THE UNIVERSITY OF TEXAS AT AUSTIN
McCOMBS SCHOOL OF BUSINESS

Simulation 3

Lecture 24

STA 371G

Example 1: Simulating a betting game

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- What will your bank look like after 20 hands of blackjack?

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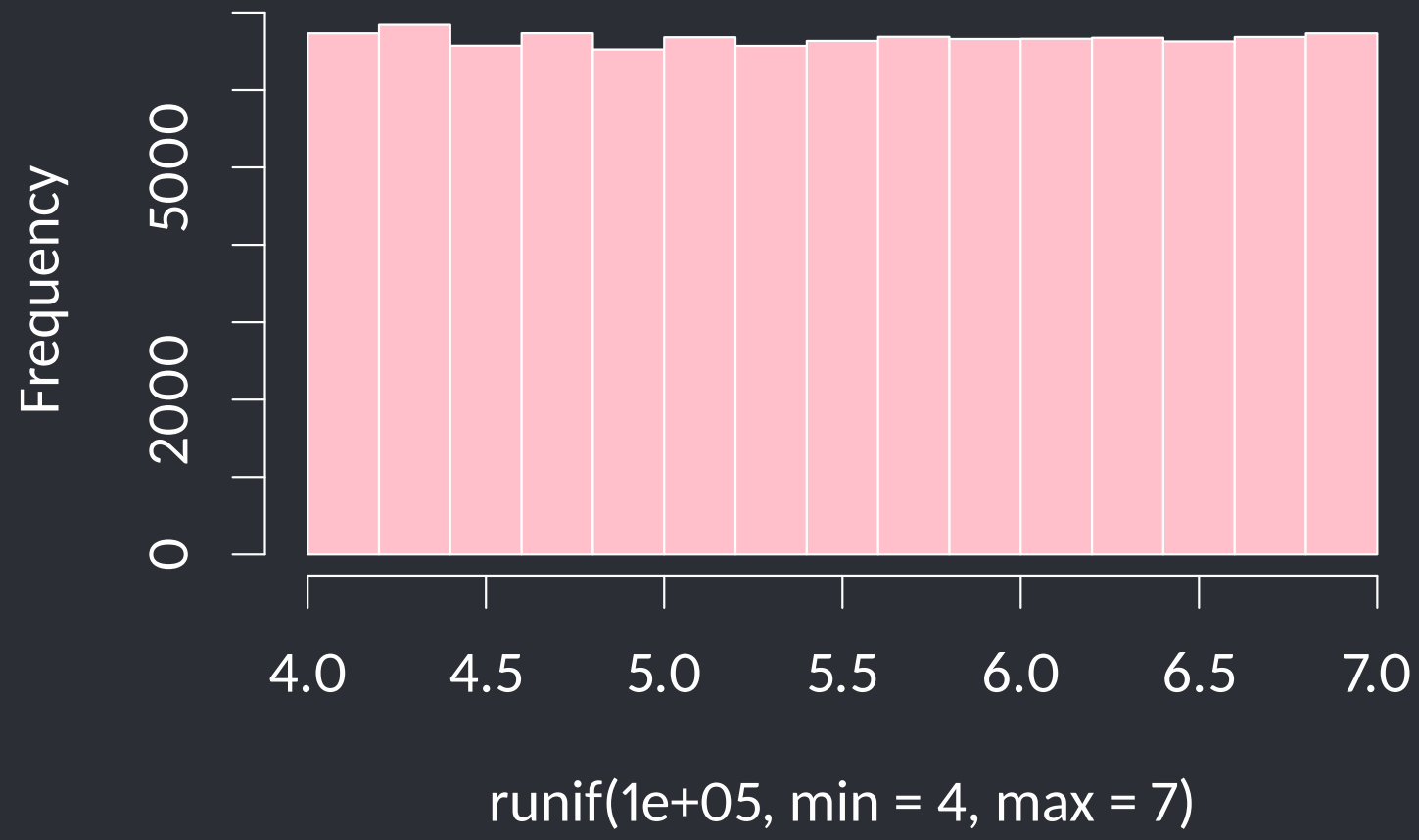
- Without any parameters, it samples from the range $[0, 1]$.

```
hist(runif(100000, min=4, max=7), col="pink", main="")
```



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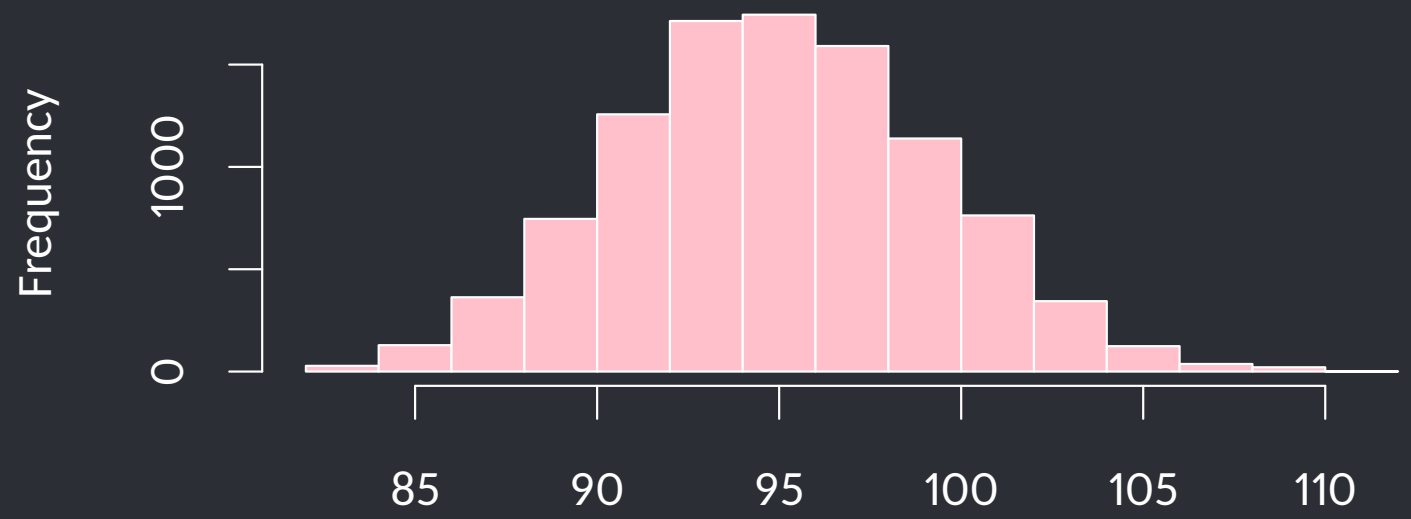
- For example, `runif(1)` randomly selects one number uniformly from $[0, 1]$, so it will be less than 0.2 about 20% of the time.
- To simulate an event that has a 20% chance of happening:

```
if (runif(1) < 0.2) {
  # The event happened.
} else {
  # The event did not happen.
}
```

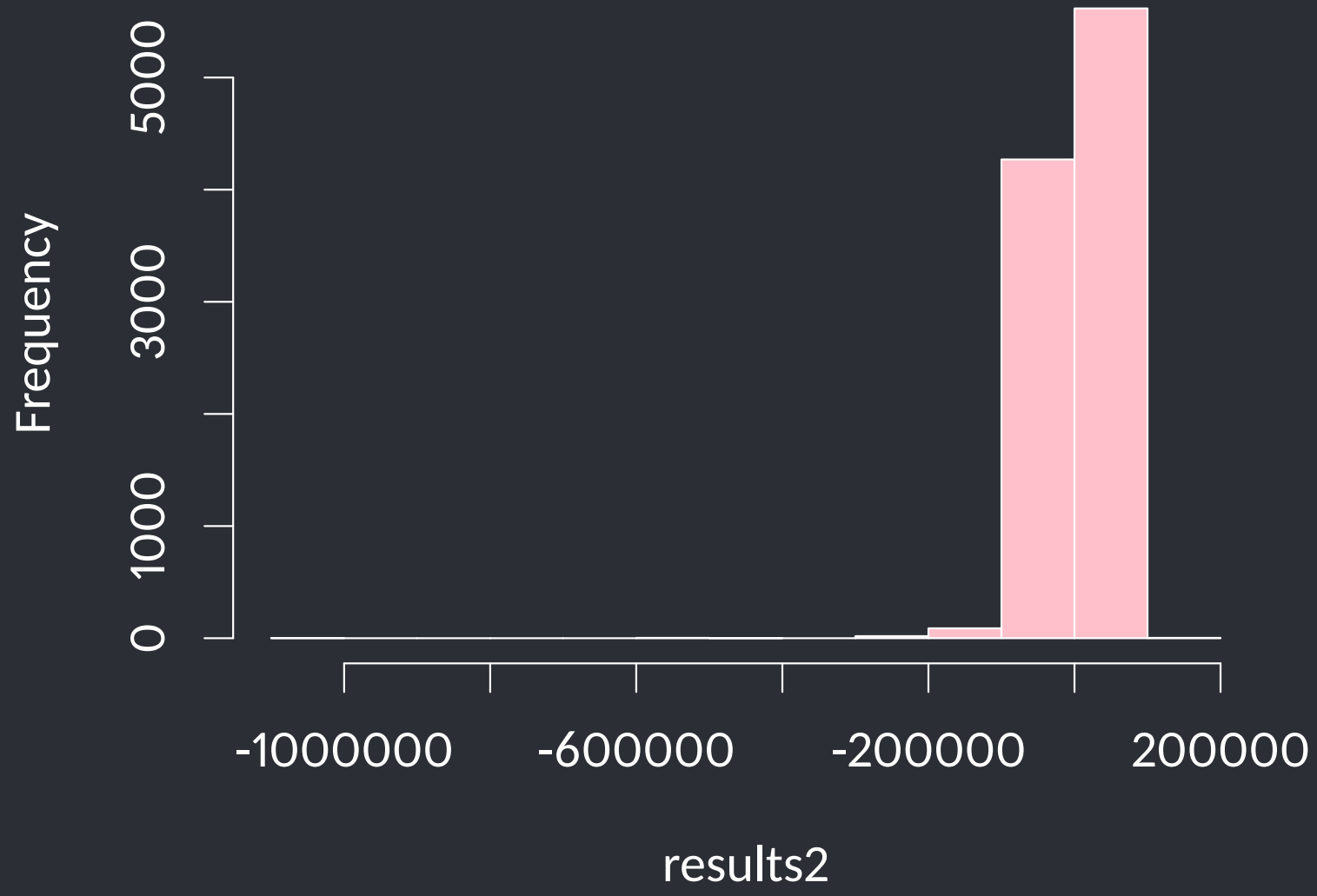
```r
results <- replicate(10000, {
  bank <- 100
  bet <- 1
  for (hand in 1:20) {
    if (runif(1) < 0.4) {
      bank <- bank + bet
    } else {
      bank <- bank - bet
    }
  }
  return(bank)
})
hist(results, col="pink", main="")
```



- Let's model another betting strategy. Suppose that if we lose, we double our bet in an effort to recover the previous loss.
- This way, if we lose, a win on the next hand would cancel out the losses.
- This is called a *Martingale betting strategy*.

```r
results2 <- replicate(10000, {
  bank <- 100
  bet <- 1
  for (hand in 1:20) {
    win <- (runif(1) < 0.4)
    if (win) {
      bank <- bank + bet
    } else {
      bank <- bank - bet
      bet <- 2 * bet
    }
  }
  return(bank)
})
```

```
hist(results2, col="pink", main="")
```



Examining percentiles of outcomes

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- To look at the 5th, 50th (median), and 95th percentile result:

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quantile(results2, probs=c(.05, .5, .95))
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```
    5%    50%    95%
-31001    271  10409
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```

- In other words: under the Martingale strategy, 5% of the time our bank will end up less than —$31001.1, 50% of the time we will end up with less than $271, etc.

Comparing the strategies

Strategy	Original	Martingale
Expected total after 20 hands	95.96	-4026.97
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You could do better with the Martingale strategy, but you'll probably end up doing *much* worse!

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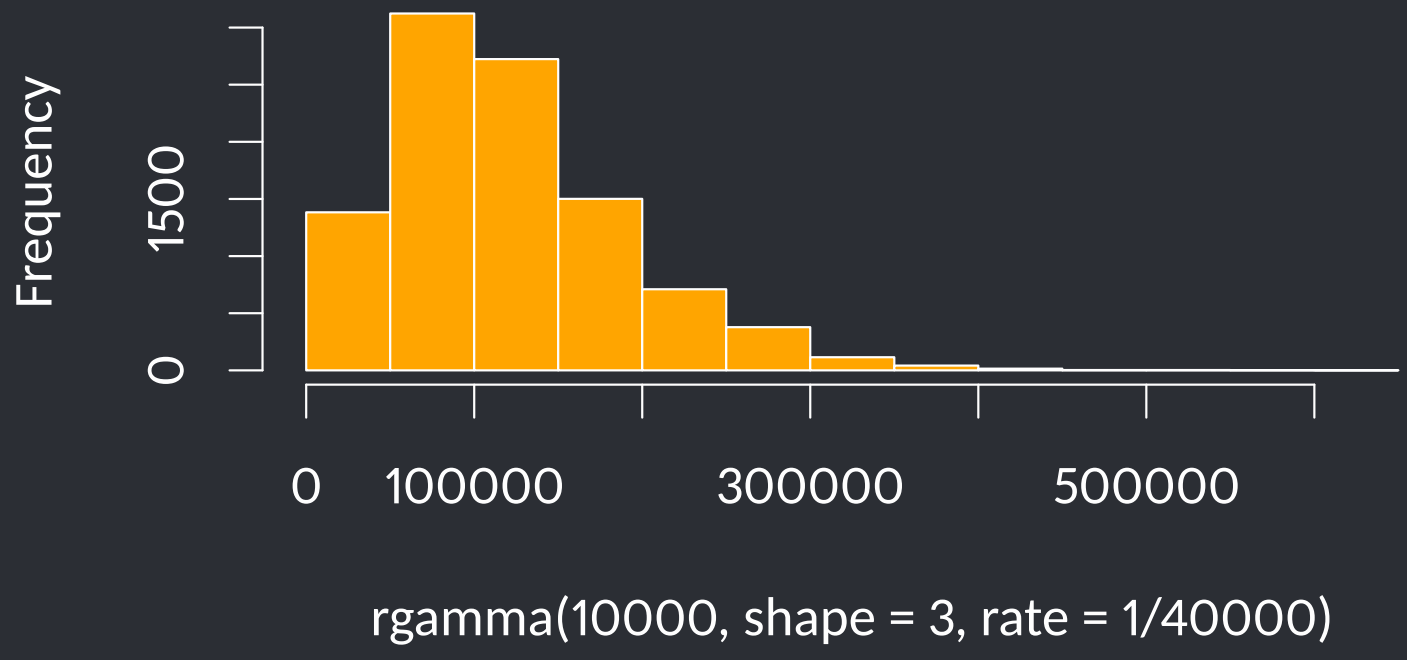
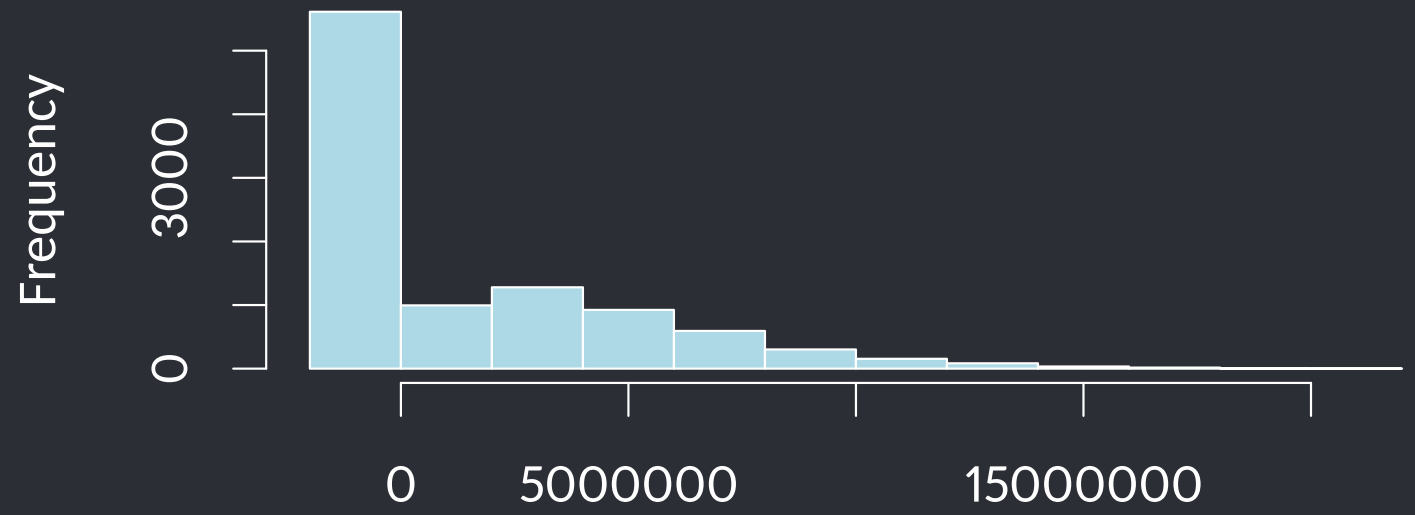
- Let's model the problem of oil drilling: you are planning to drill for oil in a newly-discovered field.
- Setting up the drilling equipment costs $1M.
- There's a 45% chance that you strike oil.
- If you strike oil, you will generate money—but how much depends on the price of oil and how much demand there is.

- Suppose that the price of oil is normally distributed, with a mean of $45/barrel and an SD of $8.
- Suppose that the demand (the number of barrels we can sell) has a *gamma distribution* with shape 3 and rate 1/40000 (the gamma distribution can be used to model many processes, like waiting times and consumer demand, which must be ≥ 0 and has a long right tail):

```
hist(rgamma(10000, shape=3, rate=1/40000),
  col="orange", main="")
```



```r
results <- replicate(10000, {
  if (runif(1) < 0.45) {
    price <- rnorm(1, mean=45, sd=8)
    demand <- rgamma(1, shape=3, rate=1/40000)
    revenue <- price * demand - 1000000
  } else {
    revenue <- -1000000
  }
  return(revenue)
})
hist(results, col="lightblue", main="")
```



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- It's more realistic to not assume this will necessarily be the case.
- Suppose that production also has a gamma distribution with shape 3 and rate 1/40000.
- How much do we make if we decide to drill for oil?

```r
results <- replicate(10000, {
  if (runif(1) < 0.45) {
    price <- rnorm(1, mean=45, sd=8)
    demand <- rgamma(1, shape=3, rate=1/40000)
    production <- rgamma(1, shape=3, rate=1/40000)
    barrels.sold <- min(production, demand)
    revenue <- price * barrels.sold - 1000000
  } else {
    revenue <- -1000000
  }
  return(revenue)
})
hist(results, col="lightblue", main="")
```