Initialization

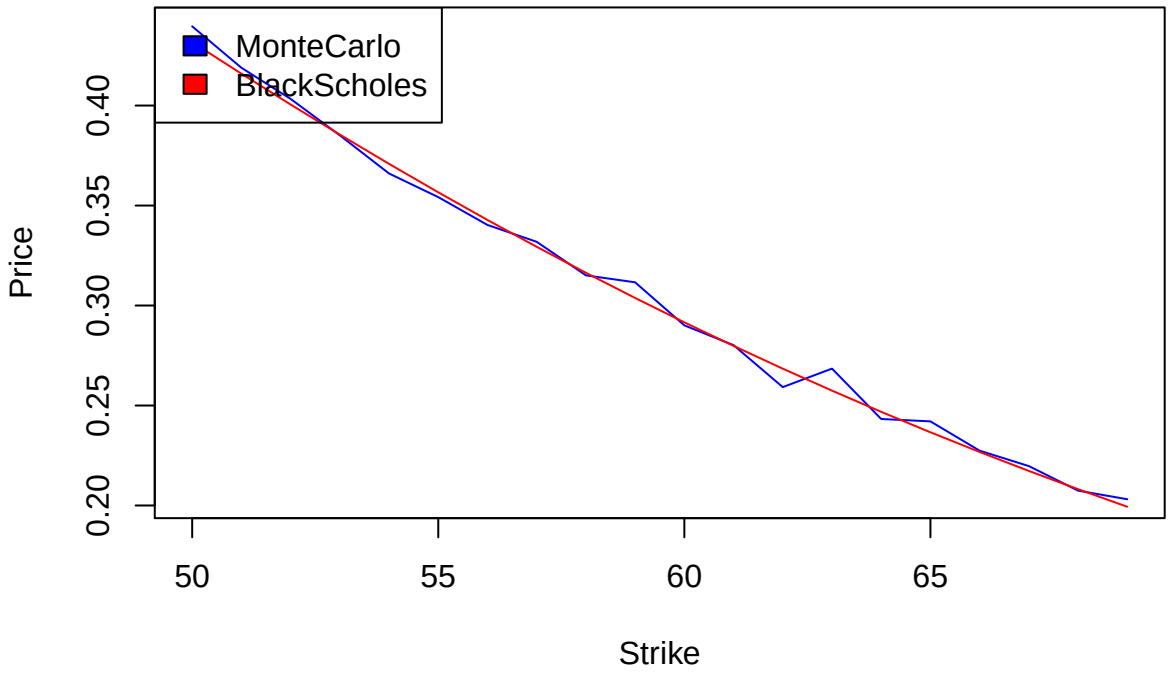
```
init_price <- 50
K <- 50
r<- 0.0175
sigma <- 0.2
T <- 5
M <- 10000
N <- 10000
```

Code for Black Scholes and Monte Carlo Pricing

```
BS_V0 <- function(S_0, K, r, sigma, T){
  d2 <- (log(S_0/K) + (r - sigma^2/2)*T)/(sigma * sqrt(T))
  res <- pnorm(d2) * exp(-r * T)
  return(res)
}

MC_V0 <- function(S_0, K, r, sigma, T, N, M){
  payoff <- rep(0,M)
  for (i in 1:M){
    s <- S_0
    for (n in 1:N){
      s <- s + r*s*(T/N) + sigma * s * sample(c(-1,1), 1) * sqrt(T/N)
    }
    if (s>=K){
      payoff[[i]] <- 1
    } else {
      payoff[[i]] <- 0
    }
  }
  res <- (1 + r * (T/N))^-N * mean(payoff)
}
```

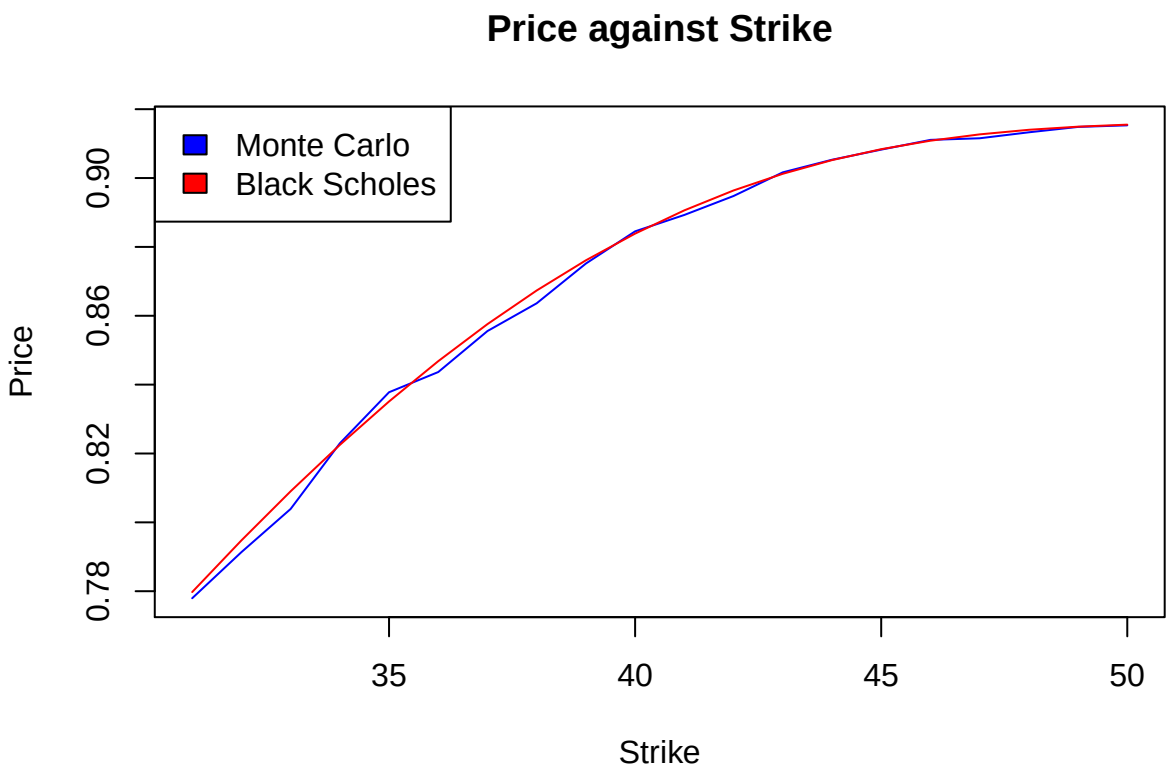
Out of money

```
MC <- c(0:19)
BS <- c(0:19)

for (i in 0:20){
  MC[i] <- MC_V0(init_price, K+i, r, sigma, T, M, N)
  BS[i] <- BS_V0(init_price, K+i, r, sigma, T)
}

plot(50:69, MC, main = "plot K = 50,...,70, M=N=1000", ylab = "Price", xlab="Strike", type = "l", col =
lines(50:69, BS, col = "red")
legend("topleft",
       c("MonteCarlo","BlackScholes"),
       fill=c("blue","red"))
```



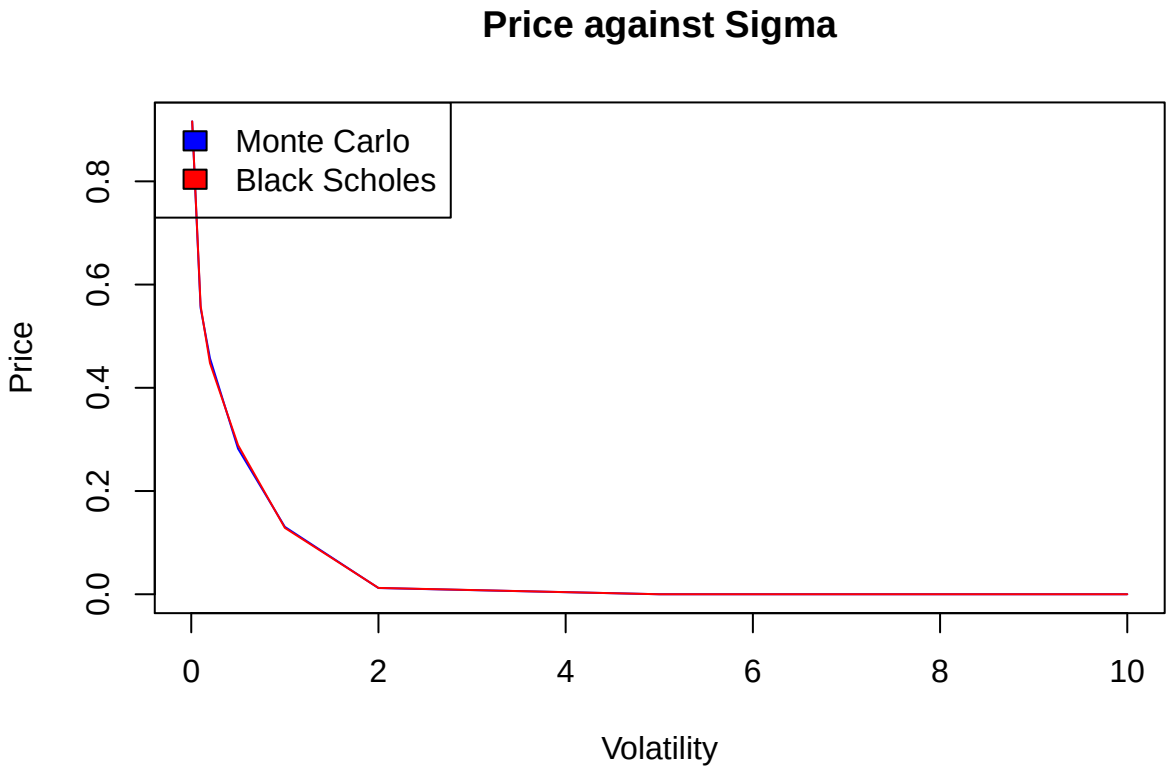
Vary in the money Options

```
priceMC <- rep(0,20)
priceBS <- rep(0,20)

for (i in 0:19){
  priceMC[[i+1]] <- MC_V0(init_price, K-19-i, r, sigma, T, M, N)
  priceBS[[i+1]] <- BS_V0(init_price, K-19-i, r, sigma, T)
}
plot(K-rev(c(0:19)), priceMC, main = "Price against Strike", ylab = "Price" , xlab = "Strike", type = "
lines(K-rev(c(0:19)), priceBS, col="red")
legend("topleft", c("Monte Carlo", "Black Scholes"), fill=c("blue", "red"))
```



Vary sigma

```
sigmas = c(0.01, 0.1, 0.2, 0.5, 1, 2, 5, 10)
priceMC = rep(0, length(sigmas))
priceBS = rep(0, length(sigmas))
for (i in 1:length(sigmas)){
  priceMC[[i]] <- MC_V0(init_price, K, r, sigmas[i], T, M, N)
  priceBS[[i]] <- BS_V0(init_price, K, r, sigmas[i], T)
}
plot(sigmas, priceMC, main = "Price against Sigma", ylab="Price",xlab="Volatility", type="l", col="blue
lines(sigmas, priceBS, col="red")
legend("topleft", c("Monte Carlo", "Black Scholes"), fill = c("blue","red"))
```


Price against Sigma
Monte Carlo
Black Scholes
Price
0.0
0.2
0.4
0.6
0.8
0
2
4
6
8
10
Volatility