ภาคผนวก ก

ฟังก์ชันและการแจกแจงที่สำคัญ

1. ฟังก์ชันแกมมา (Gamma Function)

นิยาม ฟังก์ชันแกมมาเขียนแทนด้วย $\Gamma(y)$ คือ $\Gamma(y) = \int_0^\infty e^{-t}t^{y-1}dt \quad ; \ y>0$

คุณสมบัติของฟังก์ชันแกมมาที่สำคัญ คือ

1) $\Gamma(y) = (y-1)\Gamma(y-1)$

2) $\Gamma(y) = (y-1)!$

3) $\Gamma(0) = \infty \ , \ \Gamma\left(\frac{1}{2}\right) = \sqrt{\pi}$

4) $\frac{\Gamma(y)}{x^y} = \int_0^\infty e^{-xt}t^{y-1}dt \quad ; \quad x>0$

5) $\frac{\Gamma(y+\alpha^{-1})}{\Gamma(\alpha^{-1})} = \prod_{j=0}^{y_i-1}(j+\alpha^{-1})$

$$\frac{\Gamma(y+\alpha^{-1})}{\Gamma(\alpha^{-1})} = \frac{(y+\alpha^{-1}-1)!}{(\alpha^{-1}-1)!}$$

$$= \frac{(y+\alpha^{-1}-1)(y+\alpha^{-1}-2)...(y+\alpha^{-1}-y)(y+\alpha^{-1}-y-1)!}{(\alpha^{-1}-1)!}$$

$$= (y+\alpha^{-1}-1)(y+\alpha^{-1}-2)...(y+\alpha^{-1}-y)$$

$$= (y-1+\alpha^{-1})(y-2+\alpha^{-1})...(1-1+\alpha^{-1})$$

$$= \prod_{j=0}^{y_i-1}(j+\alpha^{-1})$$

$$\therefore \quad \frac{\Gamma(y+\alpha^{-1})}{\Gamma(\alpha^{-1})} = \prod_{j=0}^{y_i-1}(j+\alpha^{-1})$$

2. การแจกแจงทวินามแบบลบที่มีความแปรปรวนเป็นฟังก์ชันกำลังสองของค่าเฉลี่ย(NB2)

การแจกแจง NB2 ได้ถูกพัฒนามาจากการแจกแจงปัวซง โดยการสมมุติให้ค่าเฉลี่ยของการแจกแจงปัวซงเป็นตัวแปรสุ่มที่มีการแจกแจงแบบแกมมา (Gamma distribution) (Lawless, 1987 และ Hinde and Demètrio , 1998) ดังนี้

ให้ Y_i เป็นตัวแปรสุ่มที่มีการแจกแจงปัวซง โดยมี probability mass function ดังนี้

$$f(y_i \mid \theta_i) = \frac{e^{-\theta_i}\theta_i^{y_i}}{y_i!} \quad , \quad y_i = 0,1,2,...$$

โดยที่ $$E(Y_i \mid \theta_i) = Var(Y_i \mid \theta_i) = \theta_i$$

ให้ θ_i เป็นตัวแปรเชิงสุ่มที่มีการแจกแจงแบบแกมมา (Gamma distribution) ที่มีพารามิเตอร์ ϕ และ λ_i ที่มี p.d.f ดังนี้

$$g(\theta_i;\phi^{-1},\lambda_i) = \frac{1}{\Gamma(\phi^{-1})\lambda_i^{\phi^{-1}}}\theta_i^{\phi^{-1}-1}e^{\frac{-\theta_i}{\lambda_i}} \quad , \quad \theta_i > 0 , \phi^{-1} > 0 , \lambda_i > 0$$

โดยที่ $E(\theta_i) = \frac{\lambda_i}{\phi}$ และ $Var(\theta_i) = \frac{\lambda_i^2}{\phi}$

ดังนั้น joint p.d.f. ของ Y_i และ θ_i คือ

$$f(y_i,\theta_i) = f(y_i \mid \theta_i)g(\theta_i;\phi^{-1},\lambda_i)$$

$$= \frac{e^{-\theta_i}\theta_i^{y_i}}{y_i!}\cdot\frac{1}{\Gamma(\phi^{-1})\lambda_i^{\phi^{-1}}}\theta_i^{\phi^{-1}-1}e^{\frac{-\theta_i}{\lambda_i}}$$

ดังนั้น marginal probability mass function ของ Y_i คือ

$$f(y_i) = \int_0^\infty f(y_i,\theta_i)\,d\theta_i$$

$$= \int_0^\infty \frac{e^{-\theta_i}\theta_i^{y_i}}{y_i!}\cdot\frac{1}{\Gamma(\phi^{-1})\lambda_i^{\phi^{-1}}}\theta_i^{\phi^{-1}-1}e^{\frac{-\theta_i}{\lambda_i}}\,d\theta_i$$

$$= \frac{1}{y_i!\Gamma(\phi^{-1})\lambda_i^{\phi^{-1}}}\int_0^{\infty} e^{-\theta_i-\frac{\theta_i}{\lambda_i}}\theta_i^{y_i+\phi^{-1}-1}\,d\theta_i$$

$$= \frac{1}{y_i!\Gamma(\phi^{-1})\lambda_i^{\phi^{-1}}}\int_0^{\infty} e^{-\theta_i(1+\frac{1}{\lambda_i})}\theta_i^{y_i+\phi^{-1}-1}\,d\theta_i$$

$$= \frac{1}{y_i!\Gamma(\phi^{-1})\lambda_i^{\phi^{-1}}(1+\frac{1}{\lambda_i})^{y_i+\phi^{-1}}}\int_0^{\infty} e^{-\theta_i(1+\frac{1}{\lambda_i})}\left(\theta_i(1+\frac{1}{\lambda_i})\right)^{y_i+\phi^{-1}-1} d\left(\theta_i(1+\frac{1}{\lambda_i})\right)$$

$$= \frac{1}{y_i!\Gamma(\phi^{-1})\lambda_i^{\phi^{-1}}(1+\frac{1}{\lambda_i})^{y_i+\phi^{-1}}}\Gamma(y_i+\phi^{-1})$$

$$= \frac{\lambda_i^{y_i}\Gamma(y_i+\phi^{-1})}{y_i!\Gamma(\phi^{-1})(1+\lambda_i)^{y_i+\phi^{-1}}}$$

เนื่องจาก $\mu_i=\frac{\lambda_i}{\phi}$ นั้นคือ $\lambda_i=\mu_i\phi$

ดังนั้น Y_i มีการแจกแจงทวินามแบบลบ ที่มี marginal distribution function อยู่ในรูปของ

$$f(y_i;\mu_i,\phi) = \frac{\Gamma(y_i+\phi^{-1})\mu_i^{y_i}\phi^{y_i}}{y_i!\Gamma(\phi^{-1})(1+\phi\mu_i)^{y_i+\phi^{-1}}} \quad ; \quad y_i=0,1,2,\ldots;\phi>0$$

ที่มี $E(Y_i) = E\left[E(Y_i\mid\theta_i)\right] = \frac{\lambda_i}{\phi} = \mu_i$

และ $Var(Y_i) = E\left[Var(Y_i\mid\theta_i)\right]+Var\left[E(Y_i\mid\theta_i)\right] = \mu_i(1+\phi\mu_i)$

สมมติให้ ϕ_i เป็นฟังก์ชันของ $\mu_i(=\lambda_i/\phi_i)$ จะได้ว่า $\phi_i=\alpha\mu_i^{c-1}$, $\alpha>0$ โดยที่ α เป็นค่าคงที่ c เป็นสเกลาร์

ดังนั้น รูปทั่วไปของการแจกแจงทวินามแบบลบ (Gurmu and Trivedi ,1992) คือ

$$f(y_i;\mu_i,\alpha) = \begin{cases} \frac{\Gamma(y_i+\alpha^{-1}\mu_i^{1-c})}{y_i!\Gamma(\alpha^{-1}\mu_i^{1-c})}\frac{\mu_i^{cy_i}\alpha^{y_i}}{(1+\alpha\mu_i^{c})^{y_i+\alpha^{-1}\mu_i^{1-c}}} & , \quad y_i=0,1,2,\ldots;\alpha>0 \\ 0 & , \quad \text{otherwise} \end{cases}$$

โดยที่ $E(Y_i)=\mu_i$ และ $Var(Y_i)=\mu_i(1+\alpha\mu_i^{c})$

μ คือค่าเฉลี่ย และ α คือ Dispersion parameter ถ้า $\alpha = 0$ ตัวแบบ NB จะลดรูปเป็นการแจกแจงปัวซง c เป็นดัชนีที่แสดงความสัมพันธ์ระหว่างความแปรปรวนและค่าเฉลี่ยของการแจกแจงทวินามแบบลบ ซึ่งการแจกแจงทวินามแบบลบมีหลายรูปแบบตามลักษณะของความ สัมพันธ์ระหว่างความแปรปรวนและค่าเฉลี่ย แต่ในวิทยานิพนธ์ฉบับนี้จะเน้นศึกษากระบวนการวิเคราะห์ข้อมูลทวินามแบบลบที่มีความแปรปรวนเป็นฟังก์ชันกำลังสองค่าเฉลี่ย

การแจกแจง NB2

เมื่อ c = 1 ตัวแปรสุ่ม Y มีการแจกแจงทวินามแบบลบ โดยมีฟังก์ชันความน่าจะเป็นอยู่ในรูปของ

$$f(y_i;\mu_i,\alpha) = \begin{cases} \dfrac{\Gamma(y_i+\alpha^{-1})}{y_i!\Gamma(\alpha^{-1})}\dfrac{\mu_i^{y_i}\alpha^{y_i}}{(1+\alpha\mu_i)^{y_i+\alpha^{-1}}} & , \quad y_i = 0,1,2,\ldots\ ;\alpha > 0 \\ 0 & , \quad \text{otherwise} \end{cases}$$

โดยที่ $E(Y_i) = \mu_i$ และ $Var(Y_i) = \mu_i(1+\alpha\mu_i)$

นั่นคือ ตัวแบบ NB2 มีค่าความแปรปรวนเป็นฟังก์ชันกำลังสองของค่าเฉลี่ย (Quadratic mean-variance negative binomial model: NB2)

ภาคผนวก ข

โปรแกรม R ที่สำคัญ

1. โปรแกรม fit NB2 พร้อมคำนวณค่า Robust standard error

```
nb2.fit.robust <- function(y,X.mat)
   {
       S.E <- 0
       llikf <- 0
       fit.pois <- pois.fit(y)
       beta <- coefficients(fit.pois)
       lamb <- fitted(fit.pois)
       hii <- lm.influence(fit.pois)$hat #leverage
       al <- (sum((y-lamb)^2/lamb)-
             fit.pois$df.residual)/sum(lamb*(1-hii))
          al.old <- al
          al.new <- 0
          al.diff <- al.old
          i <- 0
       beta.al <- c(beta, al)
       plikf <- -2*sum(y*log(lamb)-lamb-lgamma(y+1))
       while(al.diff > 0.001) {
       trigam <- -(trigamma(y+1/al)-trigamma(1/al))
       digam <- digamma(y+1/al)-digamma(1/al)
       s1 <- (y - lamb)/(1+al * lamb)
       S1 <- t(X.mat) %*% s1   # for beta
       s2 <- -((al)^(-2) *(digam-(al*(y-lamb))/(1+al*lamb)
             -log(1+al*lamb)))
       S2 <- sum(s2)   #for alpha
       c1 <- ((1 + al * y) * lamb)/((1 + al * lamb)^2)
       I1 <- (t(X.mat) %*% diag(c1[1:length(c1)])) %*%X.mat
       i21 <- -(2*(al)^(-3)*(digam - (al*(y-lamb))/(1+al * lamb)
              -log(1+al*lamb)))
       i22 <- -(al)^(-4)*(-trigam+(y+al*lamb^2)/(1/al+lamb)^2)
       I2 <- i21 + i22
       I2 <- sum(I2)   #for alpha
       i12 <- (y - lamb) * lamb/((1 + al * lamb)^2)
       I12 <- t(X.mat) %*% i12 # for beta,alpha
       S <- c(S1, S2)
       PI1 <- c(I12, I2)
       PI2 <- rbind(I1, t(I12))
       PI <- cbind(PI2, PI1)
       library(MASS)
       PI.inv <- ginv(PI)
       S.E <- sqrt(PI.inv)
       beta.al <- beta.al + S %*% PI.inv
       beta <- beta.al[1:length(beta.al) - 1]
       lamb <- exp(X.mat%*%beta)
       aa <- beta.al[length(beta.al)]
```

```
      al <- ifelse(aa <= 0,0.05,aa)
      llik <- -2*sum(lgamma(y+1/(al))-lgamma(1/(al))
              +y*log(al*lamb/(1+al*lamb))-1/(al)*log(1+al*lamb))
      llikf <- llik+2*sum(lgamma(y+1))  #this includes y!term
      AIC <- llikf + 2*length(beta.al)
         al.new <- al
         al.diff <- abs((al.old - al.new))
         al.old <- al.new
         i <- i+1
         }
      beta <-round(beta,7)
      se <- NULL
      for(i in 1:nrow(S.E))
      {
      ii <- (S.E[i,i]); se <- c(se,ii)
      }
      ss1 <- s1 # for beta
      ss2 <- s2
      S2 <- sum(ss2^2)   #for alpha
      ss <- ss1*ss2
      ssbb<- t(X.mat)%*%ss
      w2 <- ss1^2
      w22 <- t(X.mat)%*%w2%*%X.mat
      ssbl <- rbind(ssbb,S2)   #for beta alpha 3x1
      sslb <- rbind(w22,t(ssbb)) # for beta beta alpha 3x2
      sws <- cbind(sslb ,ssbl)
      V <- PI.inv%*%(sws) %*% PI.inv
      V <- sqrt(V)
      se.beta <- round(se[1:length(beta)],7)
      len <- length(se.beta)+1
      se.al <- se[len]; len <- len +1
      zval.beta <- round(beta/se.beta, 7)
      pval.beta <- 2*pnorm(abs(zval.beta),lower.tail=F)
      y.sum <- cbind(beta,se.beta,zval.beta,pval.beta)
      colnames(y.sum) <- c("Estimate","Std.Error","z value",
                           "Pr(>|z|)")
      name <- dimnames(X.mat)[[2]]; name <- name[2:length(name)]
      rownames(y.sum) <- c("Intercept", name)
      Alpha <- rbind(al, se.al); colnames(Alpha) <- c("")
      rownames(Alpha) <- c("alpha :", "S.E (alpha)")
      result <- list(loglinear.model=y.sum,dispersion= Alpha
                ,beta.nb2=beta,al.nb2=al,SE=S.E,
                fitted.value=lamb,I.obs=PI,plikf=plikf,
                nblikf=llikf,AIC =AIC,no.iter=i,Robust.SE=V)

      result
   }
```

2. โปรแกรม plot กราฟ Half normal plot with simulated envelope ของตัวแบบถดถอยปัวซง

```
hnp<- function( object)
   {
       rmax <- 0 ; drmax <- 0
       rme <- 0 ; drme <- 0
       minr <- 0; dminr <- 0
       resides <- hnp.pois(object)
       r.sim <- resids
       sres <- r.sim[[1]]
       for(i in 1:nrow(r.sim[[2]])) {
       rmax[i] <- max(r.sim[[2]][i, ])
       rme[i] <- mean(r.sim[[2]][i, ])
       minr[i] <- min(r.sim[[2]][i, ])}
       rmin <- minr ; rmax <- rmax; rmean <- rme
       sres <-sres
       n <- length(sres)
       I <- seq(1,n,by=1)
       Nd <- qnorm((i+n-0.125)/(2*n+0.5))
       mi.y <- min(as.integer(sres))#1
       ma.y <- max(as.integer(c(sres,rmax)))+0.5 #1
       mi.x <- min(as.integer(nd))-0.5 #1
       ma.x <- max(as.integer(nd))+0.5 #1
       par(pty="s")
       plot(nd,sres,xlab="Half-poisson scores",main="poisson
            respone data",ylab="Standardizes Deviance
            Residuals",type="n",axes =F,ylim=c(mi.y,ma.y))
       axis(1,at=seq(mi.x ,ma.x , by=0.5))
       axis(2,at=seq(mi.y ,ma.y , by=0.25))
       points(nd,sres,pch=4,mkh=0.06)
       lines(nd,rmin,lty=1)
       lines(nd,rmean,lty=12)
       lines(nd,rmax,lty=1)
   }
hnp.pois <- function(object)
   {
       mu <- fitted(object)
       n <- length(mu)
       r.sim <- matrix(0 , n,19)
       rmax <- 0
       rme <- 0
       minr <- 0
       ys <- 0
       obres <- resid(object)
       hi <- lm.influence(object)$hat
       sres <- obres/sqrt((1-hi))
       sres <- sort(abs(sres))
       sd <- sqrt(object $deviance/ object $df.residual)
       for(i in 1:19) {
       ys <- rpois(n,mu)
       object $model[1] <- ys
       ys.glm <- glm(object $model,family=poisson)
       hi <- lm.influence(ys.glm)$hat
```

```
        r.sim[,i] <- resid(ys.glm)/sqrt((1-hi))
        r.sim[,i] <- sort(abs(r.sim[,i]))
        }
        resides <- list(sres=sres,r.sim=r.sim)
        resids
    }
```

3. โปรแกรมกราฟ Half normal plot with simulated envelope ของตัวแบบถดถอย NB2

```
hnp <- function( object,y,X.mat)
   {
        rmax <- 0 ; drmax <- 0
        rme <- 0; drme <- 0
        minr <- 0; dminr <- 0
        resides <- hnp.nb2(object,y,X.mat)
        r.sim <- resids
        sres <- r.sim[[1]]
        for(i in 1:nrow(r.sim[[2]])) {
        rmax[i] <- max(r.sim[[2]][i, ])
        rme[i] <- mean(r.sim[[2]][i, ])
        minr[i] <- min(r.sim[[2]][i, ])}
        rmin <- minr ; rmax <- rmax; rmean <- rme
        sres <-sres
        n <- length(sres)
        i <- seq(1,n,by=1)
        nd <- qnorm((i+n-0.125)/(2*n+0.5))
        mi.y <- min(as.integer(sres))#1
        ma.y <- max(as.integer(c(sres,rmax))) + 0.5 #1
        mi.x <- min(as.integer (nd))-0.5 #1
        ma.x <- max(as.integer (nd))+0.5 #1
        par(pty="s")
        plot(nd,sres,xlab="Half-normal scores",main="NB2 model"
             ,ylab="Standardizes deviance residuals",type="n" ,
             axes =F,ylim=c(mi.y,ma.y))
        axis(1,at=seq(mi.x ,ma.x , by=0.5))
        axis(2,at=seq(mi.y ,ma.y , by=0.25))
        points(nd,sres,pch=4,mkh=0.06)
        lines(nd,rmin,lty=1)
        lines(nd,rmean,lty=12)
        lines(nd,rmax,lty=1)
   }
hnp.nb2 <- function(object,y,X.mat)
   {
        mu <- fitted(object)
        n <- length(mu)
        al <- object$dispersion[1]
        r.sim <- matrix(0, n,19)
        rmax <- 0
        rme <- 0
        minr <- 0
```

```
        ys <- 0
        wii <- (1+(al*mu))*mu
        wii1 <- c(wii)
        wiim <- diag(wii1)
        hii <- diag(sqrt(wiim)%*%(X.mat%*%solve(t(X.mat)%*%wiim
               %*%X.mat)%*%t(X.mat))%*%sqrt(wiim))
        sres <- sqrt(2*(abs((y*log(y/mu))-((y+(1/al))
                *log((1+(al*y))/(1+(al*mu)))))))/sqrt(1-hii)
        sres <- round(sres, 4); sres<-sort(abs(sres))
        for(i in 1:19)
           {
           ee <- rgamma (n,1/al)*al
           ys <- rpois(n, mu*ee)
           ys.nb2 <- nb2.fit(ys,X.mat)
           mu.sim <- fitted(ys.nb2)
           al.sim <- ys.nb2$dispersion[1]
           wiis <- (1+( al.sim *mu.sim))*mu.sim
           wii1s <- c(wiis)
           wiims <- diag(wii1s)
           hiis <- diag(sqrt(wiims)%*%(X.mat%*%solve(t(X.mat)%*%
                   wiims%*%X.mat)%*%t(X.mat))%*%sqrt(wiims))
           r.sim[,i] <- sqrt(2*(abs((ys*log(ys/mu.sim))-ys))/
                        ((ys+(1/al.sim))*log((1+(al.sim*(1+(al.sim
                        *mu.sim)))))))/ sqrt(1-hiis)
           r.sim[,i] <- replace(r.sim[,i], r.sim[,i]=="NaN", 0)
           r.sim[,i] <- round(r.sim[,i],4)
           r.sim[,i] <- sort(abs(r.sim[,i]));is.na(r.sim[,i]) <- 0
             }
        resides <- list(sres=sres,r.sim=r.sim)
        resids
   }
```

4. โปรแกรม Simulation study สำหรับคำนวณค่าความน่าจะเป็นของการเกิด Type I error สำหรับ Score test ของ Dean (1992) และ Wang-Shu Lu (1997)

4.1 โปรแกรม Simulation study สำหรับคำนวณค่าคำนวณค่าความน่าจะเป็นของการเกิด Type I error

```
score_test <- function(object,z)
   {
        R <- 5000; sc.dean1 <- NULL ; sc.dean2 <- NULL
        sc.wang1 <- NULL ; sc.wang2 <- NULL
        ys <- 0
        mu <- fitted(object)
        n <- length(mu)
        for (i in 1: R)
           {
           ys <- rpois(n,mu)
```

```
          object$model[,1] <- ys
          ys.pois <- glm(object$model,family=poisson)
          dean1 <- function(object){
             mu <- fitted(object)
             y <- object$model[,1]
             n <- length(mu)
             for(i in 1:n){
                pb1 <- (sum((y-mu)^2 - y ))/(2*sum(mu^2))^(1/2)
             }
          pb1}
          dean2 <- function (object){
             mu <- fitted(object)
             y <- object$model[,1]
             n <- length(mu)
             hi<-lm.influence(object)$hat
                for(i in 1:n){
            pb2 <- (sum((y-mu)^2-y +(hi*mu)))/(2*sum(mu^2))^(1/2)
                }
          pb2}
          wang1 <- function (object){
             mu <- fitted(object)
             y <- object$model[,1]
             n <- length(mu)
                for(i in 1:n){
                s1 <- (sum((y-mu)^2 - y))/(2*sum(mu^2))^(1/2)
                }
          s1}
          wang2 <- function (object){
             mu <- fitted(object)
             y <- object$model[,1]
             n <- length(mu)
             p <-length(object$coefficient)
             c <- (n - p)/n
                for(i in 1:n){
                  s2 <- (sum((y-mu)^2-(c*y)))/(2*sum(mu^2))^(1/2)
                }
          s2}
          scd1 <- dean1(ys.pois)
          sc.dean1 <- c(sc.dean1,scd1)
          scd2 <- dean2(ys.pois)
          sc.dean2 <- c(sc.dean2,scd2)
          scw1 <- wang1(ys.pois)
          sc.wang1 <- c(sc.wang1,scw1)
          scw2 <- wang2(ys.pois)
          sc.wang2 <- c(sc.wang2,scw2)
        }
       pd1 <- sum(sc.dean1>=z) /R
       pd1 <- round(pd1,3)
       pd2 <- sum(sc.dean2>=z) /R
       pd2 <- round(pd2,3)
       pw1 <- sum(sc.wang1>=z)/R
       pw1 <- round(pw1,3)
       pw2 <- sum(sc.wang2>=z) /R
       pw2 <- round(pw2,3)
       sc.deanwang <- list(PD1=pd1,PD2=pd2,PW1=pw1,PW2=pw2)
}
```

4.2 โปรแกรมจัดค่าความน่าจะเป็นของการเกิด Type I error สำหรับ Score test ของ Dean (1992) เมื่อขนาดตัวอย่าง n = 25

```
score_testD1 <- function(object11,object12,object13,object14){
       z11_10 <- score_test(object11,1.281)
       z11_05 <- score_test(object11,1.645)
       z11_01 <- score_test(object11,2.326)
       z12_10 <- score_test(object12,1.281)
       z12_05 <- score_test(object12,1.645)
       z12_01 <- score_test(object12,2.326)
       z13_10 <- score_test(object13,1.281)
       z13_05 <- score_test(object13,1.645)
       z13_01 <- score_test(object13,2.326)
       z14_10 <- score_test(object14,1.281)
       z14_05 <- score_test(object14,1.645)
       z14_01 <- score_test(object14,2.326)
   model11 <- cbind(z11_10$PD1,z11_05$PD1,z11_01$PD1,z11_10$PD2,
              z11_05$PD2,z11_01$PD2)
   model12 <- cbind(z12_10$PD1,z12_05$PD1,z12_01$PD1,z12_10$PD2,
              z12_05$PD2,z12_01$PD2)
   model13 <- cbind(z13_10$PD1,z13_05$PD1,z13_01$PD1,z13_10$PD2,
              z13_05$PD2,z13_01$PD2)
   model14 <- cbind(z14_10$PD1,z14_05$PD1,z14_01$PD1,z14_10$PD2,
              z14_05$PD2,z14_01$PD2)
   model1 <- rbind(model11,model12,model13,model14)
   colnames(model1) <- c("PD1_0.10","PD_0.05","PD1_0.01",
                         "PD2_0.10" ,"PD2_0.05","PD2_0.01" )
   rownames(model1) <- c("model11","model12","model13","model14")
   result <- list(n_25=model1)
result
}
```

4.3 โปรแกรมจัดค่าความน่าจะเป็นของการเกิด Type I error สำหรับ Score test ของ Wang-Shu Lu (1997) เมื่อขนาดตัวอย่าง n = 25

```
score_testW1 <- function(object11,object12,object13,object14){
       z11_10 <- score_test(object11,1.281)
       z11_05 <- score_test(object11,1.645)
       z11_01 <- score_test(object11,2.325)
       z12_10 <- score_test(object12,1.281)
       z12_05 <- score_test(object12,1.645)
       z12_01 <- score_test(object12,2.325)
       z13_10 <- score_test(object13,1.281)
       z13_05 <- score_test(object13,1.645)
       z13_01 <- score_test(object13,2.325)
       z14_10 <- score_test(object14,1.281)
       z14_05 <- score_test(object14,1.645)
       z14_01 <- score_test(object14,2.325)
```

```
   model11 <- cbind(z11_10$PW1,z11_05$PW1,z11_01$PW1,z11_10$PW2,
               z11_05$PW2,z11_01$PW2)
   model12 <- cbind(z12_10$PW1,z12_05$PW1,z12_01$PW1,z12_10$PW2,
               z12_05$PW2,z12_01$PW2)
   model13 <- cbind(z13_10$PW1,z13_05$PW1,z13_01$PW1,z13_10$PW2,
               z13_05$PW2,z13_01$PW2)
   model14 <- cbind(z14_10$PW1,z14_05$PW1,z14_01$PW1,z14_10$PW2,
               z14_05$PW2,z14_01$PW2)
   model1 <- rbind(model11,model12,model13,model14)
   colnames(model1) <- c("PW1_0.10","PW1_0.05","PW1_0.01",
                         "PW2_0.10","PW2_0.05","PW2_0.01")
   rownames(model1) <- c("model11","model12","model13","model14")
   result <- list(n_25=model1)
result
}
```

4.4 โปรแกรมจัดค่าความน่าจะเป็นของการเกิด Type I error สำหรับ Score test ของ Dean (1992) เมื่อขนาดตัวอย่าง n = 50

```
score_testD2 <- function(object21,object22,object23,object24){
       z21_10 <- score_test(object21,1.281)
       z21_05 <- score_test(object21,1.645)
       z21_01 <- score_test(object21,2.326)
       z22_10 <- score_test(object22,1.281)
       z22_05 <- score_test(object22,1.645)
       z22_01 <- score_test(object22,2.326)
       z23_10 <- score_test(object23,1.281)
       z23_05 <- score_test(object23,1.645)
       z23_01 <- score_test(object23,2.326)
       z24_10 <- score_test(object24,1.281)
       z24_05 <- score_test(object24,1.645)
       z24_01 <- score_test(object24,2.326)
   model21 <- cbind(z21_10$PD1,z21_05$PD1,z21_01$PD1,z21_10$PD2,
              z21_05$PD2, z21_01$PD2)
   model22 <- cbind(z22_10$PD1,z22_05$PD1,z22_01$PD1,z22_10$PD2,
              z22_05$PD2, z22_01$PD2)
   model23 <- cbind(z23_10$PD1,z23_05$PD1,z23_01$PD1,z23_10$PD2,
              z23_05$PD2, z23_01$PD2)
   model24 <- cbind(z24_10$PD1,z24_05$PD1,z24_01$PD1,z24_10$PD2,
              z24_05$PD2, z24_01$PD2)
   model2 <- rbind(model21,model22,model23,model24)
   colnames(model2) <- c("PD1_0.10","PD1_0.05","PD1_0.01",
                         "PD2_0.10","PD2_0.05","PD2_0.01" )
   rownames(model2) <- c("model21","model22","model23","model24")
   result <- list(n_50=model2)
result
}
```

4.5 โปรแกรมจัดค่าความน่าจะเป็นของการเกิด Type I error สำหรับ Score test ของ Wang-Shu Lu (1997) เมื่อขนาดตัวอย่าง n = 50

```
score_testW2 <- function(object21,object22,object23,object24){
       z21_10 <- score_test(object21,1.281)
       z21_05 <- score_test(object21,1.645)
       z21_01 <- score_test(object21,2.326)
       z22_10 <- score_test(object22,1.281)
       z22_05 <- score_test(object22,1.645)
       z22_01 <- score_test(object22,2.326)
       z23_10 <- score_test(object23,1.281)
       z23_05 <- score_test(object23,1.645)
       z23_01 <- score_test(object23,2.326)
       z24_10 <- score_test(object24,1.281)
       z24_05 <- score_test(object24,1.645)
       z24_01 <- score_test(object24,2.326)
   model21 <- cbind(z21_10$PW1,z21_05$PW1,z21_01$PW1,z21_10$PW2,
              z21_05$PW2,z21_01$PW2)
   model22 <- cbind(z22_10$PW1,z22_05$PW1,z22_01$PW1,z22_10$PW2,
              z22_05$PW2,z22_01$PW2)
   model23 <- cbind(z23_10$PW1,z23_05$PW1,z23_01$PW1,z23_10$PW2,
              z23_05$PW2,z23_01$PW2)
   model24 <- cbind(z24_10$PW1,z24_05$PW1,z24_01$PW1,z24_10$PW2,
              z24_05$PW2, z24_01$PW2)
   model2 <- rbind(model21,model22,model23,model24)
   colnames(model2) <- c("PW1_0.10","PW1_0.05","PW1_0.01",
                         "PW2_0.10","PW2_0.05","PW2_0.01")
   rownames(model2) <- c("model21","model22","model23","model24")
   result <- list(n_50=model2)
result
}
```

4.6 โปรแกรมจัดค่าความน่าจะเป็นของการเกิด Type I error สำหรับ Score test ของ Dean (1992) เมื่อขนาดตัวอย่าง n = 75

```
score_testD3 <- function(object31,object32,object33,object34){
       z31_10 <- score_test(object31,1.281)
       z31_05 <- score_test(object31,1.645)
       z31_01 <- score_test(object31,2.326)
       z32_10 <- score_test(object32,1.281)
       z32_05 <- score_test(object32,1.645)
       z32_01 <- score_test(object32,2.326)
       z33_10 <- score_test(object33,1.281)
       z33_05 <- score_test(object33,1.645)
       z33_01 <- score_test(object33,2.326)
       z34_10 <- score_test(object34,1.281)
       z34_05 <- score_test(object34,1.645)
       z34_01 <- score_test(object34,2.326)
```

```
   model31 <- cbind(z31_10$PD1,z31_05$PD1,z31_01$PD1,z31_10$PD2,
              z31_05$PD2,z31_01$PD2)
   model32 <- cbind(z32_10$PD1,z32_05$PD1,z32_01$PD1,z32_10$PD2,
              z32_05$PD2,z32_01$PD2)
   model33 <- cbind(z33_10$PD1,z33_05$PD1,z33_01$PD1,z33_10$PD2,
              z33_05$PD2,z33_01$PD2)
   model34 <- cbind(z34_10$PD1,z34_05$PD1,z34_01$PD1,z34_10$PD2,
              z34_05$PD2,z34_01$PD2)
   model3 <- rbind(model31,model32,model33,model34)
   colnames(model3) <- c("PD1_0.10","PD1_0.05","PD1_0.01",
                       "PD2_0.10","PD2_0.05","PD2_0.01")
   rownames(model3) <- c("model31","model32","model33","model34")
   result <- list(n_75=model3)
result
}
```

4.7 โปรแกรมจัดค่าความน่าจะเป็นของการเกิด Type I error สำหรับ Score test ของ Wang-Shu Lu (1997) เมื่อขนาดตัวอย่าง n = 75

```
score_testW3 <- function(object31,object32,object33,object34){
       z31_10 <- score_test(object31,1.281)
       z31_05 <- score_test(object31,1.645)
       z31_01 <- score_test(object31,2.326)
       z32_10 <- score_test(object32,1.281)
       z32_05 <- score_test(object32,1.645)
       z32_01 <- score_test(object32,2.326)
       z33_10 <- score_test(object33,1.281)
       z33_05 <- score_test(object33,1.645)
       z33_01 <- score_test(object33,2.326)
       z34_10 <- score_test(object34,1.281)
       z34_05 <- score_test(object34,1.645)
       z34_01 <- score_test(object34,2.326)
   model31 <- cbind(z31_10$PW1,z31_05$PW1,z31_01$PW1,z31_10$PW2,
              z31_05$PW2,z31_01$PW2)
   model32 <- cbind(z32_10$PW1,z32_05$PW1,z32_01$PW1,z32_10$PW2,
              z32_05$PW2,z32_01$PW2)
   model33 <- cbind(z33_10$PW1,z33_05$PW1,z33_01$PW1,z33_10$PW2,
              z33_05$PW2,z33_01$PW2)
   model34 <- cbind(z34_10$PW1,z34_05$PW1,z34_01$PW1,z34_10$PW2,
              z34_05$PW2,z34_01$PW2)
   model3 <- rbind(model31,model32,model33,model34)
   colnames(model3) <- c("PW1_0.10","PW1_0.05","PW1_0.01",
                       "PW2_0.10", "PW2_0.05", "PW2_0.01" )
   rownames(model3) <- c("model31","model32","model33","model34")
   result <- list(n_75=model3)
result
}
```

4.8 โปรแกรมจัดค่าความน่าจะเป็นของการเกิด Type I error สำหรับ Score test ของ Dean (1992) เมื่อขนาดตัวอย่าง n = 100

```
score_testD4 <- function(object41,object42,object43,object44){
       z41_10 <- score_test(object41,1.281)
       z41_05 <- score_test(object41,1.645)
       z41_01 <- score_test(object41,2.326)
       z42_10 <- score_test(object42,1.281)
       z42_05 <- score_test(object42,1.645)
       z42_01 <- score_test(object42,2.326)
       z43_10 <- score_test(object43,1.281)
       z43_05 <- score_test(object43,1.645)
       z43_01 <- score_test(object43,2.326)
       z44_10 <- score_test(object44,1.281)
       z44_05 <- score_test(object44,1.645)
       z44_01 <- score_test(object44,2.326)
   model41 <- cbind(z41_10$PD1,z41_05$PD1,z41_01$PD1,z41_10$PD2,
              z41_05$PD2,z41_01$PD2)
   model42 <- cbind(z42_10$PD1,z42_05$PD1,z42_01$PD1,z42_10$PD2,
              z42_05$PD2,z42_01$PD2)
   model43 <- cbind(z43_10$PD1,z43_05$PD1,z43_01$PD1,z43_10$PD2,
              z43_05$PD2,z43_01$PD2)
   model44 <- cbind(z44_10$PD1,z44_05$PD1,z44_01$PD1,z44_10$PD2,
              z44_05$PD2,z44_01$PD2)
   model4 <- rbind(model41,model42,model43,model44)
   colnames(model4) <- c("PD1_0.10","PD1_0.05","PD1_0.01",
                         "PD2_0.10", "PD2_0.05", "PD2_0.01" )
   rownames(model4) <- c("model41","model42","model43","model44")
   result <- list(n_100=model4)
result
}
```

4.9 โปรแกรมจัดค่าความน่าจะเป็นของการเกิด Type I error สำหรับ Score test ของ Wang-Shu Lu (1997) เมื่อขนาดตัวอย่าง n = 100

```
score_testW4 <- function(object41,object42,object43,object44){
       z41_10 <- score_test(object41,1.281)
       z41_05 <- score_test(object41,1.645)
       z41_01 <- score_test(object41,2.326)
       z42_10 <- score_test(object42,1.281)
       z42_05 <- score_test(object42,1.645)
       z42_01 <- score_test(object42,2.326)
       z43_10 <- score_test(object43,1.281)
       z43_05 <- score_test(object43,1.645)
       z43_01 <- score_test(object43,2.326)
       z44_10 <- score_test(object44,1.281)
       z44_05 <- score_test(object44,1.645)
       z44_01 <- score_test(object44,2.326)
```

```
   model41 <- cbind(z41_10$PW1,z41_05$PW1,z41_01$PW1,z41_10$PW2,
              z41_05$PW2,z41_01$PW2)
   model42 <- cbind(z42_10$PW1,z42_05$PW1,z42_01$PW1,z42_10$PW2,
              z42_05$PW2, z42_01$PW2)
   model43 <- cbind(z43_10$PW1,z43_05$PW1,z43_01$PW1,z43_10$PW2,
              z43_05$PW2,z43_01$PW2)
   model44 <- cbind(z44_10$PW1,z44_05$PW1,z44_01$PW1,z44_10$PW2,
              z44_05$PW2, z44_01$PW2)
   model4 <- rbind(model41,model42,model43,model44)
   colnames(model4) <- c("PW1_0.10","PW1_0.05","PW1_0.01",
                         "PW2_0.10", "PW2_0.05", "PW2_0.01" )
   rownames(model4) <- c("model41","model42","model43","model44")
   result <- list(n_100=model4)
result
}
```

5. โปรแกรม Simulation study สำหรับคำนวณ Power of the test ของ Score test ของ Dean (1992) และ Wang-Shu Lu (1997)

5.1 โปรแกรม Simulation study สำหรับคำนวณ Power of the test

```
score_test <- function(object,z,al) {
       R <- 5000; sc.dean1 <- NULL ; sc.dean2 <- NULL
       sc.wang1 <- NULL ; sc.wang2 <- NULL
       ys <- 0
       mu <- fitted(object)
       n <- length(mu)
       al <- 0.25
       for (i in 1: R) {
          ee <- rgamma(n,1/al)*al
          ys <- rpois(n, mu*ee)
          object$model[,1] <- ys
          ys.pois <- glm(object$model,family=poisson)
          dean1 <- function (object){
             mu <- fitted(object)
             y <- object$model[,1]
             n <- length(mu)
             for(i in 1:n){
                pb1 <- (sum((y-mu)^2-y))/(2*sum(mu^2))^(1/2)
             }
          pb1}
          dean2 <- function(object){
             mu <- fitted(object)
             y <- object$model[,1]
             n <- length(mu)
             hi <- lm.influence(object)$hat
             for(i in 1:n){
```

```
            pb2 <- (sum((y-mu)^2-y+(hi*mu)))/(2*sum(mu^2))^(1/2)
               }
            pb2
            }
            wang1 <- function(object){
               mu <- fitted(object)
               y <- object$model[,1]
               n <- length(mu)
               for(i in 1:n){
                  s1 <- (sum((y-mu)^2-y))/(2*sum(mu^2))^(1/2)
               }
            s1}
            wang2 <- function(object){
               mu <- fitted(object)
               y <- object$model[,1]
               n <- length(mu)
               p <- length(object$coefficient)
               c <- (n - p)/n
               for(i in 1:n){
                  s2 <- (sum((y-mu)^2 -(c*y)))/(2*sum(mu^2))^(1/2)
               }
            s2
            }
         scd1 <- dean1(ys.pois)
         sc.dean1 <- c(sc.dean1,scd1)
         scd2 <- dean2(ys.pois)
         sc.dean2 <- c(sc.dean2,scd2)
         scw1 <- wang1(ys.pois)
         sc.wang1 <- c(sc.wang1,scw1)
         scw2 <- wang2(ys.pois)
         sc.wang2 <- c(sc.wang2,scw2)
         }
         qd1 <- sum(sc.dean1<z)/R
         qd1 <- 1-qd1
         qd1 <- round(qd1,3)
         qd2 <- sum(sc.dean2<z)/R
         qd2 <- 1-qd2
         qd2 <- round(qd2,3)
         qw1 <- sum(sc.wang1<z)/R
         qw1 <- 1-qw1
         qw1 <- round(qw1,3)
         qw2 <- sum(sc.wang2<z)/R
         qw2 <- 1-qw2
         qw2 <- round(qw2,3)
         sc.deanwang <- list(QD1=qd1,QD2=qd2,QW1=qw1,QW2=qw2)
}
```

5.2 โปรแกรมจัดค่า Power of the test สำหรับ Score test ของ Dean (1992) เมื่อขนาดตัวอย่าง n = 25

```
score_testD1 <- function(object11,object12,object13,object14){
       z11_10 <- score_test(object11,1.281)
       z11_05 <- score_test(object11,1.645)
       z11_01 <- score_test(object11,2.326)
       z12_10 <- score_test(object12,1.281)
       z12_05 <- score_test(object12,1.645)
       z12_01 <- score_test(object12,2.326)
       z13_10 <- score_test(object13,1.281)
       z13_05 <- score_test(object13,1.645)
       z13_01 <- score_test(object13,2.326)
       z14_10 <- score_test(object14,1.281)
       z14_05 <- score_test(object14,1.645)
       z14_01 <- score_test(object14,2.326)
   model11 <- cbind(z11_10$QD1,z11_05$QD1,z11_01$QD1,z11_10$QD2,
              z11_05$QD2,z11_01$QD2)
   model12 <- cbind(z12_10$QD1,z12_05$QD1,z12_01$QD1,z12_10$QD2,
              z12_05$QD2,z12_01$QD2)
   model13 <- cbind(z13_10$QD1,z13_05$QD1,z13_01$QD1,z13_10$QD2,
              z13_05$QD2, z13_01$QD2)
   model14 <- cbind(z14_10$QD1,z14_05$QD1,z14_01$QD1,z14_10$QD2,
              z14_05$QD2,z14_01$QD2)
   model1 <- rbind(model11,model12,model13,model14)
   colnames(model1) <- c("QD1_0.10","QD_0.05","QD1_0.01",
                         "QD2_0.10","QD2_0.05","QD2_0.01")
   rownames(model1) <- c("model11","model12","model13","model14")
   result <- list(n_25=model1)
result
}
```

5.3 โปรแกรมจัดค่า Power of the test สำหรับ Score test ของ Wang-Shu Lu (1997) เมื่อขนาดตัวอย่าง n = 25

```
score_testW1 <- function(object11,object12,object13,object14){
       z11_10 <- score_test(object11,1.281)
       z11_05 <- score_test(object11,1.645)
       z11_01 <- score_test(object11,2.325)
       z12_10 <- score_test(object12,1.281)
       z12_05 <- score_test(object12,1.645)
       z12_01 <- score_test(object12,2.325)
       z13_10 <- score_test(object13,1.281)
       z13_05 <- score_test(object13,1.645)
       z13_01 <- score_test(object13,2.325)
       z14_10 <- score_test(object14,1.281)
       z14_05 <- score_test(object14,1.645)
       z14_01 <- score_test(object14,2.325)
```

```
   model11 <- cbind(z11_10$QW1,z11_05$QW1,z11_01$QW1,z11_10$QW2,
               z11_05$QW2,z11_01$QW2)
   model12 <- cbind(z12_10$QW1,z12_05$QW1,z12_01$QW1,z12_10$QW2,
               z12_05$QW2,z12_01$QW2)
   model13 <- cbind(z13_10$QW1,z13_05$QW1,z13_01$QW1,z13_10$QW2,
               z13_05$QW2,z13_01$QW2)
   model14 <- cbind(z14_10$QW1,z14_05$QW1,z14_01$QW1,z14_10$QW2,
               z14_05$QW2,z14_01$QW2)
   model1 <- rbind(model11,model12,model13,model14)
   colnames(model1) <- c("QW1_0.10","QW1_0.05","QW1_0.01",
                         "QW2_0.10","QW2_0.05","QW2_0.01")
   rownames(model1) <- c("model11","model12","model13","model14")
   result <- list(n_25=model1)
result
}
```

5.3 โปรแกรมจัดค่า Power of the test สำหรับ Score test ของ Dean (1992) เมื่อขนาดตัวอย่าง n = 50

```
score_testD2 <- function(object21,object22,object23,object24){
        z21_10 <- score_test(object21,1.281)
        z21_05 <- score_test(object21,1.645)
        z21_01 <- score_test(object21,2.326)
        z22_10 <- score_test(object22,1.281)
        z22_05 <- score_test(object22,1.645)
        z22_01 <- score_test(object22,2.326)
        z23_10 <- score_test(object23,1.281)
        z23_05 <- score_test(object23,1.645)
        z23_01 <- score_test(object23,2.326)
        z24_10 <- score_test(object24,1.281)
        z24_05 <- score_test(object24,1.645)
        z24_01 <- score_test(object24,2.326)
   model21 <- cbind(z21_10$QD1,z21_05$QD1,z21_01$QD1,z21_10$QD2,
               z21_05$QD2, z21_01$QD2)
   model22 <- cbind(z22_10$QD1,z22_05$QD1,z22_01$QD1,z22_10$QD2,
               z22_05$QD2, z22_01$QD2)
   model23 <- cbind(z23_10$QD1,z23_05$QD1,z23_01$QD1,z23_10$QD2,
               z23_05$QD2, z23_01$QD2)
   model24 <- cbind(z24_10$QD1,z24_05$QD1,z24_01$QD1,z24_10$QD2,
               z24_05$QD2,z24_01$QD2)
   model2 <- rbind(model21,model22,model23,model24)
   colnames(model2) <- c("QD1_0.10","QD1_0.05","QD1_0.01",
                         "QD2_0.10", "QD2_0.05", "QD2_0.01" )
   rownames(model2) <- c("model21","model22","model23","model24")
   result <- list(n_50=model2)
result
}
```

5.5 โปรแกรมจัดค่า Power of the test สำหรับ Score test ของ Wang-Shu Lu (1997) เมื่อขนาดตัวอย่าง n = 50

```
score_testW2 <- function(object21,object22,object23,object24){
       z21_10 <- score_test(object21,1.281)
       z21_05 <- score_test(object21,1.645)
       z21_01 <- score_test(object21,2.326)
       z22_10 <- score_test(object22,1.281)
       z22_05 <- score_test(object22,1.645)
       z22_01 <- score_test(object22,2.326)
       z23_10 <- score_test(object23,1.281)
       z23_05 <- score_test(object23,1.645)
       z23_01 <- score_test(object23,2.326)
       z24_10 <- score_test(object24,1.281)
       z24_05 <- score_test(object24,1.645)
       z24_01 <- score_test(object24,2.326)
   model21 <- cbind(z21_10$QW1,z21_05$QW1,z21_01$QW1,z21_10$QW2,
              z21_05$QW2, z21_01$QW2)
   model22 <- cbind(z22_10$QW1,z22_05$QW1,z22_01$QW1,z22_10$QW2,
              z22_05$QW2,z22_01$QW2)
   model23 <- cbind(z23_10$QW1,z23_05$QW1,z23_01$QW1,z23_10$QW2,
              z23_05$QW2,z23_01$QW2)
   model24 <- cbind(z24_10$QW1,z24_05$QW1,z24_01$QW1,z24_10$QW2,
              z24_05$QW2,z24_01$QW2)
   model2 <- rbind(model21,model22,model23,model24)
   colnames(model2) <- c("QW1_0.10","QW1_0.05","QW1_0.01",
                         "QW2_0.10","QW2_0.05","QW2_0.01")
   rownames(model2) <- c("model21","model22","model23","model24")
   result <- list(n_50=model2)
result
}
```

5.6 โปรแกรมจัดค่า Power of the test สำหรับ Score test ของ Dean (1992) เมื่อขนาดตัวอย่าง n = 75

```
score_testD3 <- function(object31, object32, object33, object34){
       z31_10 <- score_test(object31,1.281)
       z31_05 <- score_test(object31,1.645)
       z31_01 <- score_test(object31,2.326)
       z32_10 <- score_test(object32,1.281)
       z32_05 <- score_test(object32,1.645)
       z32_01 <- score_test(object32,2.326)
       z33_10 <- score_test(object33,1.281)
       z33_05 <- score_test(object33,1.645)
       z33_01 <- score_test(object33,2.326)
       z34_10 <- score_test(object34,1.281)
       z34_05 <- score_test(object34,1.645)
       z34_01 <- score_test(object34,2.326)
```

```
   model31 <- cbind(z31_10$QD1,z31_05$QD1,z31_01$QD1,z31_10$QD2,
               z31_05$QD2,z31_01$QD2)
   model32 <- cbind(z32_10$QD1,z32_05$QD1,z32_01$QD1,z32_10$QD2,
               z32_05$QD2,z32_01$QD2)
   model33 <- cbind(z33_10$QD1,z33_05$QD1,z33_01$QD1,z33_10$QD2,
               z33_05$QD2,z33_01$QD2)
   model34 <- cbind(z34_10$QD1,z34_05$QD1,z34_01$QD1,z34_10$QD2,
               z34_05$QD2,z34_01$QD2)
   model3 <- rbind(model31,model32,model33,model34)
   colnames(model3) <- c("QD1_0.10","QD1_0.05","QD1_0.01",
                         "QD2_0.10","QD2_0.05","QD2_0.01" )
   rownames(model3) <- c("model31","model32","model33","model34")
   result <- list(n_75=model3)
result
}
```

5.7 โปรแกรมจัดค่า Power of the test สำหรับ Score test ของ Wang-Shu Lu (1997) เมื่อขนาดตัวอย่าง n = 75

```
score_testW3 <- function(object31,object32,object33,object34){
       z31_10 <- score_test(object31,1.281)
       z31_05 <- score_test(object31,1.645)
       z31_01 <- score_test(object31,2.326)
       z32_10 <- score_test(object32,1.281)
       z32_05 <- score_test(object32,1.645)
       z32_01 <- score_test(object32,2.326)
       z33_10 <- score_test(object33,1.281)
       z33_05 <- score_test(object33,1.645)
       z33_01 <- score_test(object33,2.326)
       z34_10 <- score_test(object34,1.281)
       z34_05 <- score_test(object34,1.645)
       z34_01 <- score_test(object34,2.326)
   model31 <- cbind(z31_10$QW1,z31_05$QW1,z31_01$QW1,z31_10$QW2,
               z31_05$QW2,z31_01$QW2)
   model32 <- cbind(z32_10$QW1,z32_05$QW1,z32_01$QW1,z32_10$QW2,
               z32_05$QW2,z32_01$QW2)
   model33 <- cbind(z33_10$QW1,z33_05$QW1,z33_01$QW1,z33_10$QW2,
               z33_05$QW2,z33_01$QW2)
   model34 <- cbind(z34_10$QW1,z34_05$QW1,z34_01$QW1,z34_10$QW2,
               z34_05$QW2,z34_01$QW2)
   model3 <- rbind(model31,model32,model33,model34)
   colnames(model3) <- c("QW1_0.10","QW1_0.05","QW1_0.01",
                         "QW2_0.10","QW2_0.05","QW2_0.01" )
   rownames(model3) <- c("model31","model32","model33","model34")
   result <- list(n_75=model3)
result
}
```

5.7 โปรแกรมจัดค่า Power of the test สำหรับ Score test ของ Dean (1992) เมื่อขนาดตัวอย่าง n = 100

```
score_testD4 <- function(object41,object42,object43,object44){
       z41_10 <- score_test(object41,1.281)
       z41_05 <- score_test(object41,1.645)
       z41_01 <- score_test(object41,2.326)
       z42_10 <- score_test(object42,1.281)
       z42_05 <- score_test(object42,1.645)
       z42_01 <- score_test(object42,2.326)
       z43_10 <- score_test(object43,1.281)
       z43_05 <- score_test(object43,1.645)
       z43_01 <- score_test(object43,2.326)
       z44_10 <- score_test(object44,1.281)
       z44_05 <- score_test(object44,1.645)
       z44_01 <- score_test(object44,2.326)
   model41 <- cbind(z41_10$QD1,z41_05$QD1,z41_01$QD1,z41_10$QD2,
              z41_05$QD2,z41_01$QD2)
   model42 <- cbind(z42_10$QD1,z42_05$QD1,z42_01$QD1,z42_10$QD2,
              z42_05$QD2,z42_01$QD2)
   model43 <- cbind(z43_10$QD1,z43_05$QD1,z43_01$QD1,z43_10$QD2,
              z43_05$QD2,z43_01$QD2)
   model44 <- cbind(z44_10$QD1,z44_05$QD1,z44_01$QD1,z44_10$QD2,
              z44_05$QD2,z44_01$QD2)
   model4 <- rbind(model41,model42,model43,model44)
   colnames(model4) <- c("QD1_0.10","QD1_0.05","QD1_0.01",
                       "QD2_0.10", "QD2_0.05","QD2_0.01" )
   rownames(model4) <- c("model41","model42","model43","model44")
   result <- list(n_100=model4)
result
}
```

5.9 โปรแกรมจัดค่า Power of the test สำหรับ Score test ของ Wang-Shu Lu (1997) เมื่อขนาดตัวอย่าง n = 100

```
score_testW4 <- function(object41, object42, object43, object44){
       z41_10 <- score_test(object41,1.281)
       z41_05 <- score_test(object41,1.645)
       z41_01 <- score_test(object41,2.326)
       z42_10 <- score_test(object42,1.281)
       z42_05 <- score_test(object42,1.645)
       z42_01 <- score_test(object42,2.326)
       z43_10 <- score_test(object43,1.281)
       z43_05 <- score_test(object43,1.645)
       z43_01 <- score_test(object43,2.326)
       z44_10 <- score_test(object44,1.281)
       z44_05 <- score_test(object44,1.645)
       z44_01 <- score_test(object44,2.326)
```

```
   model41 <- cbind(z41_10$QW1,z41_05$QW1,z41_01$QW1,z41_10$QW2,
              z41_05$QW2,z41_01$QW2)
   model42 <- cbind(z42_10$QW1,z42_05$QW1,z42_01$QW1,z42_10$QW2,
              z42_05$QW2,z42_01$QW2)
   model43 <- cbind(z43_10$QW1,z43_05$QW1,z43_01$QW1,z43_10$QW2,
              z43_05$QW2,z43_01$QW2)
   model44 <- cbind(z44_10$QW1,z44_05$QW1,z44_01$QW1,z44_10$QW2,
              z44_05$QW2,z44_01$QW2)
   model4 <- rbind(model41,model42,model43,model44)
   colnames(model4) <- c("QW1_0.10","QW1_0.05","QW1_0.01",
                         "QW2_0.10","QW2_0.05","QW2_0.01")
   rownames(model4) <- c("model41","model42","model43","model44")
   result <- list(n_100=model4)
result
}
```

6. โปรแกรม Simulation study สำหรับ Robust standard error จำลองข้อมูลภายใต้การแจกแจง NB2 ทำการ fit NB2

6.1 โปรแกรม Simulation study สำหรับ Robust standard error จำลองข้อมูลภายใต้การแจกแจง NB2 แล้ว fit NB2 ของตัวแบบ $\ln(\mu) = 1.95$

```
pois.fit <- function(y) {
   y.pois <- glm(y~1,family=poisson)
   y.pois
}

robust.nb2 <- function(beta, al ,X.mat) {
       ys <- 0
       se.nb2.beta0 <- NULL; se.nb2.al <- NULL
       rv.nb2.beta0 <- NULL; rv.nb2.al <- NULL
       beta0.nb2.sim <- NULL; al.nb2.sim <- NULL
       mu <- exp(X.mat%*%beta); n <- length(mu)
       source("nb2fit.robust.txt")
       for (i in 1:R) {
          ee <- rgamma(n,1/al)*al
          ys <- rpois(n, mu*ee)
          ys.nb2R <- nb2.fit.robust(ys,X.mat)
          beta0.nb2.sim <- c(ys.nb2R$beta.nb2[1],beta0.nb2.sim)
          al.nb2.sim <- c(al.nb2.sim,ys.nb2R$al.nb2)
          se1.nb2 <-ys.nb2R$SE
          se2.nb2 <-diag(se1.nb2); se20.nb2 <- se2.nb2[1]
          se2al.nb2 <- se2.nb2[2]
          se.nb2.beta0 <- c(se.nb2.beta0, se20.nb2)
          se.nb2.al <- c(se.nb2.al, se2al.nb2)
          rv1.nb2 <-ys.nb2R$Robust.SE
          rv2.nb2 <- diag(rv1.nb2); rv20.nb2 <- rv2.nb2[1]
          rv2al.nb2 <- rv2.nb2[2]
          rv.nb2.beta0 <- c(rv.nb2.beta0, rv20.nb2)
          rv.nb2.al <- c(rv.nb2.al, rv2al.nb2)
```

```
          un.nb2.beta0 <- var(beta0.nb2.sim)
          un.nb2.beta0 <- sqrt(un.nb2.beta0)
          un.nb2.beta0 <- round(un.nb2.beta0,5)
          un.nb2.al <- var(al.nb2.sim)
          un.nb2.al <- sqrt(un.nb2.al)
          un.nb2.al <- round(un.nb2.al,5)
       }
       beta0.nb2.sim1 <- mean(beta0.nb2.sim,na.rm=T)
       beta0.nb2.sim1 <- round(beta0.nb2.sim1,5)
       al.nb2.sim1 <- mean(al.nb2.sim,na.rm=T)
       al.nb2.sim1 <- round(al.nb2.sim1,5)
       se.nb2.beta0 <- mean(se.nb2.beta0,na.rm=T)
       se.nb2.beta0 <- round(se.nb2.beta0,5)
       se.nb2.al <- mean(se.nb2.al,na.rm=T)
       se.nb2.al <- round(se.nb2.al,5)
       rv.nb2.beta0 <- mean(rv.nb2.beta0,na.rm=T)
       rv.nb2.beta0 <- round(rv.nb2.beta0,5)
       rv.nb2.al <- mean(rv.nb2.al,na.rm=T)
       rv.nb2.al <- round(rv.nb2.al,5)
       beta0_NB2 <- cbind(beta0.nb2.sim1,se.nb2.beta0,
                    rv.nb2.beta0,un.nb2.beta0)
       al_NB2 <- cbind(al.nb2.sim1,se.nb2.al,rv.nb2.al,un.nb2.al)
       totalNB2 <- rbind(beta0_NB2,al_NB2)
       colnames(totalNB2) <- c("seta","Asy.SE","Robust.SE",
                              "Unbias.SE")
       rownames(totalNB2) <- c( "beta0" , "alpha")
       result <- list( NB2=totalNB2 )
result
}
```

6.2 โปรแกรม Simulation study สำหรับ Robust standard error จำลองข้อมูลภายใต้การแจกแจง NB2 แล้ว fit NB2 ของตัวแบบ $\ln(\mu) = 2.5 + 0.5x_1$

```
pois.fit <- function(y) {
   y.pois <- glm(y~x11,family=poisson)
   y.pois
}

robust.nb2 <- function(beta, al ,X.mat) {
       ys <- 0
       se.nb2.beta0 <- NULL; se.nb2.beta1 <- NULL
       se.nb2.al <- NULL; rv.nb2.beta0 <- NULL
       rv.nb2.beta1 <- NULL; rv.nb2.al <- NULL
       beta0.nb2.sim <- NULL; beta1.nb2.sim <- NULL
       al.nb2.sim <- NULL
       mu <- exp(X.mat%*%beta); n <- length(mu)
       source("nb2fit.robust.txt")
       for (i in 1:R) {
          ee <- rgamma (n,1/al)*al
          ys <- rpois(n, mu*ee)
```

```
          ys.nb2R <- nb2.fit.robust(ys,X.mat)
          beta0.nb2.sim <- c(ys.nb2R$beta.nb2[1],beta0.nb2.sim)
          beta1.nb2.sim <- c(ys.nb2R $beta.nb2[2],beta1.nb2.sim)
          al.nb2.sim <- c(al.nb2.sim, ys.nb2R$al.nb2)
          se1.nb2<-ys.nb2R$SE
          se2.nb2 <- diag(se1.nb2); se20.nb2 <- se2.nb2[1];
          se21.nb2 <- se2.nb2[2]; se2al.nb2 <- se2.nb2[3]
          se.nb2.beta0 <- c(se.nb2.beta0, se20.nb2)
          se.nb2.beta1 <- c(se.nb2.beta1, se21.nb2)
          se.nb2.al <- c(se.nb2.al, se2al.nb2)
          rv1.nb2 <-ys.nb2R$Robust.SE
          rv2.nb2 <- diag(rv1.nb2); rv20.nb2 <- rv2.nb2[1];
          rv21.nb2 <- rv2.nb2[2] ; rv2al.nb2 <- rv2.nb2[3]
          rv.nb2.beta0 <- c(rv.nb2.beta0,rv20.nb2)
          rv.nb2.beta1 <- c(rv.nb2.beta1,rv21.nb2)
          rv.nb2.al <- c(rv.nb2.al,rv2al.nb2)
          un.nb2.beta0 <- var(beta0.nb2.sim)
          un.nb2.beta0 <- sqrt(un.nb2.beta0)
          un.nb2.beta0 <- round(un.nb2.beta0,5)
          un.nb2.beta1 <- var(beta1.nb2.sim)
          un.nb2.beta1 <- sqrt(un.nb2.beta1)
          un.nb2.beta1 <- round(un.nb2.beta1,5)
          un.nb2.al <- var(al.nb2.sim)
          un.nb2.al <- sqrt(un.nb2.al)
          un.nb2.al <- round(un.nb2.al,5)
       }
       beta0.nb2.sim1 <- mean(beta0.nb2.sim,na.rm=T)
       beta0.nb2.sim1 <- round(beta0.nb2.sim1,5)
       beta1.nb2.sim1 <- mean(beta1.nb2.sim,na.rm=T)
       beta1.nb2.sim1 <- round(beta1.nb2.sim1,5)
       al.nb2.sim1 <- mean(al.nb2.sim,na.rm=T)
       al.nb2.sim1 <- round(al.nb2.sim1,5)
       se.nb2.beta0 <- mean(se.nb2.beta0,na.rm=T)
       se.nb2.beta0 <- round(se.nb2.beta0,5)
       se.nb2.beta1 <- mean(se.nb2.beta1,na.rm=T)
       se.nb2.beta1 <- round(se.nb2.beta1,5)
       se.nb2.al <- mean(se.nb2.al,na.rm=T)
       se.nb2.al <- round(se.nb2.al,5)
       rv.nb2.beta0 <- mean(rv.nb2.beta0,na.rm=T)
       rv.nb2.beta0 <- round(rv.nb2.beta0,5)
       rv.nb2.beta1 <- mean(rv.nb2.beta1,na.rm=T)
       rv.nb2.beta1 <- round(rv.nb2.beta1,5)
       rv.nb2.al <- mean(rv.nb2.al,na.rm=T)
       rv.nb2.al <- round(rv.nb2.al,5)
       beta0_NB2 <- cbind(beta0.nb2.sim1,se.nb2.beta0,
                    rv.nb2.beta0,un.nb2.beta0)
       beta1_NB2 <- cbind(beta1.nb2.sim1,se.nb2.beta1,
                    rv.nb2.beta1,un.nb2.beta1)
       al_NB2 <- cbind(al.nb2.sim1,se.nb2.al,rv.nb2.al,un.nb2.al)
       totalNB2 <- rbind(beta0_NB2,beta1_NB2,al_NB2)
       colnames(totalNB2) <- c("seta","Asy.SE","Robust.SE" ,
                             "Unbias.SE")
       rownames(totalNB2) <- c("beta0","beta1","alpha")
       result <- list( NB2=totalNB2 )
result
}
```

6.3 โปรแกรม Simulation study สำหรับ Robust standard error จำลองข้อมูลภายใต้การแจกแจง NB2 แล้ว fit NB2 ของตัวแบบ $\ln(\mu) = 2.5 - 0.15x_1 + 0.25x_2$

```
pois.fit <- function(y) {
   y.pois <- glm(y~x11+x12,family=poisson)
   y.pois
}

robust.nb2 <- function(beta, al ,X.mat) {
       ys <- 0
       se.nb2.beta0 <- NULL;se.nb2.beta1 <- NULL
       se.nb2.beta2 <- NULL; se.nb2.al <- NULL
       rv.nb2.beta0 <- NULL; rv.nb2.beta1 <- NULL
       rv.nb2.beta2 <- NULL; rv.nb2.al <- NULL
       beta0.nb2.sim <- NULL; beta1.nb2.sim <- NULL
       beta2.nb2.sim <- NULL; al.nb2.sim <- NULL
       mu <- exp(X.mat%*%beta) ; n <- length(mu)
       source("nb2fit.robust.txt")
       for (i in 1:R) {
          ee <- rgamma(n,1/al)*al
          ys <- rpois(n, mu*ee)
          ys.nb2R <- nb2.fit.robust(ys,X.mat)
          beta0.nb2.sim <- c(ys.nb2R$beta.nb2[1],beta0.nb2.sim)
          beta1.nb2.sim <- c(ys.nb2R $beta.nb2[2],beta1.nb2.sim)
          beta2.nb2.sim <- c(ys.nb2R $beta.nb2[3],beta2.nb2.sim)
          al.nb2.sim <- c(al.nb2.sim,ys.nb2R$al.nb2)
          se1.nb2 <- ys.nb2R$SE
          se2.nb2 <- diag(se1.nb2); se20.nb2 <-se2.nb2[1]
          se21.nb2 <- se2.nb2[2]; se22.nb2 <-se2.nb2[3]
          se2al.nb2 <- se2.nb2[4]
          se.nb2.beta0 <- c(se.nb2.beta0,se20.nb2)
          se.nb2.beta1 <- c(se.nb2.beta1,se21.nb2)
          se.nb2.beta2 <- c(se.nb2.beta2,se22.nb2)
          se.nb2.al <- c(se.nb2.al, se2al.nb2)
          rv1.nb2 <- ys.nb2R$Robust.SE
          rv2.nb2 <- diag(rv1.nb2); rv20.nb2 <- rv2.nb2[1]
          rv21.nb2 <- rv2.nb2[2]; rv22.nb2 <- rv2.nb2[3]
          rv2al.nb2 <- rv2.nb2[4]
          rv.nb2.beta0 <- c(rv.nb2.beta0,rv20.nb2)
          rv.nb2.beta1 <- c(rv.nb2.beta1,rv21.nb2)
          rv.nb2.beta2 <- c(rv.nb2.beta2,rv22.nb2)
          rv.nb2.al <- c(rv.nb2.al, rv2al.nb2)
         un.nb2.beta0 <- var(beta0.nb2.sim)
          un.nb2.beta0 <- sqrt(un.nb2.beta0)
          un.nb2.beta0 <- round(un.nb2.beta0,5)
          un.nb2.beta1 <- var(beta1.nb2.sim)
          un.nb2.beta1 <- sqrt(un.nb2.beta1)
          un.nb2.beta1 <- round(un.nb2.beta1,5)
          un.nb2.beta2 <- var(beta2.nb2.sim)
          un.nb2.beta2 <- sqrt(un.nb2.beta2)
          un.nb2.beta2 <- round(un.nb2.beta2,5)
          un.nb2.al <- var (al.nb2.sim)
          un.nb2.al <- sqrt(un.nb2.al)
          un.nb2.al <- round(un.nb2.al,5)
```

```
        }
        beta0.nb2.sim1 <- mean(beta0.nb2.sim,na.rm=T)
        beta0.nb2.sim1 <- round(beta0.nb2.sim1,5)
        beta1.nb2.sim1 <- mean(beta1.nb2.sim,na.rm=T)
        beta1.nb2.sim1 <- round(beta1.nb2.sim1,5)
        beta2.nb2.sim1 <- mean(beta2.nb2.sim,na.rm=T)
        beta2.nb2.sim1 <- round(beta2.nb2.sim1,5)
        al.nb2.sim1 <- mean(al.nb2.sim,na.rm=T)
        al.nb2.sim1 <- round(al.nb2.sim1,5)
        se.nb2.beta0 <- mean(se.nb2.beta0,na.rm=T)
        se.nb2.beta0 <- round(se.nb2.beta0,5)
        se.nb2.beta1 <- mean(se.nb2.beta1,na.rm=T)
        se.nb2.beta1 <- round(se.nb2.beta1,5)
        se.nb2.beta2 <- mean(se.nb2.beta2,na.rm=T)
        se.nb2.beta2 <- round(se.nb2.beta2,5)
        se.nb2.al <- mean(se.nb2.al,na.rm=T)
        se.nb2.al <- round(se.nb2.al,5)
        rv.nb2.beta0 <- mean(rv.nb2.beta0 ,na.rm=T)
        rv.nb2.beta0 <- round(rv.nb2.beta0,5)
        rv.nb2.beta1 <- mean(rv.nb2.beta1 ,na.rm=T)
        rv.nb2.beta1 <- round(rv.nb2.beta1,5)
        rv.nb2.beta2 <- mean(rv.nb2.beta2 ,na.rm=T)
        rv.nb2.beta2 <- round(rv.nb2.beta2,5)
        rv.nb2.al <- mean(rv.nb2.al,na.rm=T)
        rv.nb2.al <- round(rv.nb2.al,5)
        beta0_NB2 <- cbind(beta0.nb2.sim1,se.nb2.beta0,
                     rv.nb2.beta0,un.nb2.beta0)
        beta1_NB2 <- cbind(beta1.nb2.sim1,se.nb2.beta1,
                     rv.nb2.beta1,un.nb2.beta1)
        beta2_NB2 <- cbind(beta2.nb2.sim1,se.nb2.beta2,
                     rv.nb2.beta2,un.nb2.beta2)
        al_NB2 <- cbind(al.nb2.sim1,se.nb2.al,rv.nb2.al,un.nb2.al)
        totalNB2 <- rbind(beta0_NB2,beta1_NB2,beta2_NB2,al_NB2)
        colnames(totalNB2) <- c("seta","Asy.SE","Robust.SE",
                               "Unbias.SE")
        rownames(totalNB2) <- c("beta0","beta1","beta2","alpha")
        result <- list( NB2=totalNB2 )
result
}
```

6.4 โปรแกรม Simulation study สำหรับ Robust standard error จำลองข้อมูลภายใต้การแจกแจง NB2 แล้ว fit NB2 ของตัวแบบ $\ln(\mu) = 3.25 - 0.65x_1 + 0.75x_2 + 0.25x_1x_2$

```
pois.fit <- function(y) {
   y.pois <- glm(y~x11*x12,family=poisson)
   y.pois
}

robust.nb2 <- function(beta, al ,X.mat) {
       ys <- 0
       se.nb2.beta0 <- NULL; se.nb2.beta1 <- NULL;
       se.nb2.beta2 <- NULL; se.nb2.beta3 <- NULL
```

```
se.nb2.al <- NULL; rv.nb2.beta0 <- NULL
rv.nb2.beta1 <- NULL; rv.nb2.beta2 <- NULL
rv.nb2.beta3 <- NULL; rv.nb2.al<- NULL
beta0.nb2.sim <- NULL; beta1.nb2.sim <- NULL
beta2.nb2.sim <- NULL;beta3.nb2.sim <- NULL
al.nb2.sim <- NULL
mu <- exp(X.mat%*%beta) ; n <- length(mu)
source("nb2fit.robust.txt")
for (i in 1:R) {
   ee <- rgamma(n,1/al)*al
   ys <- rpois(n, mu*ee)
   ys.nb2R <- nb2.fit.robust(ys,X.mat)
   beta0.nb2.sim <- c(ys.nb2R$beta.nb2[1],beta0.nb2.sim)
   beta1.nb2.sim <- c(ys.nb2R$beta.nb2[2],beta1.nb2.sim)
   beta2.nb2.sim <- c(ys.nb2R$beta.nb2[3],beta2.nb2.sim)
   beta3.nb2.sim <- c(ys.nb2R$beta.nb2[4],beta3.nb2.sim)
   al.nb2.sim <- c(al.nb2.sim,ys.nb2R$al.nb2)
   se1.nb2<-ys.nb2R$SE
   se2.nb2<-diag(se1.nb2); se20.nb2 <- se2.nb2[1]
   se21.nb2 <- se2.nb2[2]; se22.nb2 <- se2.nb2[3]
   se23.nb2 <- se2.nb2[4]; se2al.nb2 <- se2.nb2[5]
   se.nb2.beta0 <- c(se.nb2.beta0,se20.nb2)
   se.nb2.beta1 <- c(se.nb2.beta1,se21.nb2)
   se.nb2.beta2 <- c(se.nb2.beta2,se22.nb2)
   se.nb2.beta3 <- c(se.nb2.beta3,se23.nb2)
   se.nb2.al <- c(se.nb2.al,se2al.nb2)
   rv1.nb2<-ys.nb2R$Robust.SE
   rv2.nb2<- diag(rv1.nb2); rv20.nb2 <-rv2.nb2[1]
   rv21.nb2 <- rv2.nb2[2]; rv22.nb2 <- rv2.nb2[3]
   rv23.nb2 <- rv2.nb2[4]; rv2al.nb2 <- rv2.nb2[5]
   rv.nb2.beta0 <- c(rv.nb2.beta0,rv20.nb2)
   rv.nb2.beta1 <- c(rv.nb2.beta1,rv21.nb2)
   rv.nb2.beta2 <- c(rv.nb2.beta2,rv22.nb2)
   rv.nb2.beta3 <- c(rv.nb2.beta3,rv23.nb2)
   rv.nb2.al <- c(rv.nb2.al,rv2al.nb2)
   un.nb2.beta0 <- var(beta0.nb2.sim)
   un.nb2.beta0 <- sqrt(un.nb2.beta0)
   un.nb2.beta0 <- round(un.nb2.beta0,5)
   un.nb2.beta1 <- var(beta1.nb2.sim)
   un.nb2.beta1 <- sqrt(un.nb2.beta1)
   un.nb2.beta1 <- round(un.nb2.beta1,5)
   un.nb2.beta2 <- var(beta2.nb2.sim)
   un.nb2.beta2 <- sqrt(un.nb2.beta2)
   un.nb2.beta2 <- round(un.nb2.beta2,5)
   un.nb2.beta3 <- var(beta3.nb2.sim)
   un.nb2.beta3 <- sqrt(un.nb2.beta3)
   un.nb2.beta3 <- round(un.nb2.beta3,5)
   un.nb2.al <- var(al.nb2.sim)
   un.nb2.al <- sqrt(un.nb2.al)
   un.nb2.al <- round(un.nb2.al,5)
}
beta0.nb2.sim1 <- mean(beta0.nb2.sim,na.rm=T)
beta0.nb2.sim1 <- round(beta0.nb2.sim1,5)
beta1.nb2.sim1 <- mean(beta1.nb2.sim,na.rm=T)
beta1.nb2.sim1 <- round(beta1.nb2.sim1,5)
```

```
        beta2.nb2.sim1 <- mean(beta2.nb2.sim,na.rm=T)
        beta2.nb2.sim1 <- round(beta2.nb2.sim1,5)
        beta3.nb2.sim1 <- mean(beta3.nb2.sim,na.rm=T)
        beta3.nb2.sim1 <- round(beta3.nb2.sim1,5)
        al.nb2.sim1 <- mean(al.nb2.sim,na.rm=T)
        al.nb2.sim1 <- round(al.nb2.sim1,5)
        se.nb2.beta0 <- mean(se.nb2.beta0,na.rm=T)
        se.nb2.beta0 <- round(se.nb2.beta0,5)
        se.nb2.beta1 <- mean(se.nb2.beta1,na.rm=T)
        se.nb2.beta1 <- round(se.nb2.beta1,5)
        se.nb2.beta2 <- mean(se.nb2.beta2,na.rm=T)
        se.nb2.beta2 <- round(se.nb2.beta2,5)
        se.nb2.beta3 <- mean(se.nb2.beta3,na.rm=T)
        se.nb2.beta3 <- round(se.nb2.beta3,5)
        se.nb2.al <- mean(se.nb2.al,na.rm=T)
        se.nb2.al <- round(se.nb2.al,5)
        rv.nb2.beta0 <- mean(rv.nb2.beta0,na.rm=T)
        rv.nb2.beta0 <- round(rv.nb2.beta0,5)
        rv.nb2.beta1 <- mean(rv.nb2.beta1,na.rm=T)
        rv.nb2.beta1 <- round(rv.nb2.beta1,5)
        rv.nb2.beta2 <- mean(rv.nb2.beta2,na.rm=T)
        rv.nb2.beta2 <- round(rv.nb2.beta2,5)
        rv.nb2.beta3 <- mean(rv.nb2.beta3,na.rm=T)
        rv.nb2.beta3 <- round(rv.nb2.beta3,5)
        rv.nb2.al <- mean(rv.nb2.al,na.rm=T)
        rv.nb2.al <- round(rv.nb2.al,5)
        beta0_NB2 <- cbind(beta0.nb2.sim1,se.nb2.beta0,
                     rv.nb2.beta0,un.nb2.beta0)
        beta1_NB2 <- cbind(beta1.nb2.sim1,se.nb2.beta1,
                     rv.nb2.beta1,un.nb2.beta1)
        beta2_NB2 <- cbind(beta2.nb2.sim1,se.nb2.beta2,
                     rv.nb2.beta2,un.nb2.beta2)
        beta3_NB2 <- cbind(beta3.nb2.sim1,se.nb2.beta3,
                     rv.nb2.beta3,un.nb2.beta3)
        al_NB2 <- cbind(al.nb2.sim1,se.nb2.al,rv.nb2.al,un.nb2.al)
        totalNB2 <-rbind(beta0_NB2,beta1_NB2,beta2_NB2,beta3_NB2,
                    al_NB2)
        colnames(totalNB2) <- c("seta","Asy.SE","Robust.SE",
                              "Unbias.SE")
        rownames(totalNB2) <- c("beta0","beta1","beta2","beta3",
                              "alpha")
        result <- list( NB2=totalNB2 )
result
}
```

7. โปรแกรม Simulation study สำหรับ Robust standard error จำลองข้อมูลภายใต้การแจกแจง NB1 ทำการ fit NB2

7.1 โปรแกรม Simulation study สำหรับ Robust standard error จำลองข้อมูลภายใต้การแจกแจง NB1 แล้ว fit NB2 ของตัวแบบ $\ln(\mu) = 1.95$

```
pois.fit <- function(y) {
   y.pois <- glm(y~1,family=poisson)
   y.pois
}

robust.nb2 <- function(beta, al ,X.mat) {
       ys <- 0
       se.nb2.beta0 <- NULL; se.nb2.al <- NULL
       rv.nb2.beta0 <- NULL; rv.nb2.al <- NULL
       beta0.nb2.sim <- NULL; al.nb2.sim <- NULL
       mu <- exp(X.mat%*%beta); n <- length(mu)
       source("nb2fit.robust.txt")
       for (i in 1:R) {
          ee <- rgamma(n,mu/al)*(al/mu)
          ys <- rpois(n, mu*ee)
          ys.nb2R <- nb2.fit.robust(ys,X.mat)
          beta0.nb2.sim <- c(ys.nb2R$beta.nb2[1],beta0.nb2.sim)
          al.nb2.sim <- c(al.nb2.sim,ys.nb2R$al.nb2)
          se1.nb2<-ys.nb2R$SE
          se2.nb2<-diag(se1.nb2); se20.nb2 <- se2.nb2[1]
          se2al.nb2 <- se2.nb2[2]
          se.nb2.beta0 <- c(se.nb2.beta0,se20.nb2)
          se.nb2.al <- c(se.nb2.al,se2al.nb2)
          rv1.nb2<-ys.nb2R$Robust.SE
          rv2.nb2<- diag(rv1.nb2); rv20.nb2 <- rv2.nb2[1]
          rv2al.nb2 <- rv2.nb2[2]
          rv.nb2.beta0 <- c(rv.nb2.beta0,rv20.nb2)
          rv.nb2.al <- c(rv.nb2.al,rv2al.nb2)
          un.nb2.beta0 <- var(beta0.nb2.sim)
          un.nb2.beta0 <- sqrt(un.nb2.beta0)
          un.nb2.beta0 <- round(un.nb2.beta0,5)
          un.nb2.al <- var (al.nb2.sim)
          un.nb2.al <- sqrt(un.nb2.al)
          un.nb2.al <- round(un.nb2.al,5)
       }
       beta0.nb2.sim1 <- mean(beta0.nb2.sim,na.rm=T)
       beta0.nb2.sim1 <- round(beta0.nb2.sim1,5)
       al.nb2.sim1 <- mean(al.nb2.sim,na.rm=T)
       al.nb2.sim1 <- round(al.nb2.sim1,5)
       se.nb2.beta0 <- mean(se.nb2.beta0,na.rm=T)
       se.nb2.beta0 <- round(se.nb2.beta0,5)
       se.nb2.al <- mean(se.nb2.al,na.rm=T)
       se.nb2.al <- round(se.nb2.al,5)
```

```
       rv.nb2.beta0 <- mean(rv.nb2.beta0,na.rm=T)
       rv.nb2.beta0 <- round(rv.nb2.beta0,5)
       rv.nb2.al <- mean(rv.nb2.al,na.rm=T)
       rv.nb2.al <- round(rv.nb2.al,5)
       beta0_NB2 <- cbind(beta0.nb2.sim1,se.nb2.beta0,
                    rv.nb2.beta0,un.nb2.beta0)
       al_NB2 <- cbind(al.nb2.sim1,se.nb2.al,rv.nb2.al,un.nb2.al)
       totalNB2 <- rbind(beta0_NB2,al_NB2)
       colnames(totalNB2) <- c("seta","Asy.SE","Robust.SE",
                              "Unbias.SE")
       rownames(totalNB2) <- c("beta0","alpha")
       result <- list( NB2=totalNB2 )
result
}
```

7.2 โปรแกรม Simulation study สำหรับ Robust standard error จำลองข้อมูลภายใต้การแจกแจง NB1 แล้ว fit NB2 ของตัวแบบ $\ln(\mu) = 2.5 + 0.5x_1$

```
pois.fit <- function(y) {
   y.pois <- glm(y~x11,family=poisson)
   y.pois
}

robust.nb2 <- function(beta, al ,X.mat) {
       ys <- 0
       se.nb2.beta0 <- NULL; se.nb2.beta1 <- NULL
       se.nb2.al <- NULL; rv.nb2.beta0 <- NULL
       rv.nb2.beta1 <- NULL; rv.nb2.al <- NULL
       beta0.nb2.sim <- NULL; beta1.nb2.sim <- NULL
       al.nb2.sim <-NULL
       mu <- exp(X.mat%*%beta); n <- length(mu)
       source("nb2fit.robust.txt")
       for (i in 1:R) {
          ee <- rgamma(n,mu/al)*(al/mu)
          ys <- rpois(n, mu*ee)
          ys.nb2R <- nb2.fit.robust(ys,X.mat)
          beta0.nb2.sim <- c(ys.nb2R$beta.nb2[1],beta0.nb2.sim)
          beta1.nb2.sim <- c(ys.nb2R$beta.nb2[2],beta1.nb2.sim)
          al.nb2.sim <- c(al.nb2.sim, ys.nb2R$al.nb2)
          se1.nb2<-ys.nb2R$SE
          se2.nb2<-diag(se1.nb2); se20.nb2 <- se2.nb2[1]
          se21.nb2 <- se2.nb2[2]; se2al.nb2 <- se2.nb2[3]
          se.nb2.beta0 <- c(se.nb2.beta0,se20.nb2)
          se.nb2.beta1 <- c(se.nb2.beta1,se21.nb2)
          se.nb2.al <- c(se.nb2.al,se2al.nb2)
          rv1.nb2<-ys.nb2R$Robust.SE
          rv2.nb2<- diag(rv1.nb2); rv20.nb2 <- rv2.nb2[1]
          rv21.nb2 <- rv2.nb2[2];rv2al.nb2 <- rv2.nb2[3]
```

```
          rv.nb2.beta0 <- c(rv.nb2.beta0,rv20.nb2)
          rv.nb2.beta1 <- c(rv.nb2.beta1, rv21.nb2)
          rv.nb2.al <- c(rv.nb2.al,rv2al.nb2)
          un.nb2.beta0 <- var(beta0.nb2.sim)
          un.nb2.beta0 <- sqrt(un.nb2.beta0)
          un.nb2.beta0 <- round(un.nb2.beta0,5)
          un.nb2.beta1 <- var(beta1.nb2.sim)
          un.nb2.beta1 <- sqrt(un.nb2.beta1)
          un.nb2.beta1 <- round(un.nb2.beta1,5)
          un.nb2.al <- var (al.nb2.sim)
          un.nb2.al <- sqrt(un.nb2.al)
          un.nb2.al <- round(un.nb2.al,5)
       }
       beta0.nb2.sim1 <- mean(beta0.nb2.sim,na.rm=T)
       beta0.nb2.sim1 <- round(beta0.nb2.sim1,5)
       beta1.nb2.sim1 <- mean(beta1.nb2.sim,na.rm=T)
       beta1.nb2.sim1 <- round(beta1.nb2.sim1,5)
       al.nb2.sim1 <- mean(al.nb2.sim,na.rm=T)
       al.nb2.sim1 <- round(al.nb2.sim1,5)
       se.nb2.beta0 <- mean(se.nb2.beta0,na.rm=T)
       se.nb2.beta0 <- round(se.nb2.beta0,5)
       se.nb2.beta1 <- mean(se.nb2.beta1,na.rm=T)
       se.nb2.beta1 <- round(se.nb2.beta1,5)
       se.nb2.al <- mean(se.nb2.al,na.rm=T)
       se.nb2.al <- round(se.nb2.al,5)
       rv.nb2.beta0 <- mean(rv.nb2.beta0,na.rm=T)
       rv.nb2.beta0 <- round(rv.nb2.beta0,5)
       rv.nb2.beta1 <- mean(rv.nb2.beta1,na.rm=T)
       rv.nb2.beta1 <- round(rv.nb2.beta1,5)
       rv.nb2.al <- mean(rv.nb2.al,na.rm=T)
       rv.nb2.al <- round(rv.nb2.al,5)
       beta0_NB2 <- cbind(beta0.nb2.sim1,se.nb2.beta0,
                    rv.nb2.beta0,un.nb2.beta0)
       beta1_NB2 <- cbind(beta1.nb2.sim1, se.nb2.beta1,
                    rv.nb2.beta1,un.nb2.beta1)
       al_NB2 <- cbind(al.nb2.sim1,se.nb2.al,rv.nb2.al,un.nb2.al)
       totalNB2 <- rbind(beta0_NB2 , beta1_NB2 , al_NB2)
       colnames(totalNB2) <- c("seta","Asy.SE","Robust.SE",
                             "Unbias.SE")
       rownames(totalNB2) <- c("beta0","beta1","alpha")
       result <- list( NB2=totalNB2 )
result
}
```

7.3 โปรแกรม Simulation study สำหรับ Robust standard error จำลองข้อมูลภายใต้การแจกแจง NB1 แล้ว fit NB2 ของตัวแบบ $\ln(\mu) = 2.5 - 0.15x_1 + 0.25x_2$

```
pois.fit <- function(y) {
   y.pois <- glm(y~x11+x12,family=poisson)
   y.pois
}

robust.nb2 <- function(beta, al ,X.mat) {
       ys <- 0
       se.nb2.beta0 <- NULL; se.nb2.beta1 <- NULL
       se.nb2.beta2 <- NULL; se.nb2.al<-NULL
       rv.nb2.beta0 <- NULL; rv.nb2.beta1 <- NULL
       rv.nb2.beta2 <- NULL; rv.nb2.al<-NULL
       beta0.nb2.sim <- NULL; beta1.nb2.sim <- NULL
       beta2.nb2.sim <- NULL; al.nb2.sim <- NULL
       mu <- exp(X.mat%*%beta) ; n <- length(mu)
       source("nb2fit.robust.txt")
       for (i in 1:R) {
          ee <- rgamma(n,mu/al)*(al/mu)
          ys <- rpois(n, mu*ee)
          ys.nb2R <- nb2.fit.robust(ys,X.mat)
          beta0.nb2.sim <- c(ys.nb2R$beta.nb2[1],beta0.nb2.sim)
          beta1.nb2.sim <- c(ys.nb2R $beta.nb2[2],beta1.nb2.sim)
          beta2.nb2.sim <- c(ys.nb2R $beta.nb2[3],beta2.nb2.sim)
          al.nb2.sim <- c(al.nb2.sim,ys.nb2R$al.nb2)
          se1.nb2<-ys.nb2R$SE
          se2.nb2<-diag(se1.nb2); se20.nb2 <- se2.nb2[1]
          se21.nb2 <- se2.nb2[2]; se22.nb2 <- se2.nb2[3]
          se2al.nb2 <- se2.nb2[4]
          se.nb2.beta0 <- c(se.nb2.beta0, se20.nb2)
          se.nb2.beta1 <- c(se.nb2.beta1, se21.nb2)
          se.nb2.beta2 <- c(se.nb2.beta2, se22.nb2)
          se.nb2.al <- c(se.nb2.al, se2al.nb2)
          rv1.nb2<-ys.nb2R$Robust.SE
          rv2.nb2<- diag(rv1.nb2); rv20.nb2 <- rv2.nb2[1];
          rv21.nb2 <- rv2.nb2[2]; rv22.nb2 <- rv2.nb2[3]
          rv2al.nb2 <- rv2.nb2[4]
          rv.nb2.beta0 <- c(rv.nb2.beta0,rv20.nb2)
          rv.nb2.beta1 <- c(rv.nb2.beta1,rv21.nb2)
          rv.nb2.beta2 <- c(rv.nb2.beta2,rv22.nb2)
          rv.nb2.al <- c(rv.nb2.al, rv2al.nb2)
          un.nb2.beta0 <- var(beta0.nb2.sim)
          un.nb2.beta0 <- sqrt(un.nb2.beta0)
          un.nb2.beta0 <- round(un.nb2.beta0,5)
          un.nb2.beta1 <- var(beta1.nb2.sim)
          un.nb2.beta1 <- sqrt(un.nb2.beta1)
          un.nb2.beta1 <- round(un.nb2.beta1,5)
          un.nb2.beta2 <- var(beta2.nb2.sim)
          un.nb2.beta2 <- sqrt(un.nb2.beta2)
          un.nb2.beta2 <- round(un.nb2.beta2,5)
          un.nb2.al <- var (al.nb2.sim)
          un.nb2.al <- sqrt(un.nb2.al)
```

```
          un.nb2.al <- round(un.nb2.al,5)
       }
       beta0.nb2.sim1 <- mean(beta0.nb2.sim,na.rm=T)
       beta0.nb2.sim1 <- round(beta0.nb2.sim1,5)
       beta1.nb2.sim1 <- mean(beta1.nb2.sim,na.rm=T)
       beta1.nb2.sim1 <- round(beta1.nb2.sim1,5)
       beta2.nb2.sim1 <- mean(beta2.nb2.sim,na.rm=T)
       beta2.nb2.sim1 <- round(beta2.nb2.sim1,5)
       al.nb2.sim1 <- mean(al.nb2.sim,na.rm=T)
       al.nb2.sim1 <- round(al.nb2.sim1,5)
       se.nb2.beta0 <- mean(se.nb2.beta0,na.rm=T)
       se.nb2.beta0 <- round(se.nb2.beta0,5)
       se.nb2.beta1 <- mean(se.nb2.beta1,na.rm=T)
       se.nb2.beta1 <- round(se.nb2.beta1,5)
       se.nb2.beta2 <- mean(se.nb2.beta2,na.rm=T)
       se.nb2.beta2 <- round(se.nb2.beta2,5)
       se.nb2.al <- mean(se.nb2.al ,na.rm=T)
       se.nb2.al <- round(se.nb2.al,5)
       rv.nb2.beta0 <- mean(rv.nb2.beta0 ,na.rm=T)
       rv.nb2.beta0 <- round(rv.nb2.beta0,5)
       rv.nb2.beta1 <- mean(rv.nb2.beta1 ,na.rm=T)
       rv.nb2.beta1 <- round(rv.nb2.beta1,5)
       rv.nb2.beta2 <- mean(rv.nb2.beta2 ,na.rm=T)
       rv.nb2.beta2 <- round(rv.nb2.beta2,5)
       rv.nb2.al <- mean(rv.nb2.al,na.rm=T)
       rv.nb2.al <- round(rv.nb2.al,5)
       beta0_NB2 <- cbind(beta0.nb2.sim1,se.nb2.beta0,
                    rv.nb2.beta0,un.nb2.beta0)
       beta1_NB2 <- cbind(beta1.nb2.sim1,se.nb2.beta1,
                    rv.nb2.beta1,un.nb2.beta1)
       beta2_NB2 <- cbind(beta2.nb2.sim1,se.nb2.beta2,
                    rv.nb2.beta2,un.nb2.beta2)
       al_NB2 <- cbind(al.nb2.sim1,se.nb2.al,rv.nb2.al,un.nb2.al)
       totalNB2 <- rbind(beta0_NB2,beta1_NB2,beta2_NB2,al_NB2)
       colnames(totalNB2) <- c("seta","Asy.SE","Robust.SE",
                             "Unbias.SE")
       rownames(totalNB2) <- c("beta0","beta1","beta2","alpha")
       result <- list( NB2=totalNB2 )
result
}
```

7.4 โปรแกรม Simulation study สำหรับ Robust standard error จำลองข้อมูลภายใต้การแจกแจง NB1 แล้ว fit NB2 ของตัวแบบ $\ln(\mu) = 3.25 - 0.65x_1 + 0.75x_2 + 0.25x_1x_2$

```
pois.fit <- function(y) {
   y.pois <- glm(y~x11*x12,family=poisson)
   y.pois
}

robust.nb2 <- function(beta, al ,X.mat) {
       ys <- 0
```

```
se.nb2.beta0 <- NULL; se.nb2.beta1 <- NULL
se.nb2.beta2 <- NULL; se.nb2.beta3 <- NULL
se.nb2.al <- NULL; rv.nb2.beta0 <- NULL
rv.nb2.beta1 <- NULL ; rv.nb2.beta2 <- NULL
rv.nb2.beta3 <- NULL ;rv.nb2.al<-NULL
beta0.nb2.sim <- NULL; beta1.nb2.sim <- NULL
beta2.nb2.sim <- NULL; beta3.nb2.sim <- NULL
al.nb2.sim <- NULL
mu <- exp(X.mat%*%beta); n <- length(mu)
source("nb2fit.robust.txt")
for (i in 1:R) {
   ee <- rgamma(n,mu/al)*(al/mu)
   ys <- rpois(n, mu*ee)
   ys.nb2R <- nb2.fit.robust(ys,X.mat)
   beta0.nb2.sim <- c(ys.nb2R$beta.nb2[1],beta0.nb2.sim)
   beta1.nb2.sim <- c(ys.nb2R $beta.nb2[2],beta1.nb2.sim)
   beta2.nb2.sim <- c(ys.nb2R $beta.nb2[3],beta2.nb2.sim)
   beta3.nb2.sim <- c(ys.nb2R $beta.nb2[4],beta3.nb2.sim)
   al.nb2.sim <- c(al.nb2.sim,ys.nb2R$al.nb2)
   se1.nb2<-ys.nb2R$SE
   se2.nb2<-diag(se1.nb2); se20.nb2 <- se2.nb2[1]
   se21.nb2 <- se2.nb2[2]; se22.nb2 <- se2.nb2[3] ;
   se23.nb2 <- se2.nb2[4]; se2al.nb2 <- se2.nb2[5]
   se.nb2.beta0 <- c(se.nb2.beta0,se20.nb2)
   se.nb2.beta1 <- c(se.nb2.beta1,se21.nb2)
   se.nb2.beta2 <- c(se.nb2.beta2,se22.nb2)
   se.nb2.beta3 <- c(se.nb2.beta3,se23.nb2)
   se.nb2.al <- c(se.nb2.al,se2al.nb2)
   rv1.nb2<-ys.nb2R$Robust.SE
   rv2.nb2<- diag(rv1.nb2); rv20.nb2 <- rv2.nb2[1]
   rv21.nb2 <- rv2.nb2[2]; rv22.nb2 <- rv2.nb2[3] ;
   rv23.nb2 <- rv2.nb2[4]; rv2al.nb2 <- rv2.nb2[5]
   rv.nb2.beta0 <- c(rv.nb2.beta0,rv20.nb2)
   rv.nb2.beta1 <- c(rv.nb2.beta1,rv21.nb2)
   rv.nb2.beta2 <- c(rv.nb2.beta2,rv22.nb2)
   rv.nb2.beta3 <- c(rv.nb2.beta3,rv23.nb2)
   rv.nb2.al <- c(rv.nb2.al,rv2al.nb2)
   un.nb2.beta0 <- var(beta0.nb2.sim)
   un.nb2.beta0 <- sqrt(un.nb2.beta0)
   un.nb2.beta0 <- round(un.nb2.beta0,5)
   un.nb2.beta1 <- var(beta1.nb2.sim)
   un.nb2.beta1 <- sqrt(un.nb2.beta1)
   un.nb2.beta1 <- round(un.nb2.beta1,5)
   un.nb2.beta2 <- var(beta2.nb2.sim)
   un.nb2.beta2 <- sqrt(un.nb2.beta2)
   un.nb2.beta2 <- round(un.nb2.beta2,5)
   un.nb2.beta3 <- var(beta3.nb2.sim)
   un.nb2.beta3 <- sqrt(un.nb2.beta3)
   un.nb2.beta3 <- round(un.nb2.beta3,5)
   un.nb2.al <- var (al.nb2.sim)
   un.nb2.al <- sqrt(un.nb2.al)
   un.nb2.al <- round(un.nb2.al,5)
}
beta0.nb2.sim1 <- mean(beta0.nb2.sim,na.rm=T)
beta0.nb2.sim1 <- round(beta0.nb2.sim1,5)
```

```
          beta1.nb2.sim1 <- mean(beta1.nb2.sim,na.rm=T)
          beta1.nb2.sim1 <- round(beta1.nb2.sim1,5)
          beta2.nb2.sim1 <- mean(beta2.nb2.sim,na.rm=T)
          beta2.nb2.sim1 <- round(beta2.nb2.sim1,5)
          beta3.nb2.sim1 <- mean(beta3.nb2.sim,na.rm=T)
          beta3.nb2.sim1 <- round(beta3.nb2.sim1,5)
          al.nb2.sim1 <- mean(al.nb2.sim,na.rm=T)
          al.nb2.sim1 <- round(al.nb2.sim1,5)
          se.nb2.beta0 <- mean(se.nb2.beta0,na.rm=T)
          se.nb2.beta0 <- round(se.nb2.beta0,5)
          se.nb2.beta1 <- mean(se.nb2.beta1,na.rm=T)
          se.nb2.beta1 <- round(se.nb2.beta1,5)
          se.nb2.beta2 <- mean(se.nb2.beta2,na.rm=T)
          se.nb2.beta2 <- round(se.nb2.beta2,5)
          se.nb2.beta3 <- mean(se.nb2.beta3,na.rm=T)
          se.nb2.beta3 <- round(se.nb2.beta3,5)
          se.nb2.al <- mean(se.nb2.al,na.rm=T)
          se.nb2.al <- round(se.nb2.al,5)
          rv.nb2.beta0 <- mean(rv.nb2.beta0,na.rm=T)
          rv.nb2.beta0 <- round(rv.nb2.beta0,5)
          rv.nb2.beta1 <- mean(rv.nb2.beta1,na.rm=T)
          rv.nb2.beta1 <- round(rv.nb2.beta1,5)
          rv.nb2.beta2 <- mean(rv.nb2.beta2,na.rm=T)
          rv.nb2.beta2 <- round(rv.nb2.beta2,5)
          rv.nb2.beta3 <- mean(rv.nb2.beta3,na.rm=T)
          rv.nb2.beta3 <- round(rv.nb2.beta3,5)
          rv.nb2.al <- mean(rv.nb2.al,na.rm=T)
          rv.nb2.al <- round(rv.nb2.al,5)
          beta0_NB2 <- cbind(beta0.nb2.sim1, se.nb2.beta0,
                       rv.nb2.beta0, un.nb2.beta0)
          beta1_NB2 <- cbind(beta1.nb2.sim1, se.nb2.beta1,
                       rv.nb2.beta1, un.nb2.beta1)
          beta2_NB2 <- cbind(beta2.nb2.sim1, se.nb2.beta2,
                       rv.nb2.beta2, un.nb2.beta2)
          beta3_NB2 <- cbind(beta3.nb2.sim1, se.nb2.beta3,
                       rv.nb2.beta3, un.nb2.beta3)
          al_NB2 <- cbind(al.nb2.sim1,se.nb2.al,rv.nb2.al,
                    un.nb2.al)
          totalNB2 <- rbind(beta0_NB2,beta1_NB2,beta2_NB2,
                      beta3_NB2,al_NB2)
          colnames(totalNB2) <- c("seta","Asy.SE","Robust.SE",
                                  "Unbias.SE")
          rownames(totalNB2) <- c("beta0","beta1","beta2","beta3",
                                  "alpha")
          result <- list( NB2=totalNB2 )
result
}
```