is the indicator function.

Experimentation and Result

Experiment with the approximation at $n \in \{10^2, 10^3, 10^4\}$ at $t \in \{0.0, 0.67, 0.84, 1.28, 1.65, 2.32, 2.58, 3.09, 3.72\}$ to form a table.

code and results

```
t=c(0,0.67,0.84,1.28,1.65,2.32,2.58,3.09,3.72)
n=c(100,1000,10000)
p=matrix(0,nrow=9,ncol=3)
for (i in 1:9)
  for(j in 1:3){
    num=rnorm(n[j],0,1)
```

```

    p[i,j]=mean(num<=t[i])
  }
rownames(p)<-t
colnames(p)<-n
true_value<-c(pnorm(0),pnorm(0.67),pnorm(0.84),pnorm(1.28),pnorm(1.65),
              pnorm(2.32),pnorm(2.58),pnorm(3.09),pnorm(3.72))
p<-cbind(p,true_value)
p<-round(p,digits=3)
library(xtable)
options(xtable.comment=FALSE)
print(xtable(p), type="html", html.table.attributes="border=0")

```

```

## <table border=0>
## <tr> <th> </th> <th> 100 </th> <th> 1000 </th> <th> 10000 </th> <th> true_value </th> </tr>
## <tr> <td align="right"> 0 </td> <td align="right"> 0.55 </td> <td align="right"> 0.48 </td> <td align="right"> 0.48 </td> <td align="right"> 0.48 </td>
## <tr> <td align="right"> 0.67 </td> <td align="right"> 0.78 </td> <td align="right"> 0.74 </td> <td align="right"> 0.74 </td> <td align="right"> 0.74 </td>
## <tr> <td align="right"> 0.84 </td> <td align="right"> 0.82 </td> <td align="right"> 0.78 </td> <td align="right"> 0.78 </td> <td align="right"> 0.78 </td>
## <tr> <td align="right"> 1.28 </td> <td align="right"> 0.91 </td> <td align="right"> 0.90 </td> <td align="right"> 0.90 </td> <td align="right"> 0.90 </td>
## <tr> <td align="right"> 1.65 </td> <td align="right"> 0.93 </td> <td align="right"> 0.95 </td> <td align="right"> 0.95 </td> <td align="right"> 0.95 </td>
## <tr> <td align="right"> 2.32 </td> <td align="right"> 1.00 </td> <td align="right"> 0.99 </td> <td align="right"> 0.99 </td> <td align="right"> 0.99 </td>
## <tr> <td align="right"> 2.58 </td> <td align="right"> 0.99 </td> <td align="right"> 0.99 </td> <td align="right"> 0.99 </td> <td align="right"> 0.99 </td>
## <tr> <td align="right"> 3.09 </td> <td align="right"> 1.00 </td> <td align="right"> 1.00 </td> <td align="right"> 1.00 </td> <td align="right"> 1.00 </td>
## <tr> <td align="right"> 3.72 </td> <td align="right"> 1.00 </td> <td align="right"> 1.00 </td> <td align="right"> 1.00 </td> <td align="right"> 1.00 </td>
## </table>

```

Repeat the experiment 100 times

```

t=c(0,0.67,0.84,1.28,1.65,2.32,2.58,3.09,3.72)
n=c(100,1000,10000)
p=matrix(0,nrow=9,ncol=3)
pcycle=array(0,dim=c(9,3,100))
for (i in 1:9)
  for(j in 1:3)
    for (k in 1:100){
      num=rnorm(n[j],0,1)
      pcycle[i,j,k]=mean(num[j]<=t[i])
    }
dimnames(pcycle)[[1]]<-t
dimnames(pcycle)[[2]]<-n

```

The errors

```

t=c(0.0,0.67, 0.84,1.28,1.65,2.32,2.58,3.09,3.72)
n=100
e100_1=pcycle[1,1,]-c(rep(pnorm(0,0,1),100))
e100_2=pcycle[2,1,]-c(rep(pnorm(0.67,0,1),100))
e100_3=pcycle[3,1,]-c(rep(pnorm(0.84,0,1),100))
e100_4=pcycle[4,1,]-c(rep(pnorm(1.28,0,1),100))
e100_5=pcycle[5,1,]-c(rep(pnorm(1.65,0,1),100))
e100_6=pcycle[6,1,]-c(rep(pnorm(2.32,0,1),100))
e100_7=pcycle[7,1,]-c(rep(pnorm(2.58,0,1),100))
e100_8=pcycle[8,1,]-c(rep(pnorm(3.09,0,1),100))
e100_9=pcycle[9,1,]-c(rep(pnorm(3.72,0,1),100))
n=1000
e1000_1=pcycle[1,2,]-c(rep(pnorm(0,0,1),100))

```

```

e1000_2=pcycle[2,2,]-c(rep(pnorm(0.67,0,1),100))
e1000_3=pcycle[3,2,]-c(rep(pnorm(0.84,0,1),100))
e1000_4=pcycle[4,2,]-c(rep(pnorm(1.28,0,1),100))
e1000_5=pcycle[5,2,]-c(rep(pnorm(1.65,0,1),100))
e1000_6=pcycle[6,2,]-c(rep(pnorm(2.32,0,1),100))
e1000_7=pcycle[7,2,]-c(rep(pnorm(2.58,0,1),100))
e1000_8=pcycle[8,2,]-c(rep(pnorm(3.09,0,1),100))
e1000_9=pcycle[9,2,]-c(rep(pnorm(3.72,0,1),100))
n=1000
e10000_1=pcycle[1,3,]-c(rep(pnorm(0,0,1),100))
e10000_2=pcycle[2,3,]-c(rep(pnorm(0.67,0,1),100))
e10000_3=pcycle[3,3,]-c(rep(pnorm(0.84,0,1),100))
e10000_4=pcycle[4,3,]-c(rep(pnorm(1.28,0,1),100))
e10000_5=pcycle[5,3,]-c(rep(pnorm(1.65,0,1),100))
e10000_6=pcycle[6,3,]-c(rep(pnorm(2.32,0,1),100))
e10000_7=pcycle[7,3,]-c(rep(pnorm(2.58,0,1),100))
e10000_8=pcycle[8,3,]-c(rep(pnorm(3.09,0,1),100))
e10000_9=pcycle[9,3,]-c(rep(pnorm(3.72,0,1),100))
E=cbind.data.frame(e100_1,e100_2,e100_3,e100_4,e100_5,e100_6,e100_7,e100_8,e100_9,e1000_1,e1000_2,e1000_3,e1000_4,e1000_5,e1000_6,e1000_7,e1000_8,e1000_9)

```

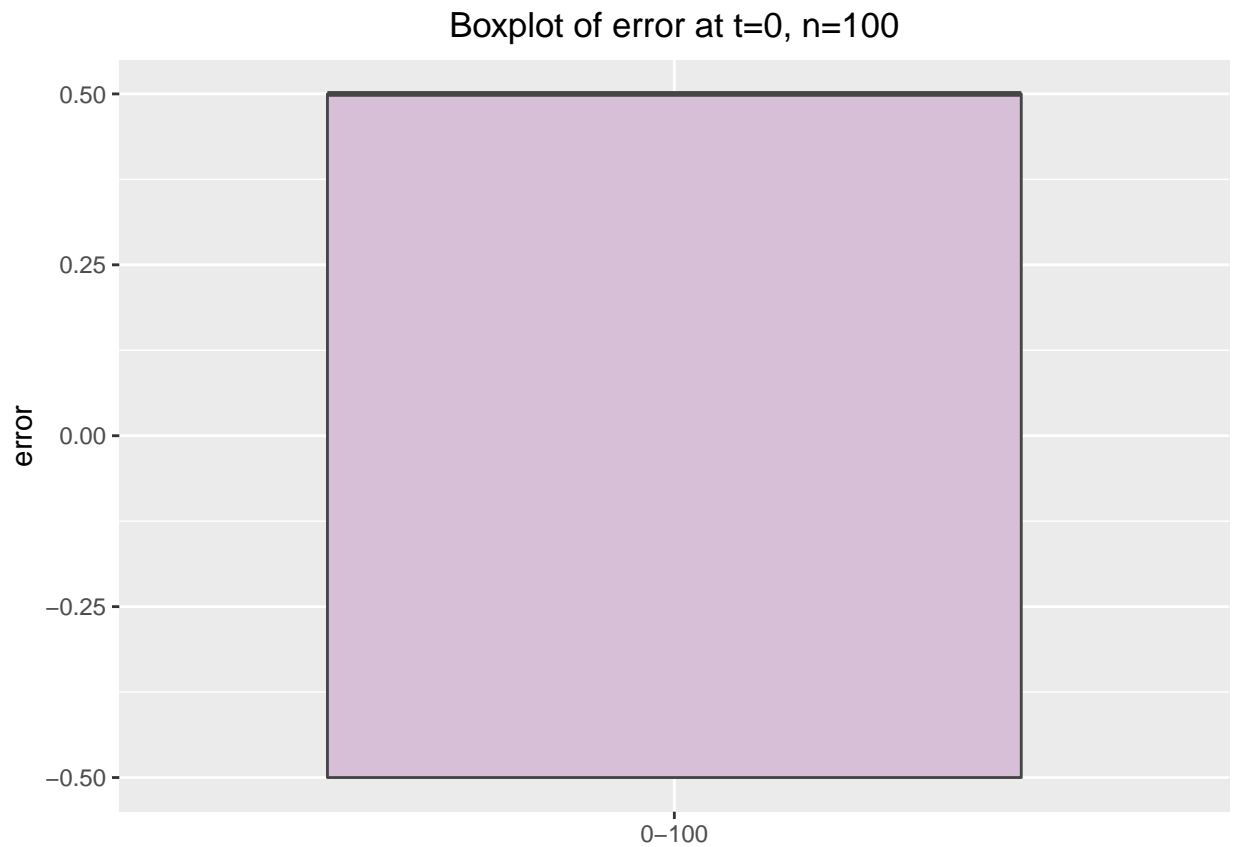
Graph

```

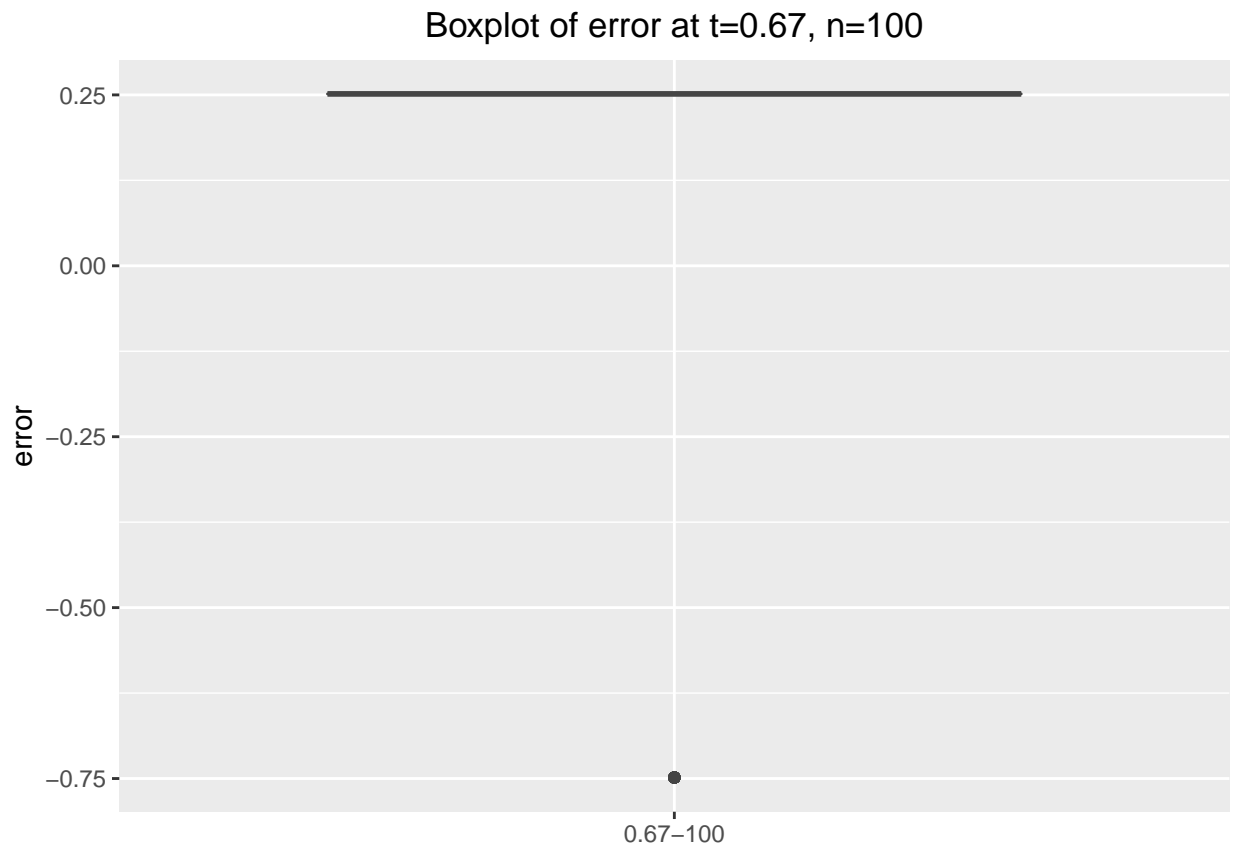
library(ggplot2)
library(lattice)
library(plyr)
library(Rmisc)

plot1<-ggplot(data=E,aes(y=e100_1,x="0-100"))+geom_boxplot(
  fill="thistle",colour="gray27")+
  labs(title="Boxplot of error at t=0, n=100",y="error",
    x=NULL)+theme(plot.title=element_text(size=13,hjust=0.5))
plot1

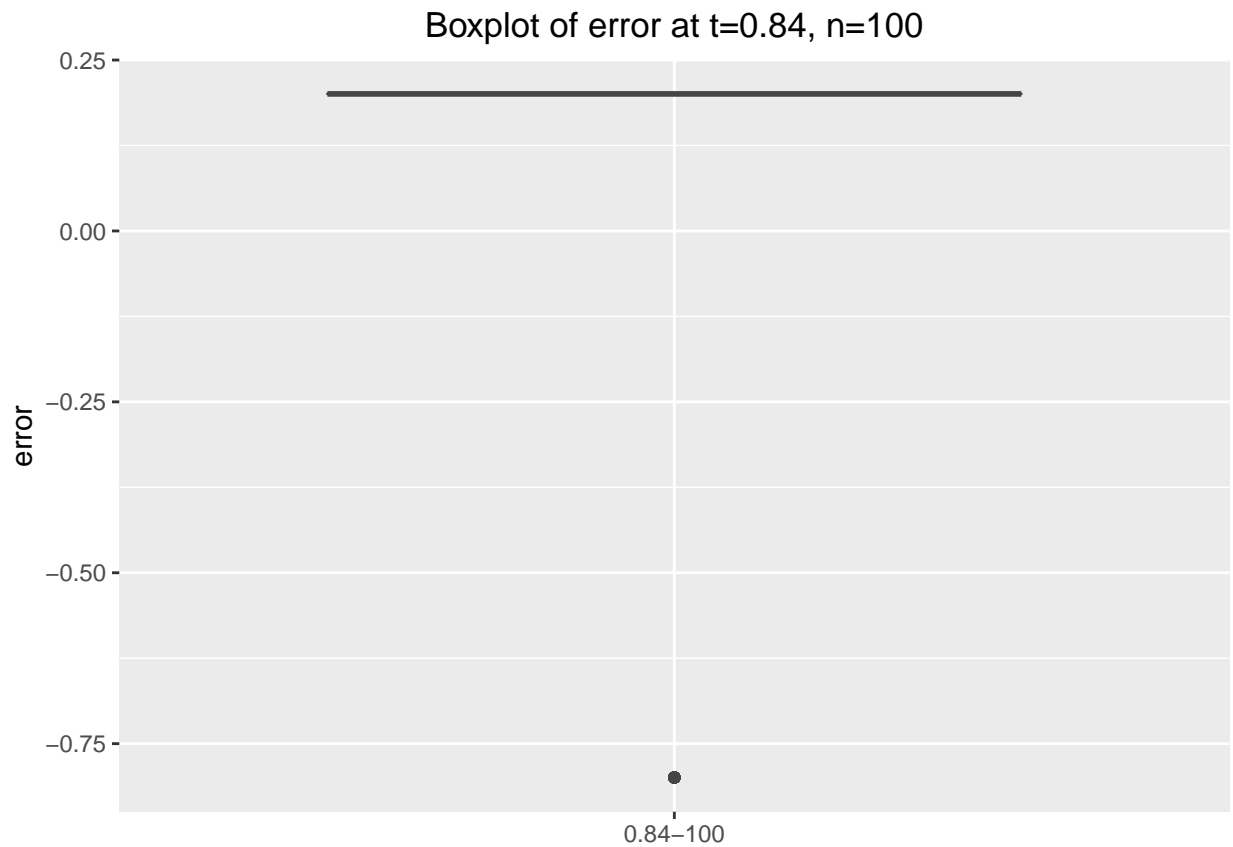
```



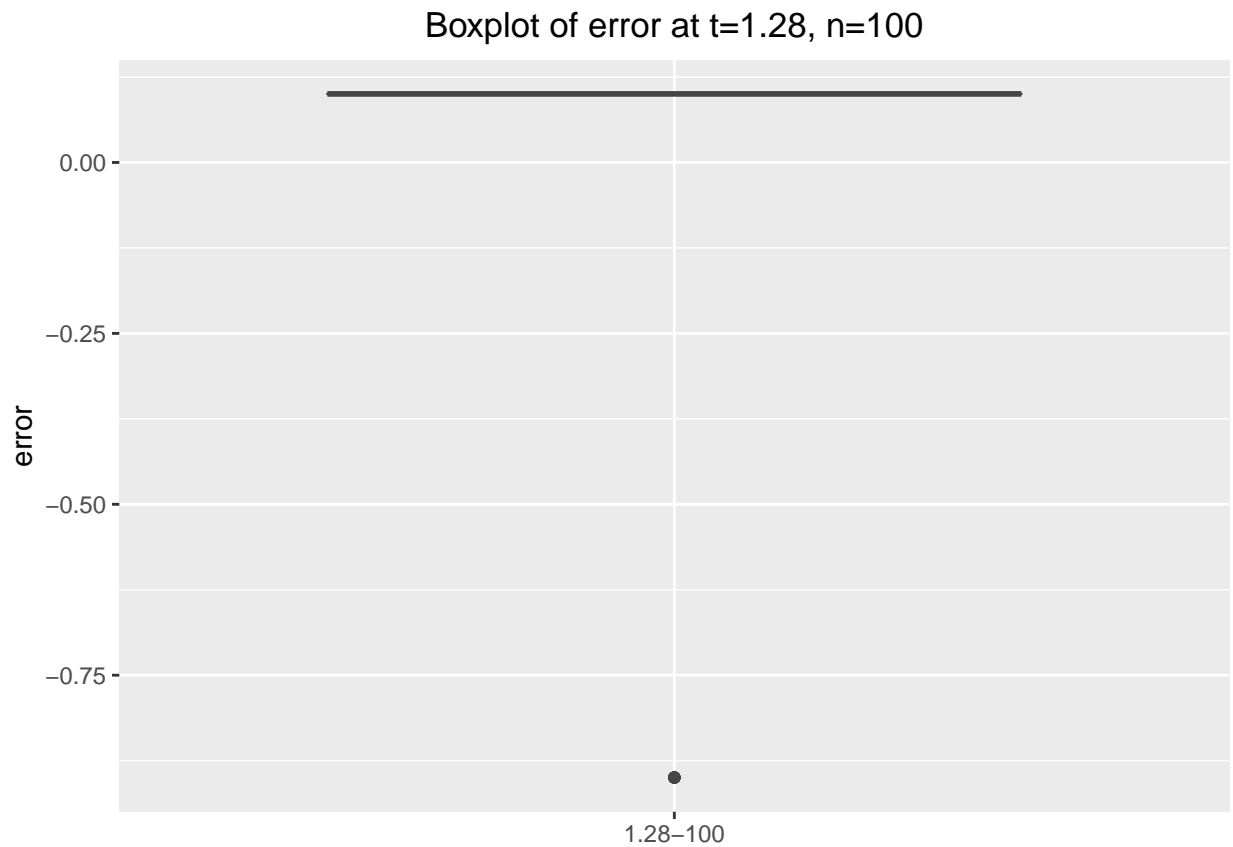
```
plot2<-ggplot(data=E,aes(y=e100_2,x="0.67-100"))+geom_boxplot(  
  fill="thistle",colour="gray27")+  
  labs(title="Boxplot of error at t=0.67, n=100",y="error",  
        x=NULL)+theme(plot.title=element_text(size=13,hjust=0.5))  
plot2
```



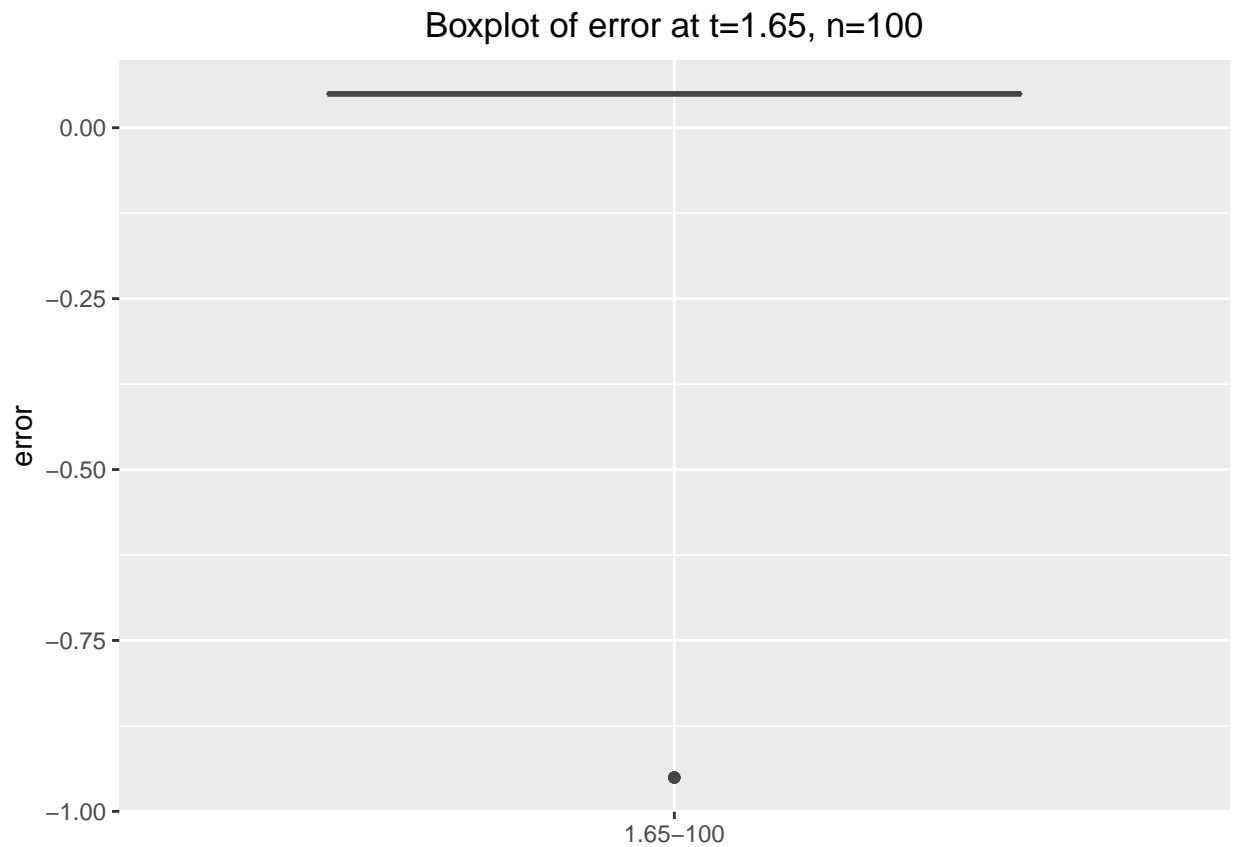
```
plot3<-ggplot(data=E,aes(y=e100_3,x="0.84-100"))+geom_boxplot(
  fill="thistle",colour="gray27")+
  labs(title="Boxplot of error at t=0.84, n=100",y="error",
    x=NULL)+theme(plot.title=element_text(size=13,hjust=0.5))
plot3
```



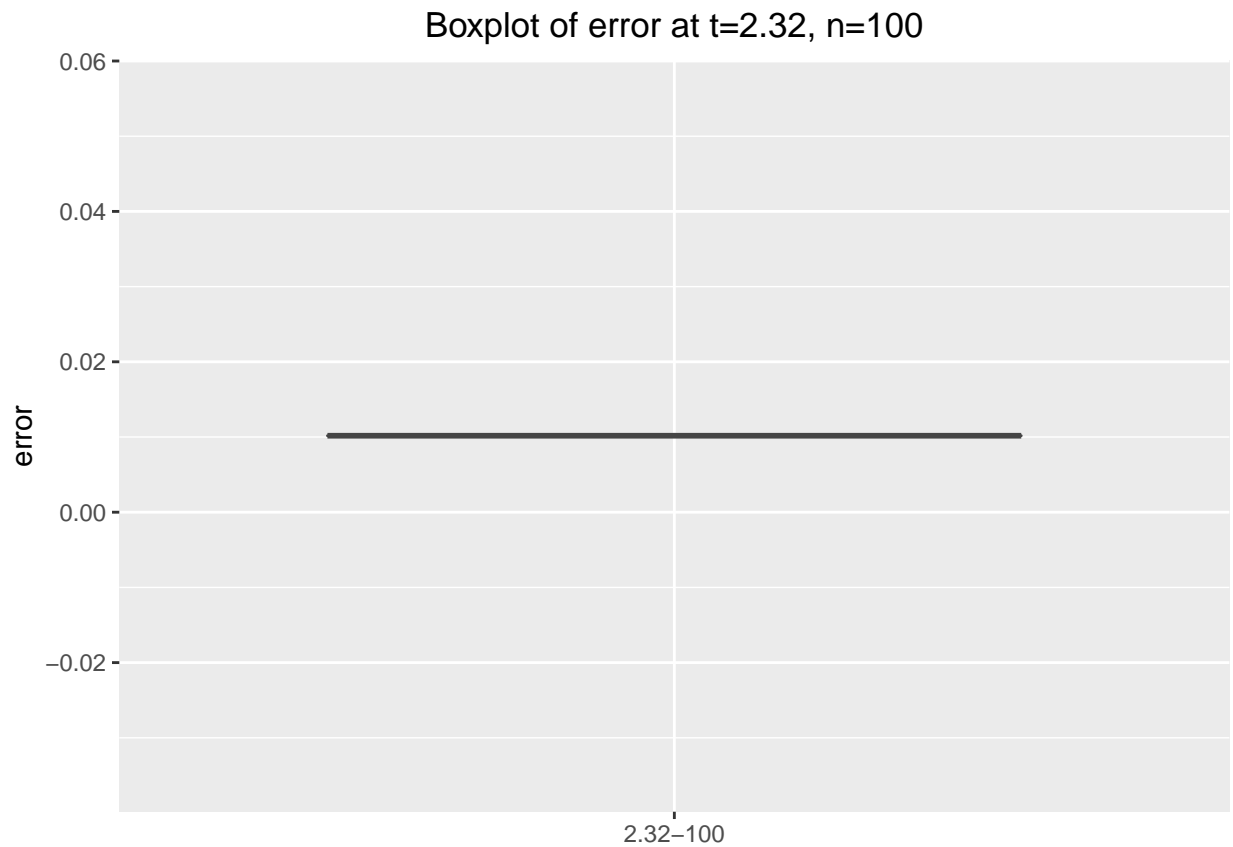
```
plot4<-ggplot(data=E,aes(y=e100_4,x="1.28-100"))+geom_boxplot(
  fill="thistle",colour="gray27")+
  labs(title="Boxplot of error at t=1.28, n=100",y="error",
    x=NULL)+theme(plot.title=element_text(size=13,hjust=0.5))
plot4
```



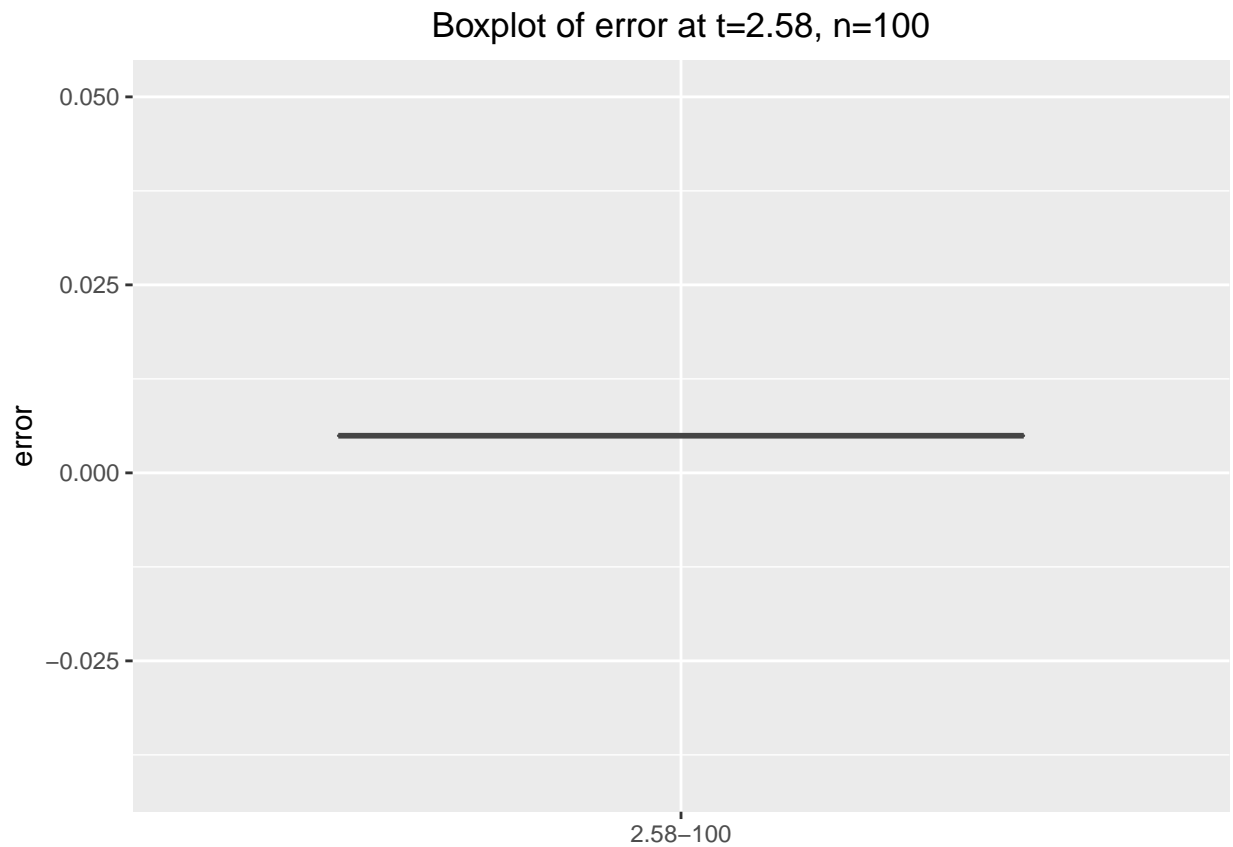
```
plot5<-ggplot(data=E,aes(y=e100_5,x="1.65-100"))+geom_boxplot(
  fill="thistle",colour="gray27")+
  labs(title="Boxplot of error at t=1.65, n=100",y="error",
    x=NULL)+theme(plot.title=element_text(size=13,hjust=0.5))
plot5
```



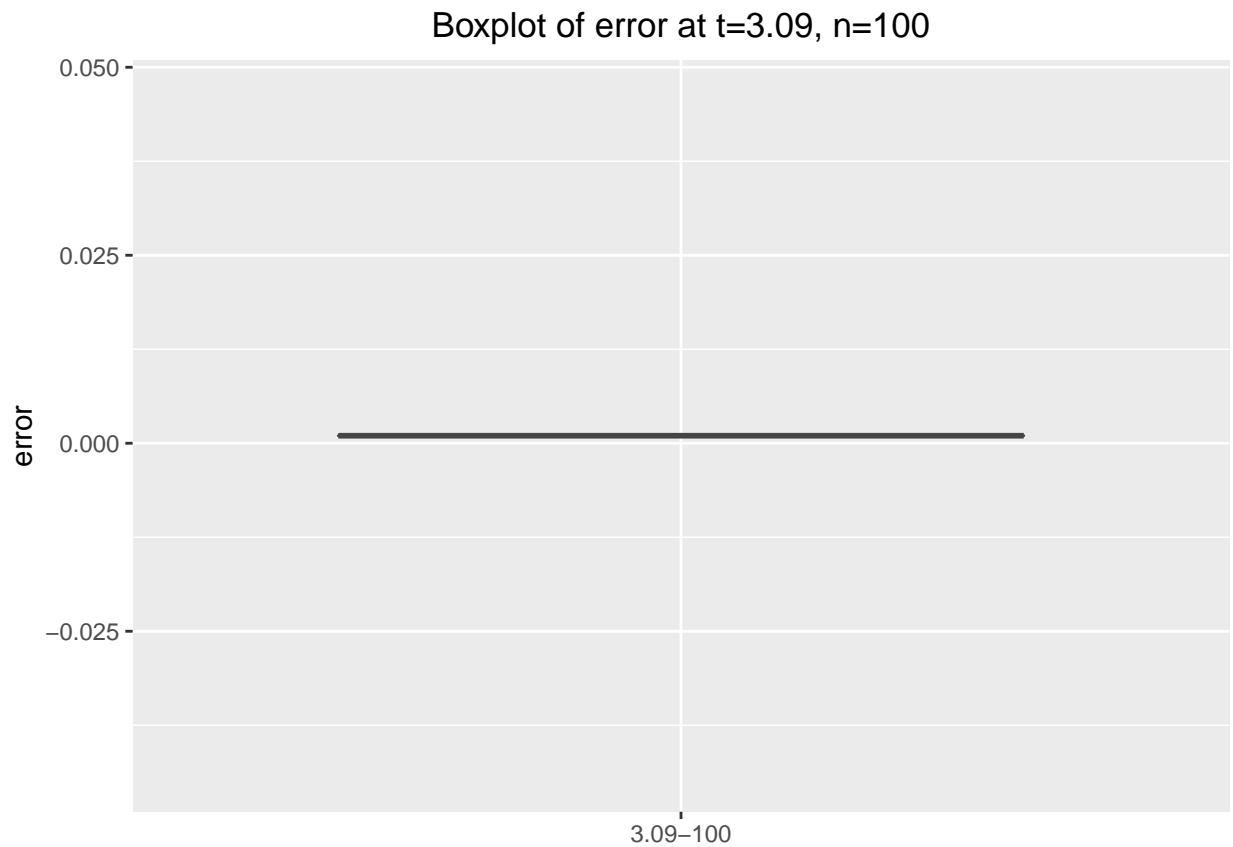
```
plot6<-ggplot(data=E,aes(y=e100_6,x="2.32-100"))+geom_boxplot(
  fill="thistle",colour="gray27")+
  labs(title="Boxplot of error at t=2.32, n=100",y="error",
    x=NULL)+theme(plot.title=element_text(size=13,hjust=0.5))
plot6
```

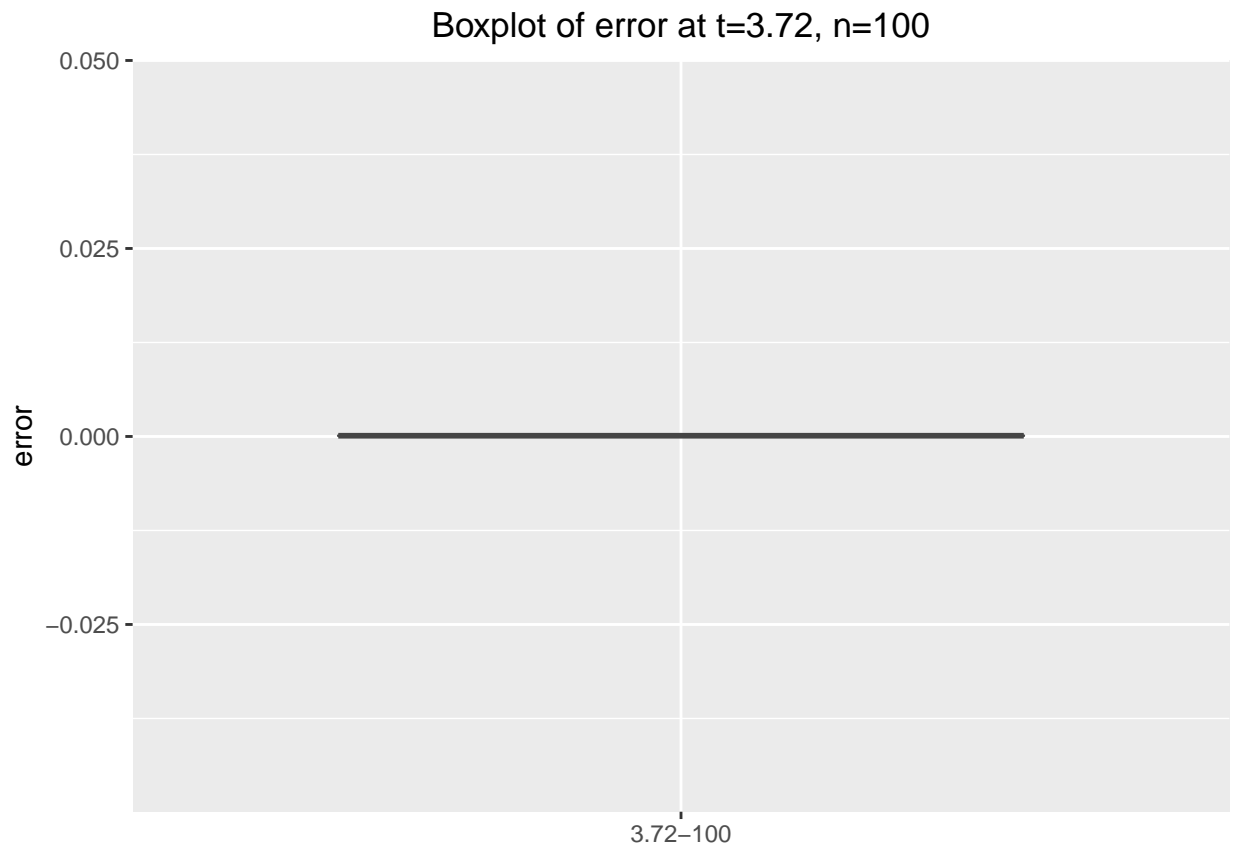
```
plot7<-ggplot(data=E,aes(y=e100_7,x="2.58-100"))+geom_boxplot(
  fill="thistle",colour="gray27")+
  labs(title="Boxplot of error at t=2.58, n=100",y="error",
    x=NULL)+theme(plot.title=element_text(size=13,hjust=0.5))
plot7
```



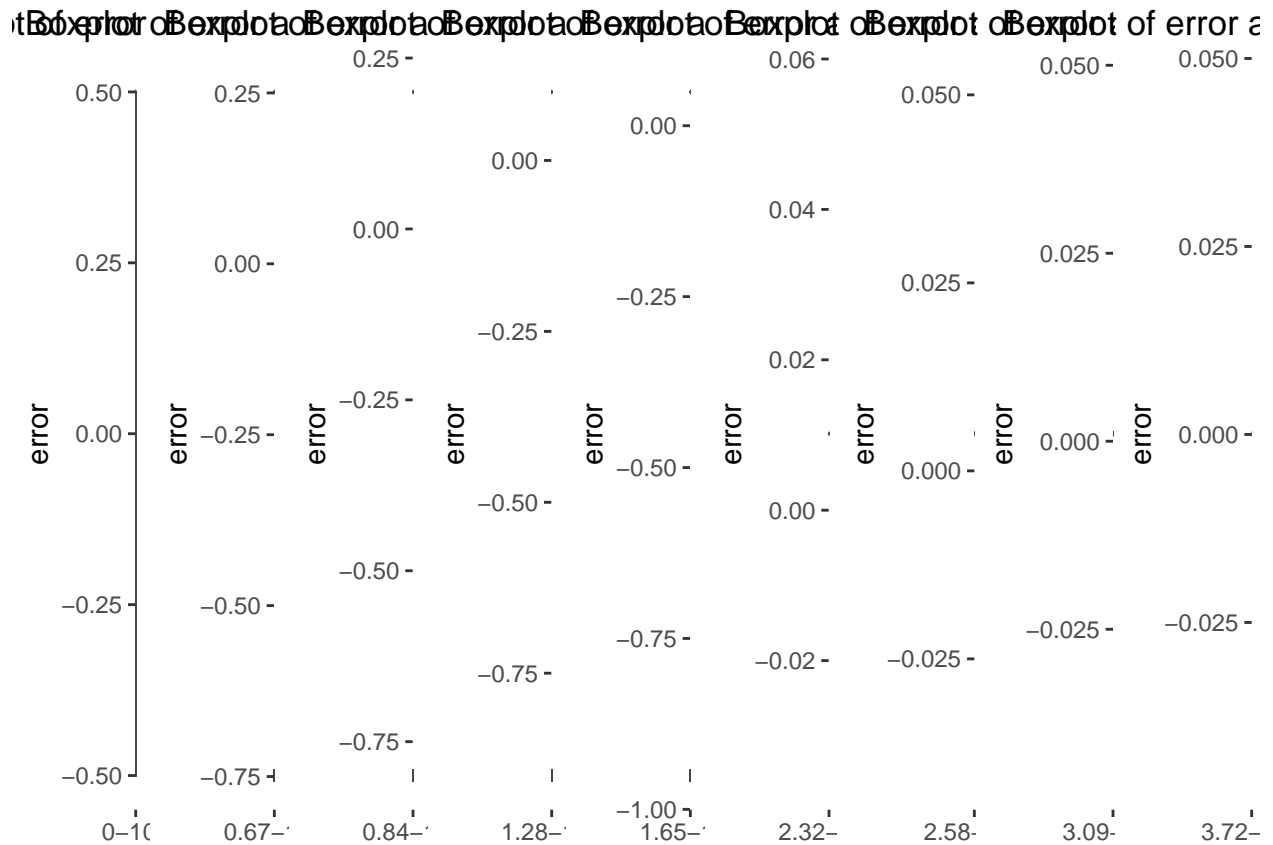
```
plot8<-ggplot(data=E,aes(y=e100_8,x="3.09-100"))+geom_boxplot(
  fill="thistle",colour="gray27")+
  labs(title="Boxplot of error at t=3.09, n=100",y="error",
    x=NULL)+theme(plot.title=element_text(size=13,hjust=0.5))
plot8
```



```
plot9<-ggplot(data=E,aes(y=e100_9,x="3.72-100"))+geom_boxplot(
  fill="thistle",colour="gray27")+
  labs(title="Boxplot of error at t=3.72, n=100",y="error",
    x=NULL)+theme(plot.title=element_text(size=13,hjust=0.5))
plot9
```



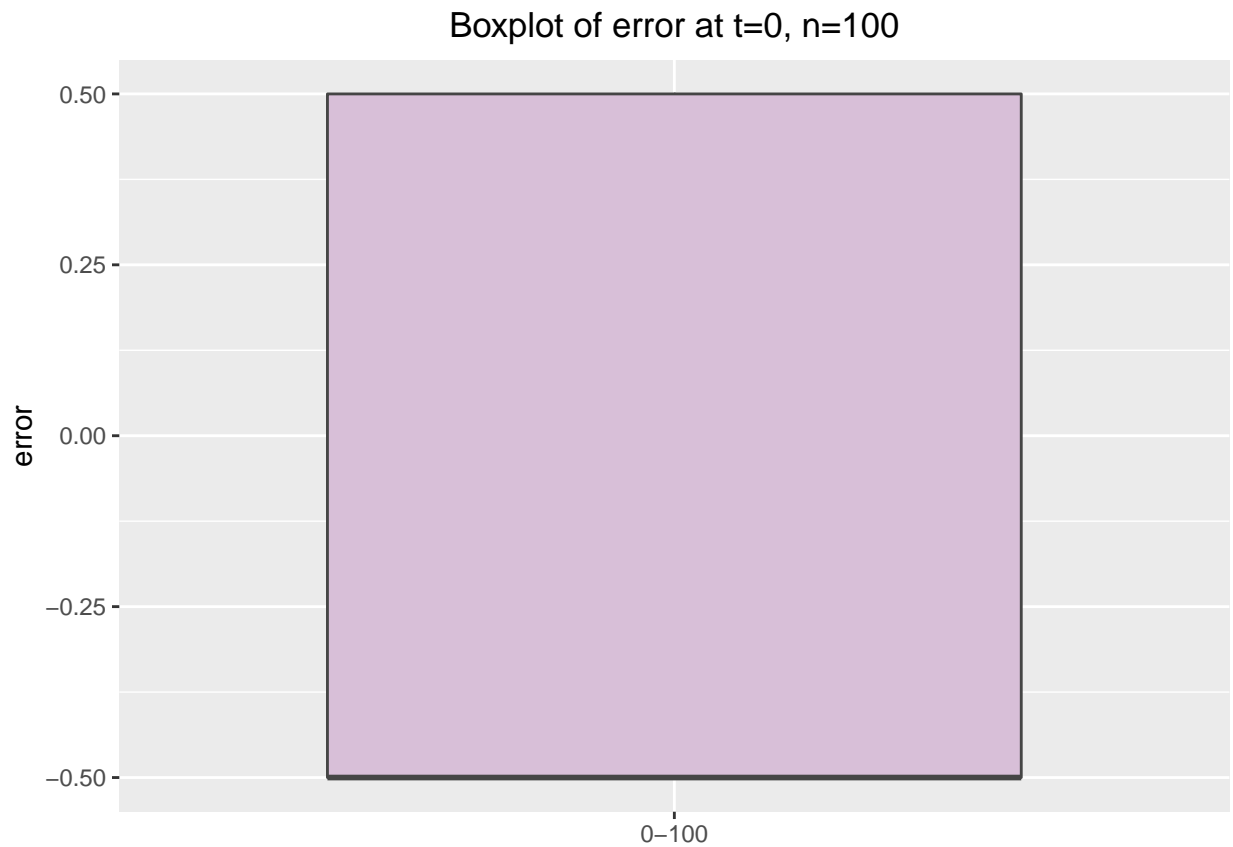
```
g1<-multiplot(plot1,plot2,plot3,plot4,plot5,plot6,plot7,plot8,plot9,cols=9)
```



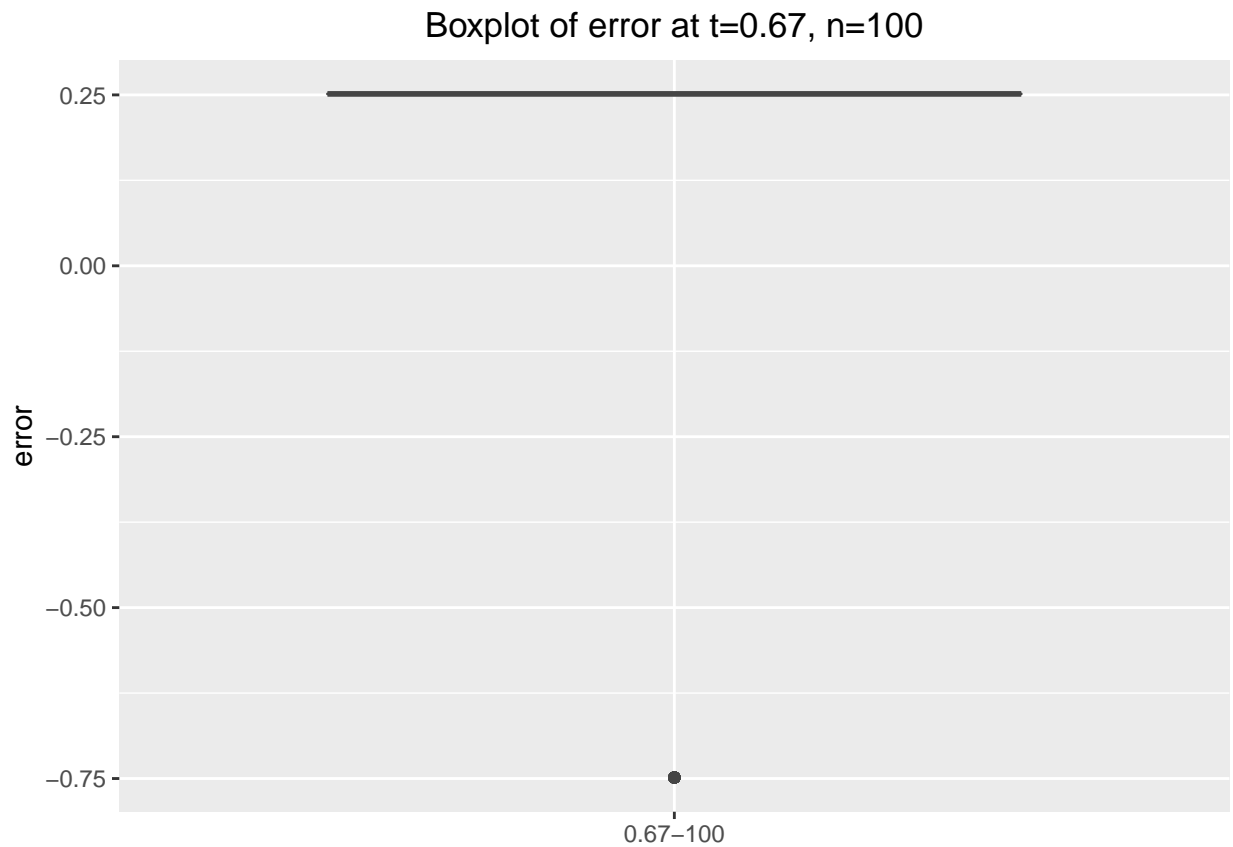
g1

NULL

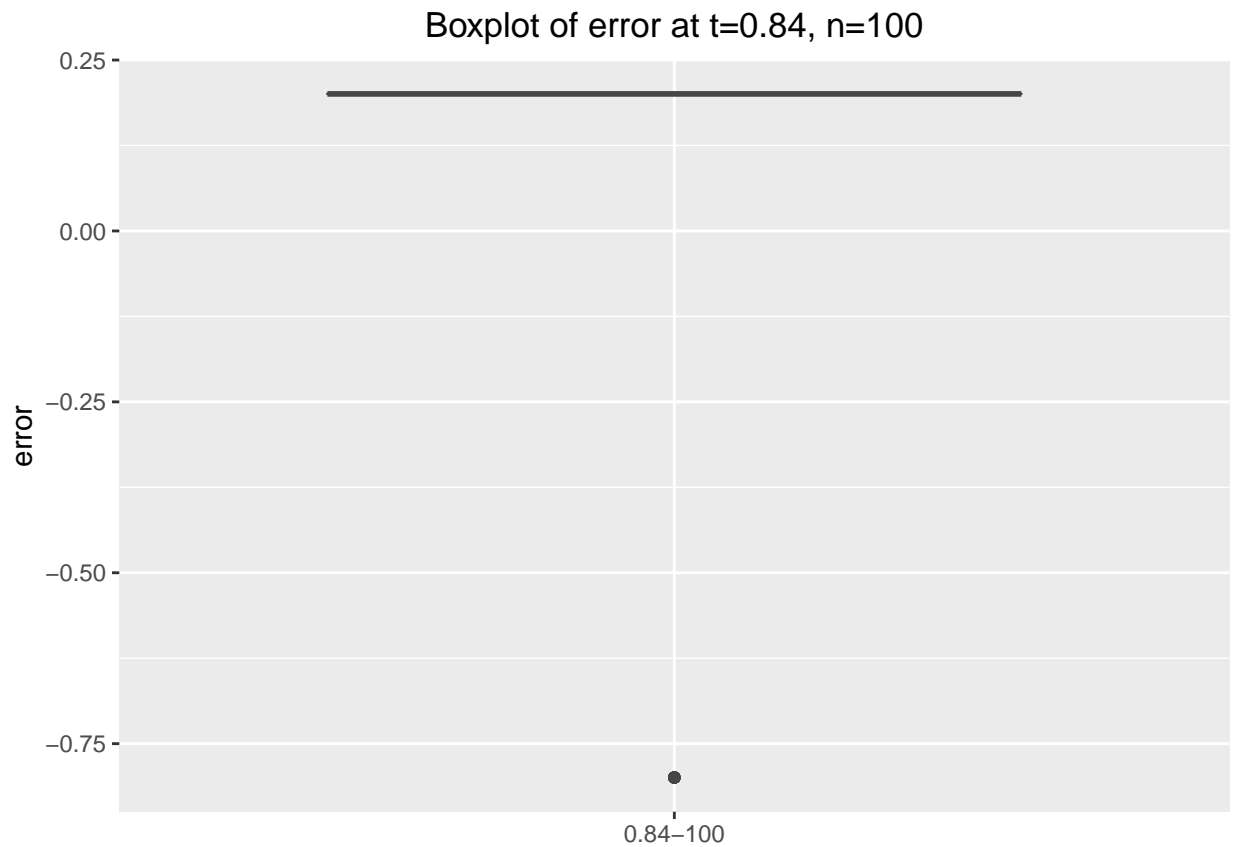
```
plot10<-ggplot(data=E,aes(y=e1000_1,x="0-100"))+geom_boxplot(
  fill="thistle",colour="gray27")+
  labs(title="Boxplot of error at t=0, n=100",y="error",
    x=NULL)+theme(plot.title=element_text(size=13,hjust=0.5))
plot10
```



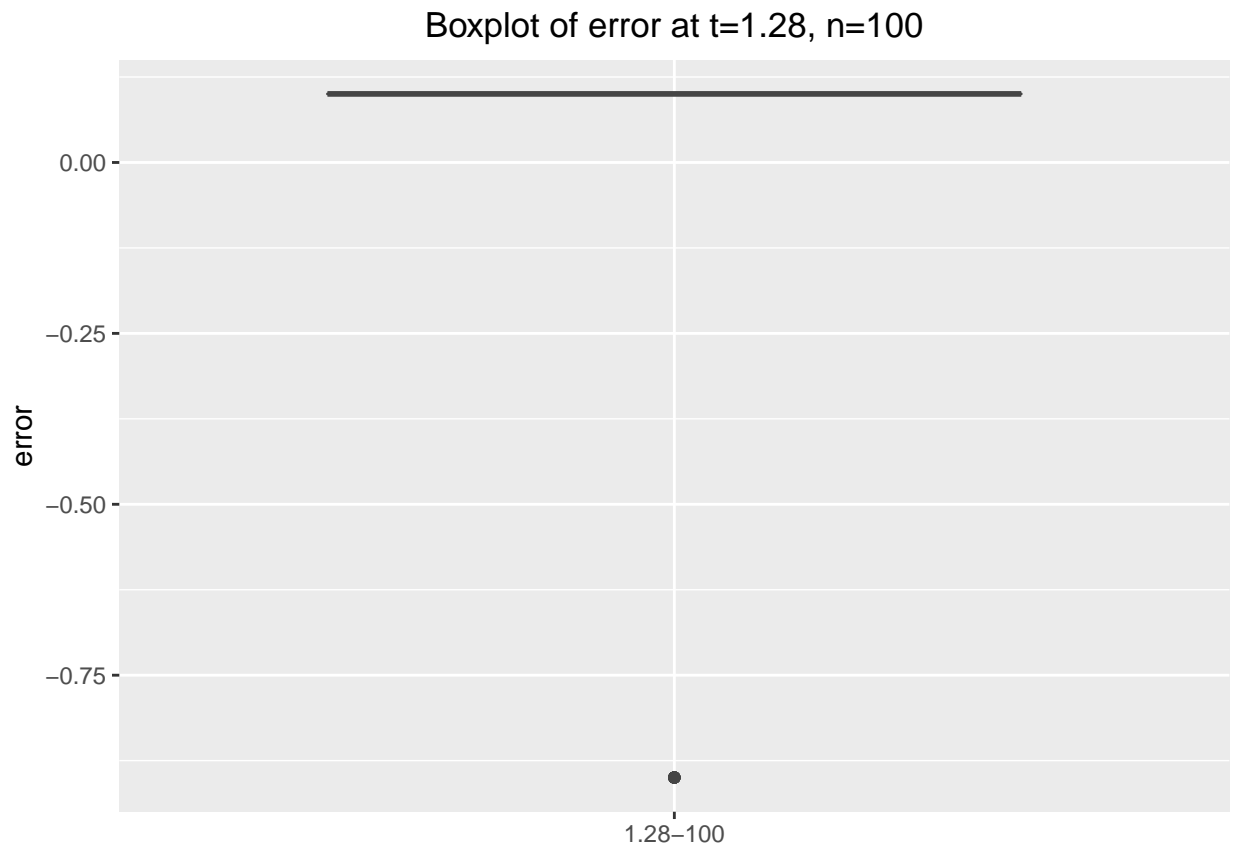
```
plot11<-ggplot(data=E,aes(y=e1000_2,x="0.67-100"))+geom_boxplot(  
  fill="thistle",colour="gray27")+  
  labs(title="Boxplot of error at t=0.67, n=100",y="error",  
        x=NULL)+theme(plot.title=element_text(size=13,hjust=0.5))  
plot11
```



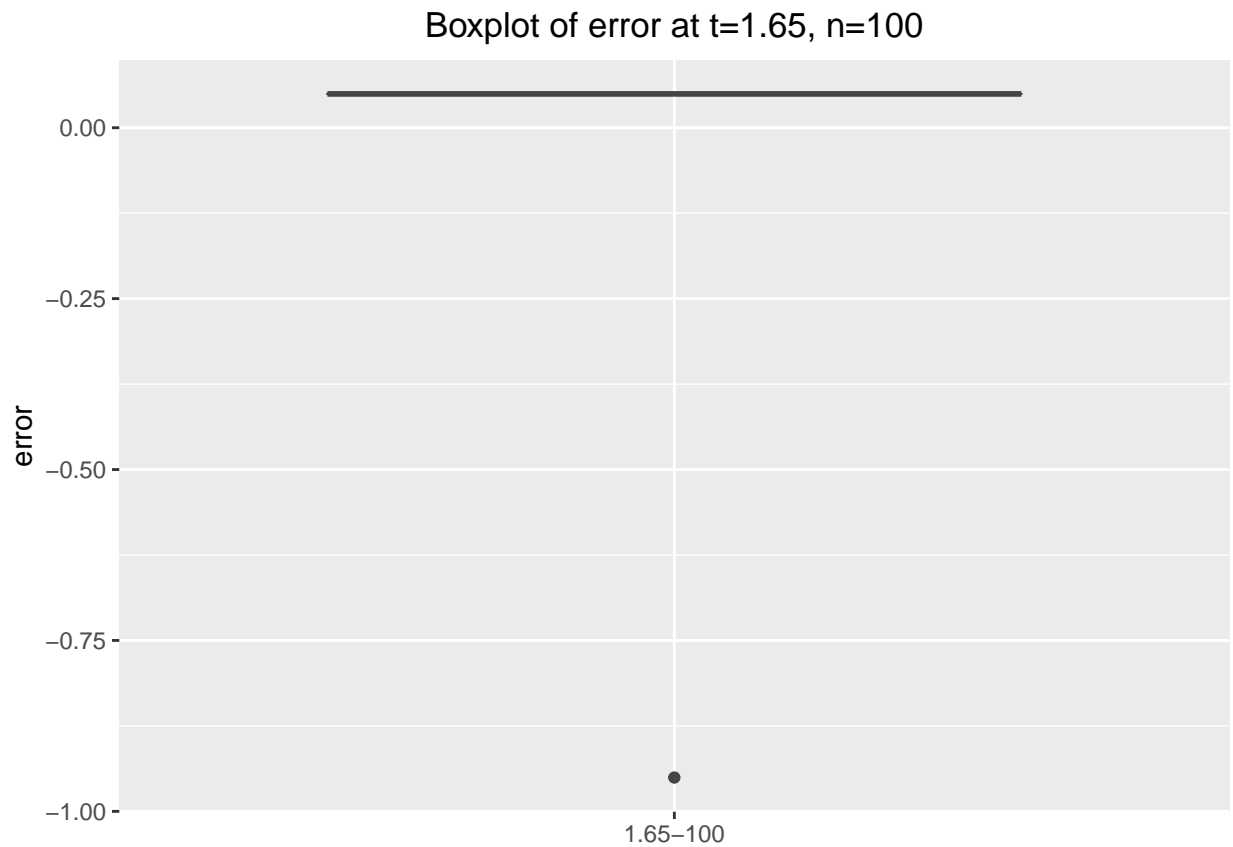
```
plot12<-ggplot(data=E,aes(y=e1000_3,x="0.84-100"))+geom_boxplot(
  fill="thistle",colour="gray27")+
  labs(title="Boxplot of error at t=0.84, n=100",y="error",
    x=NULL)+theme(plot.title=element_text(size=13,hjust=0.5))
plot12
```



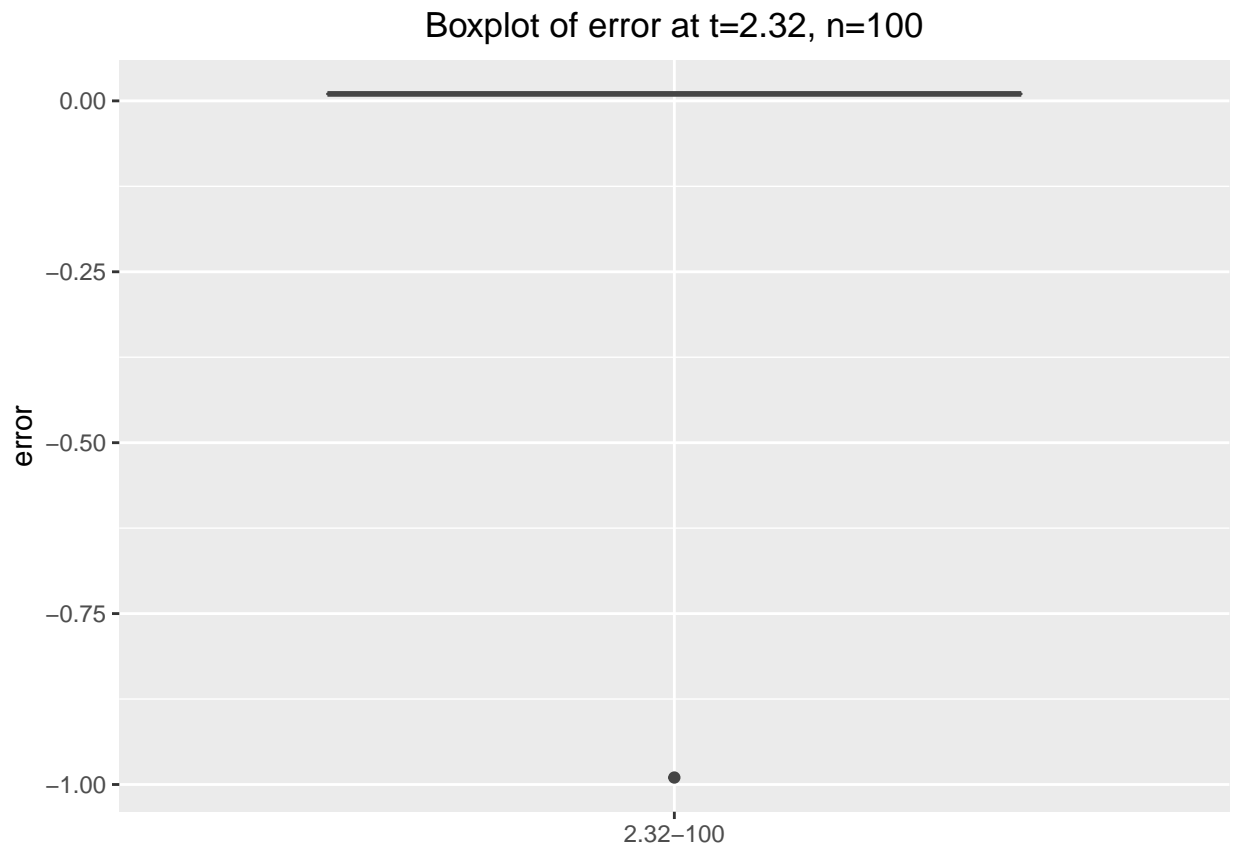
```
plot13<-ggplot(data=E,aes(y=e1000_4,x="1.28-100"))+geom_boxplot(
  fill="thistle",colour="gray27")+
  labs(title="Boxplot of error at t=1.28, n=100",y="error",
    x=NULL)+theme(plot.title=element_text(size=13,hjust=0.5))
plot13
```

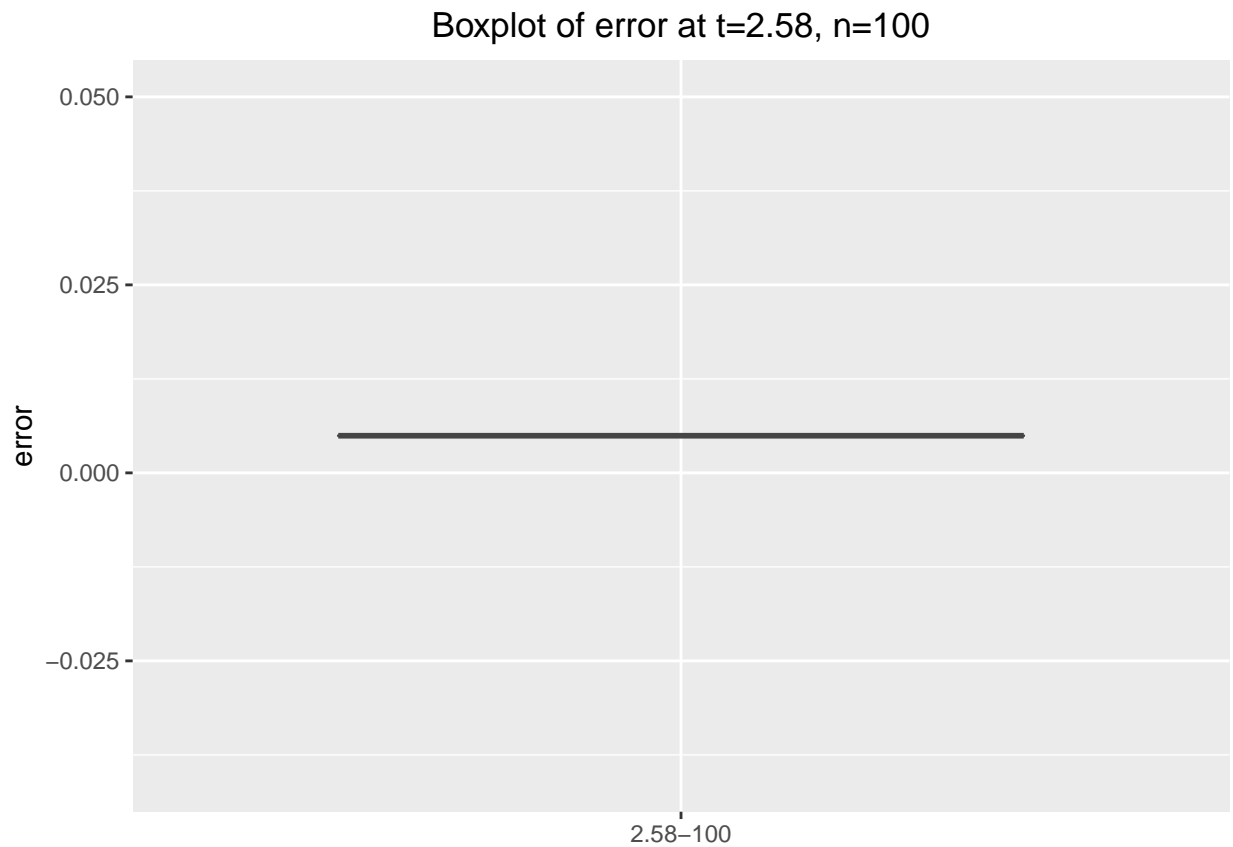
```
plot14<-ggplot(data=E,aes(y=e1000_5,x="1.65-100"))+geom_boxplot(
  fill="thistle",colour="gray27")+
  labs(title="Boxplot of error at t=1.65, n=100",y="error",
    x=NULL)+theme(plot.title=element_text(size=13,hjust=0.5))
plot14
```



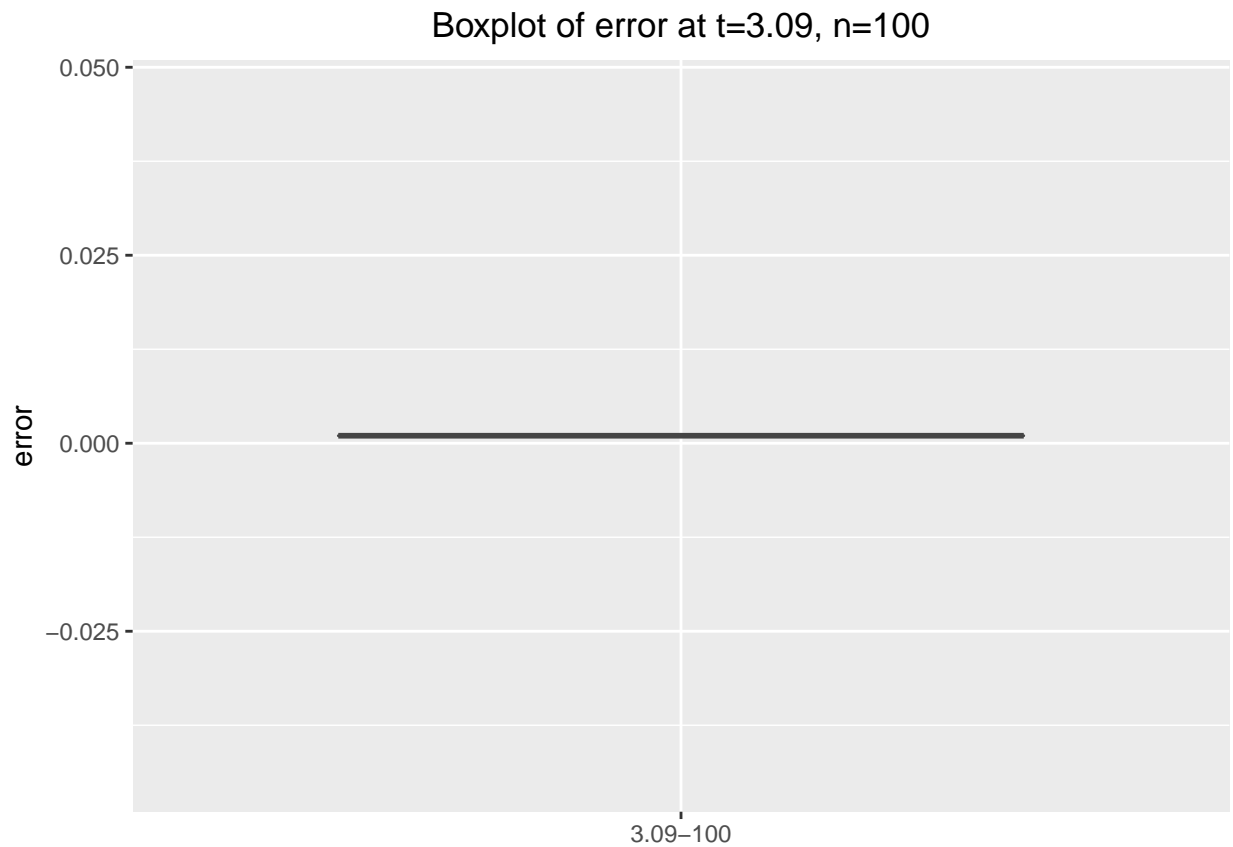
```
plot15<-ggplot(data=E,aes(y=e1000_6,x="2.32-100"))+geom_boxplot(
  fill="thistle",colour="gray27")+
  labs(title="Boxplot of error at t=2.32, n=100",y="error",
    x=NULL)+theme(plot.title=element_text(size=13,hjust=0.5))
plot15
```



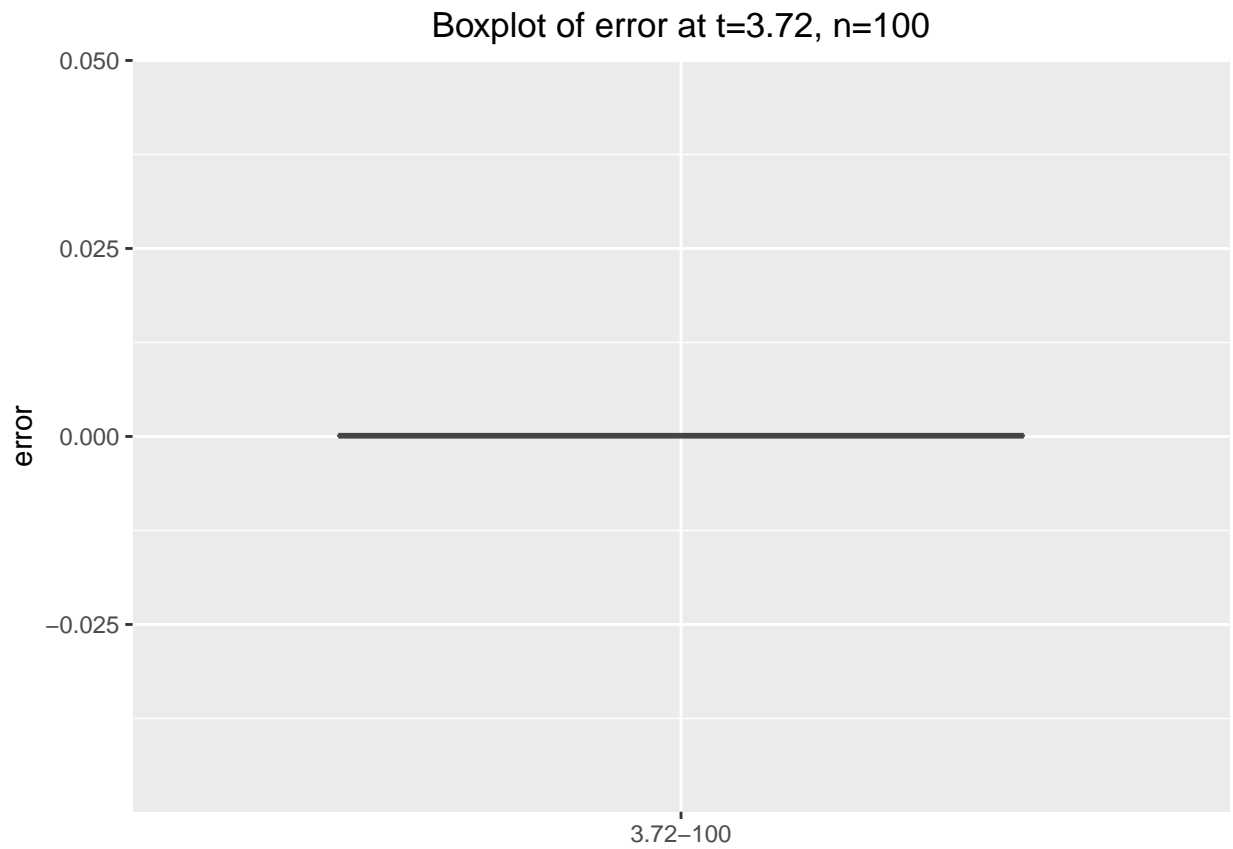
```
plot16<-ggplot(data=E,aes(y=e1000_7,x="2.58-100"))+geom_boxplot(
  fill="thistle",colour="gray27")+
  labs(title="Boxplot of error at t=2.58, n=100",y="error",
    x=NULL)+theme(plot.title=element_text(size=13,hjust=0.5))
plot16
```



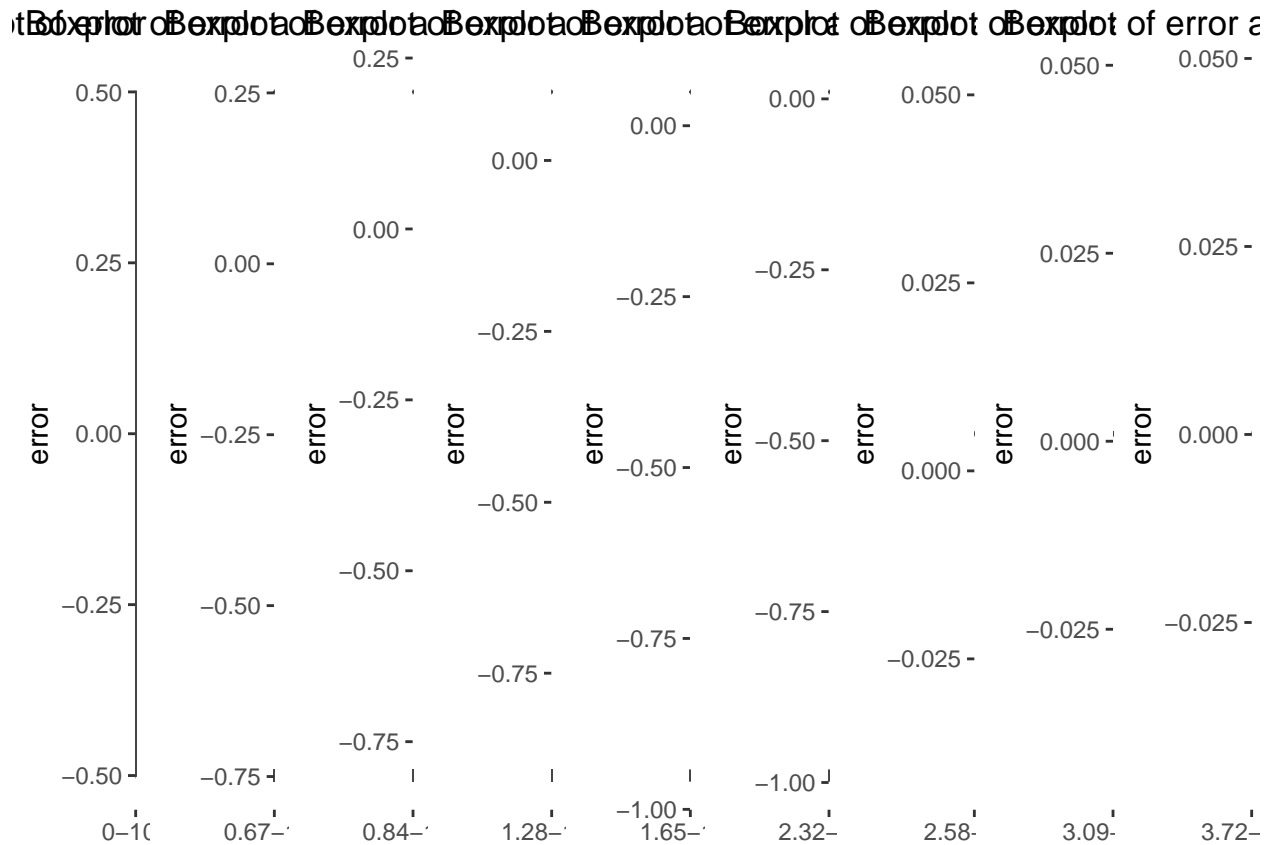
```
plot17<-ggplot(data=E,aes(y=e1000_8,x="3.09-100"))+geom_boxplot(
  fill="thistle",colour="gray27")+
  labs(title="Boxplot of error at t=3.09, n=100",y="error",
    x=NULL)+theme(plot.title=element_text(size=13,hjust=0.5))
plot17
```



```
plot18<-ggplot(data=E,aes(y=e1000_9,x="3.72-100"))+geom_boxplot(
  fill="thistle",colour="gray27")+
  labs(title="Boxplot of error at t=3.72, n=100",y="error",
    x=NULL)+theme(plot.title=element_text(size=13,hjust=0.5))
plot18
```



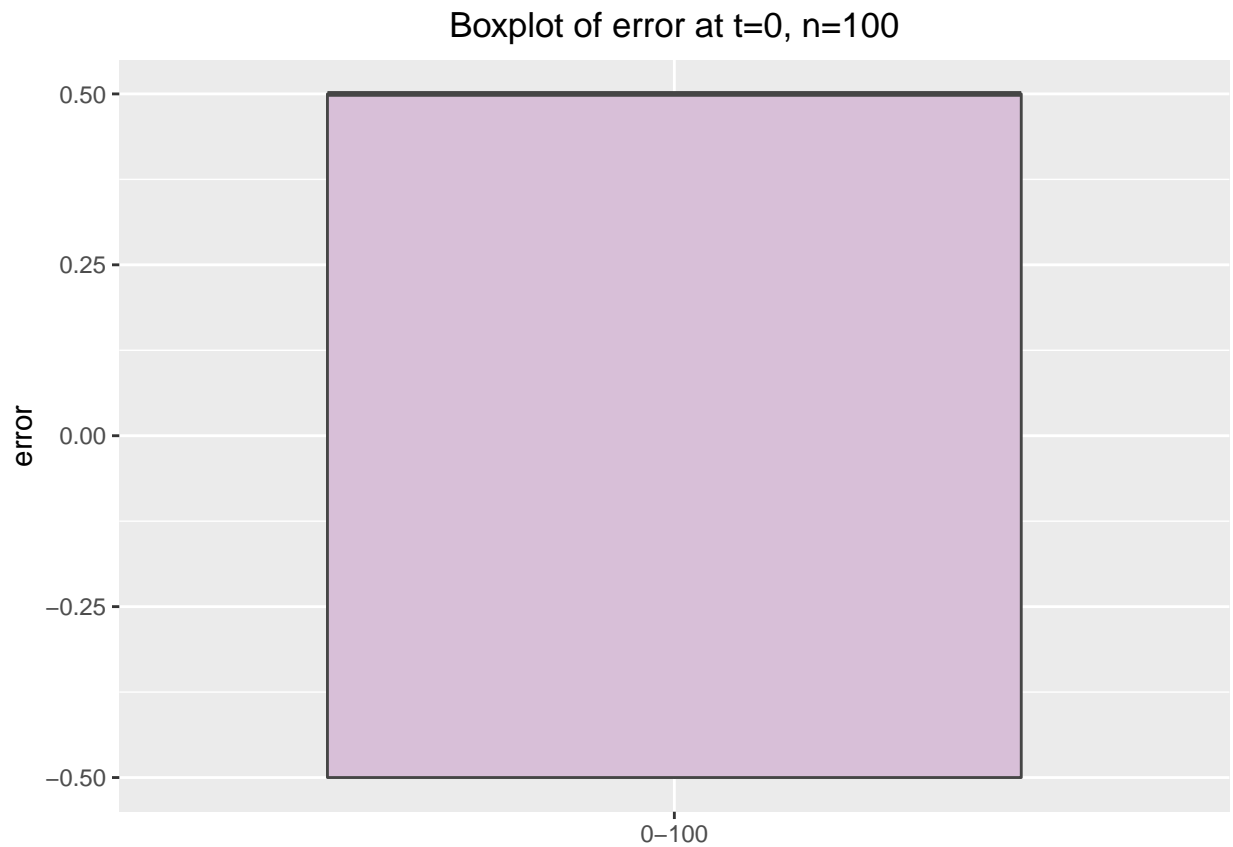
```
g2<-multiplot(plot10,plot11,plot12,plot13,plot14,plot15,plot16,plot17,plot18,cols=9)
```



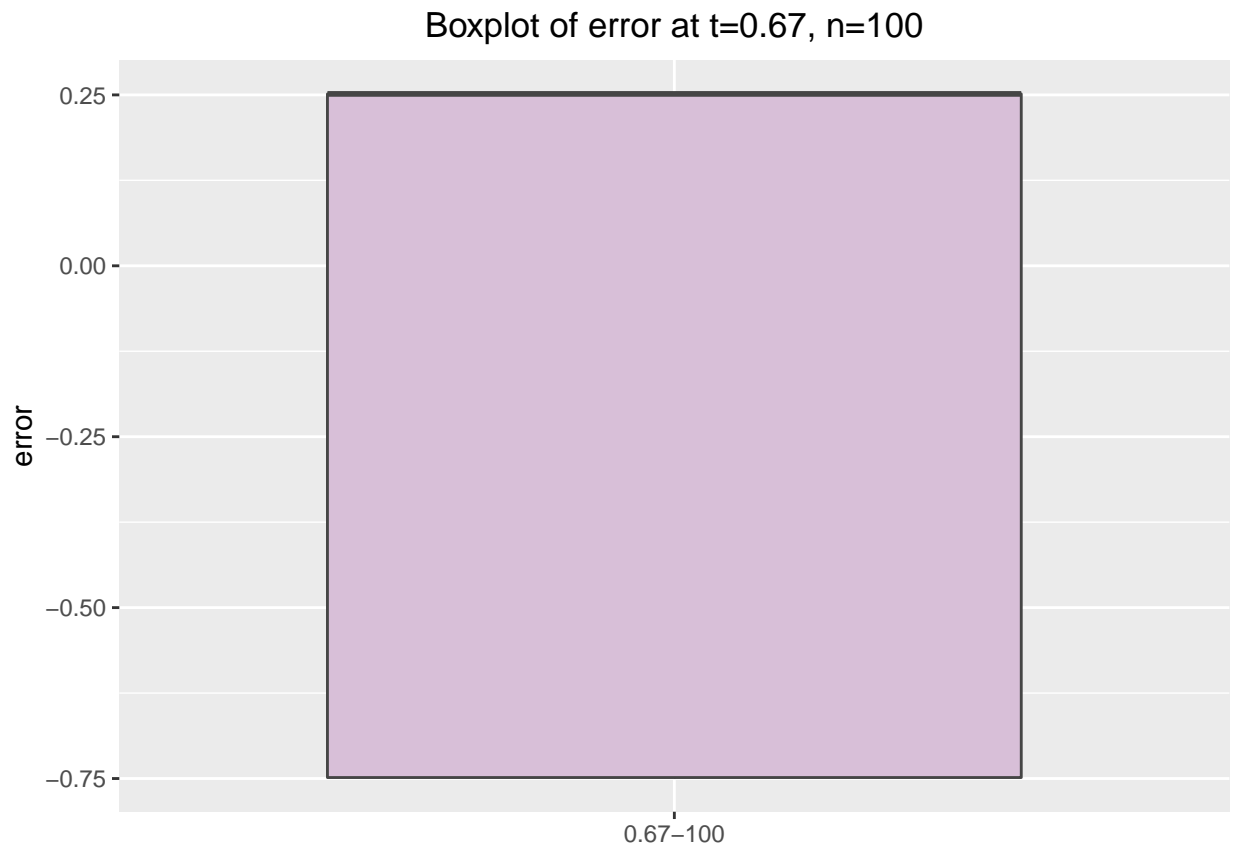
g2

NULL

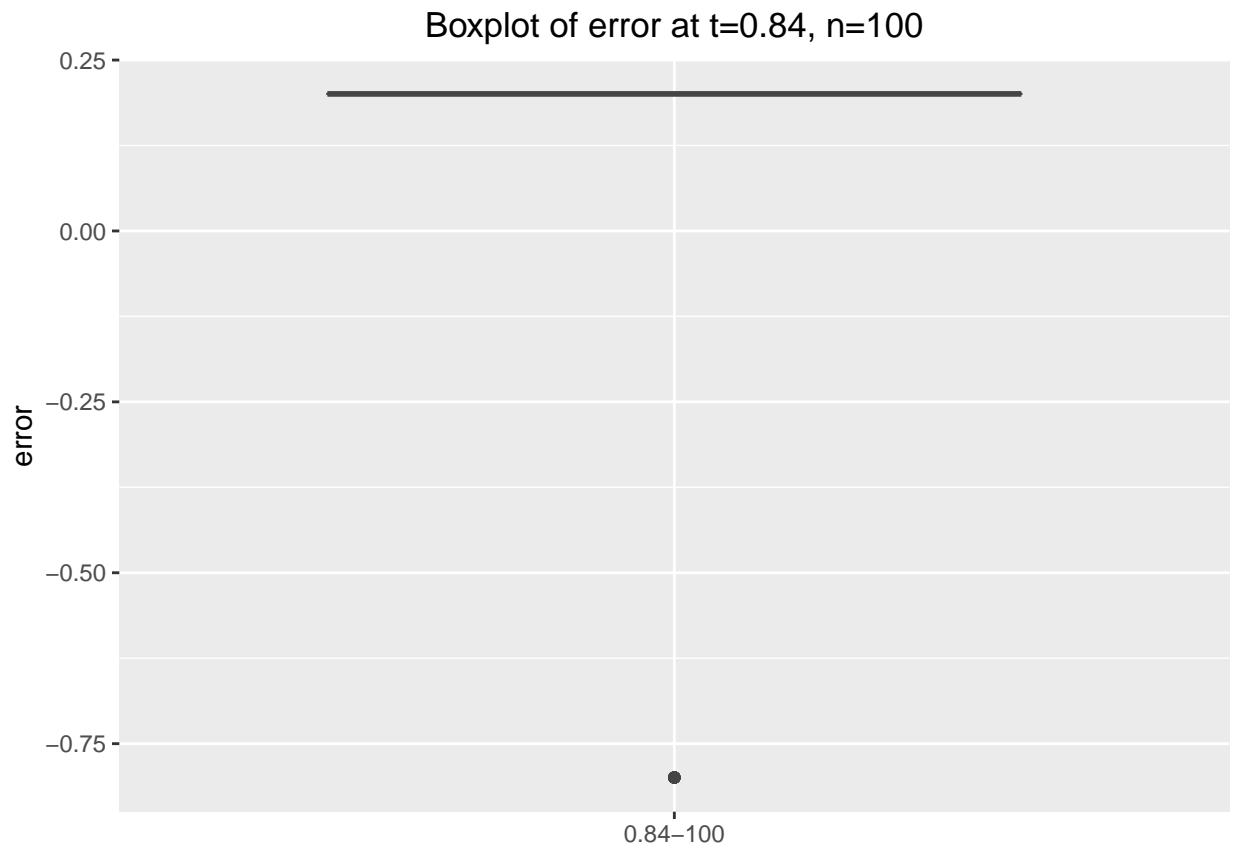
```
plot19<-ggplot(data=E,aes(y=e10000_1,x="0-100"))+geom_boxplot(
  fill="thistle",colour="gray27")+
  labs(title="Boxplot of error at t=0, n=100",y="error",
    x=NULL)+theme(plot.title=element_text(size=13,hjust=0.5))
plot19
```



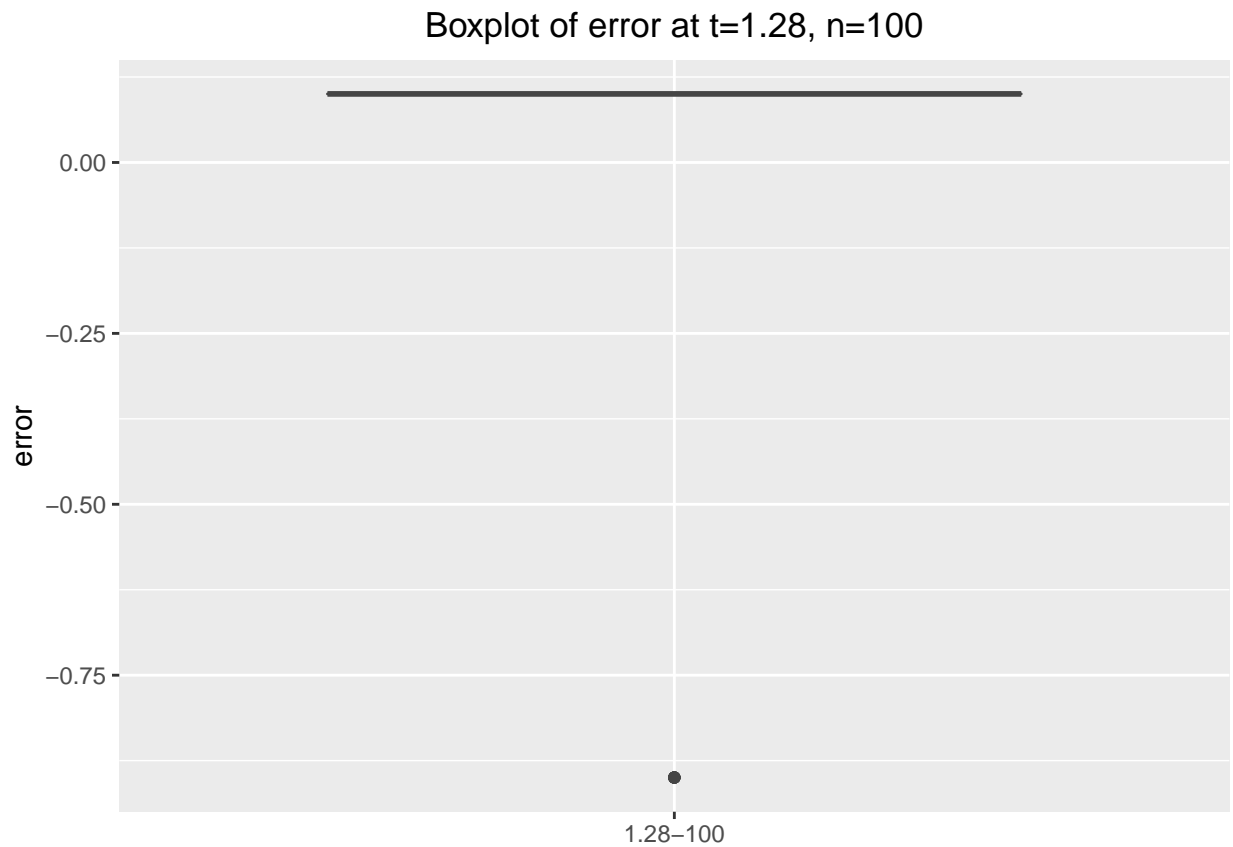
```
plot20<-ggplot(data=E,aes(y=e10000_2,x="0.67-100"))+geom_boxplot(  
  fill="thistle",colour="gray27")+  
  labs(title="Boxplot of error at t=0.67, n=100",y="error",  
        x=NULL)+theme(plot.title=element_text(size=13,hjust=0.5))  
plot20
```

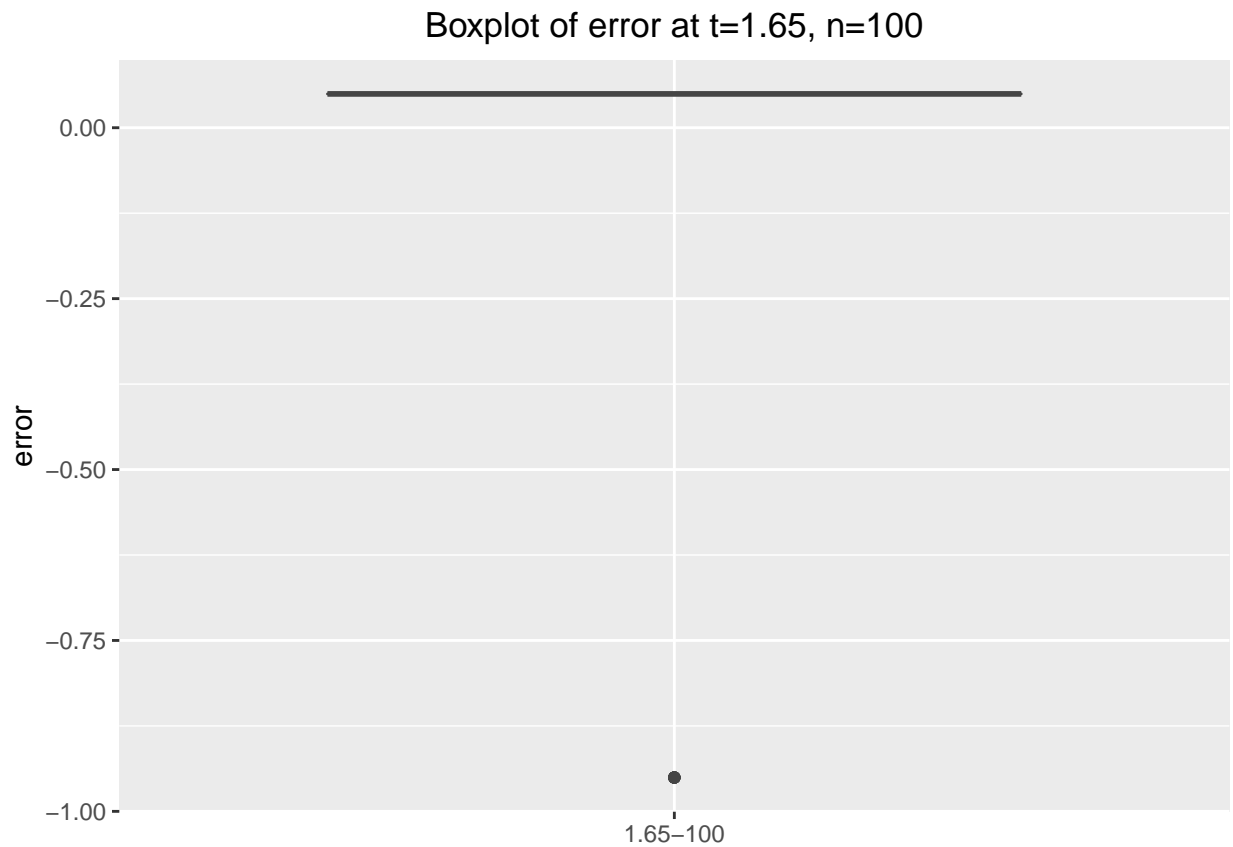
```
plot21<-ggplot(data=E,aes(y=e10000_3,x="0.84-100"))+geom_boxplot(  
  fill="thistle",colour="gray27")+  
  labs(title="Boxplot of error at t=0.84, n=100",y="error",  
        x=NULL)+theme(plot.title=element_text(size=13,hjust=0.5))  
plot21
```



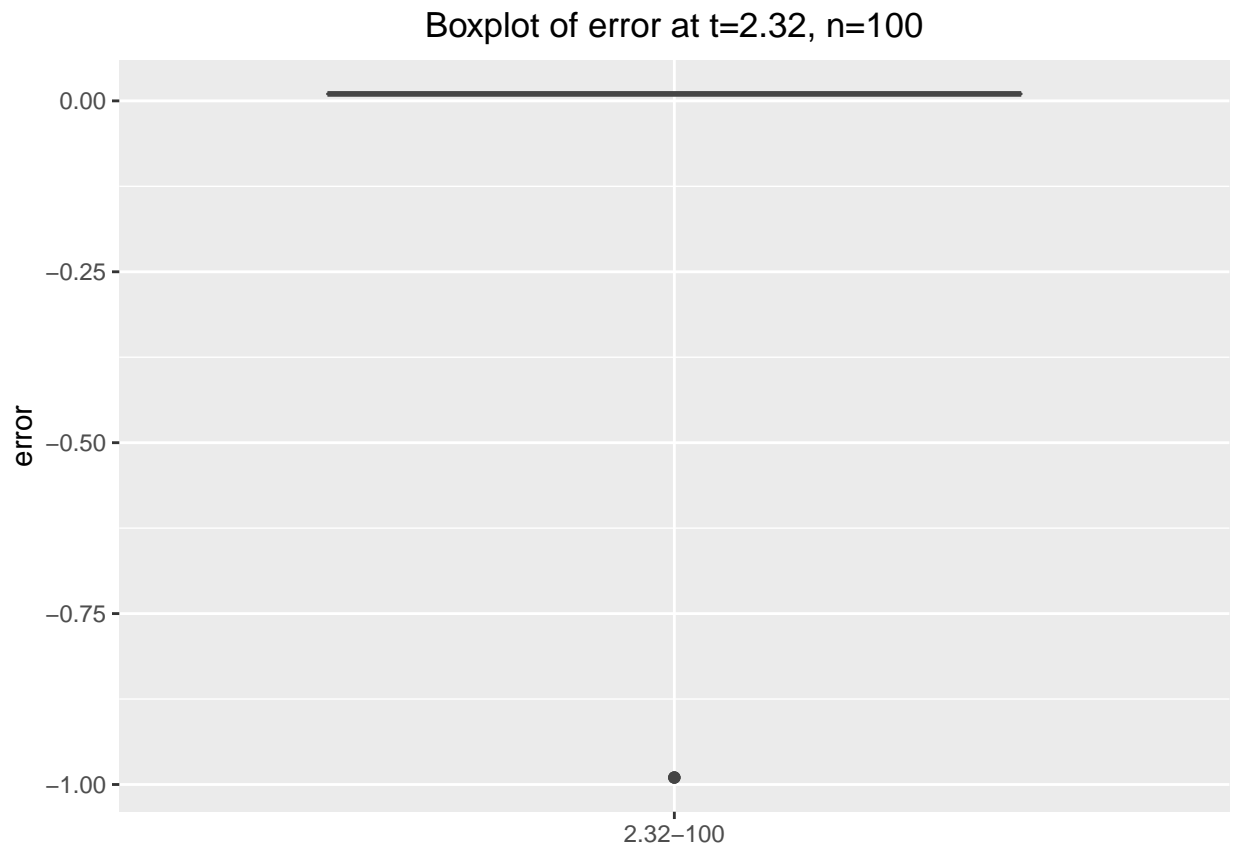
```
plot22<-ggplot(data=E,aes(y=e10000_4,x="1.28-100"))+geom_boxplot(
  fill="thistle",colour="gray27")+
  labs(title="Boxplot of error at t=1.28, n=100",y="error",
    x=NULL)+theme(plot.title=element_text(size=13,hjust=0.5))
plot22
```



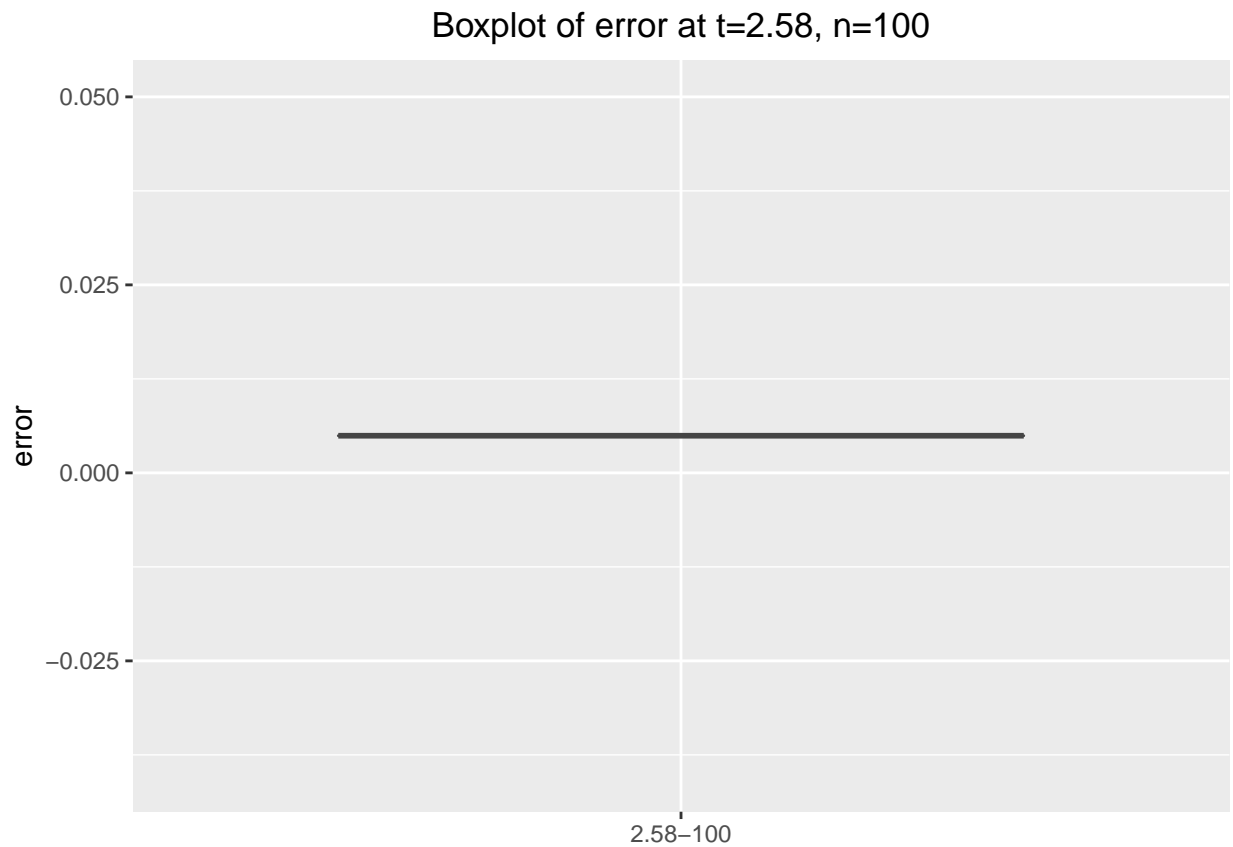
```
plot23<-ggplot(data=E,aes(y=e10000_5,x="1.65-100"))+geom_boxplot(
  fill="thistle",colour="gray27")+
  labs(title="Boxplot of error at t=1.65, n=100",y="error",
    x=NULL)+theme(plot.title=element_text(size=13,hjust=0.5))
plot23
```



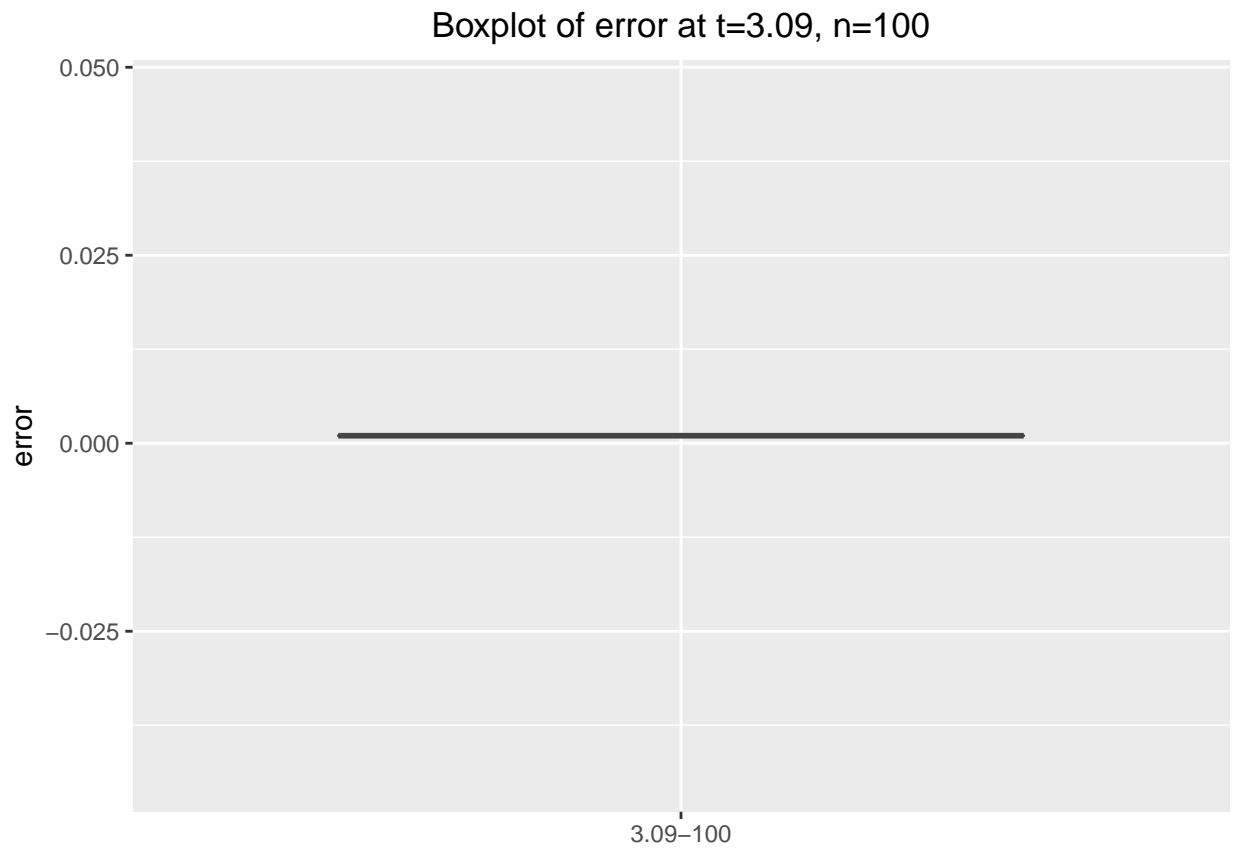
```
plot24<-ggplot(data=E,aes(y=e10000_6,x="2.32-100"))+geom_boxplot(
  fill="thistle",colour="gray27")+
  labs(title="Boxplot of error at t=2.32, n=100",y="error",
    x=NULL)+theme(plot.title=element_text(size=13,hjust=0.5))
plot24
```



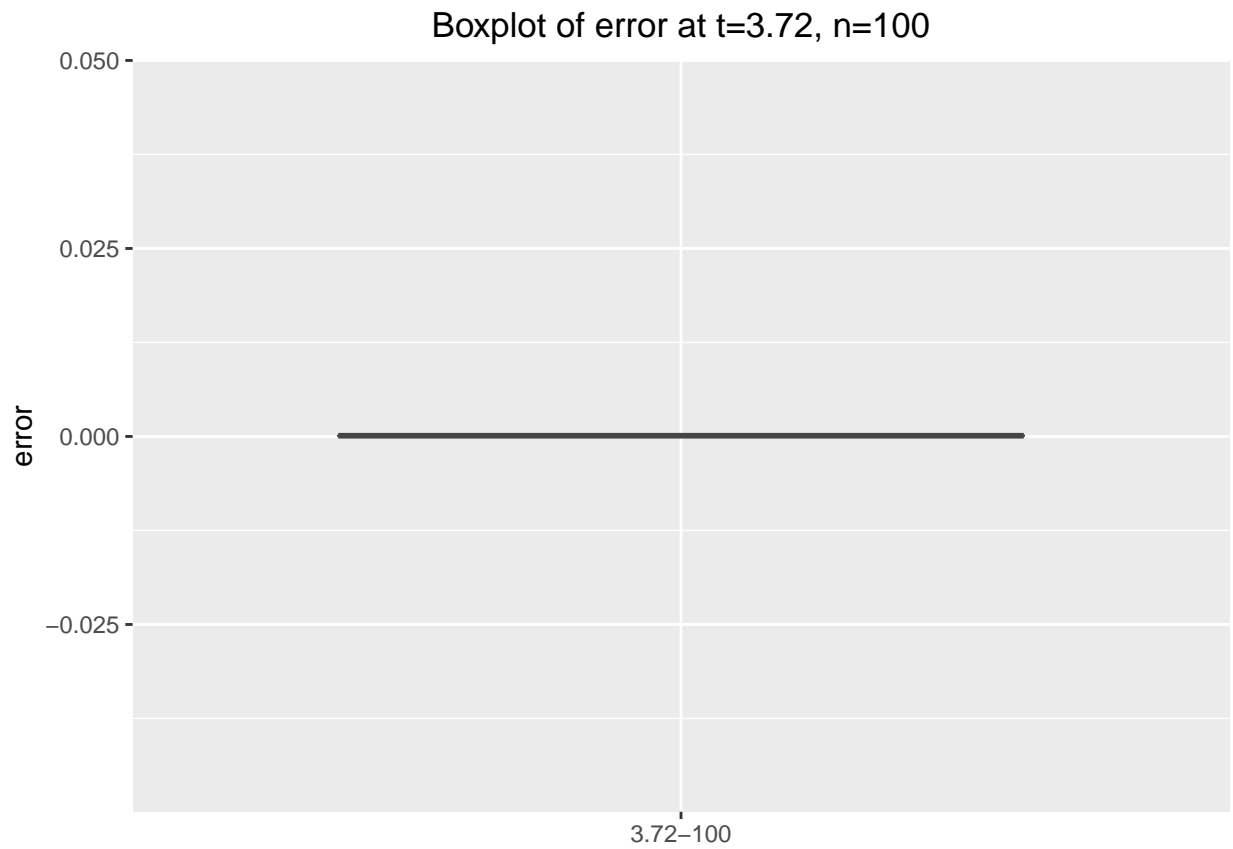
```
plot25<-ggplot(data=E,aes(y=e10000_7,x="2.58-100"))+geom_boxplot(
  fill="thistle",colour="gray27")+
  labs(title="Boxplot of error at t=2.58, n=100",y="error",
    x=NULL)+theme(plot.title=element_text(size=13,hjust=0.5))
plot25
```



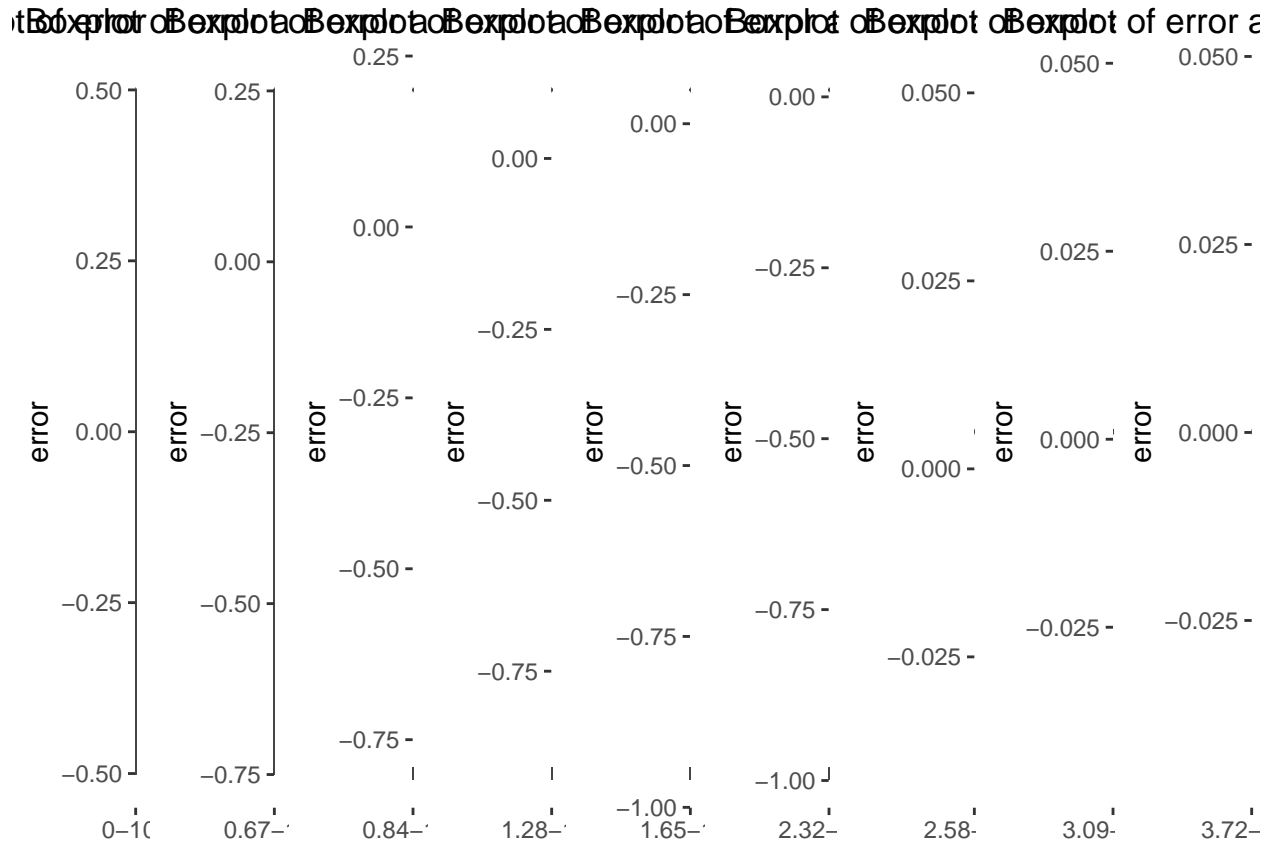
```
plot26<-ggplot(data=E,aes(y=e10000_8,x="3.09-100"))+geom_boxplot(
  fill="thistle",colour="gray27")+
  labs(title="Boxplot of error at t=3.09, n=100",y="error",
    x=NULL)+theme(plot.title=element_text(size=13,hjust=0.5))
plot26
```



```
plot27<-ggplot(data=E,aes(y=e10000_9,x="3.72-100"))+geom_boxplot(fill="thistle",colour="gray27")+labs(t.  
plot27
```



```
g3<-multiplot(plot19,plot20,plot21,plot22,plot23,plot24,plot25,plot26,plot27,cols=9)
```

g3

NULL

Summary and Discussion

I had many problems with this writing report. I think my code has many mistakes and the result is different from others.