Code

Econ/Demog C175 Lab 4: The Bet – Over and over again

Julian Simon liked to proclaim that

> The only true measure of scarcity is price …

In this lab we are going to take advantage of a database put together by David Jacks. The data for his paper “From Boom to Bust: A Typology of Real Commodity Prices in the Long Run” (2013, NBER Working Paper 18874) has consistent series of commodity prices for everything ranging from barley to zinc. For our lab we’ve selected prices since 1900.

We’re going to ask the following:

1. What has been the long-term trend in commodity prices?
2. Was Simon lucky to have won the bet?
3. Do commodity price trends differ by commodity in a way that we can understand? (This section will be more exploratory than in past labs. Here the important point is to report *what* you find, not to find a specific “right” answer.)
4. Finally, we will use our Malthusian “harvest” model to learn about renewable resources. (We may or may not get to this in class this week. If not, then this part of the lab will be pushed into next week, when we have no lab).

Hide

```
# Do not edit this chunk, but *do* press the green button to the answer key for the quiz info (the unreadable string below)
tot = 0
answer.key = "eJzNVk2P4zYMvedXEDmMd4FASZzMYHeBwSIzLdBeiqKz94EiM7YaWfLqYz359yVlJ/Phaw69GK
Fok3yP5FPET5vaPfq1WMM90HMmlPMeVRTShv7smP82n4lG2ziaf3utMID0CNpW+IIVRAfrr6sVSFvlc1n9m0Ikx8
F5eulgZNTOUhhtQ/RJsRXGcP9gZ6RCiA3CXzvodWzg5JKHoQb4hKIWCyh2BUWCn8lFDJ8pFL7QdzYHvkSSBrqxul
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U2gibgXUcdsNGcIAWsZoIpiA15nEXoku9cQAE7n0uiZ0j7EHVMlDfT1XkqgSBQHmohmu+vtJWZ53I6KINj/jjSNp
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9diq4lpApaDEHWdLJ3Kb6jc4/c14KKHcMWM5GJY/jUqGI8L8YPBDykTKKiIIFR03gcKDwB7V0yFRAJdiai66WvoH
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2aZI98qwUcaBneOqsofzeh8lqyckYCFms6+IUwQM/9DK9jTrcrj94i/8cJDp50S8M1yEIj6bP+HXPb3KHtdJS270
dpNEfmhhuZhWG9umPcga/PSNbqIwPbqw3TGOmuXHJS/guRlXQlbr+I+X+1gFbM"
library(quizify)
source.coded.txt(answer.key)
```

> Note: the most helpful reading for this lab is David Lam (2011), “How the World Survived the Population Bomb”

Part 1. Read in data and graph trends in commodity prices

These commodity prices are modified in two ways. First, the nominal prices have been adjusted for inflation. Second, all prices are indexed to 100 in 1900. This makes it easy for us to compare across commodities and over time.

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```
## get commodity data from a file on our server
file <- "/data175/Real_commodity_prices_1900_2015.csv"
commod <- read.table(file, sep = ",") # read the data into, with column header
head(commod) # looks at first few lines
```

	Beef <dbl>	Hides <dbl>	Lamb <dbl>	Pork <dbl>	Coal <dbl>	Natural.gas <dbl>	Petroleum <dbl>	Barley <dbl>	Corn <dbl>
1900	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1901	98.79	95.25	90.41	115.35	99.74	79.03	88.37	110.19	129.32
1902	97.60	94.59	90.98	133.95	105.11	78.33	89.28	108.63	152.91
1903	90.87	88.12	93.81	113.47	113.78	76.66	112.12	104.81	114.99
1904	94.32	95.05	94.32	95.96	99.76	74.38	113.50	95.48	124.54
1905	95.10	119.72	95.43	98.74	97.26	66.80	97.69	92.38	125.36

6 rows | 1-10 of 40 columns

You can scroll to the right and left using the black arrows in the display of the data.

Q1.1 What does the number 110.51 under Zinc mean?

A. Zinc costs 110.51 cents per pound

B. Zinc prices increased by about 110 percent between 1900 and 1904

C. Zinc cost about 10.51 percent more in *nominal* terms in 1904 than in 1900

D. Zinc cost 10.51 percent more in *real* terms in 1904 than in 1900

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```
##  "Replace the NA with your answer (e.g., 'A' in quotes)"
answer1.1 = "D"
quiz.check(answer1.1)
```

```
Your  answer1.1 : D
Correct.
Explanation:  Real prices adjust for inflation
```

Q1.2 What is the major use of Chromium?

A. For browsing the internet

B. As Chrome plating and stainless steel

C. As vitamin supplement for breakfast cereal

D. As a precious metal for storing value

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```
##  "Replace the NA with your answer (e.g., 'A' in quotes)"
answer1.2 = "B"
quiz.check(answer1.2)
```

```
Your  answer1.2 : B
Correct.
Explanation:  According to wikipedia, 85 percent is apparently used
.for this one purpose. Are there substitutes for protecting steel?
```

To select a value from this matrix of data you can index by the label of the row and column. For example,

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```
commod["1963", "Chromium"]
```

```
[1] 55.07
```

Hide

```
## note for those interested in R:
## the index "1963" needs to be in quotes, otherwise R will think it
## is the 1963rd row of the matrix. Here we're telling it that it is
## the row labeled "1963".
```

tells us that the real price of Chromium in 1963 was 55 percent of that in 1900.

> (Note: in the rest of the lab, when we say “price” we mean “real price”, unless otherwise stated.)

Part 2. Visualizing commodity prices

Let’s see how the price of Chromium varies over time.

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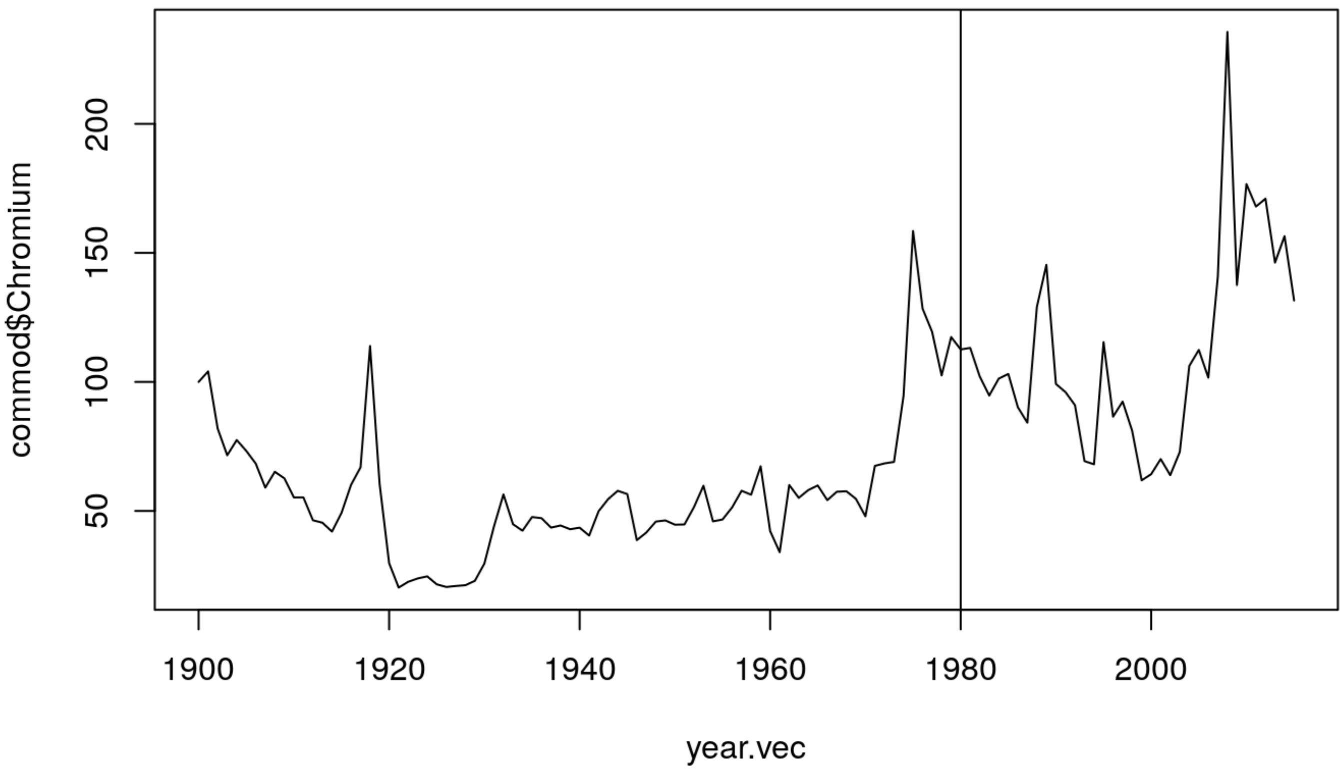
```
year.vec <- rownames(commod)
plot(year.vec, commod$Chromium, type = "l")
abline(v = 1980)                        # the date of "the bet"
```



Q2.1 How would you describe the history of Chromium prices?

A. Steadily rising

B. Steadily falling

C. Very volatile, with little clear long-term trend

D. Very volatile, with a clear upward trend

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```
##  "Replace the NA with your answer (e.g., 'A' in quotes)"
answer2.1 = "C"
quiz.check(answer2.1)
```

```
Your  answer2.1 : C
Correct.
Explanation:  There's clearly a lot of volatility. Although the price in 2015 is higher
than in 1900, this doesn't look like a clear trend, since for much of the 20th century t
he price was lower than in 1900.
```

What does “trendless” data look like?

Imagine a “random walk”, in which prices go up or down each year by some random amount that averages zero. Each realization of this random walk will have, by luck, some trend, but the underlying process generating the randomness has no trend – on average the change is “zero”. It is very easy to falsely interpret a random walk as having an underlying trend. The subject of how to make inferences about the trend of a time series is covered in an econometrics or statistics class. For now, we will just look at some realizations of the random walk to get a feeling for what random realizations of trendless data can look like.

Hide

```
## here's the function
plot.random.walk <- function(seed)
{
    set.seed(seed)                        # this initializes the random
                                          # number generator used in
                                          # sample(). If we use the same
                                          # seed, we will get the same
                                          # set of "random" numbers.
    random.steps <- sample(x = c(-1,1), size = 40, replace = TRUE)
    ## this selects the number -1 or 1 randomly 40 times
    random.walk <- cumsum(random.steps)
    ## this turns the random steps into a walk by summing them up.
    ## cumsum(c(1,2,3)) returns a vector with values 1, 3, and 6.
    plot(1:40, random.walk, type = "l")
}
```

Here’s an example

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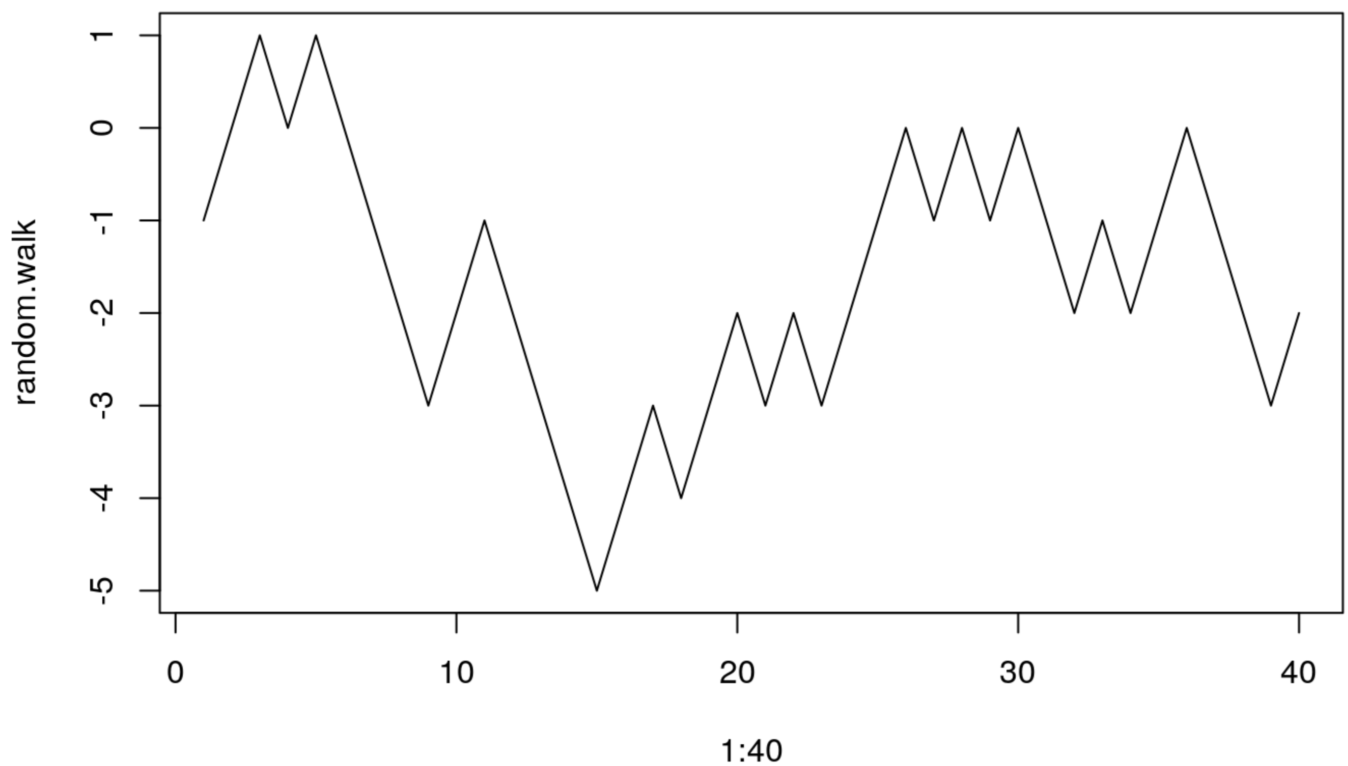
```
plot.random.walk(seed = 23)               # Here we set seed to 23
```



Modify the code below to try 1,2, 3, and 4 as “seeds”

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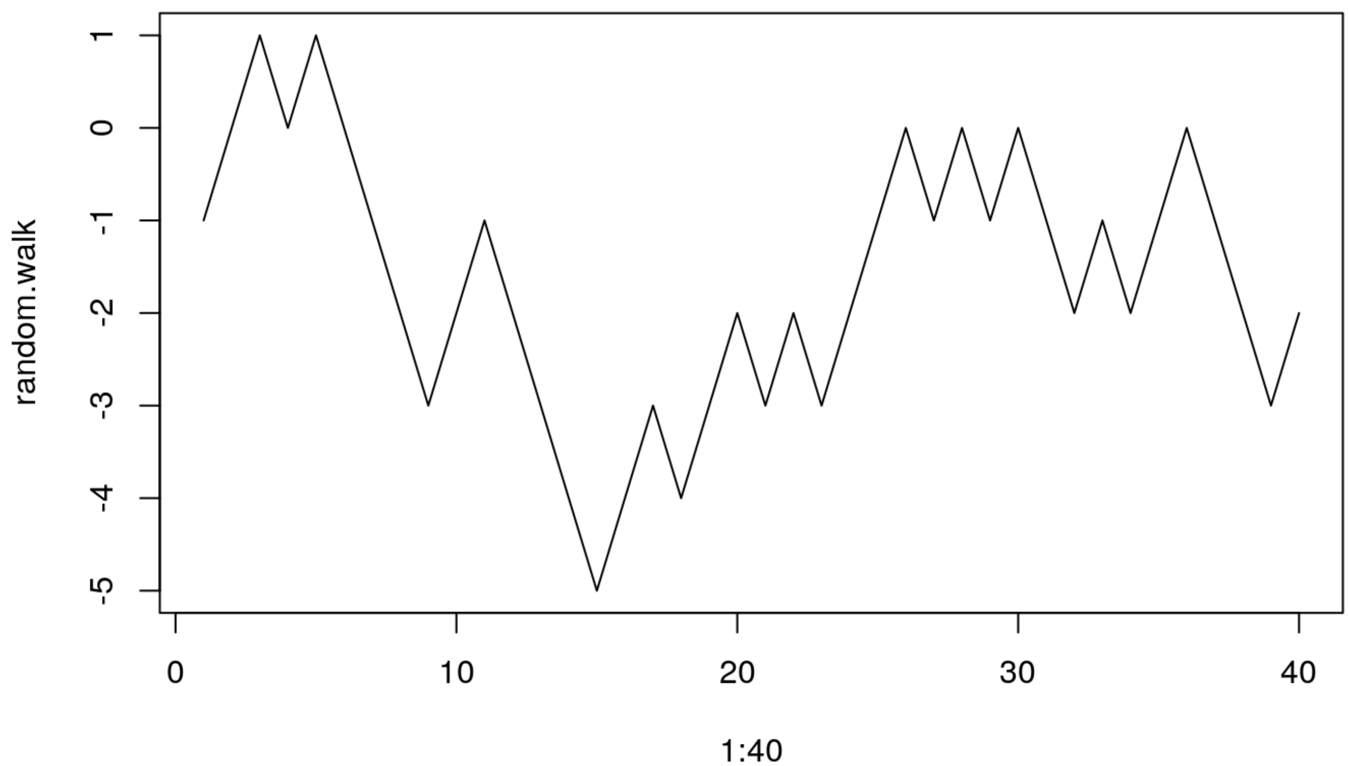
```
plot.random.walk(seed = 23)
```



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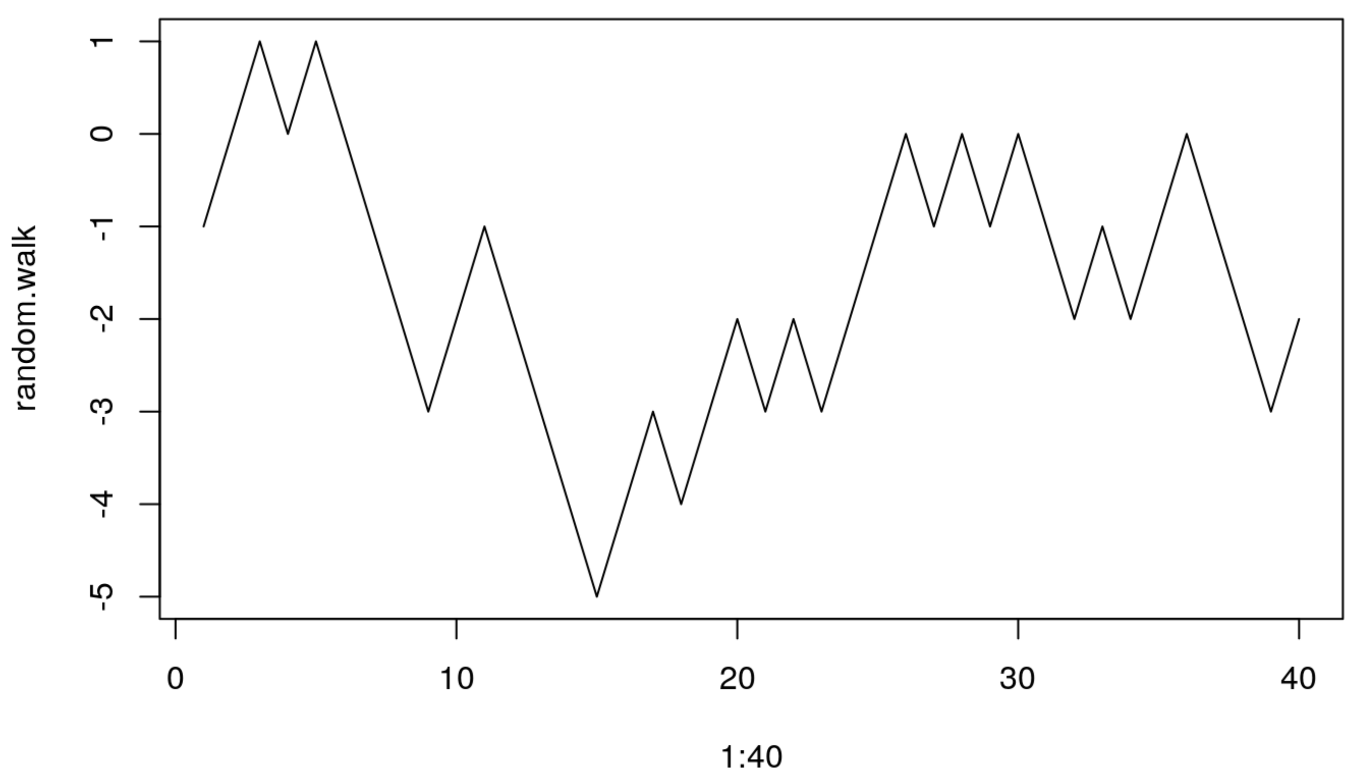
```
plot.random.walk(seed = 23)
```



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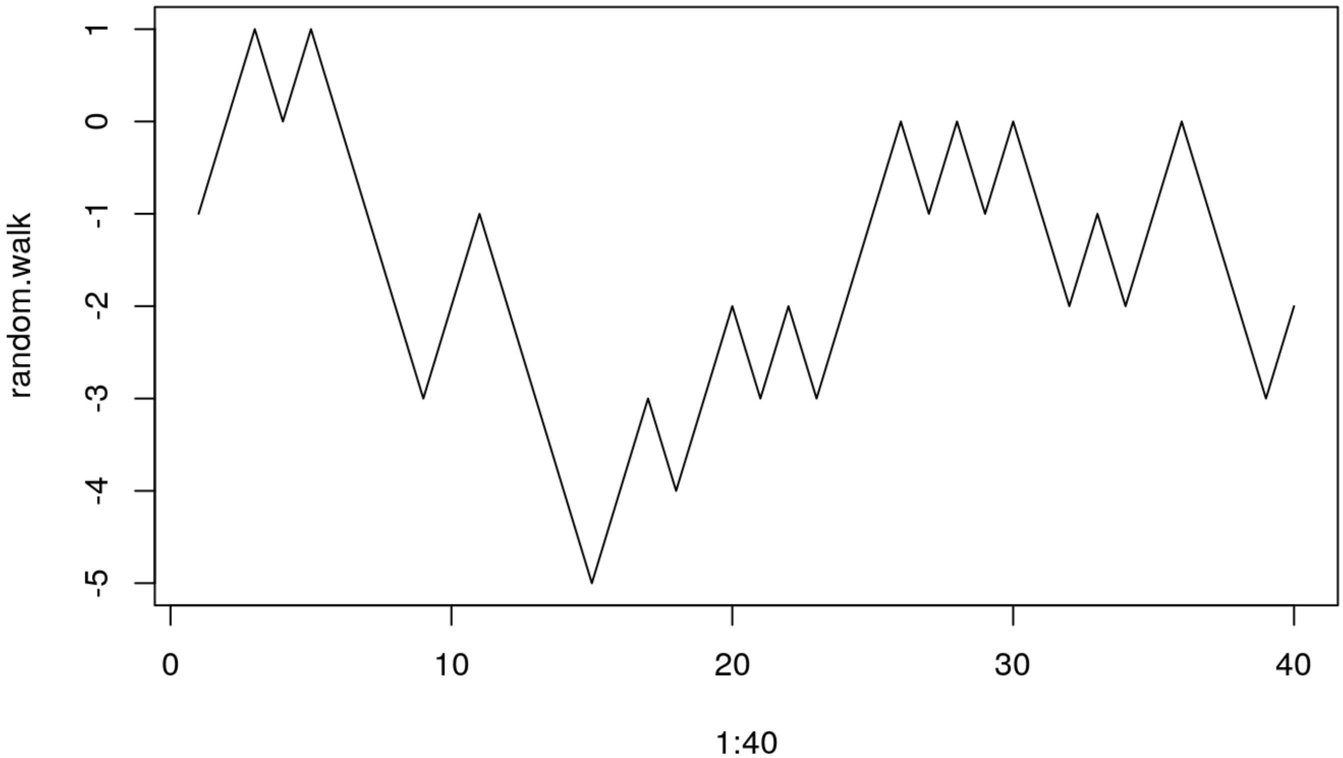
```
plot.random.walk(seed = 23)
```



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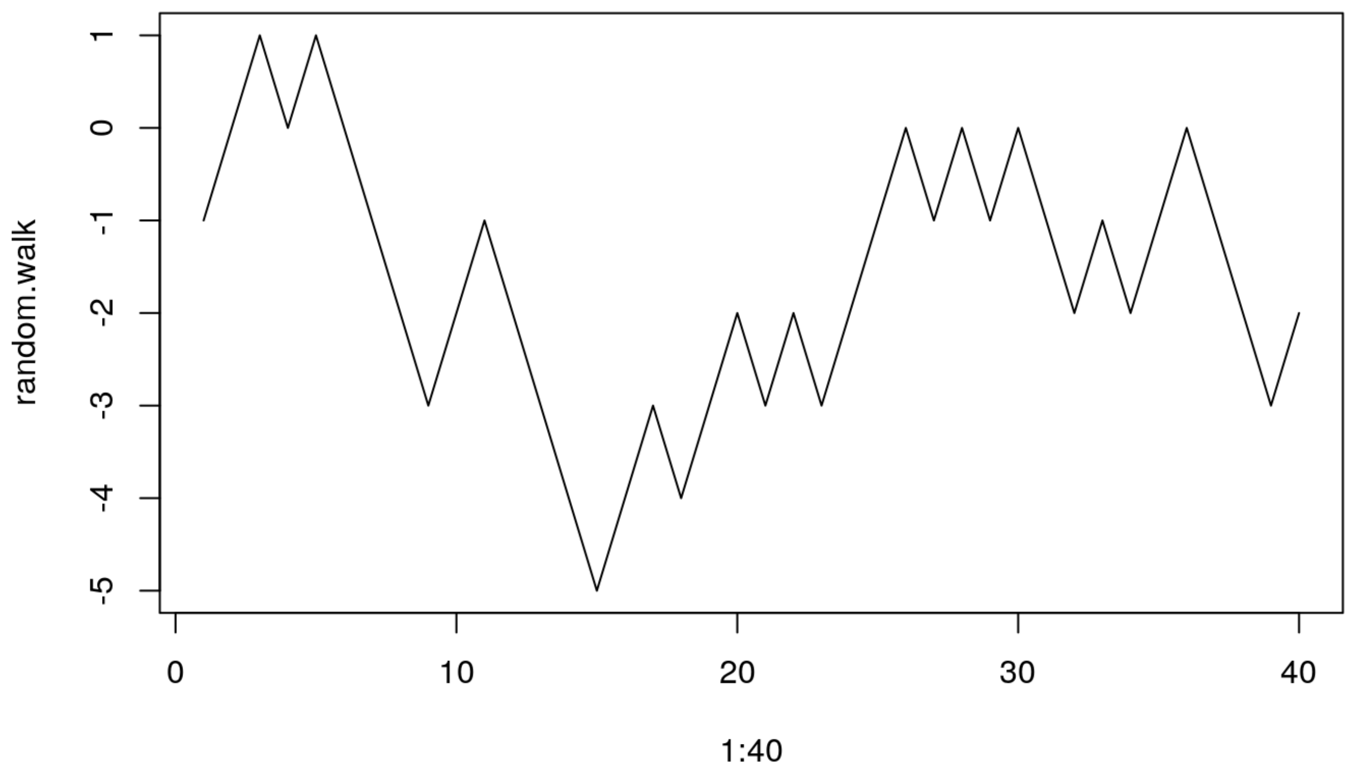
```
plot.random.walk(seed = 23)
```



Q.2.2 Which of the following seems to be true

A. Even if price changes are random, averaging zero, the realization of a random process can look like it has a trend.

B. A historical trend is the one reality we observe and we shouldn't let anyone confuse us with alternative random realizations.

C. Thinking about randomness may help us understand and interpret the reality we see and thus is a subject worth of study.

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```
##  "Replace the NA with your answer (e.g., 'A' in quotes)"
answer2.2 = "C"
quiz.check(answer2.2)
```

```
Your  answer2.2 : C
```

```
Warning in quiz.check(answer2.2) : Sorry, incorrect. Try again.

Warning in quiz.check(answer2.2) :
  Hint: Ignore automatic message about your answer being 'incorrect.'
.There is no 'correct' answer. But of course a professor would lean
.toward 'C'
```

Repeating for Tin

Plot the price of tin. You can use the same code we used for Chromium, modifying just slightly.

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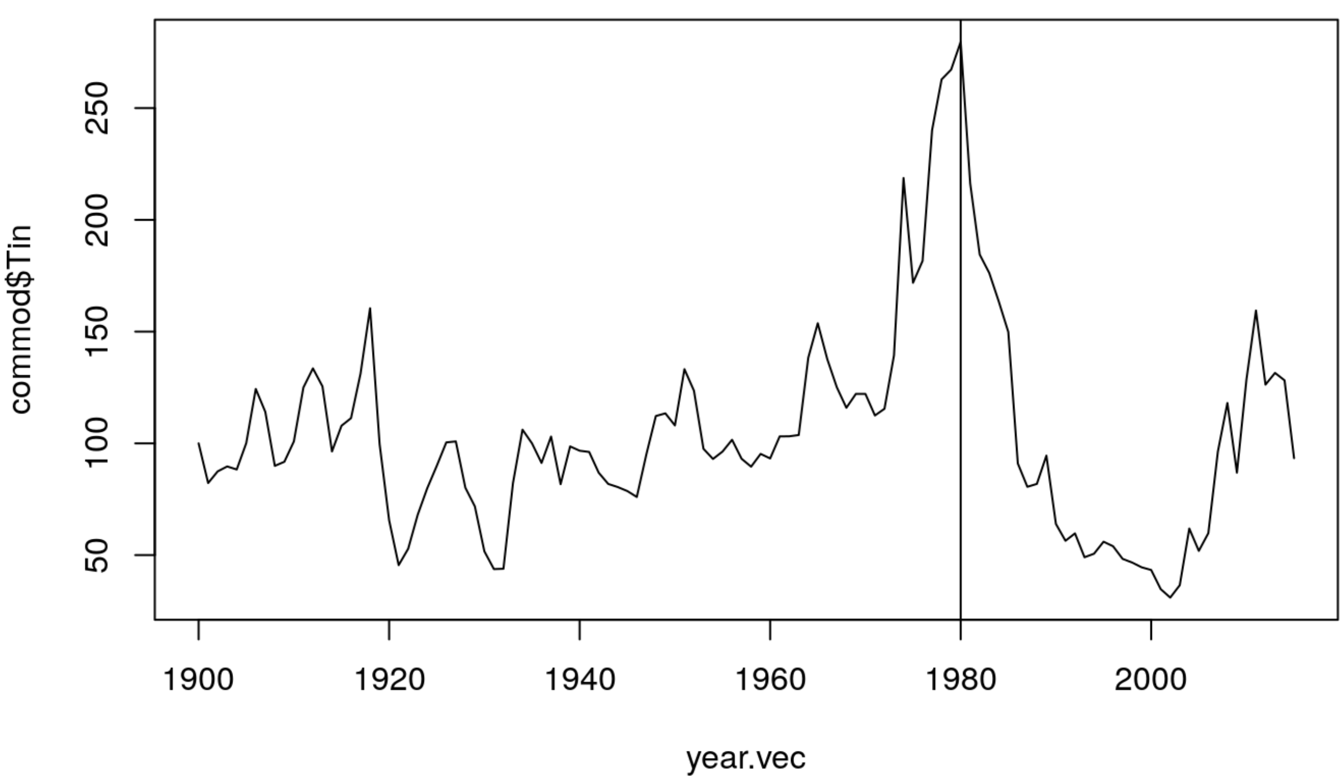
```
## put your code for Tin here
## (Hint: you can copy and modify the commands we used for Chromium)
commod["1963", "Tin"]
```

```
[1] 103.72
```

Hide

```
year.vec <- rownames(commod)
plot(year.vec, commod$Tin, type = "l")
abline(v = 1980)
```



Q2.3 Why do you think Ehrlich chose Tin as one of his commodities to bet on?

A. Tin is difficult to substitute for

B. Tin had shown a sharp increase in price for the decade or so before 1980 and so it looked like it would continue.

C. The price had been going down before 1980 and was ready for a recovery

D. There was evidence that the tin mines were running out of ore

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```
##  "Replace the NA with your answer (e.g., 'A' in quotes)"
answer2.3 = "B"
quiz.check(answer2.3)
```

```
Your  answer2.3 : B
Correct.
Explanation:  Apparently, tin prices were controlled in part by a cartel of producers. S
ee https://www.itri.co.uk/index.php?option=com_mtree&task=att_download&link_id=49605&cf_
id=24 for a discussion from an industry research source.
```

Part 3. Replicating actual bet

In the original bet, Ehrlich was allowed to choose any commodities he wished. He chose Chromium, Copper, Tin, Tungsten, and Nickel. In our data, we don't have Tungsten. We can check to see if Simon still wins with the four commodities we have.

> See the Lam reading, p. 1242 for an account of the bet.

We will use a function to compare commodities over time. This uses the indexing by label we did above. It returns the change in value of a $1000 purchase of the commodity basket in the start year. So if the function returns +100, this means that the value of the commodity basket increased by $100.

Q3.1 If the value of the basket increased by $100, who would win?

A. Simon

B. Ehrlich

C. Neither, because the value of the basket doesn't tell us if *all* of the commodities increased in price at the same time.

Hide

```
##  "Replace the NA with your answer (e.g., 'A' in quotes)"
answer3.1 = "B"
quiz.check(answer3.1)
```

```
Your  answer3.1 : B
Correct.
Explanation:  An increase in prices suggests an increase in
.'scarcity', what Ehrlich was betting on.
```

Hide

```
bet.fun <- function(start, end, basket.vec, data)
{
    ## start = 1980
    ## end = 1990
    ## data = commod
    ## basket.vec <- c("Copper", "Chromium", "Nickel", "Tin")
    year <- rownames(data)
    start.price <- data[year == start, basket.vec]
    end.price   <- data[year == end, basket.vec]
    ## we invest 1000, buyin an equal $ amount in each commodity.
    start.funds <- 1000
    dollars.per.commod <- start.funds/length(basket.vec) # e.g. $250 with 4
    ## amount purchased of each commodity
    holdings.vec <- dollars.per.commod/start.price
    ## value at the end
    value.at.end <- sum(holdings.vec * end.price)
    change.in.value <- value.at.end - start.funds
    return(change.in.value)
}

who.wins.fun <- function(change.in.value)
{
    ifelse(change.in.value > 0, "ehrlich", "simon")
}
```

Let's try this for 1980 to 1990 with Ehrlich's basket.

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```
ehrlich.basket.vec <- c("Copper", "Chromium", "Nickel", "Tin")
original.bet.result <- bet.fun("start" = 1980,
                      "end" = 1990,
                      "basket.vec" = ehrlich.basket.vec,
                      "data" = commod)
who.wins.fun(original.bet.result)
```

```
[1] "simon"
```

Q3.2 How much would Simon have won with our version of the "bet"?

A. About 300 dollars

B. He wouldn't have won. He would have lost about 300 dollars

C. About 500 dollars

D. About 100 dollars

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```
##  "Replace the NA with your answer (e.g., 'A' in quotes)"
answer3.2 = "A"
quiz.check(answer3.2)
```

```
Your  answer3.2 : A
Correct.
Explanation:  A negative number means prices went down, and so Simon would have won.
```

Part 4. Does Simon win in other periods?

Commodities are highly volatile. Even if commodities were generally rising, Ehrlich could have been unlucky about the timing of his bet.

Let’s check over all years since 1900. We can construct a “loop” using R that will repeat the bet according to our instructions. We can then save the output in a vector and make a judgement about whether Ehrlich was simply unlucky.

Here’s a simple example of a loop, in which we repeat an action 7 times, incrementing the value of “i”, and printing this value along with a label “iteration”.

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```
for (i in 1:7)   ## the variable "i" takes the value 1, 2, 3, ...
{
    ## anything in between {} is done once
    ## for each value that "i" takes
    print(c("iteration", i))
}
```

```
[1] "iteration" "1"
[1] "iteration" "2"
[1] "iteration" "3"
[1] "iteration" "4"
[1] "iteration" "5"
[1] "iteration" "6"
[1] "iteration" "7"
```

Now let’s do a loop to see who won the bet in every year of the last century.

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```
start.vec <- 1900:2005        ## a vector of years to start the bet
bet.result.vec <- rep(NA, length(start.vec)) ## an empty vector to be
                                             ## used to store the
                                             ## results
names(bet.result.vec) <- start.vec ## labeling the elements (you can ignore)
for (i in 1:length(start.vec))
{
    bet.result.vec[i] <- bet.fun(start = start.vec[i],
                                 end = start.vec[i] + 10,
                                 basket.vec = ehrlich.basket.vec,
                                 data = commod)
}
print(bet.result.vec)
```

```
       1900        1901        1902        1903        1904        1905        1906
1907        1908        1909        1910
-258.700000 -156.431856   49.123809   -2.021327 -127.212088  -95.459327  -52.223399  -2
1.845369  293.912953 -175.917402 -424.804605
       1911        1912        1913        1914        1915        1916        1917
1918        1919        1920        1921
-552.181803 -531.713958 -479.901991 -406.828864 -457.454997 -483.863734 -488.154673 -50
1.451139 -259.693188  -81.082163  216.717344
       1922        1923        1924        1925        1926        1927        1928
1929        1930        1931        1932
 243.454453  252.717049  341.054540  365.566495  331.228393  386.168194  276.108124  30
6.675598  392.074108  414.174885  351.395641
       1933        1934        1935        1936        1937        1938        1939
1940        1941        1942        1943
  38.681985  -29.656863  -72.914365 -150.671378 -113.895743   74.669806  -21.202224   -
3.043024  132.044717  202.843571  269.671205
       1944        1945        1946        1947        1948        1949        1950
1951        1952        1953        1954
 213.919871  395.367748  542.721218  291.148075  176.863221  283.016148   92.501372  -3
4.354117   84.176895   16.043674  199.861978
       1955        1956        1957        1958        1959        1960        1961
1962        1963        1964        1965
 170.674010   38.283426  107.300058  183.451841  109.764135  286.654596  400.477990  18
1.086693  314.033040  526.655925  591.149632
       1966        1967        1968        1969        1970        1971        1972
1973        1974        1975        1976
 599.870085  591.992619  507.597248  647.651367  627.592390  308.600045   97.417259  -3
8.528232 -294.608549 -353.756361 -475.654892
       1977        1978        1979        1980        1981        1982        1983
1984        1985        1986        1987
-441.250784   71.947758  -57.956949 -306.220473 -275.830073 -193.578232 -353.610315 -23
7.373103   35.802145   16.675437  -96.471592
       1988        1989        1990        1991        1992        1993        1994
1995        1996        1997        1998
-524.143483 -588.938139 -354.297500 -393.554388 -372.843395  -10.989176  366.094672   6
8.122978  768.730531 1523.535732 2017.405153
       1999        2000        2001        2002        2003        2004        2005
1150.647495 1747.100492 2599.771715 2193.400721 1525.633810  609.806673  216.228316
```

To summarize our results, let's look at them in several ways.

Plot the numbers

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```
plot(start.vec, bet.result.vec)
abline(h = 0)
```

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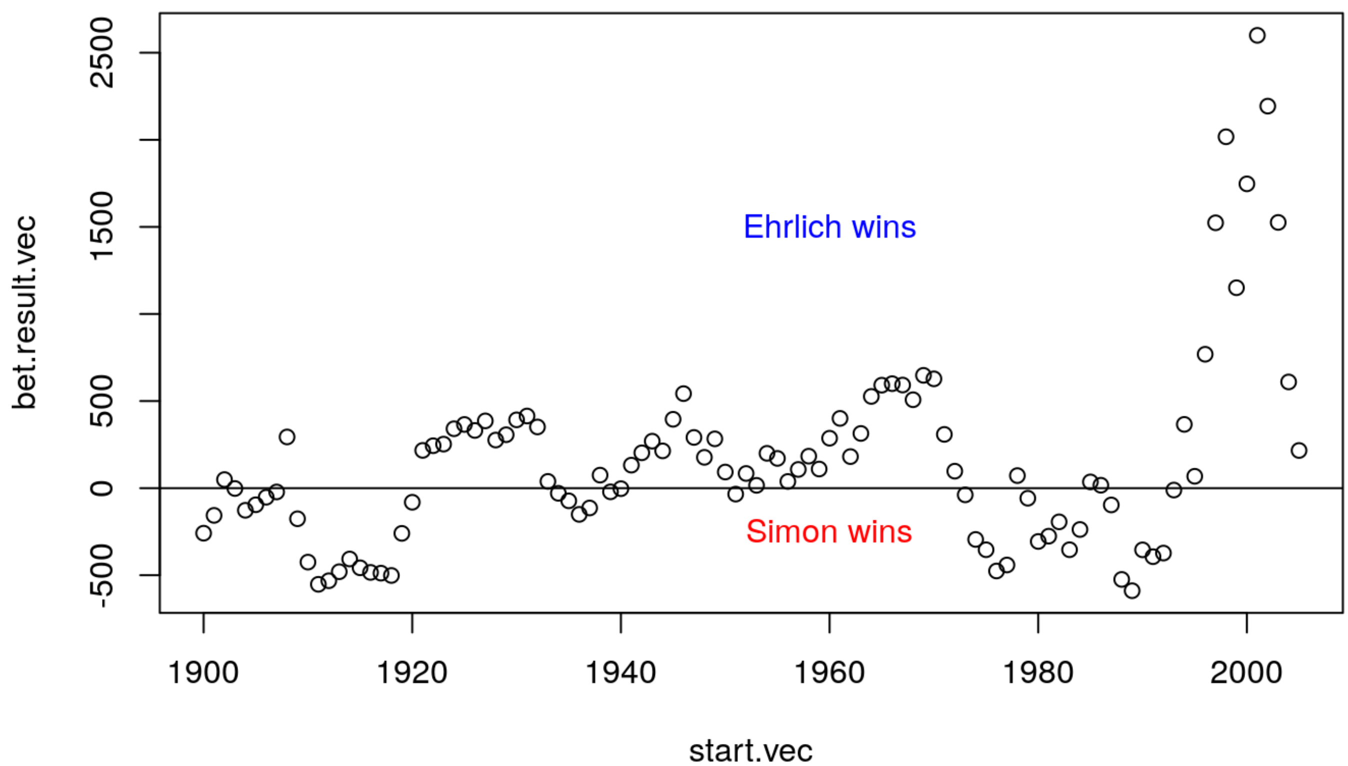
```
text(1960, 1500, "Ehrlich wins", col = "blue")
text(1960, -250, "Simon wins", col = "red")
```



In the graph, it looks like Ehrlich would have won more of the time. But not a lot more.

Let’s tabulate how many times Ehrlich and Simon would have won:

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```
## Convert to a vector of "simon" and "ehrlich", depending on who won
winners.vec <- who.wins.fun(bet.result.vec)
print(winners.vec)
```

```
     1900      1901      1902      1903      1904      1905      1906      1907      190
8      1909      1910      1911      1912
  "simon"   "simon" "ehrlich"   "simon"   "simon"   "simon"   "simon"   "simon" "ehrlic
h"   "simon"   "simon"   "simon"   "simon"
     1913      1914      1915      1916      1917      1918      1919      1920      192
1      1922      1923      1924      1925
  "simon"   "simon"   "simon"   "simon"   "simon"   "simon"   "simon"   "simon" "ehrlic
h" "ehrlich" "ehrlich" "ehrlich" "ehrlich"
     1926      1927      1928      1929      1930      1931      1932      1933      193
4      1935      1936      1937      1938
"ehrlich" "ehrlich" "ehrlich" "ehrlich" "ehrlich" "ehrlich" "ehrlich" "ehrlich"   "simo
n"   "simon"   "simon"   "simon" "ehrlich"
     1939      1940      1941      1942      1943      1944      1945      1946      194
7      1948      1949      1950      1951
  "simon"   "simon" "ehrlich" "ehrlich" "ehrlich" "ehrlich" "ehrlich" "ehrlich" "ehrlic
h" "ehrlich" "ehrlich" "ehrlich"   "simon"
     1952      1953      1954      1955      1956      1957      1958      1959      196
0      1961      1962      1963      1964
"ehrlich" "ehrlich" "ehrlich" "ehrlich" "ehrlich" "ehrlich" "ehrlich" "ehrlich" "ehrlic
h" "ehrlich" "ehrlich" "ehrlich" "ehrlich"
     1965      1966      1967      1968      1969      1970      1971      1972      197
3      1974      1975      1976      1977
"ehrlich" "ehrlich" "ehrlich" "ehrlich" "ehrlich" "ehrlich" "ehrlich" "ehrlich"   "simo
n"   "simon"   "simon"   "simon"   "simon"
     1978      1979      1980      1981      1982      1983      1984      1985      198
6      1987      1988      1989      1990
"ehrlich"   "simon"   "simon"   "simon"   "simon"   "simon"   "simon" "ehrlich" "ehrlic
h"   "simon"   "simon"   "simon"   "simon"
     1991      1992      1993      1994      1995      1996      1997      1998      199
9      2000      2001      2002      2003
  "simon"   "simon"   "simon" "ehrlich" "ehrlich" "ehrlich" "ehrlich" "ehrlich" "ehrlic
h" "ehrlich" "ehrlich" "ehrlich" "ehrlich"
     2004      2005
"ehrlich" "ehrlich"
```

Hide

```
## count number of times each won using the "table()" function
table(winners.vec)
```

```
winners.vec
ehrlich   simon
     62      44
```

Q4.1 What percent of the time would Ehrlich have won of the 106 simulated bets from 1900 to 2005?

A. About 62 percent

B. About 58 percent

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```
##  "Replace the NA with your answer (e.g., 'A' in quotes)"
answer4.1 = "B"
quiz.check(answer4.1)
```

```
Your  answer4.1 : B
Correct.
Explanation:  62/106 is about 0.58.
```

Make a fancier plot. (You don't need to understand this code.)

Hide

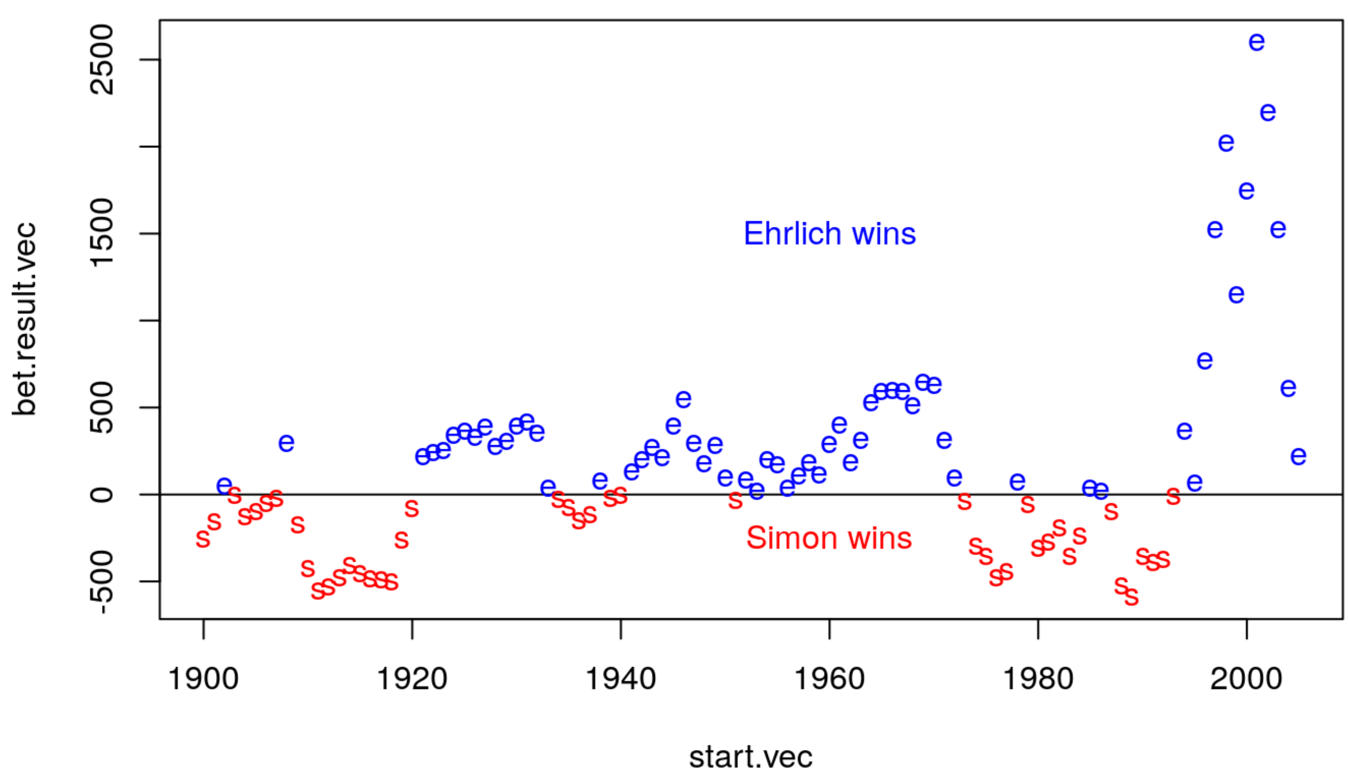
```
plot(start.vec, bet.result.vec, type = "n") #an empty plot
abline(h = 0)
```

Hide

```
e <- which(winners.vec == "ehrlich")    # T or F, to subset text()
s <- which(winners.vec == "simon")
text(x = start.vec[e], y = bet.result.vec[e], labels = "e", col = "blue")
text(x = start.vec[s], y = bet.result.vec[s], labels = "s", col = "red")
```

Hide

```
text(1960, 1500, "Ehrlich wins", col = "blue")
text(1960, -250, "Simon wins", col = "red")
```



5. Generalizing the bet to other commodities

A change in the supply of a particular commodity may or may not cause a large price change – depending on the availability of substitutes. (Note: the results from this section will be useful for your write-up of the graded questions at the end of the lab.)

The following code provides a template for a single commodity, in this case “Chromium”.

Hide

```
start.vec <- 1900:2005
result.vec <- rep(NA, length(start.vec))
for (i in 1:length(start.vec))
  {
  result.vec[i] <- bet.fun(start = start.vec[i],
                      end = start.vec[i] + 10,
                      basket.vec = c("Chromium"),
                      data = commod)
}
winner.vec <- who.wins.fun(result.vec)
cat("counts:\n")
```

```
counts:
```

Hide

```
table(winner.vec)
```

```
winner.vec
ehrlich   simon
     61      45
```

Hide

```
cat("proportions:\n")
```

```
proportions:
```

Hide

```
prop.table(table(winner.vec))
```

```
winner.vec
  ehrlich     simon
0.5754717 0.4245283
```

Well done. You are finished with the computing portion of Lab 4.

Part 5. Graded Questions

> 1. What relationship did Ehrlich expect to hold between commodity prices and population growth?

Ehrlich was worried that the rapid population growth could lead to resource starvation. Due to that, he was worried that inflation would be a problem.

> 2. Who won the bet in 1990? Given our analysis of other time periods, would you say that the winner was “lucky” or “right”, or both? [Explain your answer in 50 to 100 words.]

> As noted in the lab, this section is for you to explore and describe what you found. Whether what you find is conclusive or inconclusive, you can still get full credit by reporting whatever you found.

Simon won the bet in 1990. Simon was lucky, because according to the statistics Ehrlich had a 57.55% chance of winning from 1900 to 2000s.

> 3. Choose another easily substitutable commodity from the database. Conduct the analysis of its price as the previous part of the lab and answer the following questions.

> 3.1) Why do you think this commodity would be easily substitutable, explaining what “service” it provides with 1 or 2 sentences.

Beef, as it provides a source of protein. If beef is scarse, then it can be easily replaced with other proteins such as chicken or pork. Newer advancements in food technology has allowed for plant based substitution.

> 3.2) Attach a plot of the change of prices (“bet.result”) of the chosen commodity.

> Hint 1: there would only be your chosen commodity in the “basket.vec”. You can either modify the original “ehrlich.basket.vec” or create your own “basket.vec”. Remember to modify for-loop consistently.

> Hint 2: you don’t need to show whether Ehrlich or Simon win about this commodity. But labelling the plot with different colors can help you understand the general trend.

> Hint 3: NOT REQUIRED. To make it a better graph, you can add a title to the graph indicating the commodity you choose adding ‘main = “commodity name”’ to the syntax.

Hide

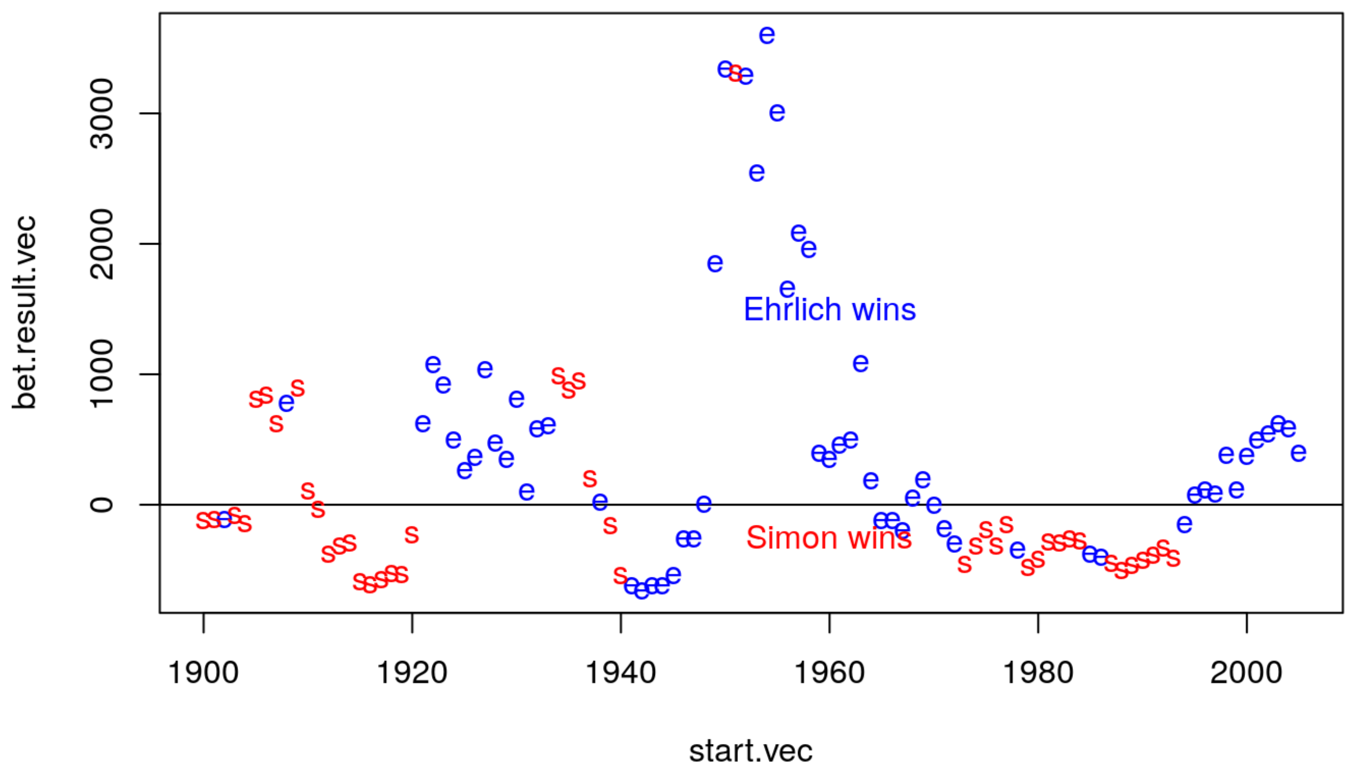
```
brian.basket.vec <- c("Beef")
start.vec <- 1900:2005        ## a vector of years to start the bet
bet.result.vec <- rep(NA, length(start.vec)) ## an empty vector to be
                                             ## used to store the
                                             ## results
names(bet.result.vec) <- start.vec ## labeling the elements (you can ignore)
for (i in 1:length(start.vec))
{
    bet.result.vec[i] <- bet.fun(start = start.vec[i],
                                 end = start.vec[i] + 10,
                                 basket.vec = brian.basket.vec,
                                 data = commod)
}

plot(start.vec, bet.result.vec, type = "n") #an empty plot
abline(h = 0)
```

Hide

```
e <- which(winners.vec == "ehrlich")    # T or F, to subset text()
s <- which(winners.vec == "simon")
text(x = start.vec[e], y = bet.result.vec[e], labels = "e", col = "blue")
text(x = start.vec[s], y = bet.result.vec[s], labels = "s", col = "red")
```

Hide

```
text(1960, 1500, "Ehrlich wins", col = "blue")
text(1960, -250, "Simon wins", col = "red")
```



> 4. Choose a commodity from the database which you think would be hard to substitute for. And explain why you think this commodity would NOT be easily substituted, explaining what "service" it provides. (In 1 or 2 sentences) [Note: you don't need to analyze the data for this problem.]

Iron is a commodity that is probably hard to substitute for. It's one of the strongest metals used for construction. Without iron, we could probably not make the most sustainable and sturdiest buildings, such as workplaces or housing, which is the service it provides.

> 5. What are two reasons prices might not reflect the long-term availability of a commodity? [A sentence on each.]

One might be due to a trend in consumer products, maybe a product or commodity has gone viral and has increased suddenly. Another might be due to epidemic or natural disasters, where examples include panic buying from COVID-19 or grocery stock shortages during natural disasters.

> 6. For the following questions, use the "app" available http://shiny.demog.berkeley.edu/josh/harvest/ (http://shiny.demog.berkeley.edu/josh/harvest/) to gather data on the relationship between harvest rate "h" and the sustainable (steady-state) yield. You can do this by moving the slider from 0 upwards by increments of 0.02.

> 6.1 There is a slight bug in the app, so that it reports sustainable yields even when harvest rate is unsustainable. How can you inspect the graphs to check on sustainability?

You can manually inspect the graph by observing that the point where the green curve intersects the red curves. When the red curve is above the green curve, this shouldn't be sustainable.

> 6.2 When h = 0.01, the sustainable yield is 0.0678, what is the sustainable yield when h = 0.02 and h = 0.04?

When h = 0.02, the sustainable yield is 0.108; h = 0.04, the sustainability yield is 0 (this is unsustainable due to the bug).

> 6.3 What harvest rate maximizes the sustainable yield? [Hint: try all of the slider values]

At h=0.022, the sustainable yield is maximized.

> 6.4 What harvest rate maximizes the yield during the first year of harvesting (this is about year 10 on the slider, or year 0 on the time axes of the graph)? (You can either report the value you find with the "app" or your theoretical answer)

With the app, the answer is h=0.15. But assuming it can go higher, 1 would be the theoretical peak.

> 6.5 Would harvest rates be higher in year "1" if we harvested at the sustainable rate found in part 6.3, or if they were .02 higher than the sustainable rate?

The sustainable yield would be higher at h = 0.024. But we would get diminishing returns in the long run.

> 6.6 When Becker advocates for attention to sustainability, how did Lam reply to his warning? (In 1 or 2 sentences).

Lam replies that instead of attention to sustainability, we need better institutions to manage the sustainability, such as functioning markets.

Congratulations! You are finished with Lab 4.