Multivariate q

Grant Adams

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Invert

Multiply out

Take derivative

Set to zero and solve for q

Numerator (sum hessian times index)

Denominator (sum hessian)

# Sim analytical q

library(MASS)  
q <- 0.5  
Nvec <- seq(50, 200, length.out = 4)  
varcov <- matrix(c(0.2,0.1,0,0,  
 0.1,0.2,0.1,0,  
 0,0.1,0.2,0.1,  
 0,0,0.1,0.2), 4, 4)  
hess <- solve(varcov)  
simddata <- exp(mvrnorm(10000, mu = log(Nvec \* q) - diag(varcov)/2, Sigma = varcov))  
  
q\_est <- (apply(simddata,1, function(x) exp(sum((hess) %\*% log(x/Nvec))/(sum(hess)))))  
mean(q\_est)

## [1] 0.472583