Dominion

R1 Functions

```
#draw 5 cards to begin in every turn
#setting
number_Copper = 60
number_Silver = 40
number_Gold = 20

number_Estate = 8
number_Duchy = 8
number_Province = 8

number_Smithy = 10
getcarda = function(deck,number = 5){
  hand = deck[1:number]
  return(hand)
}
getcardb = function(deck,number = 5){
  left = deck[-c(1:number)]
  return(left)
}

#end turn
reshuffle = function(discard){
  deck = sample(discard)
  return(deck)
}
```

R2 "Greedy" function along with 1-player setting

```r
# "greedy" strategy
buy_greedy = function(hand){
  if(sum(unlist(hand)) >= 8){
    buy_card = 0
    number_Province <<- number_Province - 1
    p = 6
  }else if(sum(unlist(hand)) >= 6){
    buy_card = 3
    number_Gold <<- number_Gold - 1
    p = 0
  }else if(sum(unlist(hand)) >= 3){
    buy_card = 2
    number_Silver <<- number_Silver - 1
    p = 0
  }else{
    buy_card = numeric(0)
    p = 0
  }
  return(list(buy_card=buy_card, points=p))
}

runtimes = 0
store = numeric(0)
for (runtimes in 1: 10000) {
  number_Copper = 60
  number_Silver = 40
  number_Gold = 20

  number_Estate = 8
  number_Duchy = 8
  number_Province = 8

  deck = c(1,1,1,1,1,1,1,0,0,0)
  deck = sample(deck)
  discard = numeric(0)
  i = 0
  p = 3
  while(number_Province>0){
    i = i+1
    if(length(deck)>=5){
      hand = getcarda(deck)
      deck= getcardb(deck)
      buy_card = buy_greedy(hand)
      buy_card2=buy_card$buy_card
      discard = c(discard,hand,buy_card2)
    }else{
      hand = deck
      deck = reshuffle(discard)
      hand2 = getcarda(deck,number=5-length(hand))
      deck = getcardb(deck,number=5-length(hand))
      hand=c(hand,hand2)
      buy_card = buy_greedy(hand)
```

```
      buy_card2 = buy_card$buy_card
      discard = c(hand,buy_card2)
    }
  }
  store <- c(store,i)

}


#minimum rounds to run out of Province under "greedy" strategies
min_rounds1 = min(store)
mean(store)
```
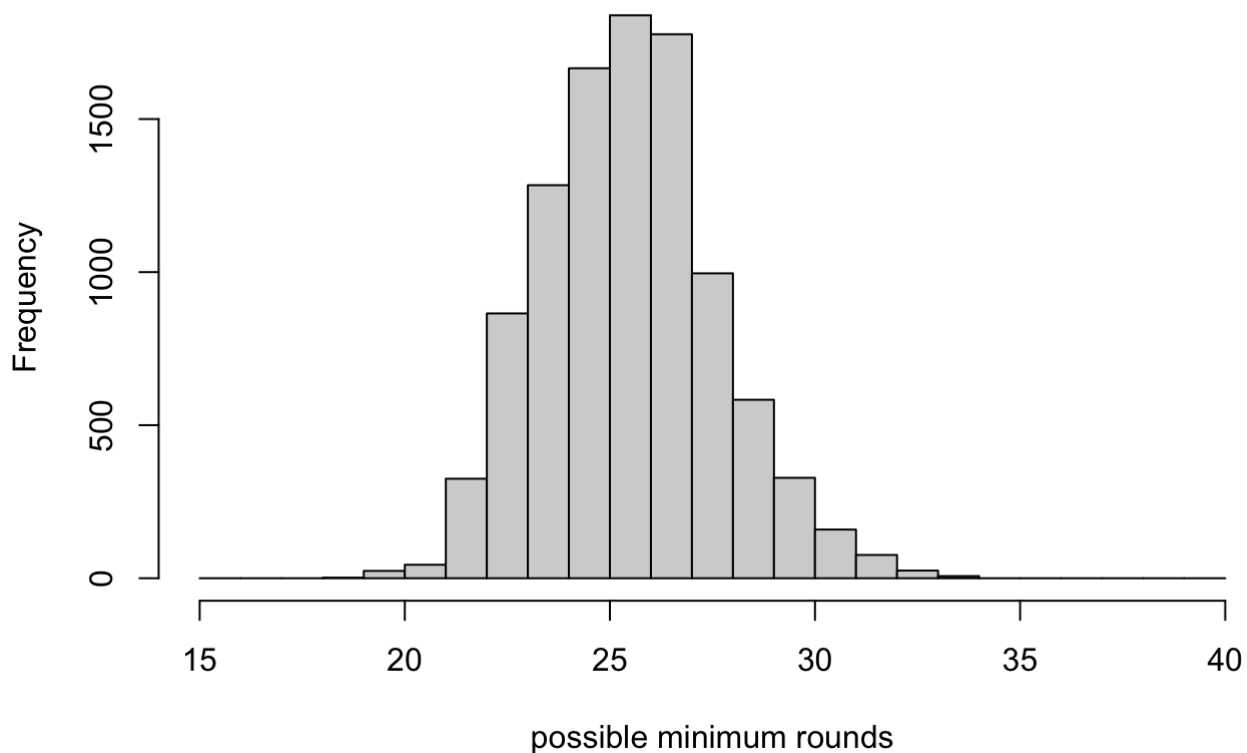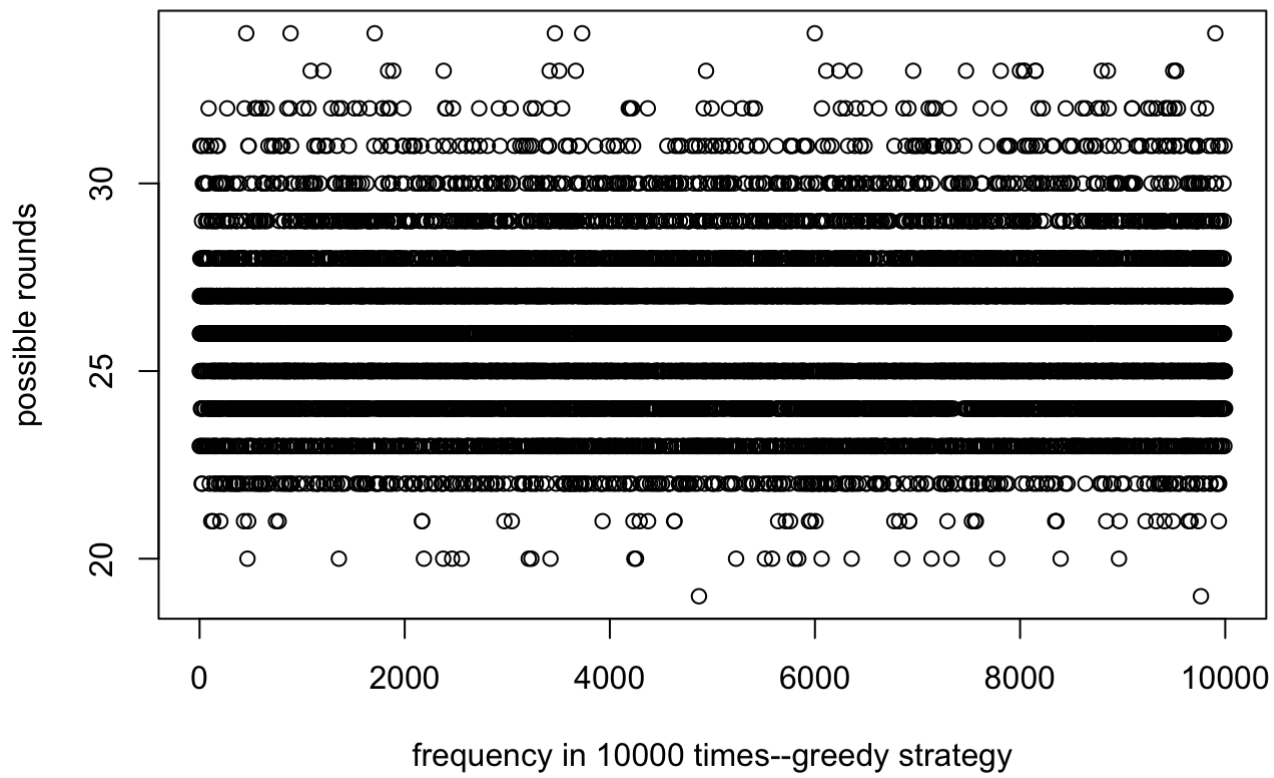
```
## [1] 25.9805
```

```
#visualization
bins = seq(15,40, by =1)
hist(store,breaks= bins, main = "the frequency of different rounds in 10000 times in Gre
edy strategy", xlab = "possible minimum rounds")
```

the frequency of different rounds in 10000 times in Greedy strategy


```
plot(store,xlab = "frequency in 10000 times--greedy strategy", ylab = "possible rounds")
```

R3 "Big-money" function along with 1-player setting

```r
#"big money" strategy
buy_bigmoney = function(hand1){
  if(sum(unlist(hand1)) >= 8){
    buy_card1 = 0
    number_Province <<- number_Province - 1
    p = 6
  }else if(sum(unlist(hand1)) >= 6){
    buy_card1 = 3
    number_Gold <<- number_Gold - 1
    p = 0
  }else if(sum(unlist(hand1)) >= 3){
    buy_card1 = 2
    number_Silver <<- number_Silver - 1
    p = 0
  }else{
    buy_card1 = 1
    number_Copper <<- number_Copper -1
    p = 0
  }
  return(list(buy_card=buy_card1, points=p))
}

runtimes = 0
store = numeric(0)

for (runtimes in 1: 10000) {
  number_Copper = 60
  number_Silver = 40
  number_Gold = 20

  number_Estate = 8
  number_Duchy = 8
  number_Province = 8
  p=3
  deck = c(1,1,1,1,1,1,1,0,0,0)
  deck = sample(deck)
  discard = numeric(0)
  i = 0
  while(number_Province>0){
    i = i+1
    if(length(deck)>=5){
      hand = getcarda(deck)
      deck= getcardb(deck)
      buy_card = buy_bigmoney(hand)
      buy_card2=buy_card$buy_card
      discard = c(discard,hand,buy_card2)
      #return(list(buy_card=buy_card1, points=p))
      #output= buy_cards(hand2,p2)
      #buy_card2=output$buy_card
      #p2=output$p
    }else{
      hand = deck
```

```
        deck = reshuffle(discard)
        hand2 = getcarda(deck,number=5-length(hand))
        deck = getcardb(deck,number=5-length(hand))
        hand=c(hand,hand2)
        buy_card = buy_bigmoney(hand)
        buy_card2=buy_card$buy_card
        discard = c(hand,buy_card2)
      }
    }
    store <- c(store,i)
}

#minimum rounds to run out of Province under "big money" strategies
min_rounds2 = min(store)
mean(store)
```
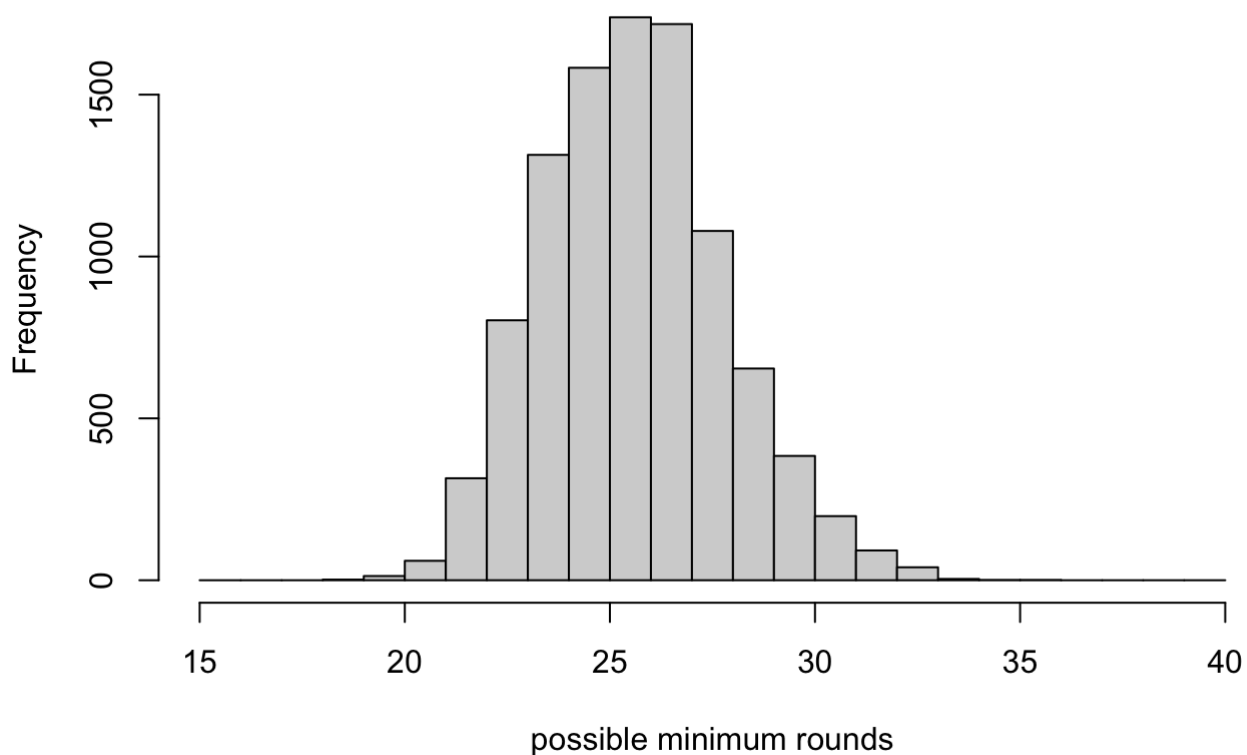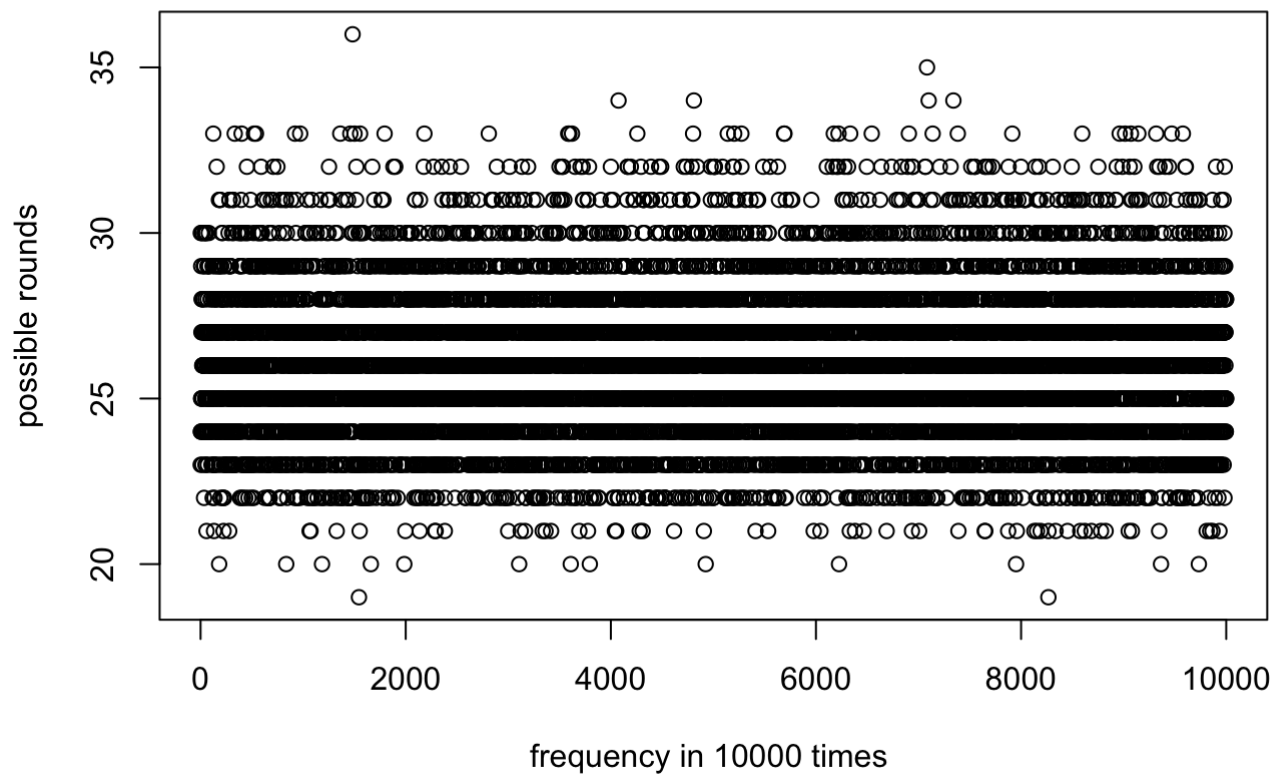
```
## [1] 26.0975
```

```
#visualization
bins = seq(15,40, by =1)
hist(store,breaks= bins, main = "the frequency of different rounds in 10000 times in 'bi
g money' strategy", xlab = "possible minimum rounds")
```

the frequency of different rounds in 10000 times in 'big money' strategy

```
plot(store,xlab = "frequency in 10000 times ", ylab = "possible rounds")
```


R4 "Wait-for-gold" function along with 1-player setting

```r
#strategy3 wait for gold
buy_waitgold = function(hand,all_cards){
  if(sum(unlist(hand)) >= 8 & sum(unlist(all_cards == 3)) >= 4){
    buy_card = 0
    number_Province <<- number_Province - 1
    p = p+6
  }else if(sum(unlist(hand)) >= 6 ){
    buy_card = 3
    number_Gold <<- number_Gold - 1
    p = 0
  }else if(sum(unlist(hand)) >= 3){
    buy_card = 2
    number_Silver <<- number_Silver - 1
    p = 0
  }else{
    buy_card = 0
    p = 0
  }
  return(list(buy_card=buy_card, points=p))
}


runtimes =0

#for loop
for (runtimes in 1: 10000) {
  number_Copper = 60
  number_Silver = 40
  number_Gold = 20

  number_Estate = 8
  number_Duchy = 8
  number_Province = 8
  p=3

  deck = c(1,1,1,1,1,1,1,0,0,0)
  deck = sample(deck)
  discard = numeric(0)
  i = 0
  while(number_Province>0){
    i = i+1
    all_cards = c(deck,discard)
    if(length(deck)>=5){
      hand = getcarda(deck)
      deck= getcardb(deck)
      buy_card = buy_waitgold(hand,all_cards)
      buy_card2 = buy_card$buy_card
      discard = c(discard,hand,buy_card2)
    }else{
      hand = deck
      deck = reshuffle(discard)
      hand2 = getcarda(deck,number=5-length(hand))
      deck = getcardb(deck,number=5-length(hand))
```

```
      hand=c(hand,hand2)
      buy_card = buy_waitgold(hand,all_cards)
      buy_card2 = buy_card$buy_card
      discard = c(hand,buy_card2)
    }
  }
  store <- c(store,i)
}

#minimum rounds to run out of Province under "greedy" strategies
min_rounds1 = min(store)
mean(store)
```
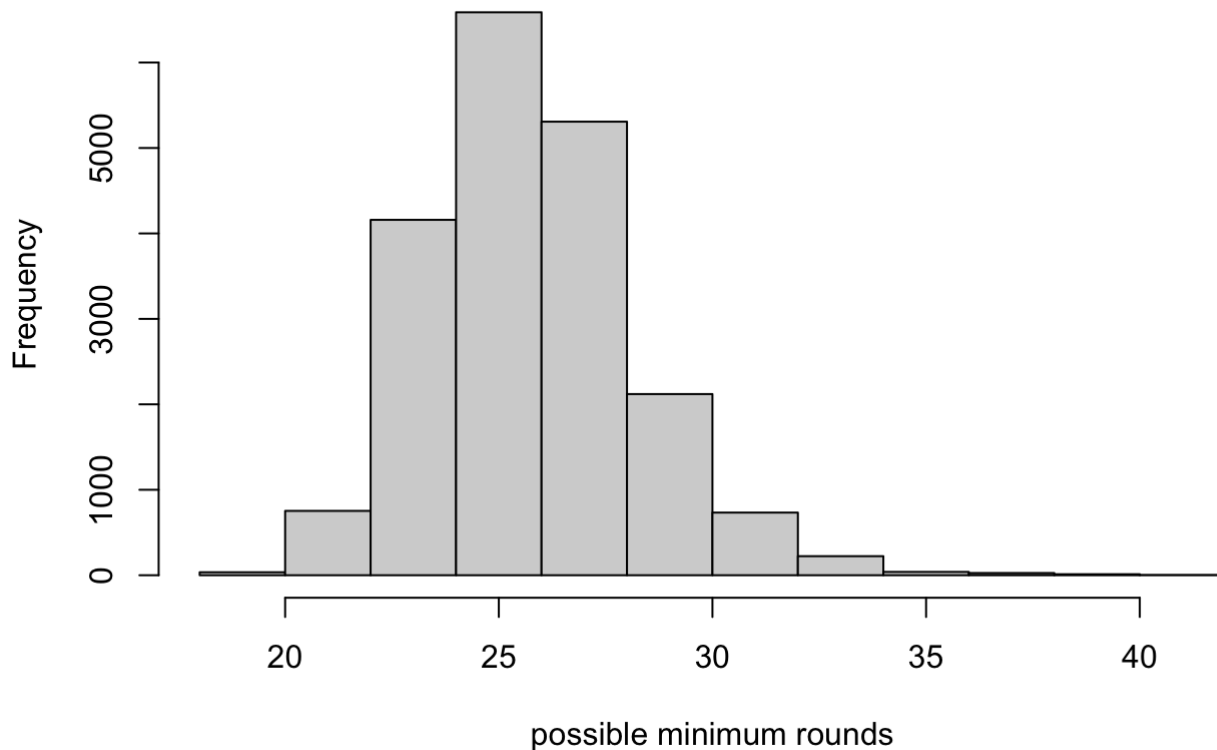
```
## [1] 26.2276
```
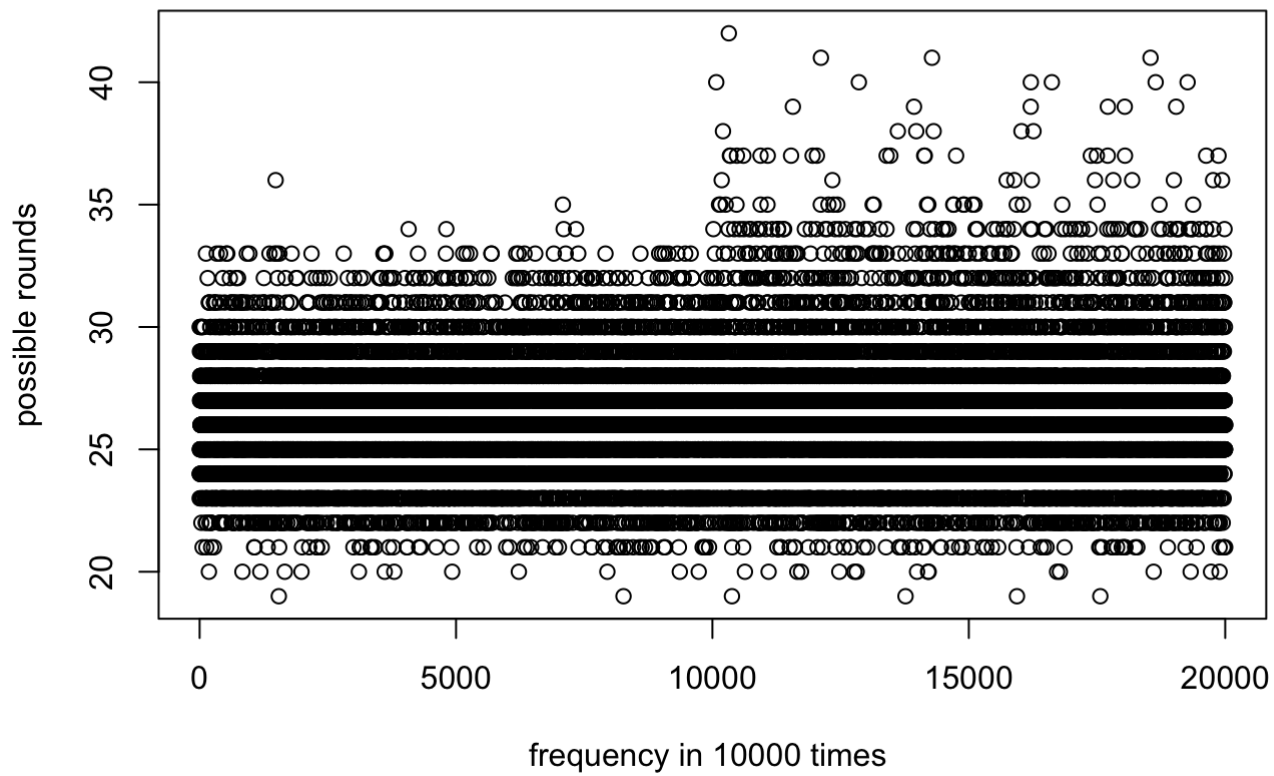
```
#visualization


hist(store, main = "the frequency of different rounds in 10000 times in 'wait-for-gold'
 strategy", xlab = "possible minimum rounds")
```

the frequency of different rounds in 10000 times in 'wait-for-gold' strateg


```
plot(store,xlab = "frequency in 10000 times ", ylab = "possible rounds")
```

frequency in 10000 times

```
#0, mean = 25.9747
#1, mean = 25.891
#2, mean = 25.8051
#3, mean = 25.7373
#4, mean = 25.7123, the least one.
#5, mean = 25.7977
#6, mean = 25.9903
#7, mean = 26.2896
#8, mean = 26.683
#...
```

R5 Two players player1: greedy strategy player2: big money strategy

```r
runtimes = 0
vi = numeric(0)
v1 = numeric(0)
v2 = numeric(0)

v1_total = list()
v2_total = list()
for (runtimes in 1: 10000){
  number_Copper = 60
  number_Silver = 40
  number_Gold = 20
  number_Estate = 8
  number_Duchy = 8
  number_Province = 8
  i=0

  deck = c(1,1,1,1,1,1,1,0,0,0)
  deck1 = sample(deck)
  discard1 = numeric(0)
  deck2 = sample(deck)
  discard2 = numeric(0)

  v1 = 0
  v2 = 0

  p1 = 3
  p2 = 3
  while(number_Province>0){
    i = i+1
    v1 = v1+p1
    v2 = v2+p2
    if(length(deck1)>=5){
      hand1 = getcarda(deck1)
      deck1= getcardb(deck1)
      buy_card1 = buy_greedy(hand1)
      p1 = buy_card1$points
      buy_card1_1 =buy_card1$buy_card
      discard1 = c(discard1,hand1,buy_card1_1)
    }else{
      hand1 = deck1
      deck1 = reshuffle(discard1)
      hand1_2 = getcarda(deck1,number=5-length(hand1))
      deck1 = getcardb(deck1,number=5-length(hand1))
      hand1=c(hand1,hand1_2)
      buy_card1 = buy_greedy(hand1)
      p1 = buy_card1$points
      buy_card1_1 = buy_card1$buy_card
      discard1 = c(hand1,buy_card1)
    }
    if(number_Province>0) {
      if(length(deck2)>=5){
        hand2 = getcarda(deck2)
```

```
        deck2= getcardb(deck2)
        buy_card2 = buy_bigmoney(hand2)
        p2 = buy_card2$points
        buy_card2_2 = buy_card2$buy_card
        discard2 = c(discard2,hand2,buy_card2_2)
      }else{
        hand2 = deck2
        deck2 = reshuffle(discard2)
        hand2_2 = getcarda(deck2,number=5-length(hand2))
        deck2 = getcardb(deck2,number=5-length(hand2))
        hand2=c(hand2,hand2_2)
        buy_card2 = buy_bigmoney(hand2)
        p2 = buy_card2$points
        buy_card2_2 = buy_card2$buy_card
        discard2 = c(hand2,buy_card2_2)
      }
    }
  }
  v1_total = append(v1,v1_total)
  v2_total = append(v2_total, v2)
  vi = c(vi,i)
}


hist((unlist(v1_total)-unlist(v2_total)), main = "greedy vs big-money",xlab = "differenc
e in victory points")
```

greedy vs big-money

difference in victory points
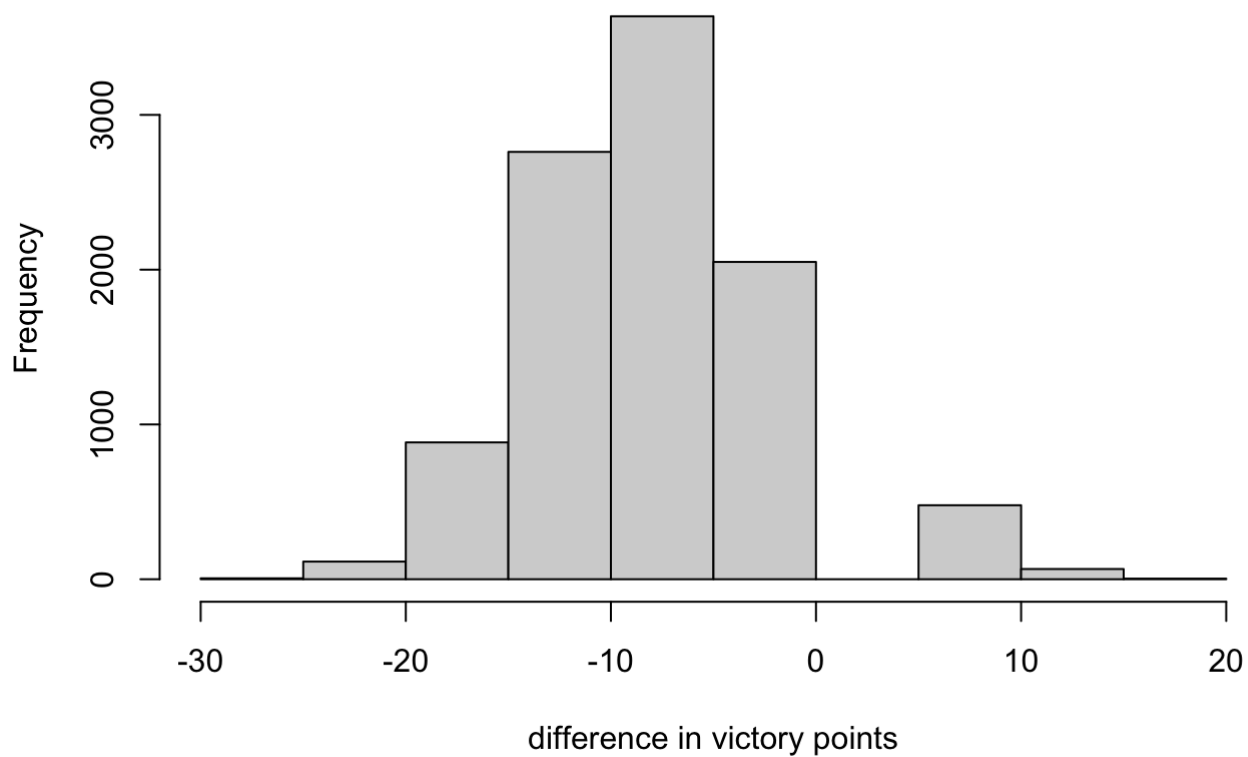
```
plot((unlist(v1_total)-unlist(v2_total)), ylab = "how many victory points player 1 wins
 out player2")
```
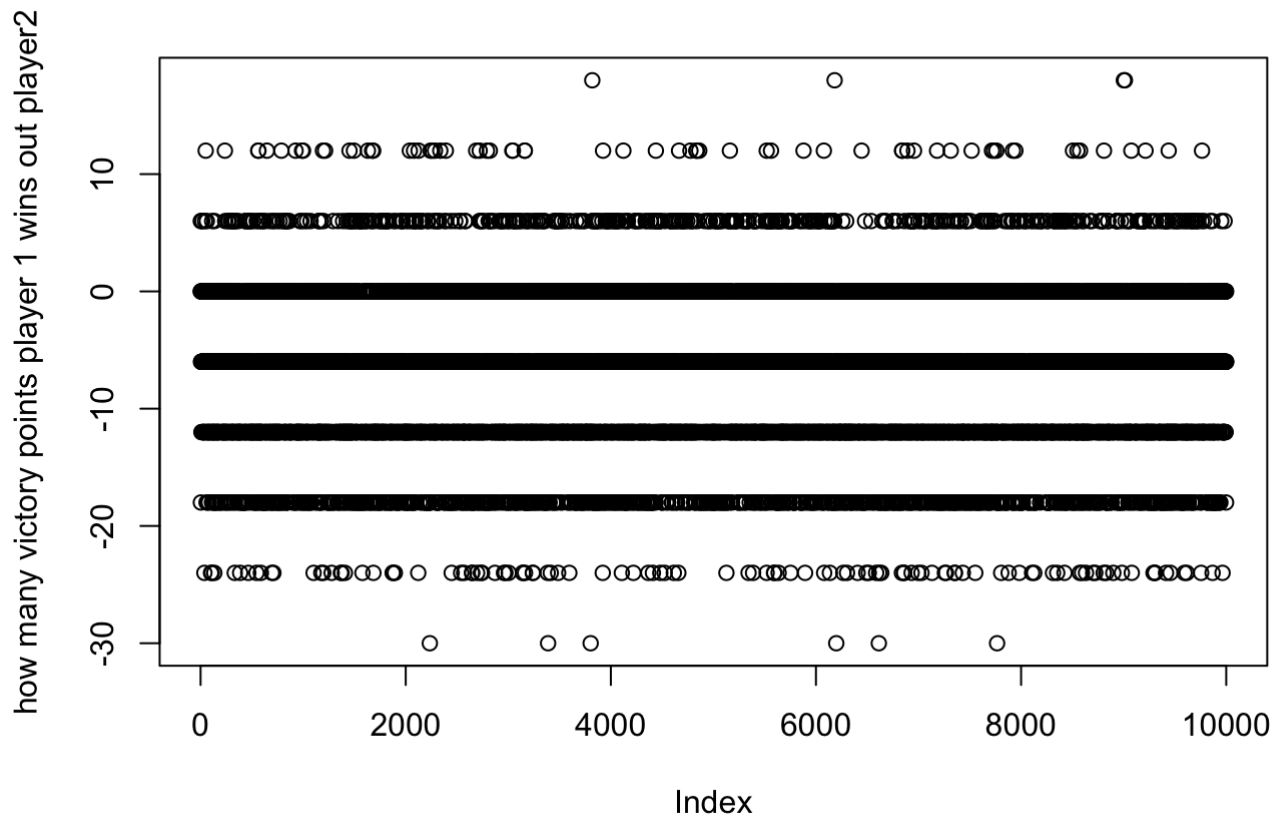
```
#here, we use v1 and v2 to denote the number of medals they two players got, and i repre
sents rounds
# player 2 wins more time

#mean((v2-v1)>0)
#deck1

#greedy strategy wins
```

R6 player1: big-money strategy player2: "greedy" strategy

```r
#switch order, still greedy strategy vs big money strategy, but now we let big-money str
ategy player go first.
#player1: big-money strategy
#player2: "greedy" strategy
runtimes = 0
vi = numeric(0)
v1 = numeric(0)
v2 = numeric(0)


v1_total = list()
v2_total = list()



for (runtimes in 1: 10000){
  number_Copper = 60
  number_Silver = 40
  number_Gold = 20
  number_Estate = 8
  number_Duchy = 8
  number_Province = 8
  i=0

  deck = c(1,1,1,1,1,1,1,0,0,0)
  deck1 = sample(deck)
  discard1 = numeric(0)
  deck2 = sample(deck)
  discard2 = numeric(0)

  v1 = 0
  v2 = 0

  p1 = 3
  p2 = 3
  while(number_Province>0){
    i = i+1
    v1 = v1+p1
    v2 = v2+p2
    if(length(deck1)>=5){
      hand1 = getcarda(deck1)
      deck1= getcardb(deck1)
      buy_card1 = buy_bigmoney(hand1)
      p1 = buy_card1$points
      buy_card1_1 =buy_card1$buy_card
      discard1 = c(discard1,hand1,buy_card1_1)
    }else{
      hand1 = deck1
      deck1 = reshuffle(discard1)
      hand1_2 = getcarda(deck1,number=5-length(hand1))
      deck1 = getcardb(deck1,number=5-length(hand1))
      hand1=c(hand1,hand1_2)
      buy_card1 = buy_bigmoney(hand1)
      p1 = buy_card1$points
```

```
            buy_card1_1 = buy_card1$buy_card
            discard1 = c(hand1,buy_card1)
        }
        if(number_Province>0) {
            if(length(deck2)>=5){
                hand2 = getcarda(deck2)
                deck2= getcardb(deck2)
                buy_card2 = buy_greedy(hand2)
                p2 = buy_card2$points
                buy_card2_2 = buy_card2$buy_card
                discard2 = c(discard2,hand2,buy_card2_2)
            }else{
                hand2 = deck2
                deck2 = reshuffle(discard2)
                hand2_2 = getcarda(deck2,number=5-length(hand2))
                deck2 = getcardb(deck2,number=5-length(hand2))
                hand2=c(hand2,hand2_2)
                buy_card2 = buy_greedy(hand2)
                p2 = buy_card2$points
                buy_card2_2 = buy_card2$buy_card
                discard2 = c(hand2,buy_card2_2)
            }
        }
    }
    v1_total = append(v1,v1_total)
    v2_total = append(v2_total, v2)
    vi = c(vi,i)
}



hist((unlist(v1_total)-unlist(v2_total)), main = "big-money vs greedy",xlab = "differenc
e in medals")
```
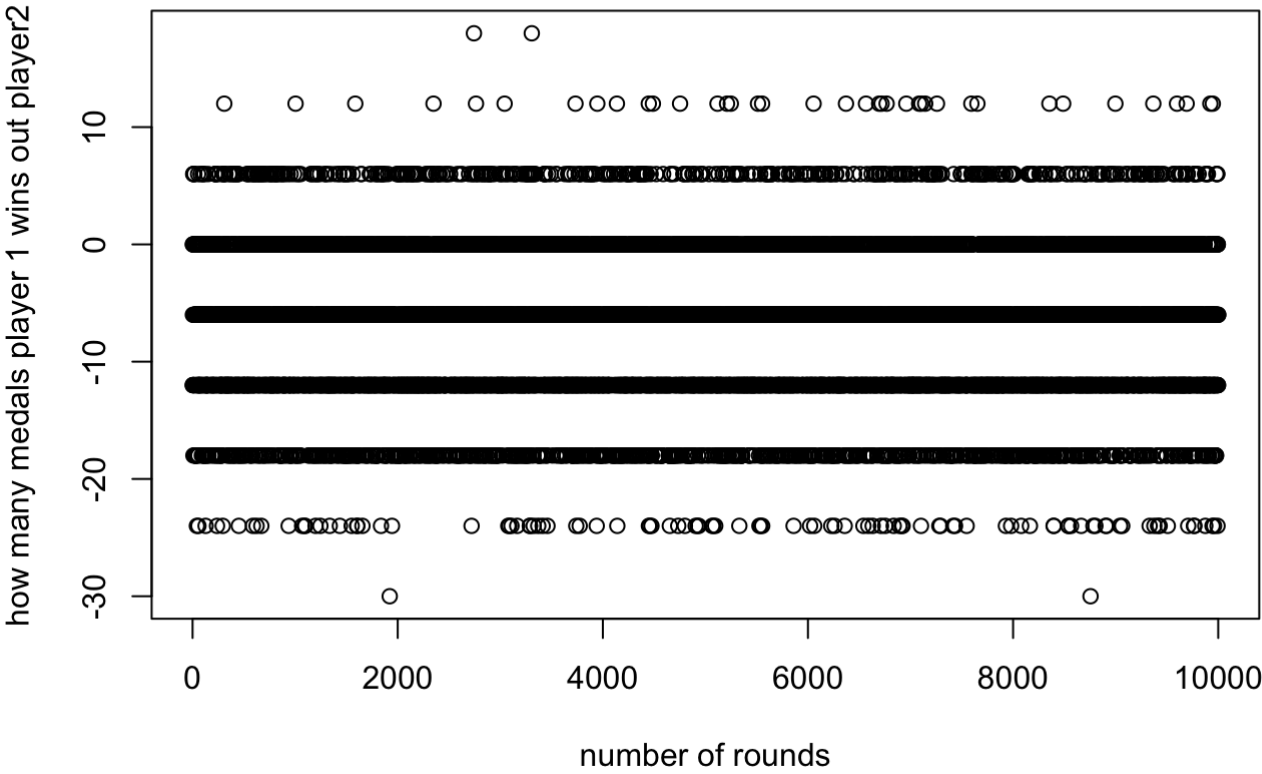
big-money vs greedy

difference in medals
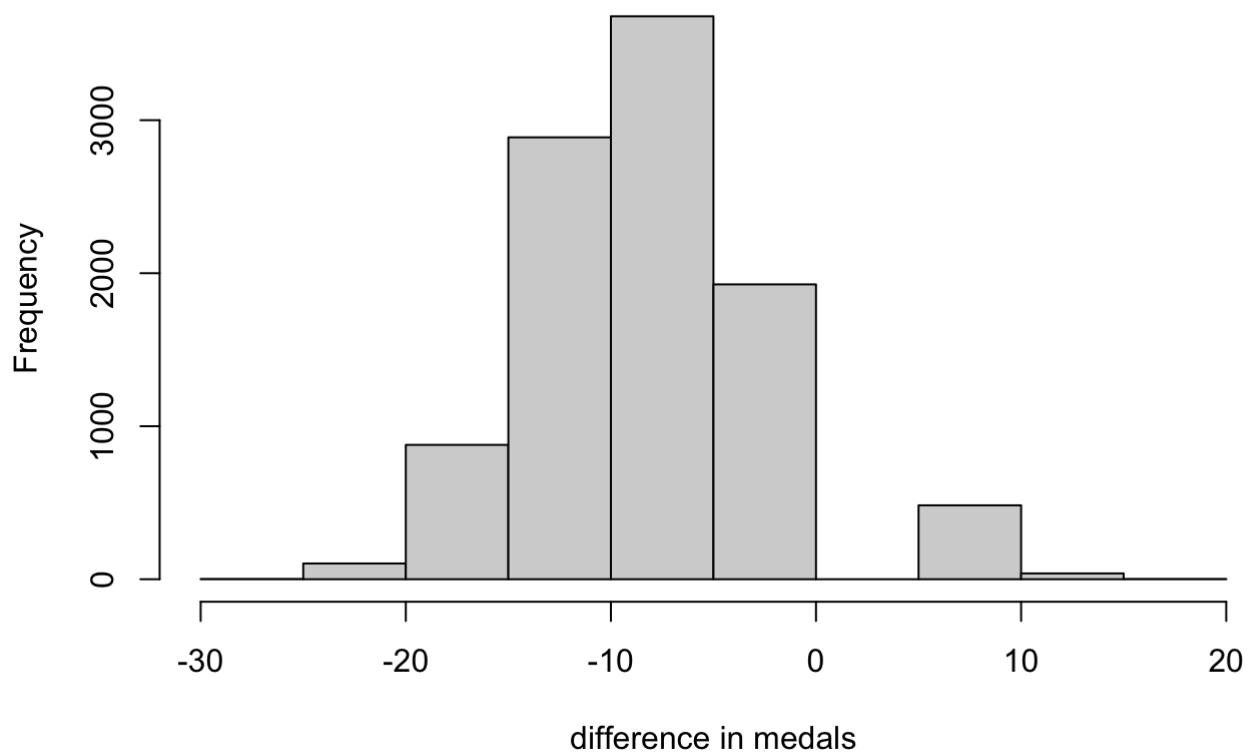
```
plot((unlist(v1_total)-unlist(v2_total)), ylab = "how many medals player 1 wins out play
er2",xlab = "number of rounds")
```

R7 player1: greedy strategy player2: "wait for gold" strategy

```r
#player1: greedy strategy
#player2: "wait for gold" strategy

runtimes = 0
vi = numeric(0)
v1 = numeric(0)
v2 = numeric(0)

v1_total = list()
v2_total = list()

for (runtimes in 1: 10000){
  number_Copper = 60
  number_Silver = 40
  number_Gold = 20
  number_Estate = 8
  number_Duchy = 8
  number_Province = 8
  i=0

  deck = c(1,1,1,1,1,1,1,0,0,0)
  deck1 = sample(deck)
  discard1 = numeric(0)
  deck2 = sample(deck)
  discard2 = numeric(0)

  v1 = 0
  v2 = 0

  p1 = 3
  p2 = 3
  while(number_Province>0){
    i = i+1
    v1 = v1+p1
    v2 = v2+p2
    if(length(deck1)>=5){
      hand1 = getcarda(deck1)
      deck1= getcardb(deck1)
      buy_card1 = buy_greedy(hand1)
      p1 = buy_card1$points
      buy_card1_1 =buy_card1$buy_card
      discard1 = c(discard1,hand1,buy_card1_1)
    }else{
      hand1 = deck1
      deck1 = reshuffle(discard1)
      hand1_2 = getcarda(deck1,number=5-length(hand1))
      deck1 = getcardb(deck1,number=5-length(hand1))
      hand1=c(hand1,hand1_2)
      buy_card1 = buy_greedy(hand1)
      p1 = buy_card1$points
      buy_card1_1 = buy_card1$buy_card
      discard1 = c(hand1,buy_card1)
```

```r
      }
    if(number_Province>0) {
        all_cards = c(deck2,discard)
        if(length(deck2)>=5){
          hand2 = getcarda(deck2)
          deck2= getcardb(deck2)
          buy_card2 = buy_waitgold(hand2,all_cards)
          p2 = buy_card2$points
          buy_card2_2 = buy_card2$buy_card
          discard2 = c(discard2,hand2,buy_card2_2)
        }else{
          hand2 = deck2
          deck2 = reshuffle(discard2)
          hand2_2 = getcarda(deck2,number=5-length(hand2))
          deck2 = getcardb(deck2,number=5-length(hand2))
          hand2=c(hand2,hand2_2)
          buy_card2 = buy_waitgold(hand2,all_cards)
          p2 = buy_card2$points
          buy_card2_2 = buy_card2$buy_card
          discard2 = c(hand2,buy_card2_2)
        }
      }
    }
  v1_total = append(v1,v1_total)
  v2_total = append(v2_total, v2)
  vi = c(vi,i)
}



hist((unlist(v1_total)-unlist(v2_total)), main = "greedy vs wait-for-gold",xlab = "diffe
rence in medals")
```

greedy vs wait-for-gold
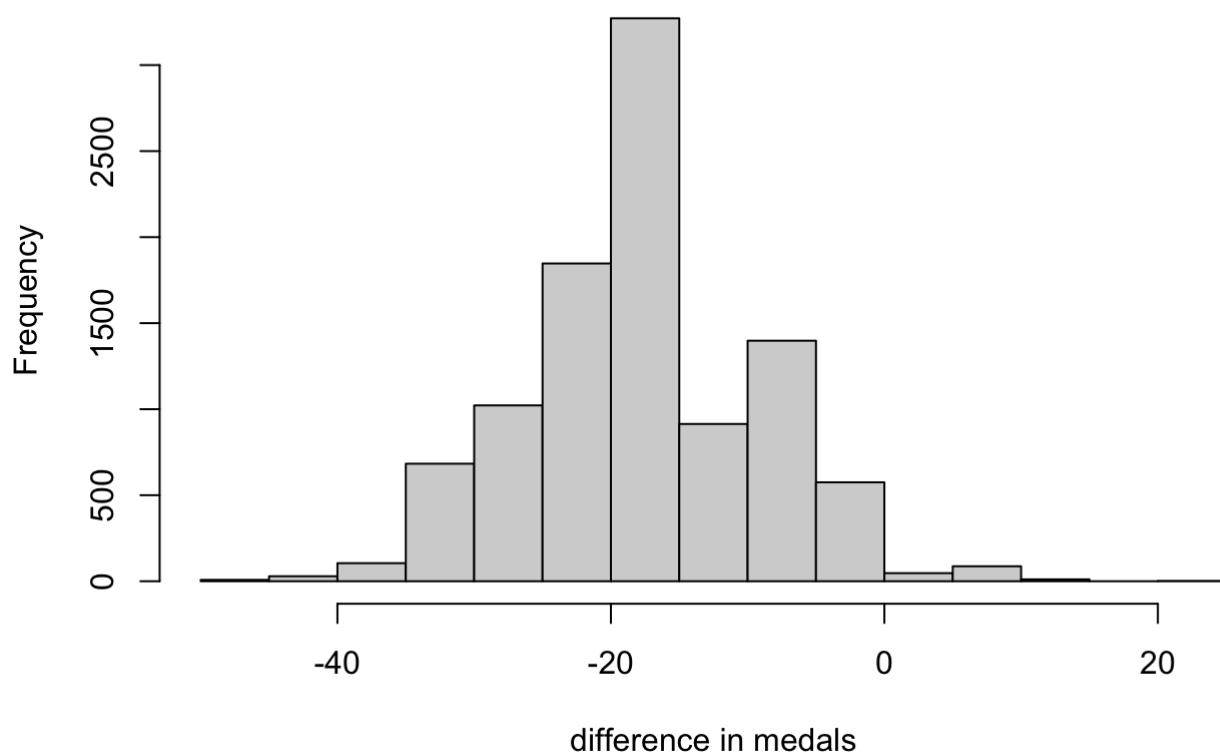

```
plot((unlist(v1_total)-unlist(v2_total)), ylab = "how many medals player 1 wins out play
er2")
```
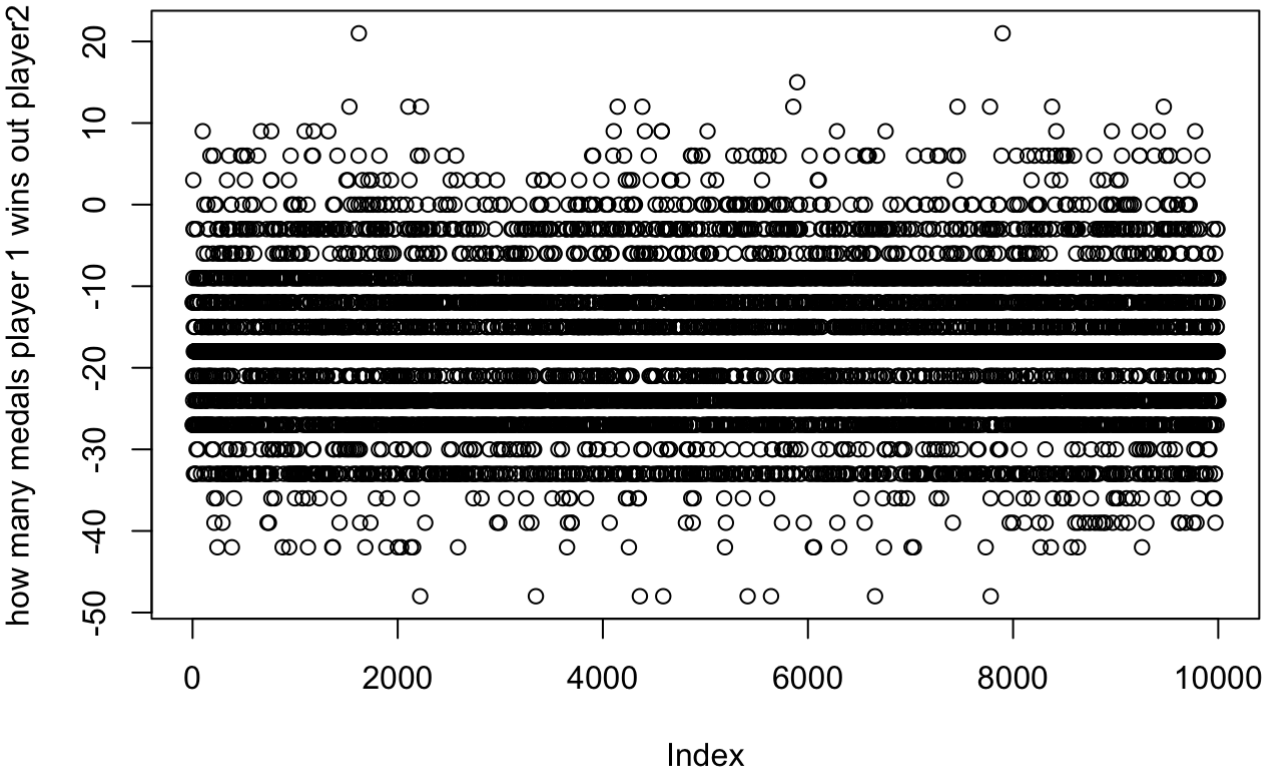
R8 player1: wait for gold strategy player2: "greedy" strategy

```r
#switch order for greedy strategy and "wait for gold" strategy
#player1: wait for gold strategy
#player2: "greedy" strategy


runtimes = 0
vi = numeric(0)
v1 = numeric(0)
v2 = numeric(0)

v1_total = list()
v2_total = list()

for (runtimes in 1: 10000){
  number_Copper = 60
  number_Silver = 40
  number_Gold = 20
  number_Estate = 8
  number_Duchy = 8
  number_Province = 8
  i=0

  deck = c(1,1,1,1,1,1,1,0,0,0)
  deck1 = sample(deck)
  discard1 = numeric(0)
  deck2 = sample(deck)
  discard2 = numeric(0)

  v1 = 0
  v2 = 0

  p1 = 3
  p2 = 3
  while(number_Province>0){
    i = i+1
    v1 = v1+p1
    v2 = v2+p2
    all_cards = c(deck1,discard)
    if(length(deck1)>=5){
      hand1 = getcarda(deck1)
      deck1= getcardb(deck1)
      buy_card1 = buy_waitgold(hand1,all_cards)
      p1 = buy_card1$points
      buy_card1_1 =buy_card1$buy_card
      discard1 = c(discard1,hand1,buy_card1_1)
    }else{
      hand1 = deck1
      deck1 = reshuffle(discard1)
      hand1_2 = getcarda(deck1,number=5-length(hand1))
      deck1 = getcardb(deck1,number=5-length(hand1))
      hand1=c(hand1,hand1_2)
      buy_card1 = buy_waitgold(hand1,all_cards)
```

```r
        p1 = buy_card1$points
        buy_card1_1 = buy_card1$buy_card
        discard1 = c(hand1,buy_card1)
      }
      if(number_Province>0) {
        if(length(deck2)>=5){
          hand2 = getcarda(deck2)
          deck2= getcardb(deck2)
          buy_card2 = buy_greedy(hand2)
          p2 = buy_card2$points
          buy_card2_2 = buy_card2$buy_card
          discard2 = c(discard2,hand2,buy_card2_2)
        }else{
          hand2 = deck2
          deck2 = reshuffle(discard2)
          hand2_2 = getcarda(deck2,number=5-length(hand2))
          deck2 = getcardb(deck2,number=5-length(hand2))
          hand2=c(hand2,hand2_2)
          buy_card2 = buy_greedy(hand2)
          p2 = buy_card2$points
          buy_card2_2 = buy_card2$buy_card
          discard2 = c(hand2,buy_card2_2)
        }
      }
    }
    v1_total = append(v1,v1_total)
    v2_total = append(v2_total, v2)
    vi = c(vi,i)
}



hist((unlist(v1_total)-unlist(v2_total)), main = "wait for gold vs greedy",xlab = "diffe
rence in medals")
```

wait for gold vs greedy

difference in medals
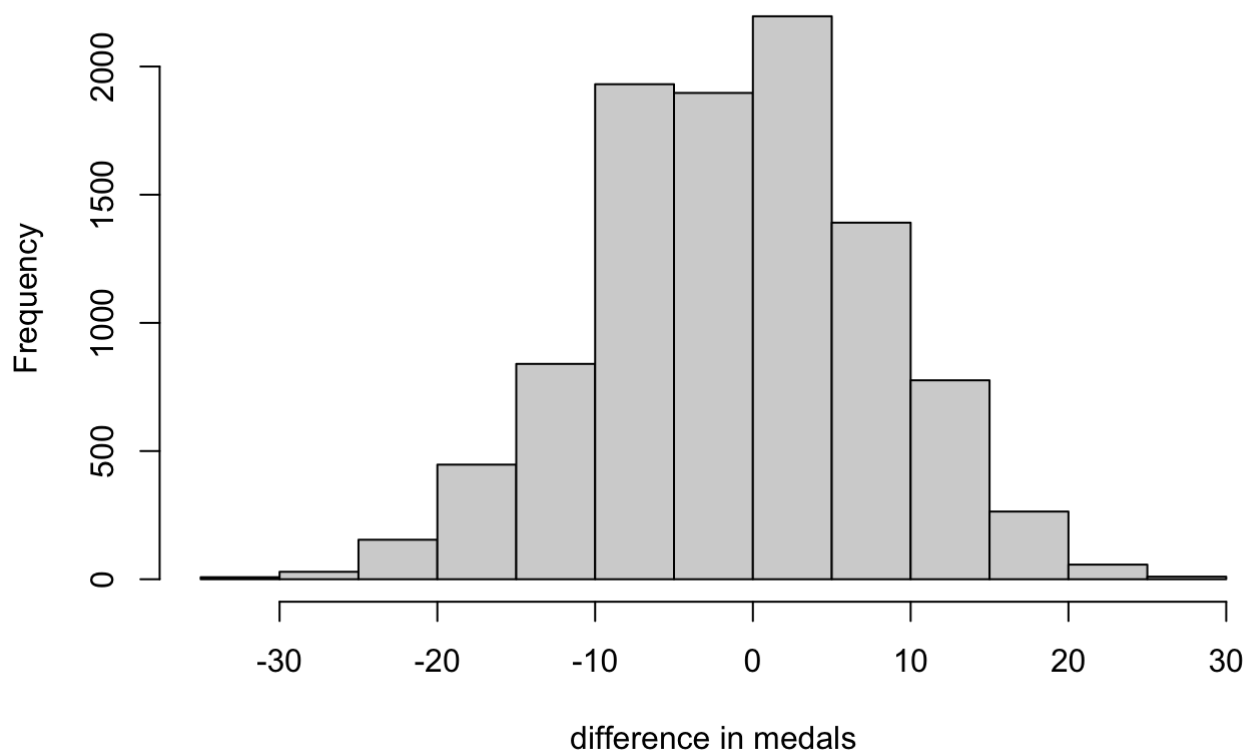
```
plot((unlist(v1_total)-unlist(v2_total)), ylab = "how many medals player 1 wins out play
er2")
```
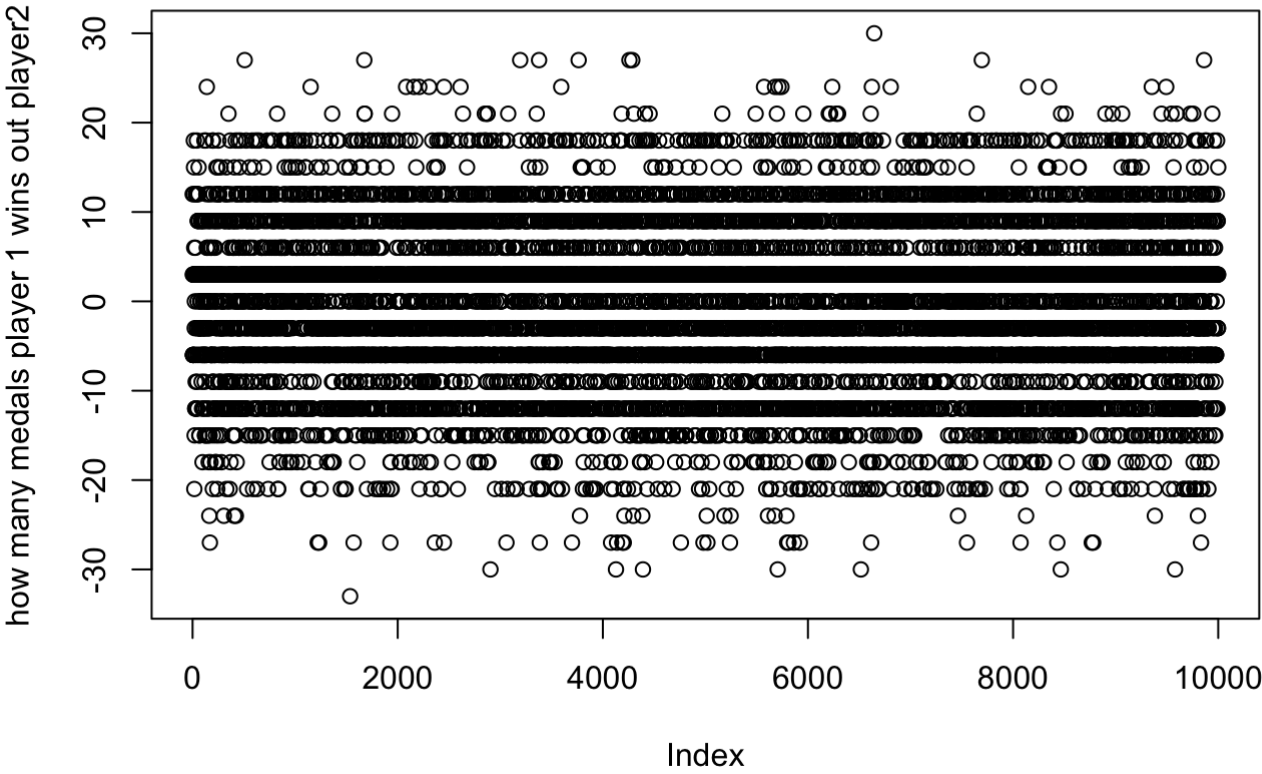
R9 player1: wait for gold strategy player2: big money strategy

```r
#now consider the "big money" strategy vs "wait for gold" strategy

#player1: wait for gold strategy
#player2: big money strategy

runtimes = 0
vi = numeric(0)
v1 = numeric(0)
v2 = numeric(0)

v1_total = list()
v2_total = list()

for (runtimes in 1: 10000){
  number_Copper = 60
  number_Silver = 40
  number_Gold = 20
  number_Estate = 8
  number_Duchy = 8
  number_Province = 8
  i=0

  deck = c(1,1,1,1,1,1,1,0,0,0)
  deck1 = sample(deck)
  discard1 = numeric(0)
  deck2 = sample(deck)
  discard2 = numeric(0)

  v1 = 0
  v2 = 0

  p1 = 3
  p2 = 3
  while(number_Province>0){
    i = i+1
    v1 = v1+p1
    v2 = v2+p2
    all_cards = c(deck1,discard)
    if(length(deck1)>=5){
      hand1 = getcarda(deck1)
      deck1= getcardb(deck1)
      buy_card1 = buy_waitgold(hand1,all_cards)
      p1 = buy_card1$points
      buy_card1_1 =buy_card1$buy_card
      discard1 = c(discard1,hand1,buy_card1_1)
    }else{
      hand1 = deck1
      deck1 = reshuffle(discard1)
      hand1_2 = getcarda(deck1,number=5-length(hand1))
      deck1 = getcardb(deck1,number=5-length(hand1))
      hand1=c(hand1,hand1_2)
      buy_card1 = buy_waitgold(hand1,all_cards)
```

```r
        p1 = buy_card1$points
        buy_card1_1 = buy_card1$buy_card
        discard1 = c(hand1,buy_card1)
      }
      if(number_Province>0) {
        if(length(deck2)>=5){
          hand2 = getcarda(deck2)
          deck2= getcardb(deck2)
          buy_card2 = buy_bigmoney(hand2)
          p2 = buy_card2$points
          buy_card2_2 = buy_card2$buy_card
          discard2 = c(discard2,hand2,buy_card2_2)
        }else{
          hand2 = deck2
          deck2 = reshuffle(discard2)
          hand2_2 = getcarda(deck2,number=5-length(hand2))
          deck2 = getcardb(deck2,number=5-length(hand2))
          hand2=c(hand2,hand2_2)
          buy_card2 = buy_bigmoney(hand2)
          p2 = buy_card2$points
          buy_card2_2 = buy_card2$buy_card
          discard2 = c(hand2,buy_card2_2)
        }
      }
    }
    v1_total = append(v1,v1_total)
    v2_total = append(v2_total, v2)
    vi = c(vi,i)
}



hist((unlist(v1_total)-unlist(v2_total)), main = "wait for gold vs big money",xlab = "di
fference in medals")
```

wait for gold vs big money

difference in medals
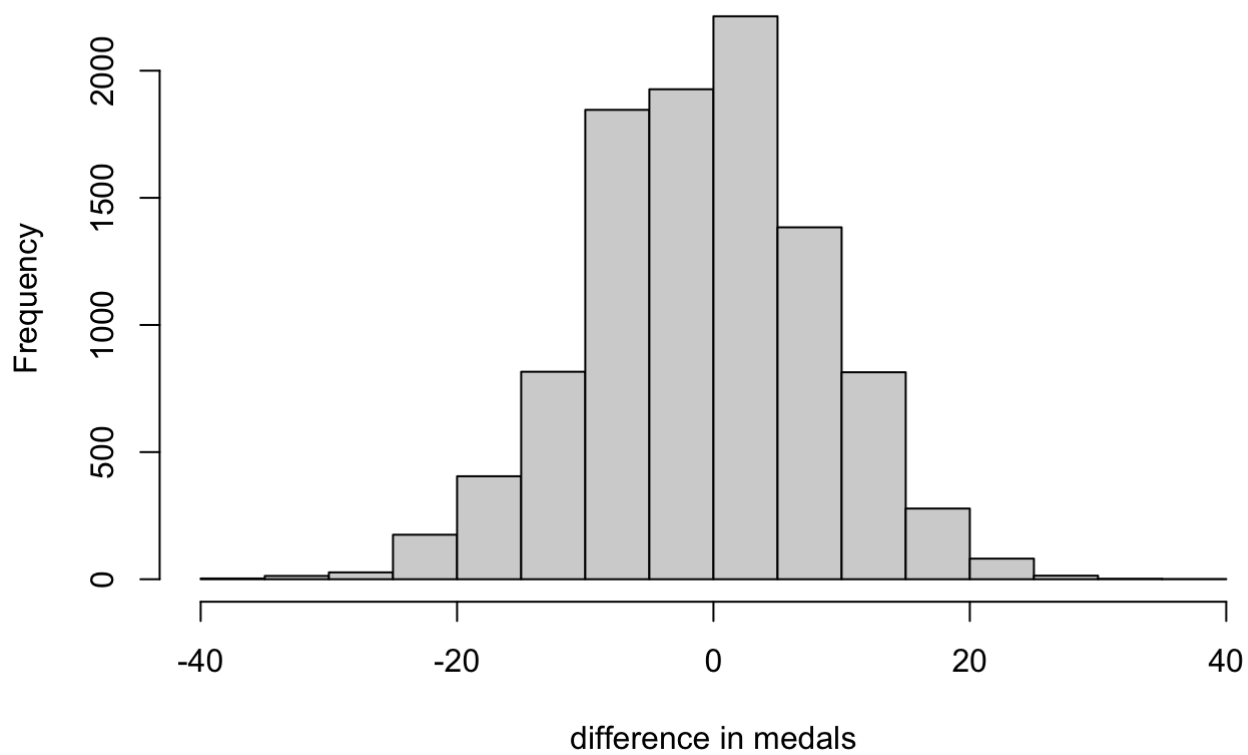
```
plot((unlist(v1_total)-unlist(v2_total)), ylab = "how many medals player 1 wins out play
er2")
```
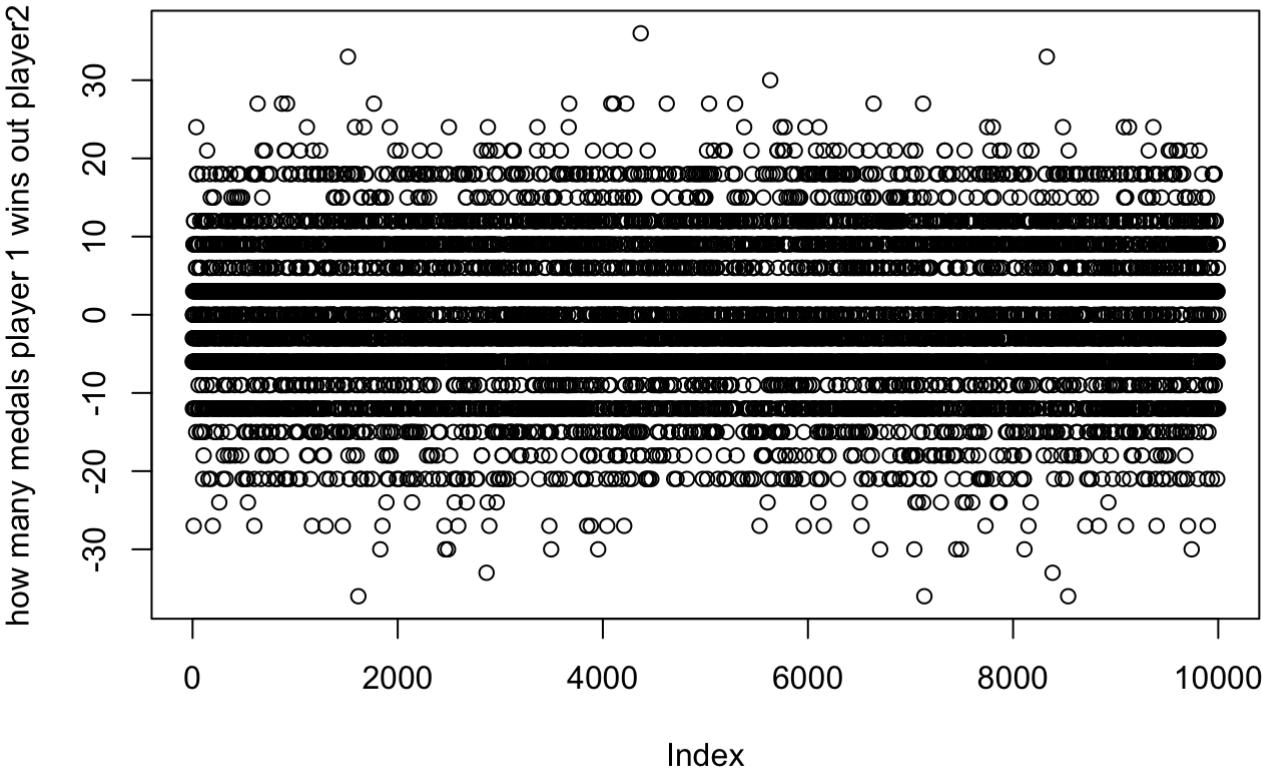
R10 player1: big-money strategy player2: "wait for gold" strategy

```r
#now consider the "big money" strategy vs "wait for gold" strategy

#player1: big-money strategy
#player2: "wait for gold" strategy
runtimes = 0
vi = numeric(0)
v1 = numeric(0)
v2 = numeric(0)


v1_total = list()
v2_total = list()


for (runtimes in 1: 10000){
  number_Copper = 60
  number_Silver = 40
  number_Gold = 20
  number_Estate = 8
  number_Duchy = 8
  number_Province = 8
  i=0

  deck = c(1,1,1,1,1,1,1,0,0,0)
  deck1 = sample(deck)
  discard1 = numeric(0)
  deck2 = sample(deck)
  discard2 = numeric(0)

  v1 = 0
  v2 = 0

  p1 = 3
  p2 = 3
  while(number_Province>0){
    i = i+1
    v1 = v1+p1
    v2 = v2+p2
    if(length(deck1)>=5){
      hand1 = getcarda(deck1)
      deck1= getcardb(deck1)
      buy_card1 = buy_bigmoney(hand1)
      p1 = buy_card1$points
      buy_card1_1 =buy_card1$buy_card
      discard1 = c(discard1,hand1,buy_card1_1)
    }else{
      hand1 = deck1
      deck1 = reshuffle(discard1)
      hand1_2 = getcarda(deck1,number=5-length(hand1))
      deck1 = getcardb(deck1,number=5-length(hand1))
      hand1=c(hand1,hand1_2)
      buy_card1 = buy_bigmoney(hand1)
      p1 = buy_card1$points
      buy_card1_1 = buy_card1$buy_card
```
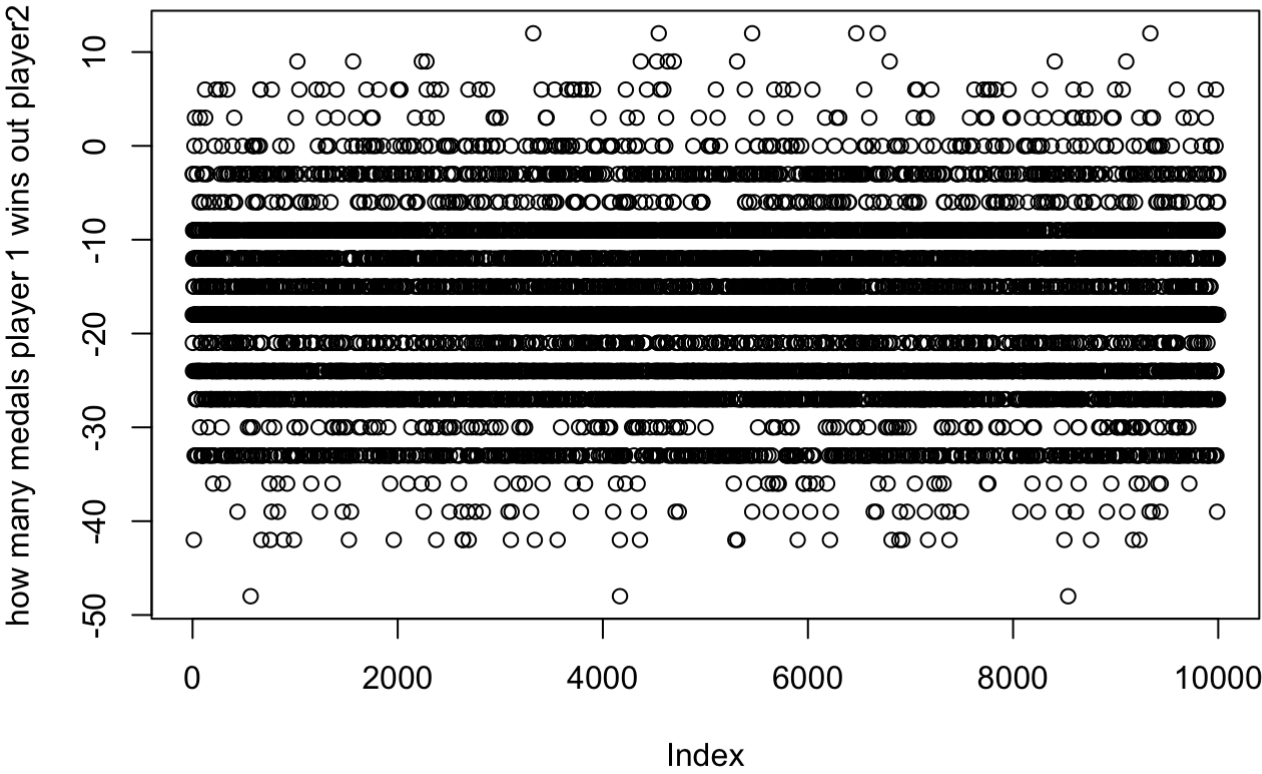
```
        discard1 = c(hand1,buy_card1)
      }
    if(number_Province>0) {
      all_cards = c(deck2,discard)
      if(length(deck2)>=5){
        hand2 = getcarda(deck2)
        deck2= getcardb(deck2)
        buy_card2 = buy_waitgold(hand2,all_cards)
        p2 = buy_card2$points
        buy_card2_2 = buy_card2$buy_card
        discard2 = c(discard2,hand2,buy_card2_2)
      }else{
        hand2 = deck2
        deck2 = reshuffle(discard2)
        hand2_2 = getcarda(deck2,number=5-length(hand2))
        deck2 = getcardb(deck2,number=5-length(hand2))
        hand2=c(hand2,hand2_2)
        buy_card2 = buy_waitgold(hand2,all_cards)
        p2 = buy_card2$points
        buy_card2_2 = buy_card2$buy_card
        discard2 = c(hand2,buy_card2_2)
      }
    }
  }
  v1_total = append(v1,v1_total)
  v2_total = append(v2_total, v2)
  vi = c(vi,i)
}


hist((unlist(v1_total)-unlist(v2_total)), main = "big money vs wait for gold",xlab = "di
fference in medals")
```

big money vs wait for gold

difference in medals
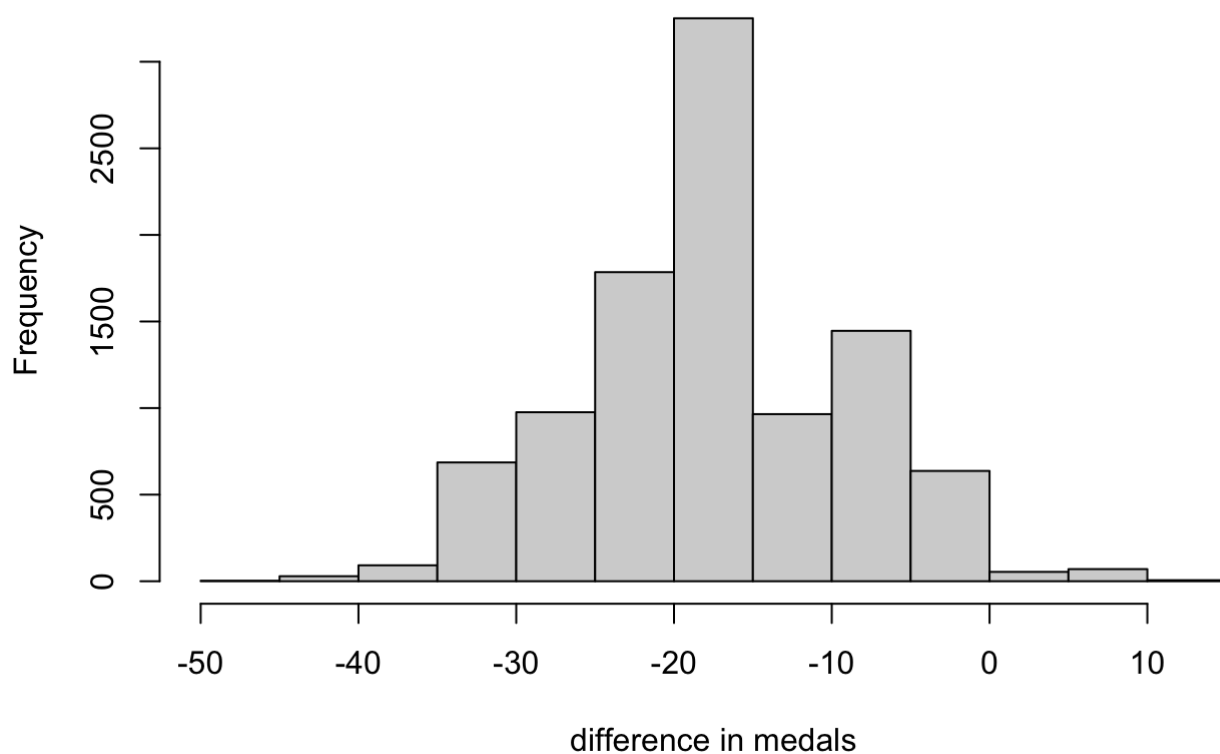
```
plot((unlist(v1_total)-unlist(v2_total)), ylab = "how many medals player 1 wins out play
er2")
```

R11 "Greedy" vs "Greedy"

```r
runtimes = 0
vi = numeric(0)
v1 = numeric(0)
v2 = numeric(0)


v1_total = list()
v2_total = list()



for (runtimes in 1: 10000){
  number_Copper = 60
  number_Silver = 40
  number_Gold = 20
  number_Estate = 8
  number_Duchy = 8
  number_Province = 8
  i=0

  deck = c(1,1,1,1,1,1,1,0,0,0)
  deck1 = sample(deck)
  discard1 = numeric(0)
  deck2 = sample(deck)
  discard2 = numeric(0)

  v1 = 0
  v2 = 0

  p1 = 3
  p2 = 3
  while(number_Province>0){
    i = i+1
    v1 = v1+p1
    v2 = v2+p2
    if(length(deck1)>=5){
      hand1 = getcarda(deck1)
      deck1= getcardb(deck1)
      buy_card1 = buy_greedy(hand1)
      p1 = buy_card1$points
      buy_card1_1 =buy_card1$buy_card
      discard1 = c(discard1,hand1,buy_card1_1)
    }else{
      hand1 = deck1
      deck1 = reshuffle(discard1)
      hand1_2 = getcarda(deck1,number=5-length(hand1))
      deck1 = getcardb(deck1,number=5-length(hand1))
      hand1=c(hand1,hand1_2)
      buy_card1 = buy_greedy(hand1)
      p1 = buy_card1$points
      buy_card1_1 = buy_card1$buy_card
      discard1 = c(hand1,buy_card1)
    }
    if(number_Province>0) {
```

```
      if(length(deck2)>=5){
        hand2 = getcarda(deck2)
        deck2= getcardb(deck2)
        buy_card2 = buy_greedy(hand2)
        p2 = buy_card2$points
        buy_card2_2 = buy_card2$buy_card
        discard2 = c(discard2,hand2,buy_card2_2)
      }else{
        hand2 = deck2
        deck2 = reshuffle(discard2)
        hand2_2 = getcarda(deck2,number=5-length(hand2))
        deck2 = getcardb(deck2,number=5-length(hand2))
        hand2=c(hand2,hand2_2)
        buy_card2 = buy_greedy(hand2)
        p2 = buy_card2$points
        buy_card2_2 = buy_card2$buy_card
        discard2 = c(hand2,buy_card2_2)
      }
    }
  }
  v1_total = append(v1,v1_total)
  v2_total = append(v2_total, v2)
  vi = c(vi,i)
}



hist((unlist(v1_total)-unlist(v2_total)), main = "greedy vs greedy",xlab = "difference i
n medals")
```
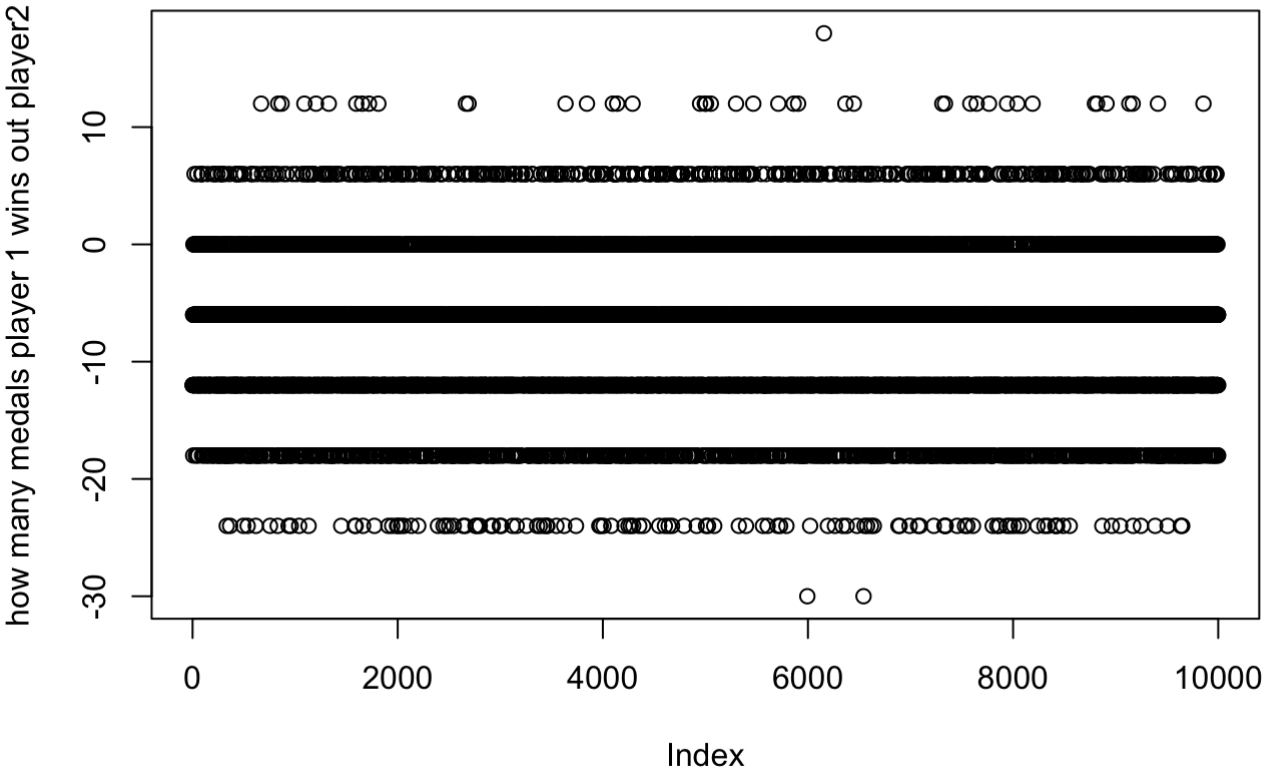
greedy vs greedy

difference in medals
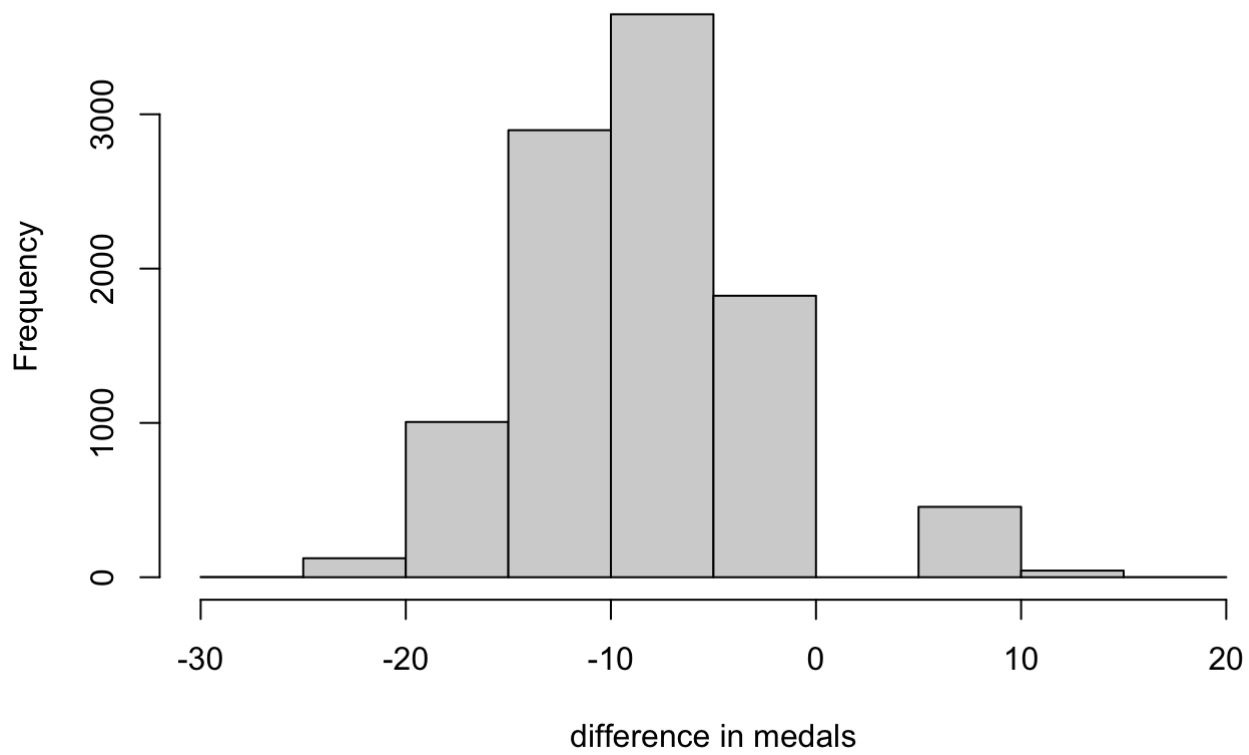
```
plot((unlist(v1_total)-unlist(v2_total)), ylab = "how many medals player 1 wins out play
er2")
```

R12 "Big-money" vs "Big-money"

```r
#player1: big-money strategy
#player2: big-money
runtimes = 0
vi = numeric(0)
v1 = numeric(0)
v2 = numeric(0)


v1_total = list()
v2_total = list()


for (runtimes in 1: 10000){
  number_Copper = 60
  number_Silver = 40
  number_Gold = 20
  number_Estate = 8
  number_Duchy = 8
  number_Province = 8
  i=0

  deck = c(1,1,1,1,1,1,1,0,0,0)
  deck1 = sample(deck)
  discard1 = numeric(0)
  deck2 = sample(deck)
  discard2 = numeric(0)


  v1 = 0
  v2 = 0


  p1 = 3
  p2 = 3
  while(number_Province>0){
    i = i+1
    v1 = v1+p1
    v2 = v2+p2
    if(length(deck1)>=5){
      hand1 = getcarda(deck1)
      deck1= getcardb(deck1)
      buy_card1 = buy_bigmoney(hand1)
      p1 = buy_card1$points
      buy_card1_1 =buy_card1$buy_card
      discard1 = c(discard1,hand1,buy_card1_1)
    }else{
      hand1 = deck1
      deck1 = reshuffle(discard1)
      hand1_2 = getcarda(deck1,number=5-length(hand1))
      deck1 = getcardb(deck1,number=5-length(hand1))
      hand1=c(hand1,hand1_2)
      buy_card1 = buy_bigmoney(hand1)
      p1 = buy_card1$points
      buy_card1_1 = buy_card1$buy_card
      discard1 = c(hand1,buy_card1)
    }
```

```r
      if(number_Province>0) {
        all_cards = c(deck2,discard)
        if(length(deck2)>=5){
          hand2 = getcarda(deck2)
          deck2= getcardb(deck2)
          buy_card2 = buy_bigmoney(hand2)
          p2 = buy_card2$points
          buy_card2_2 = buy_card2$buy_card
          discard2 = c(discard2,hand2,buy_card2_2)
        }else{
          hand2 = deck2
          deck2 = reshuffle(discard2)
          hand2_2 = getcarda(deck2,number=5-length(hand2))
          deck2 = getcardb(deck2,number=5-length(hand2))
          hand2=c(hand2,hand2_2)
          buy_card2 = buy_bigmoney(hand2)
          p2 = buy_card2$points
          buy_card2_2 = buy_card2$buy_card
          discard2 = c(hand2,buy_card2_2)
        }
      }
  }
  v1_total = append(v1,v1_total)
  v2_total = append(v2_total, v2)
  vi = c(vi,i)
}


hist((unlist(v1_total)-unlist(v2_total)), main = "big money vs big money",xlab = "differ
ence in medals")
```

big money vs big money
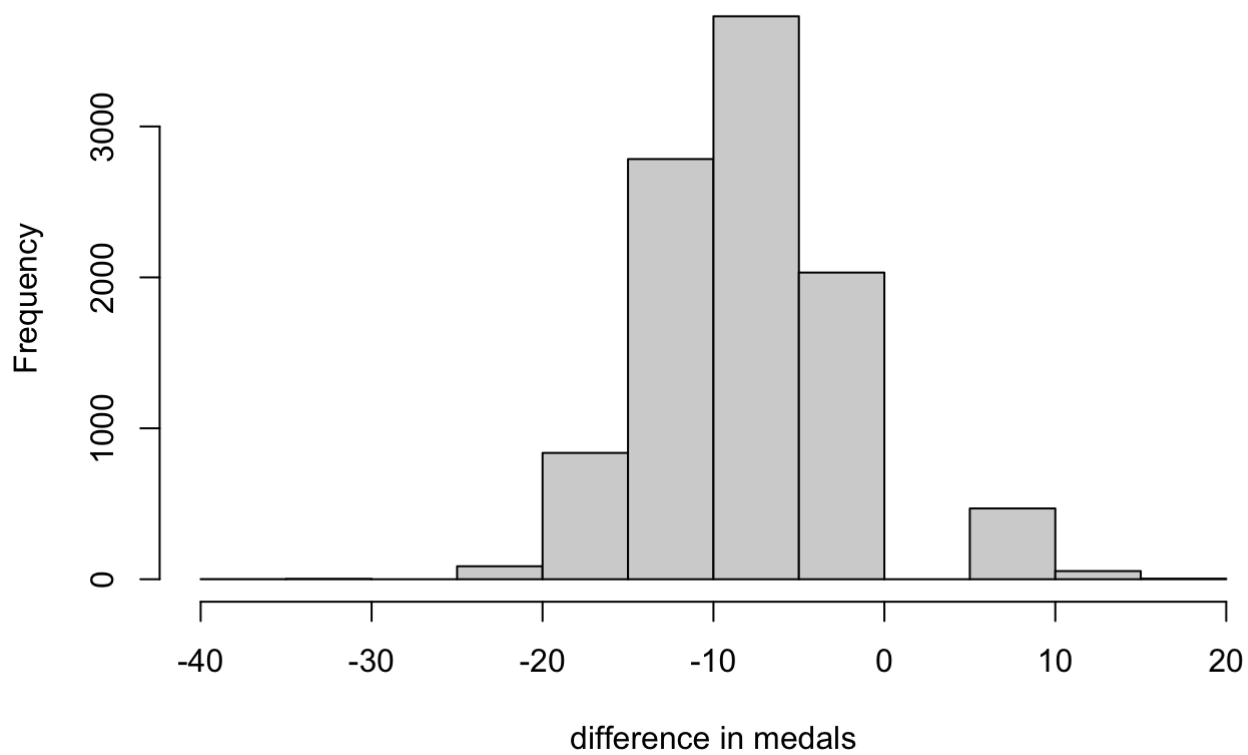
difference in medals

```
plot((unlist(v1_total)-unlist(v2_total)), ylab = "how many victory points player 1 wins
  out player2")
```
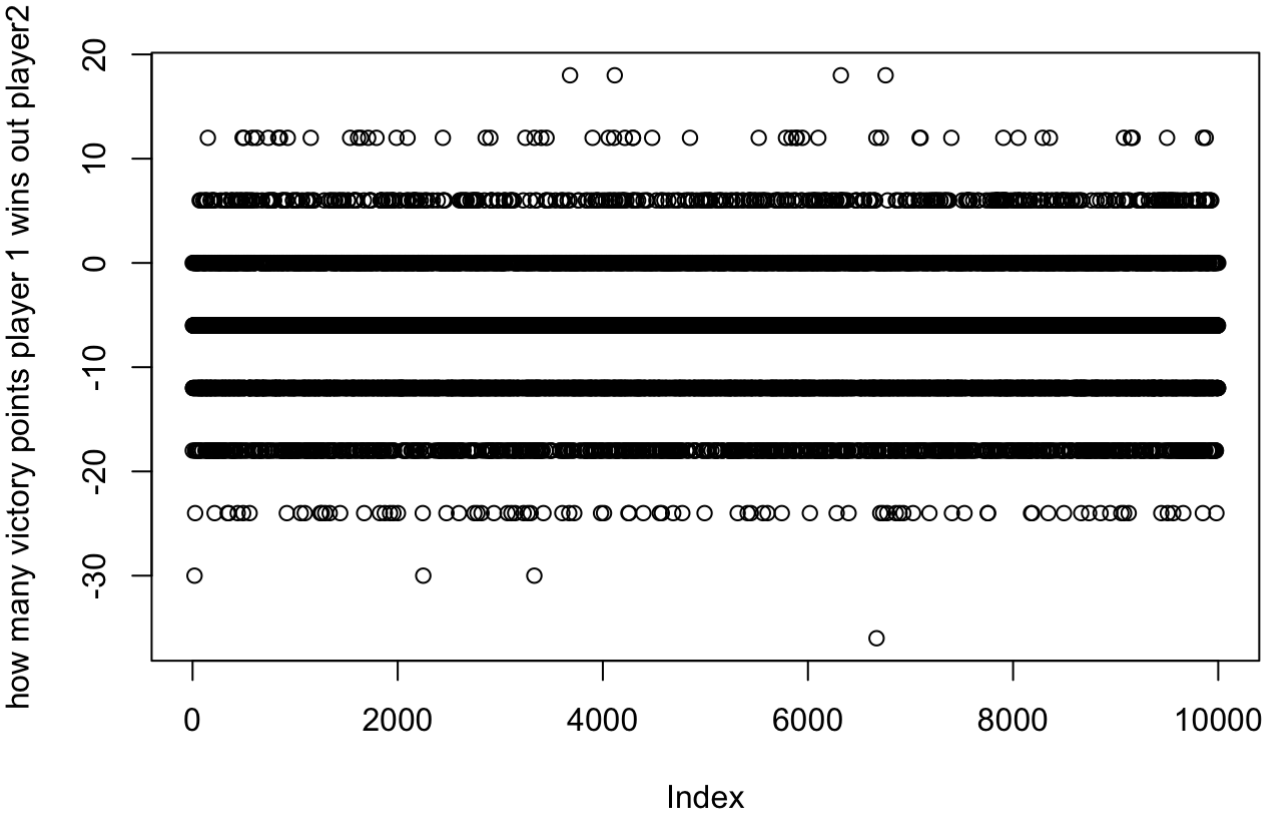
R13 "Wait-for-gold" vs "Wait-for-gold"

```
runtimes = 0
vi = numeric(0)
v1 = numeric(0)
v2 = numeric(0)

v1_total = list()
v2_total = list()

for (runtimes in 1: 10000){
  number_Copper = 60
  number_Silver = 40
  number_Gold = 20
  number_Estate = 8
  number_Duchy = 8
  number_Province = 8
  i=0

  deck = c(1,1,1,1,1,1,1,0,0,0)
  deck1 = sample(deck)
  discard1 = numeric(0)
  deck2 = sample(deck)
  discard2 = numeric(0)

  v1 = 0
  v2 = 0

  p1 = 3
  p2 = 3
  while(number_Province>0){
    i = i+1
    v1 = v1+p1
    v2 = v2+p2
    if(length(deck1)>=5){
      hand1 = getcarda(deck1)
      deck1= getcardb(deck1)
      buy_card1 = buy_waitgold(hand1,all_cards)
      p1 = buy_card1$points
      buy_card1_1 =buy_card1$buy_card
      discard1 = c(discard1,hand1,buy_card1_1)
    }else{
      hand1 = deck1
      deck1 = reshuffle(discard1)
      hand1_2 = getcarda(deck1,number=5-length(hand1))
      deck1 = getcardb(deck1,number=5-length(hand1))
      hand1=c(hand1,hand1_2)
      buy_card1 = buy_waitgold(hand1,all_cards)
      p1 = buy_card1$points
      buy_card1_1 = buy_card1$buy_card
      discard1 = c(hand1,buy_card1)
    }
    if(number_Province>0) {
      all_cards = c(deck2,discard)
```
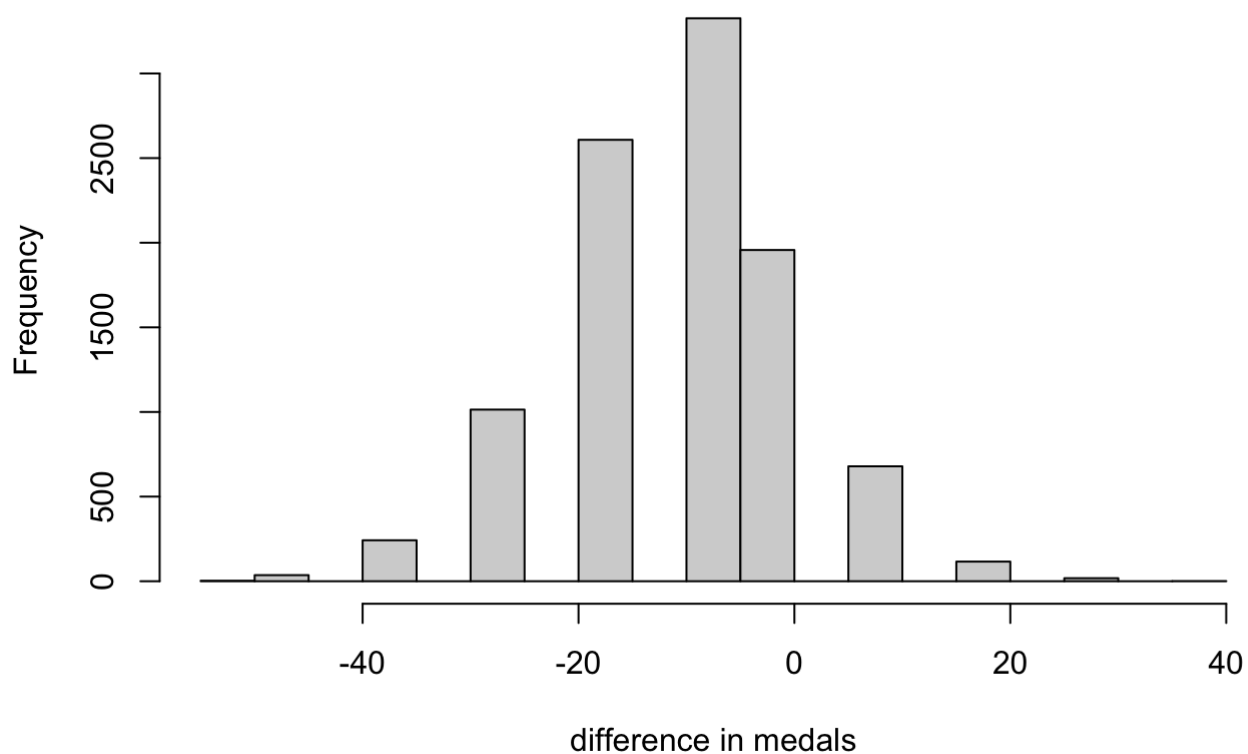
```r
      if(length(deck2)>=5){
        hand2 = getcarda(deck2)
        deck2= getcardb(deck2)
        buy_card2 = buy_waitgold(hand2,all_cards)
        p2 = buy_card2$points
        buy_card2_2 = buy_card2$buy_card
        discard2 = c(discard2,hand2,buy_card2_2)
      }else{
        hand2 = deck2
        deck2 = reshuffle(discard2)
        hand2_2 = getcarda(deck2,number=5-length(hand2))
        deck2 = getcardb(deck2,number=5-length(hand2))
        hand2=c(hand2,hand2_2)
        buy_card2 = buy_waitgold(hand2,all_cards)
        p2 = buy_card2$points
        buy_card2_2 = buy_card2$buy_card
        discard2 = c(hand2,buy_card2_2)
      }
    }
  }
  v1_total = append(v1,v1_total)
  v2_total = append(v2_total, v2)
  vi = c(vi,i)
}


hist((unlist(v1_total)-unlist(v2_total)), main = "wait for gold vs wait for gold",xlab =
"difference in medals")
```

wait for gold vs wait for gold

difference in medals

```
plot((unlist(v1_total)-unlist(v2_total)), ylab = "how many victory points player 1 wins
 out player2")
```