Populations, Samples, and Sampling Bias:

An important area in inferential statistics is the idea of taking a sample from a population and using measurements from the sample to make predictions about the entire population.

In order for this process to be effective, the sample has to be representative of the population.

A sampling bias is a flaw in the sampling procedure that prevents the sample from being representative of the population.

In general, sampling is considered fair/unbiased if every item in the population has an equal chance of being selected. If a survey is involved, the phrasing and asking of the questions must be fair.

In the following examples, determine the population being studied, determine the sample taken, and explain any possible sampling biases.

1. A research group wants to determine the percentage of voters in Harris County in favor of a new flood control tax. A sample of 1,000 phone numbers from the Houston phonebook are selected, and the people answering the phone are asked about the matter.

Population: voters in Harris County

Sample: the 1,000 people responding to the phone calls

Possible sampling biases: People with phone numbers in the Houston phonebook might not be Harris County voters.

Not all Harris County voters will have a listing in the Houston phonebook.

The method of selecting the 1,000 phone numbers is not mentioned, it might favor particular regions of Houston/Harris County.

2. The teaching performance of a professor is to be evaluated based on his students' opinions. The students' opinions will be measured by taking a sample of student evaluations. The professor chooses one of his five classes as the sample, he hands out the evaluation forms, and he remains in the room to answer any questions while the students fill out the forms.

Population: the students in the professor's classes

Sample: the class of students selected by the professor

Possible sampling biases: The selection of the sample was made by the professor, and not randomly.

The professor hands out the forms and remains in the room, which might have an influence on student responses.

Not all of the students in the class selected will necessarily be present to give an evaluation.

3. A biologist wants to estimate the number of fish in a lake. As part of the study, 250 fish are caught, tagged, and released back into the lake. Later, 500 fish are caught and examined. 18 of the captured fish are tagged, so the biologist reasons that the fraction of fish that are tagged in the lake is $\frac{250}{\text{fish population}}$, and this should be approximately the same as the fraction of tagged fish in the sample, $\frac{18}{500}$. $\frac{250}{\text{fish population}} \approx \frac{18}{500} \Rightarrow \text{fish population} \approx \frac{250 \times 500}{18} \approx 6{,}944$, so this is the prediction of the biologist for the number of fish in the lake.

Population: the fish in the lake

Sample: the 500 fish that are caught

Possible sampling biases: It might be that not all fish in the lake are catchable.

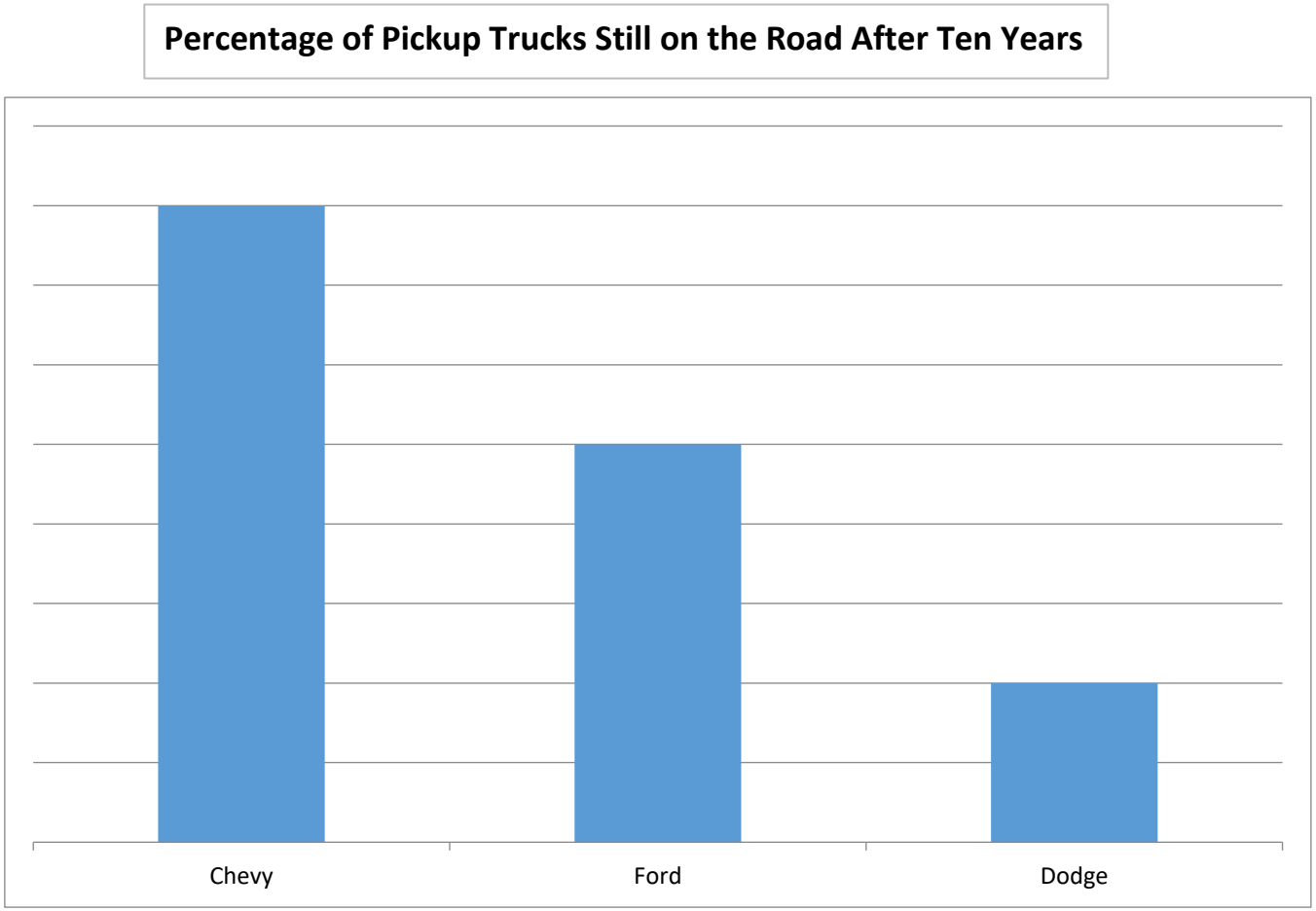
It might be that once a fish is caught, it is more/less likely to be caught again.

Where the catching of the fish occurs is not mentioned, so the process might favor a particular portion or depth of the lake.

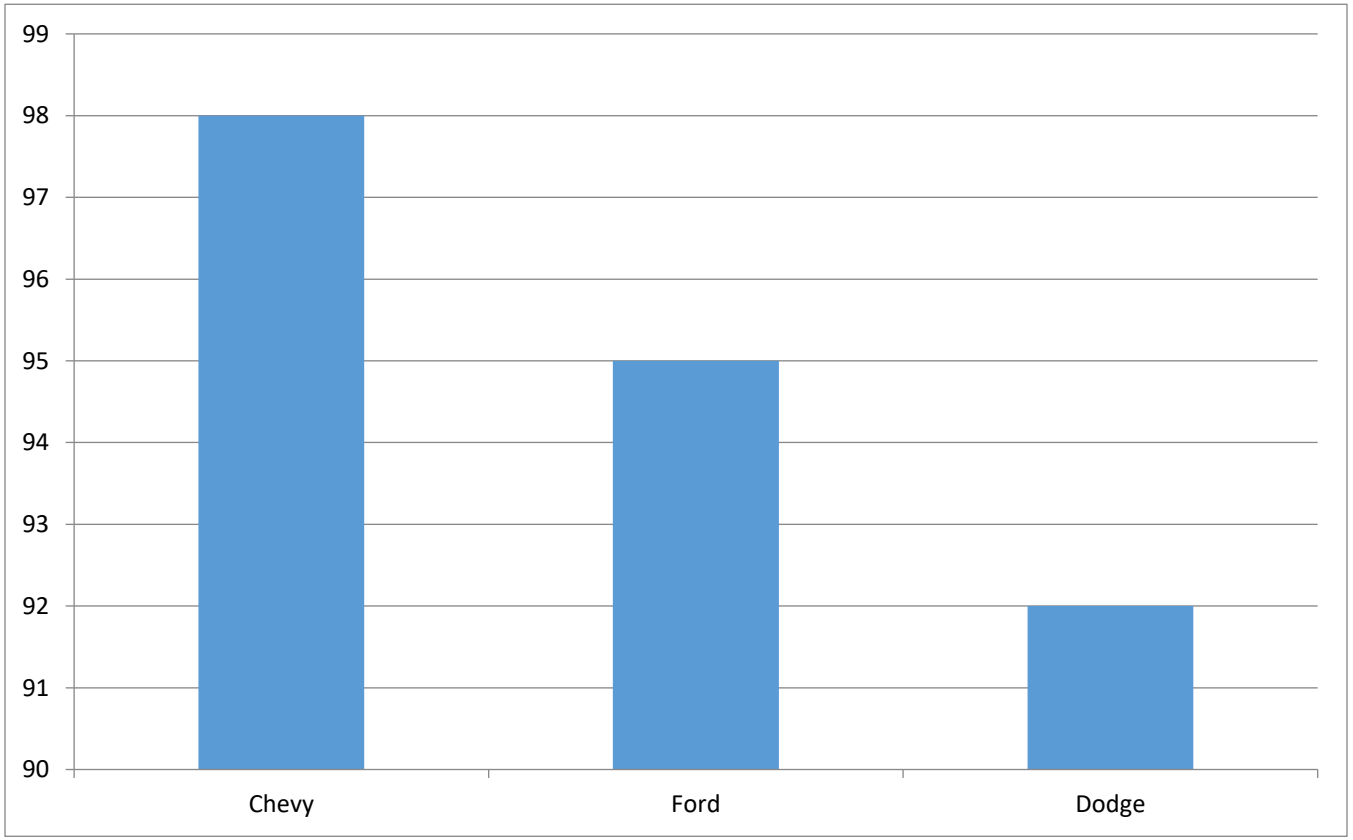
Misleading Graphs:

Statistical graphs can be misleading. Sometimes the deception is accidental, but sometimes it's intentional.

Misleading Bar Graph

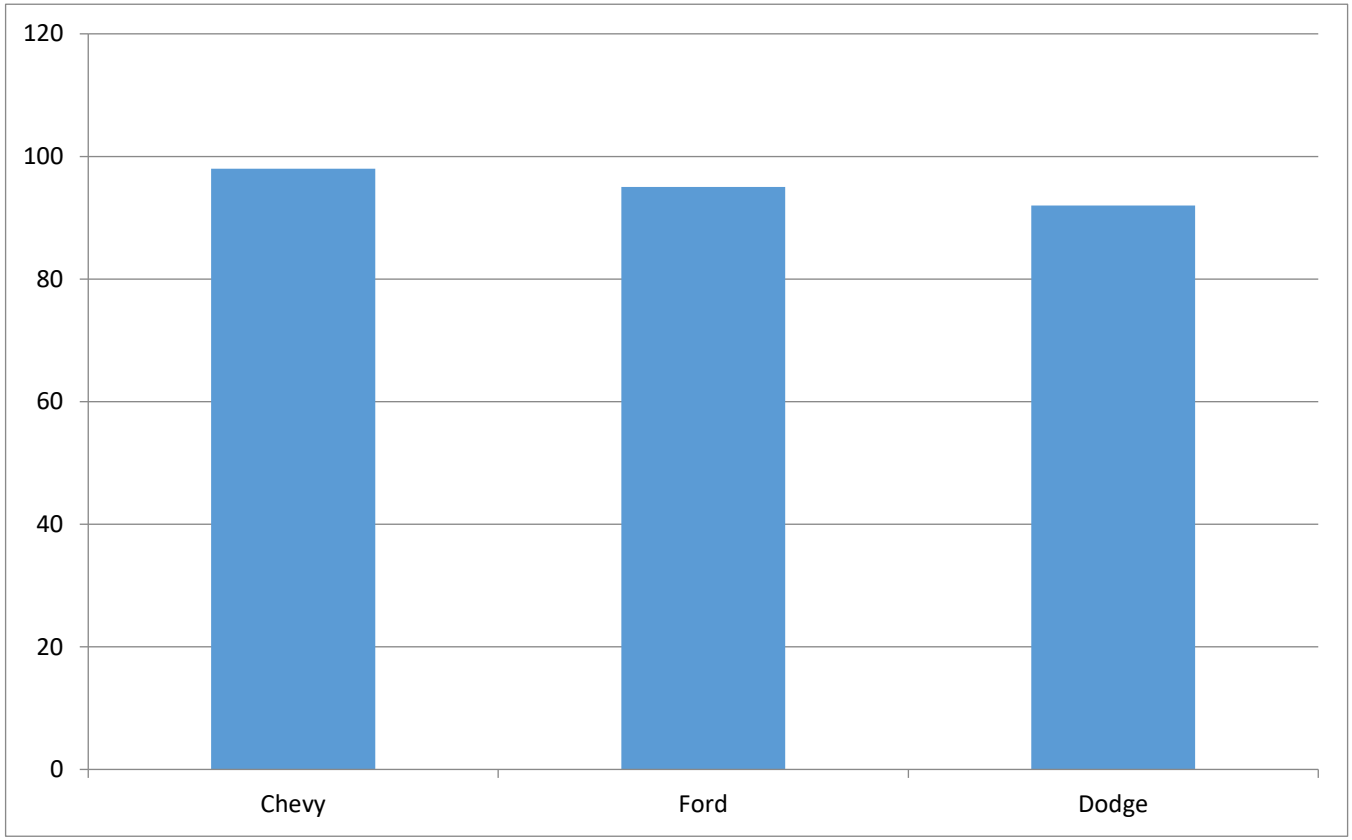


Percentage of Pickup Trucks Still on the Road After Ten Years

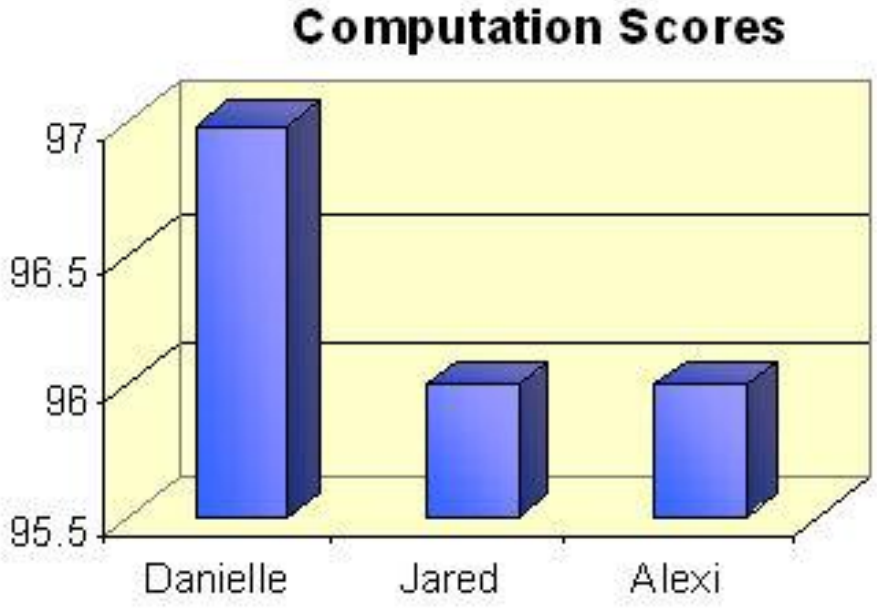


The vertical axis is visible, but it doesn't start at zero.

Percentage of Pickup Trucks Still on the Road After Ten Years



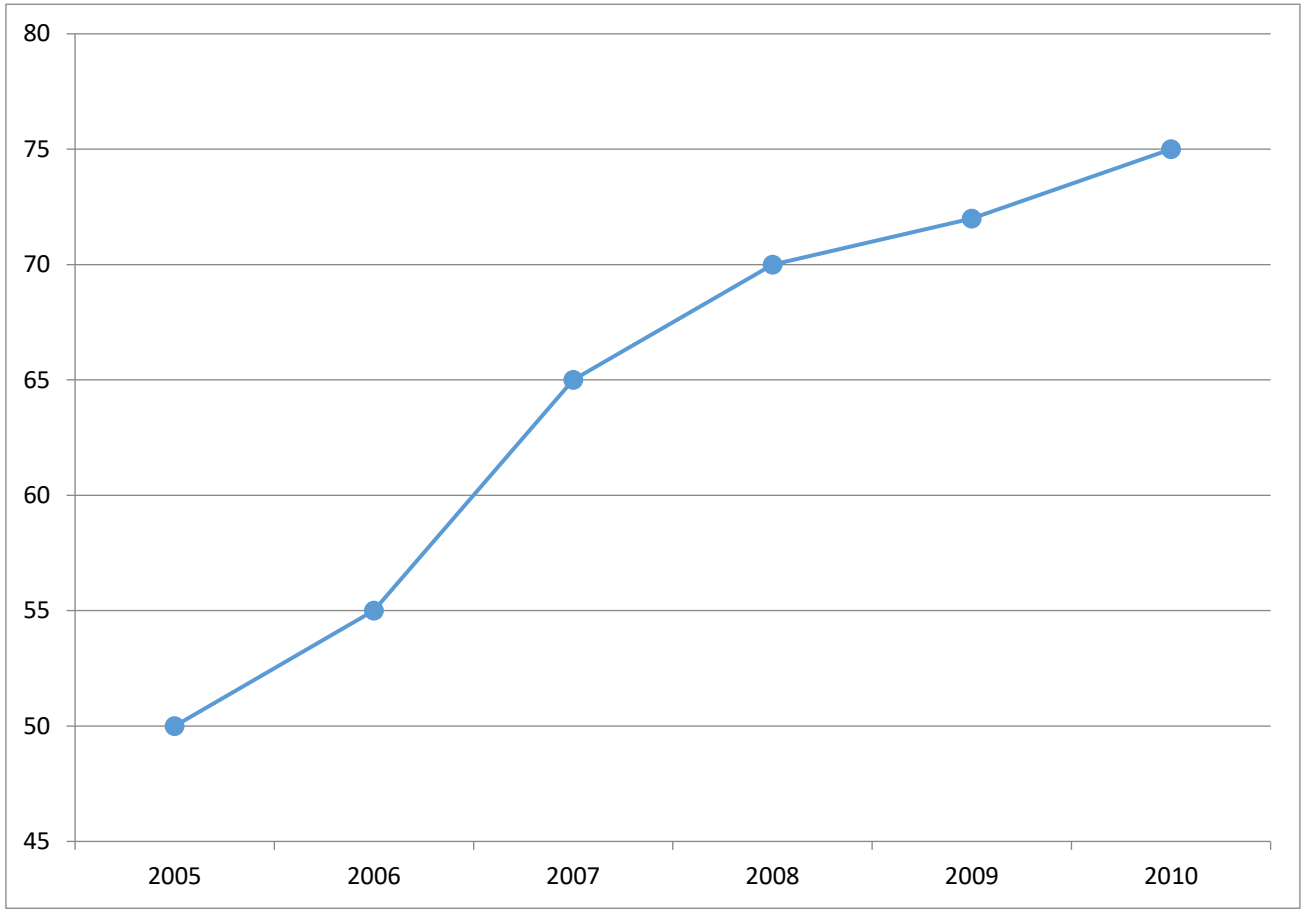
Starting the vertical axis at zero makes comparisons fair.

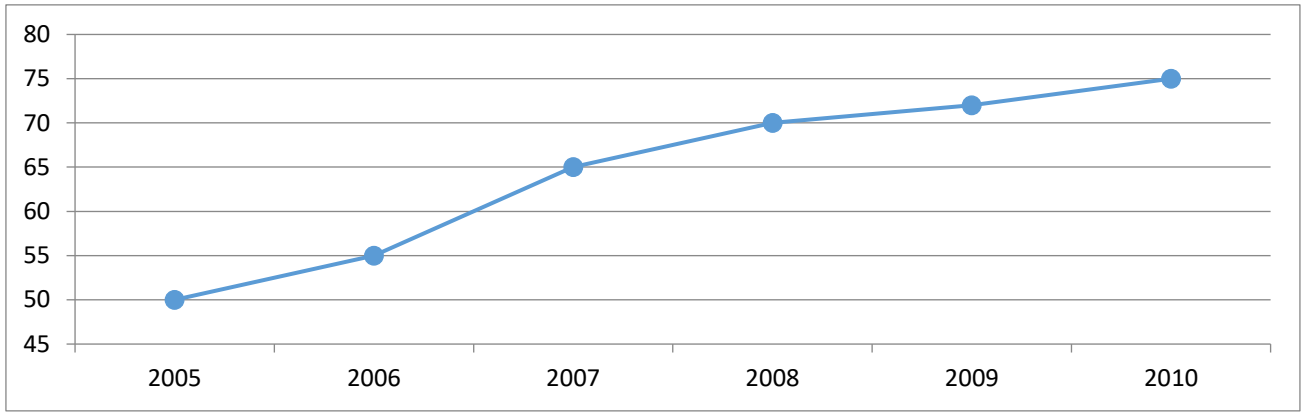


Clearly these bars don't start at zero, so comparisons in heights/values wouldn't be fair.

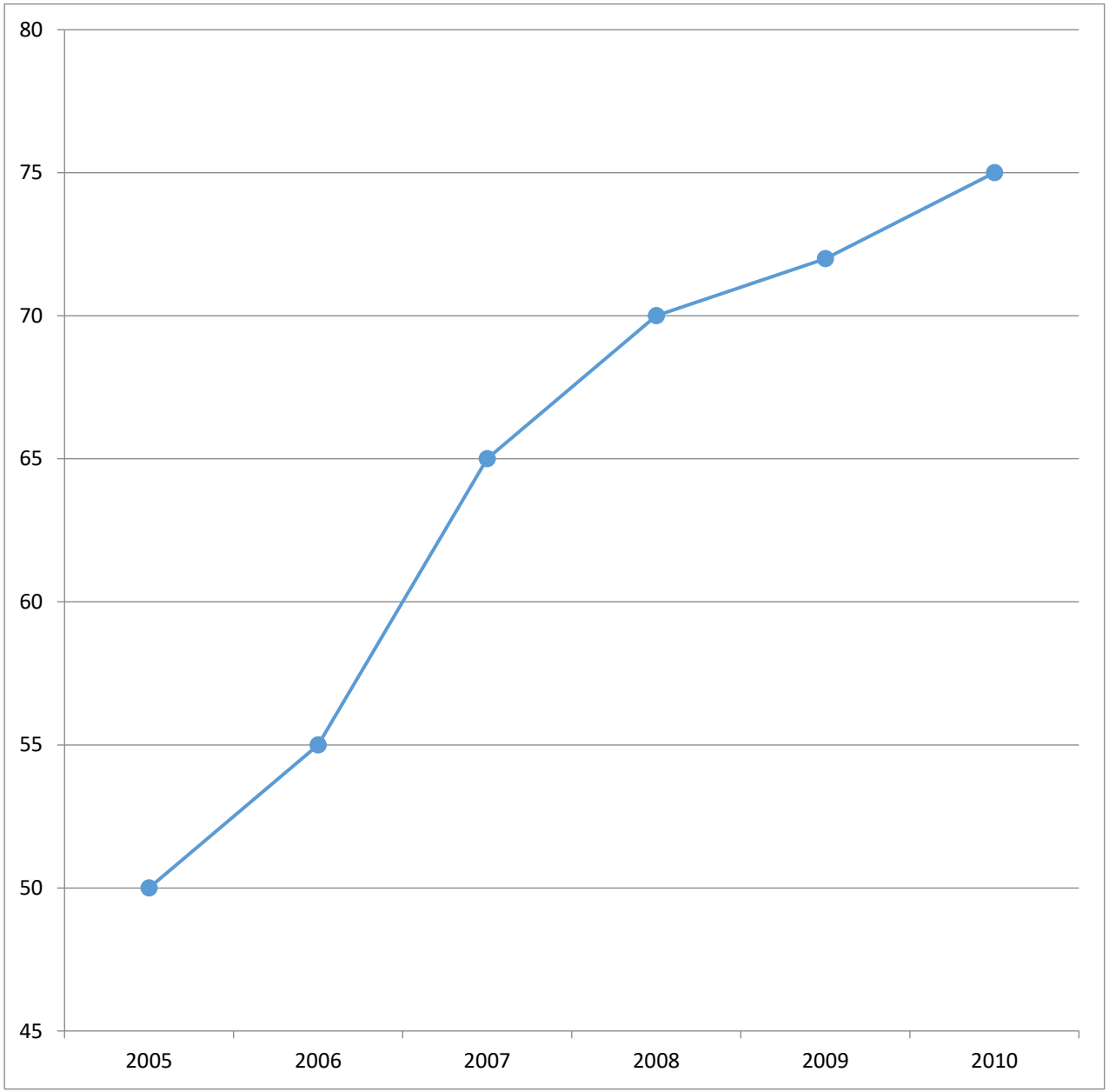
There's no starting value labelled for the stacks of books, but since 82% is not 5 times the value of 75%, we know that they can't start at zero.

Misleading Line Graph

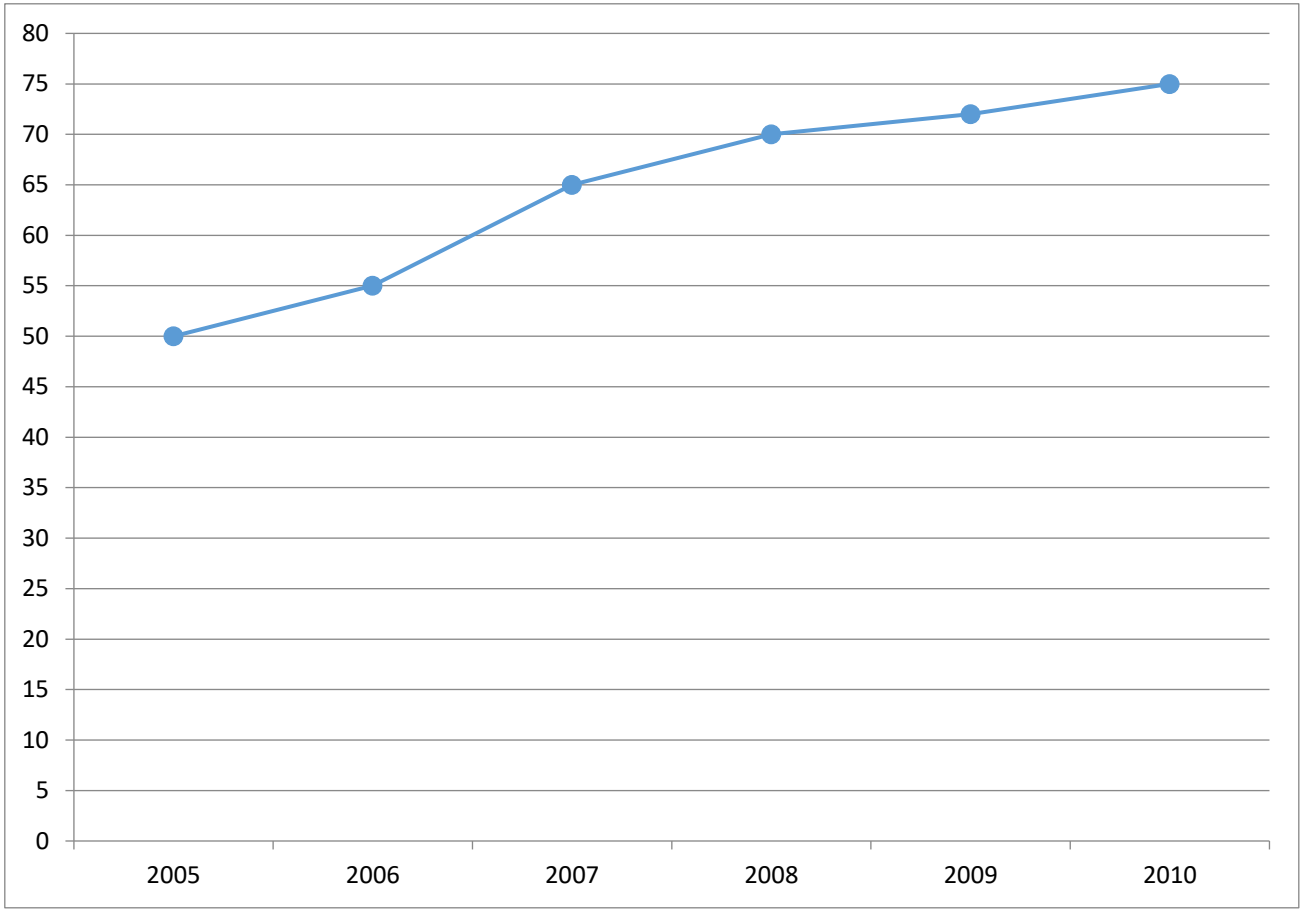




Shortening the vertical axis minimizes the upward trend.

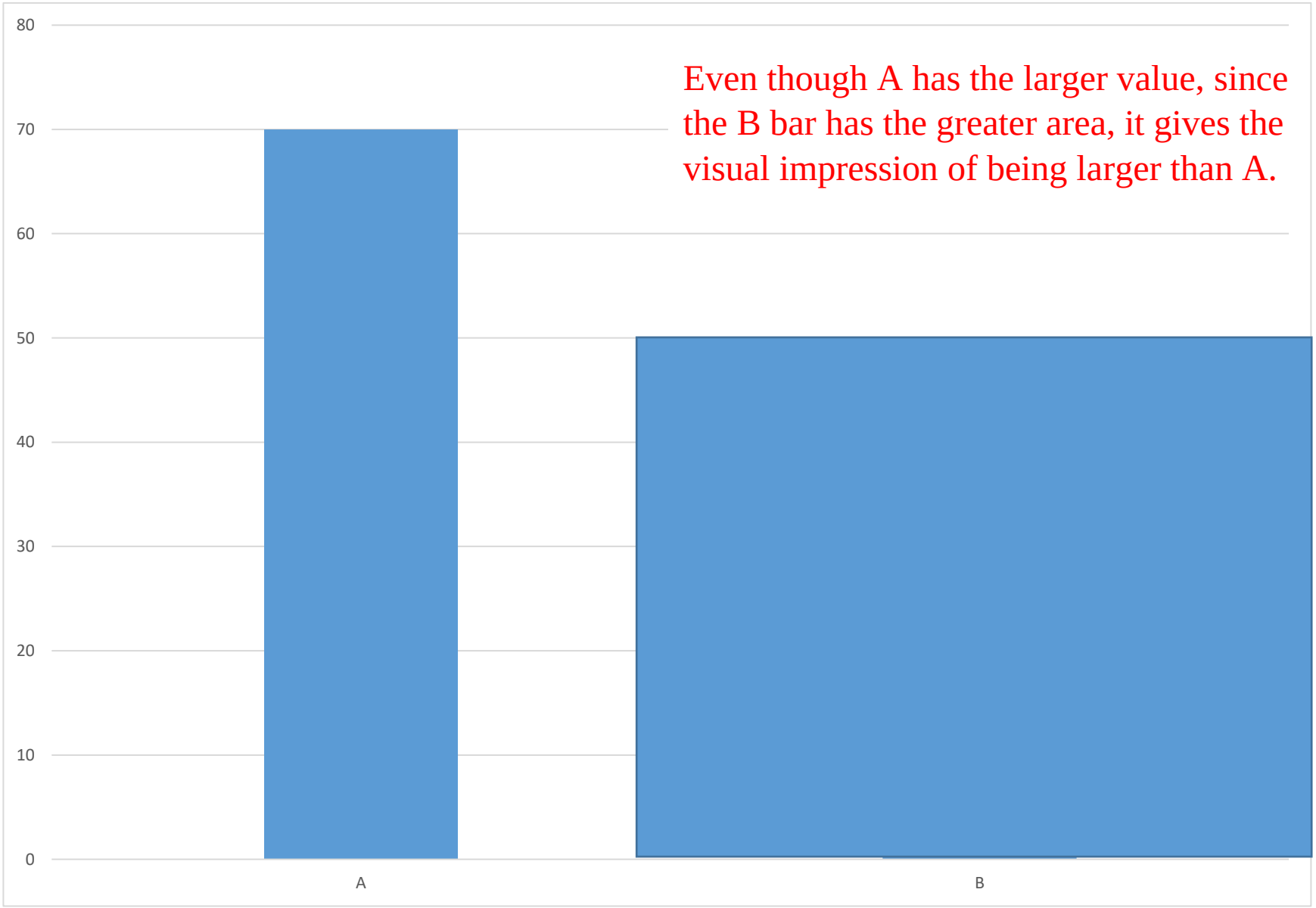


Lengthening the vertical axis enhances the upward trend.



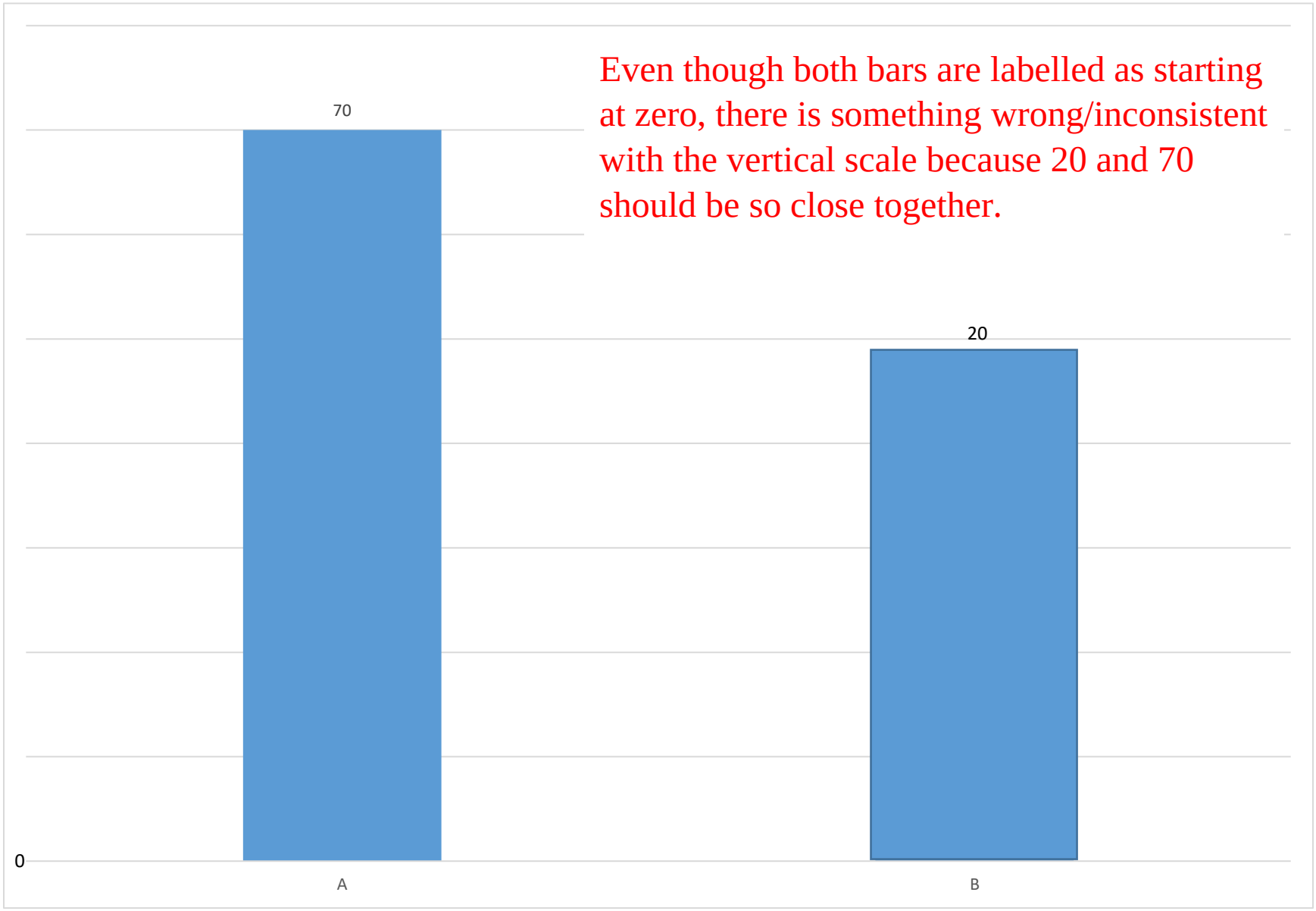
Starting the vertical axis at zero also minimizes the upward trend, and it makes comparisons fair.

Uneven Bars


80
70
60
50
40
30
20
10
0
A
B
Even though A has the larger value, since the B bar has the greater area, it gives the visual impression of being larger than A.

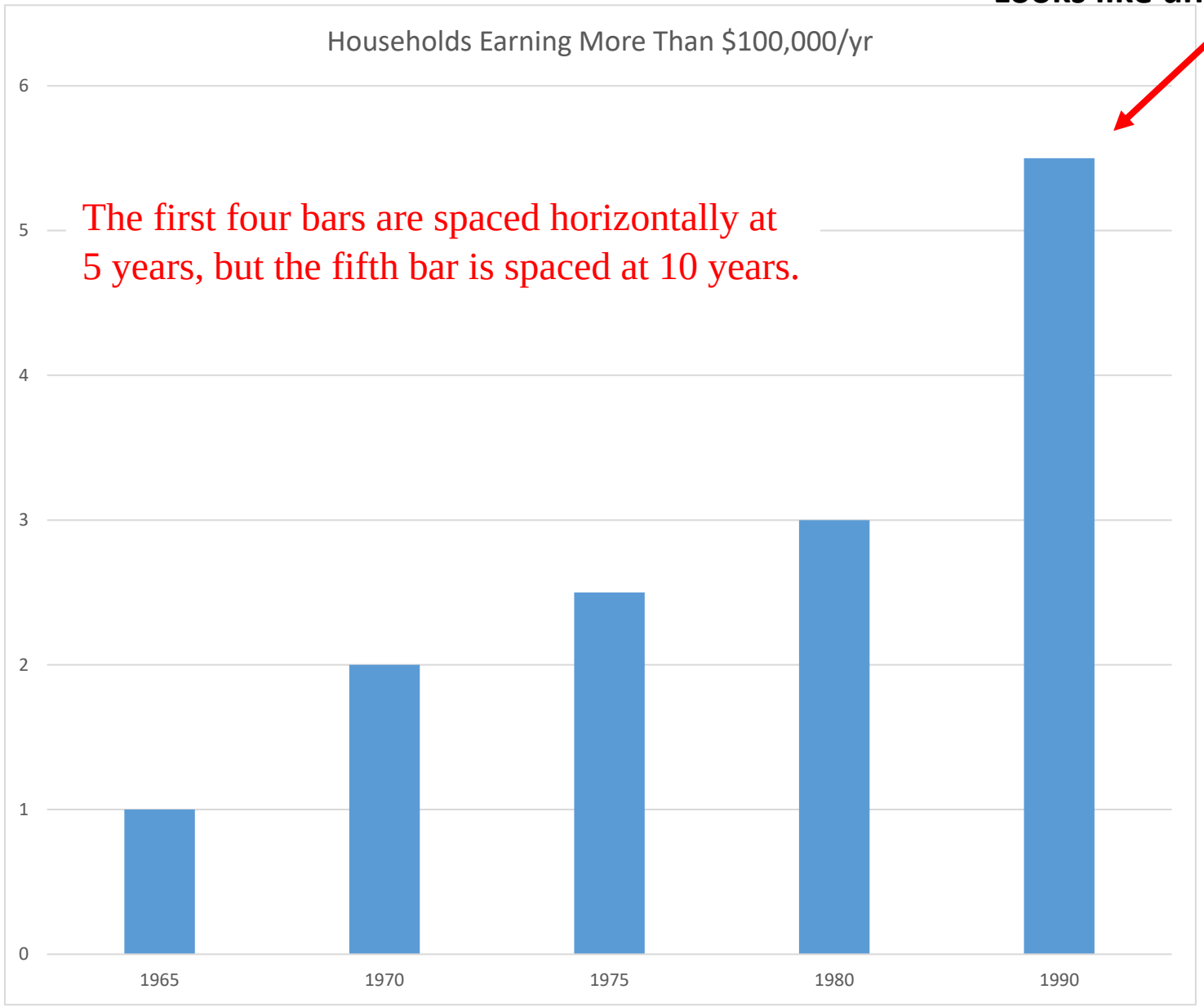
The Hockey and Baseball values are close to each other, but the larger area of the Hockey puck visually makes it seem larger.

Inconsistent Vertical Scale



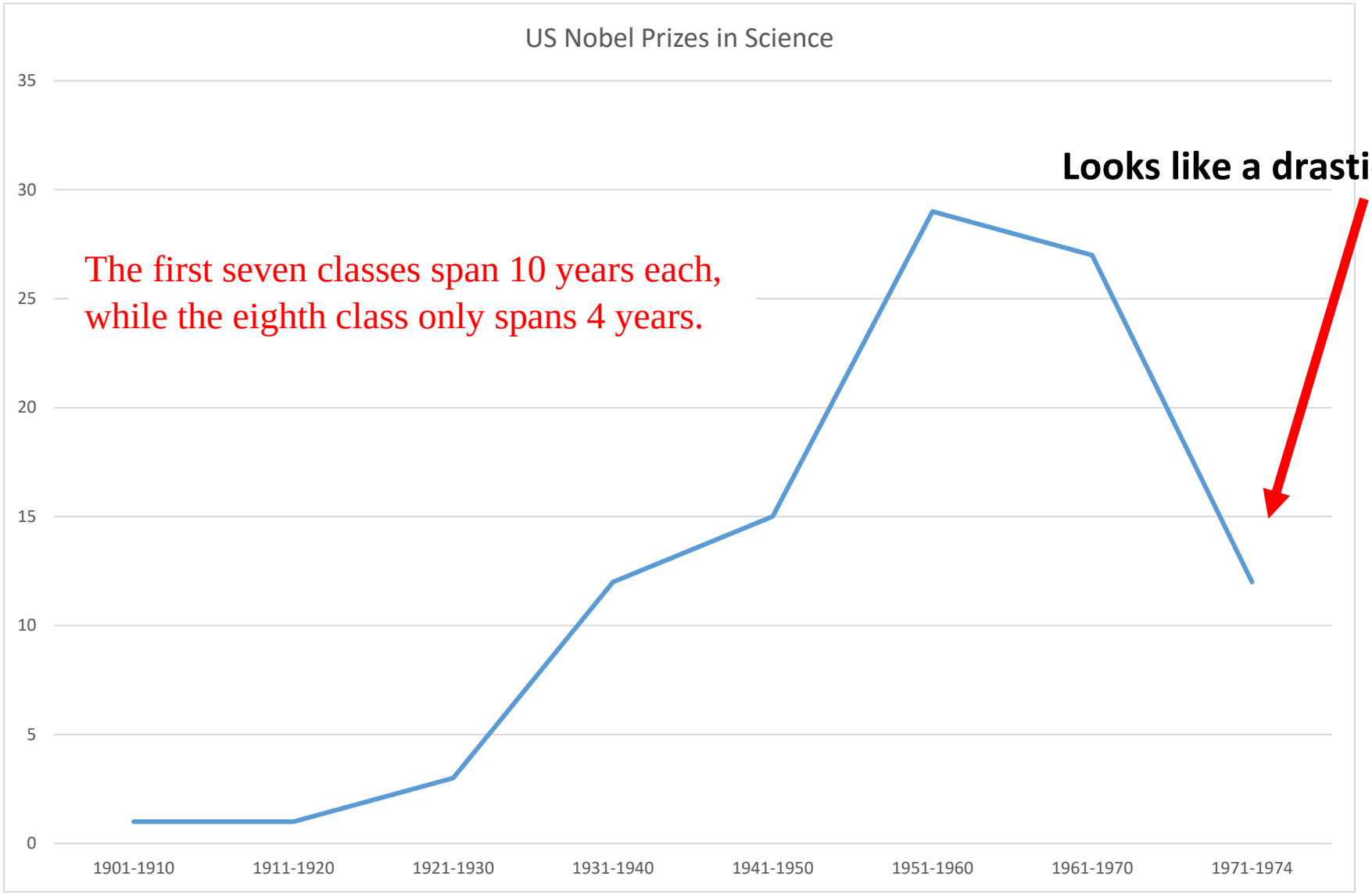
Inconsistent Horizontal Scale

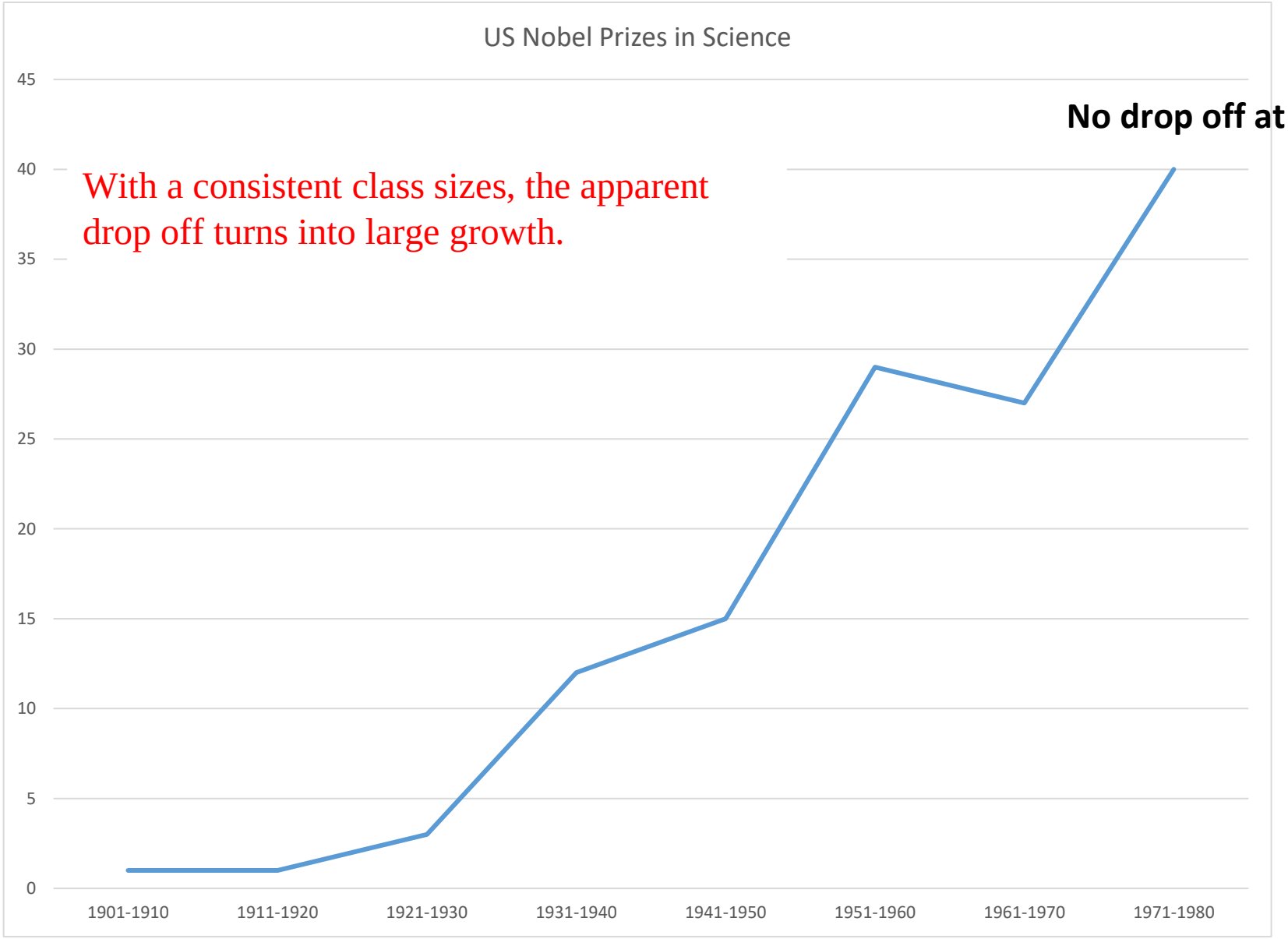
Looks like unusually large growth!



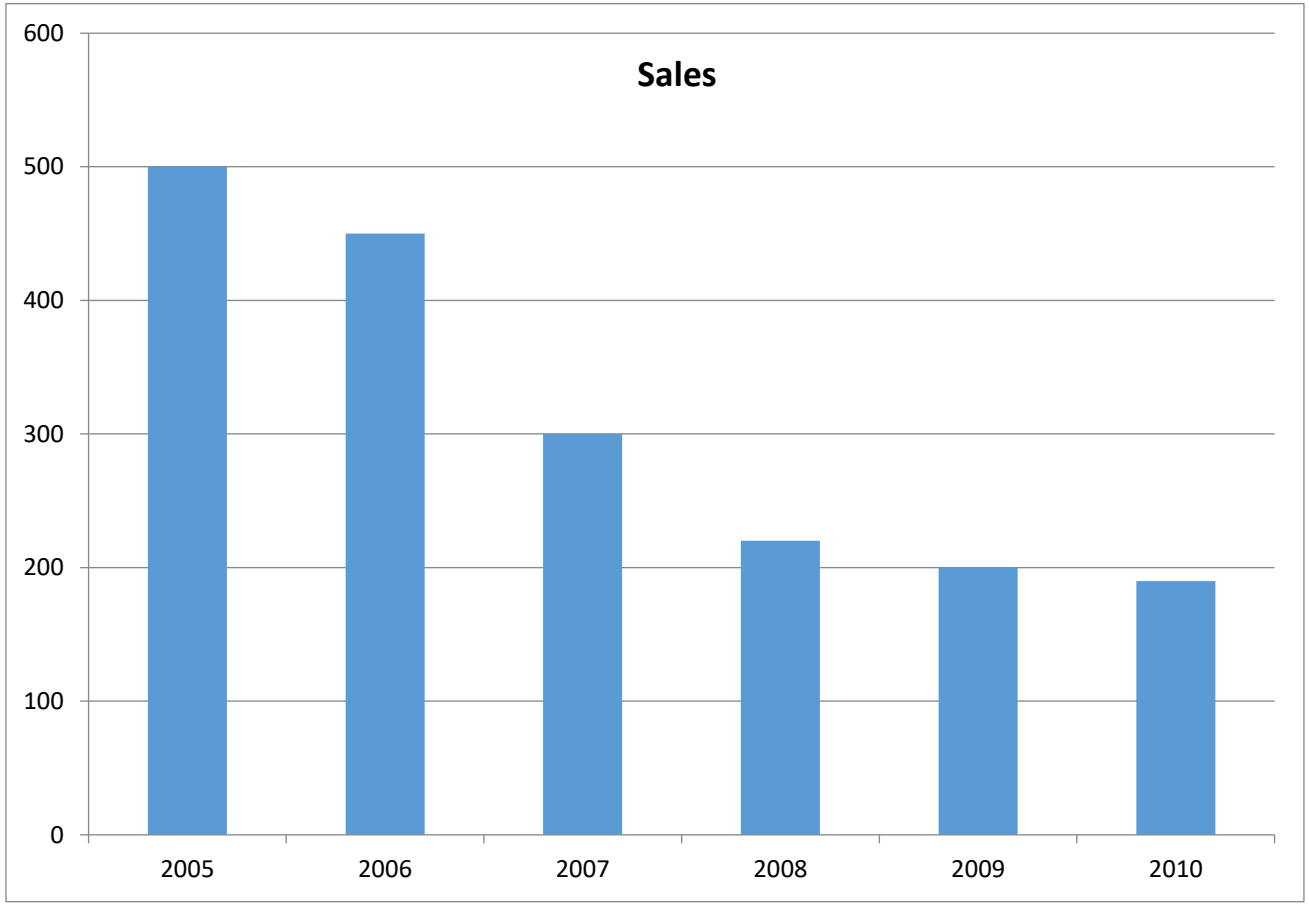

Households Earning More Than $100,000/yr
With a consistent horizontal scale, the growth trend doesn't seem so drastic.
6
5
4
3
2
1
0
1965
1970
1975
1980
1985
1990

Inconsistent Classes

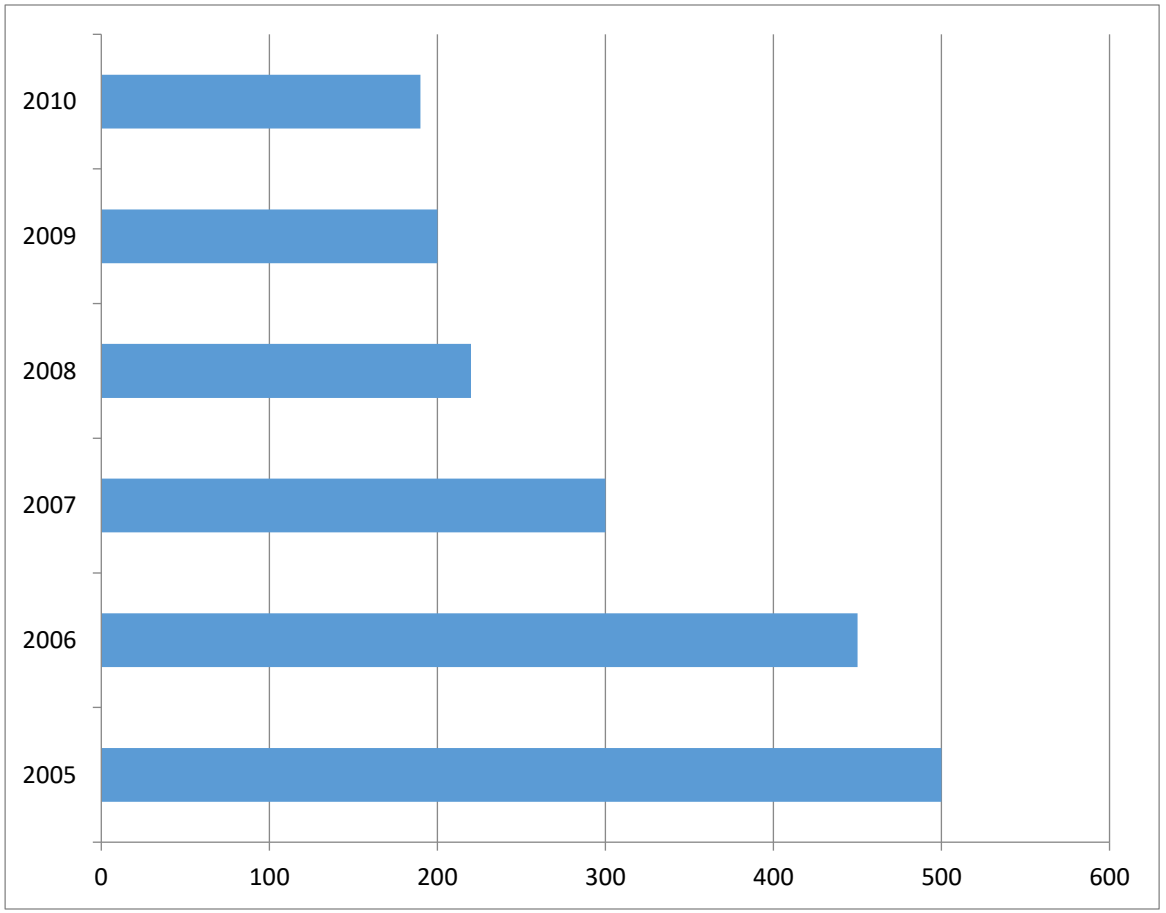



US Nobel Prizes in Science
45
40
35
30
25
20
15
10
5
0
1901-1910
1911-1920
1921-1930
1931-1940
1941-1950
1951-1960
1961-1970
1971-1980
No drop off at all!
With a consistent class sizes, the apparent drop off turns into large growth.

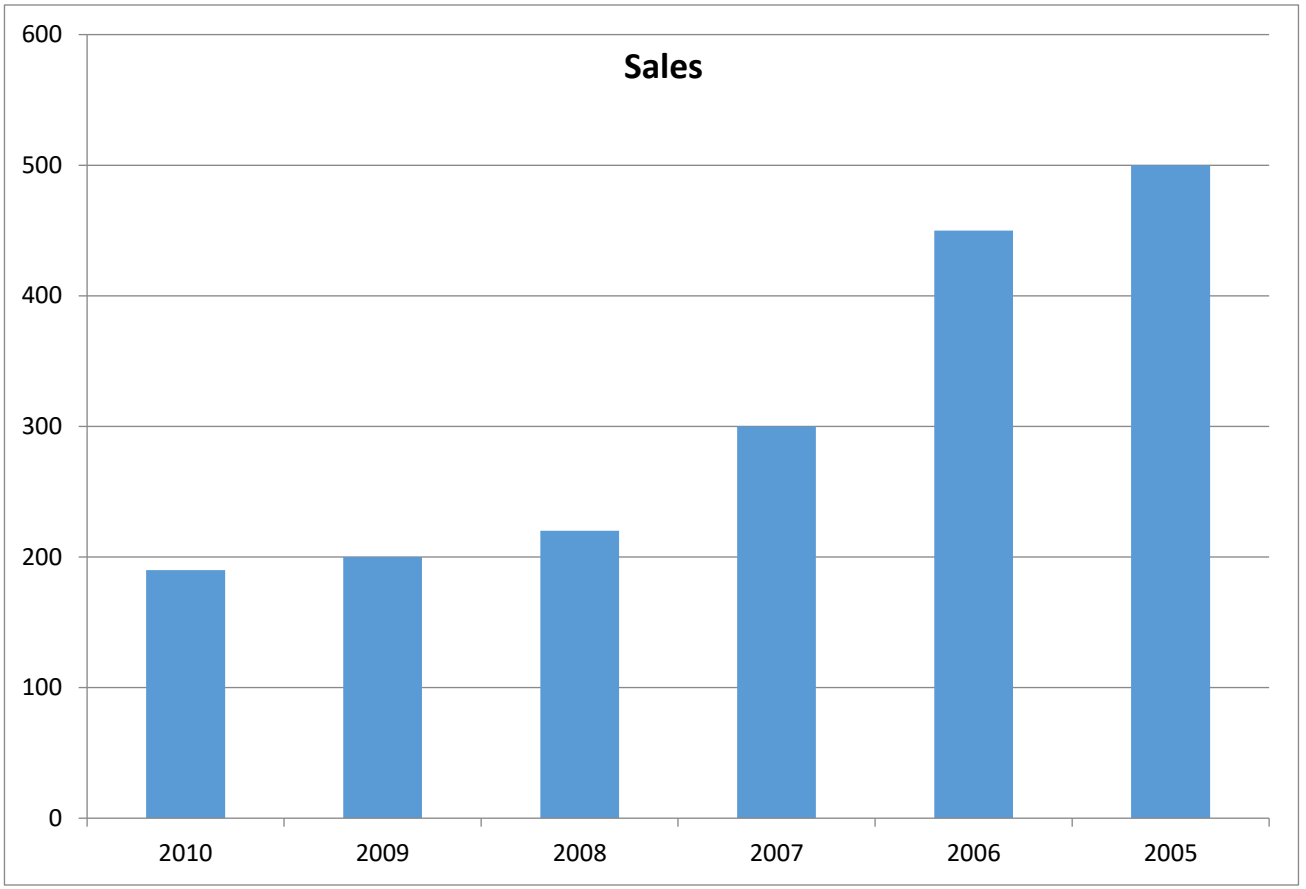
Misleading Trend



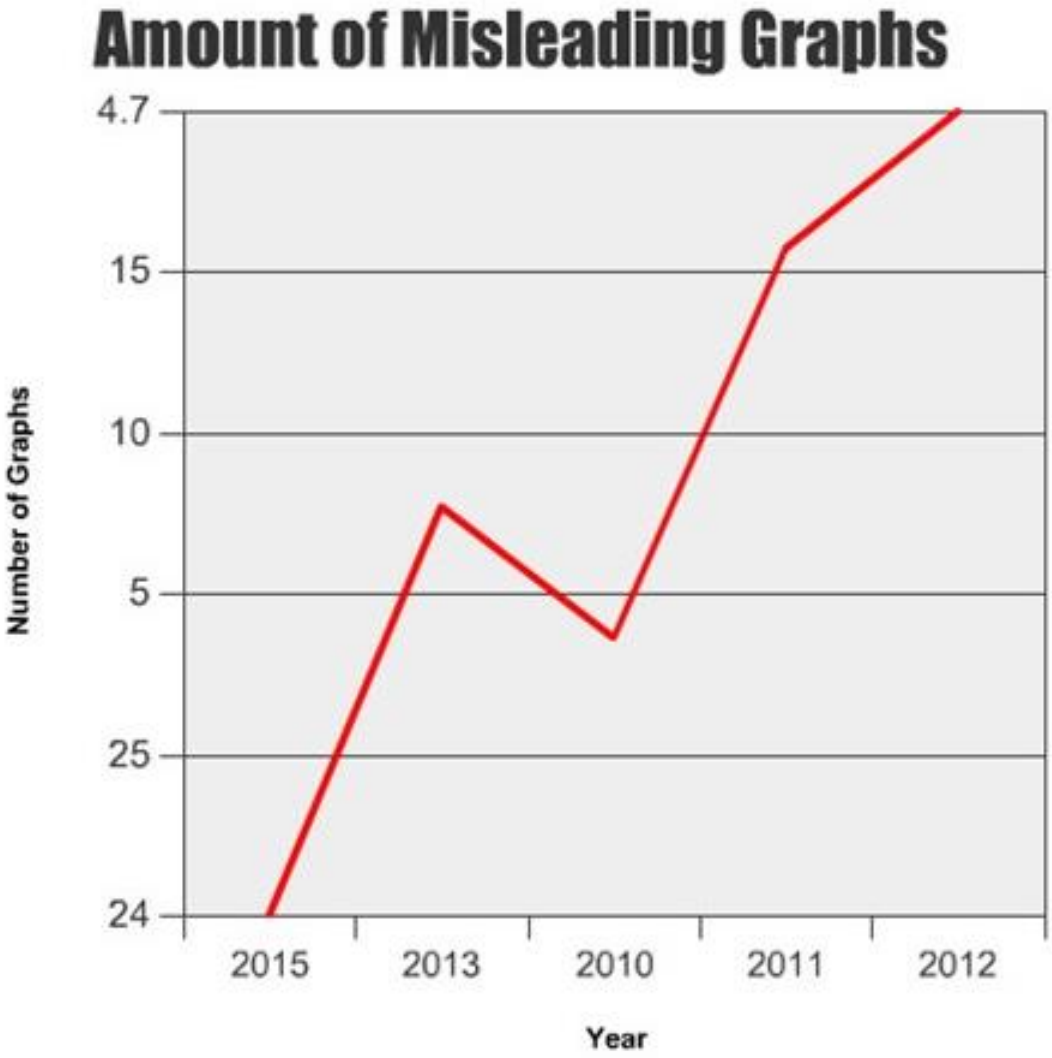
There's a definite downward trend.



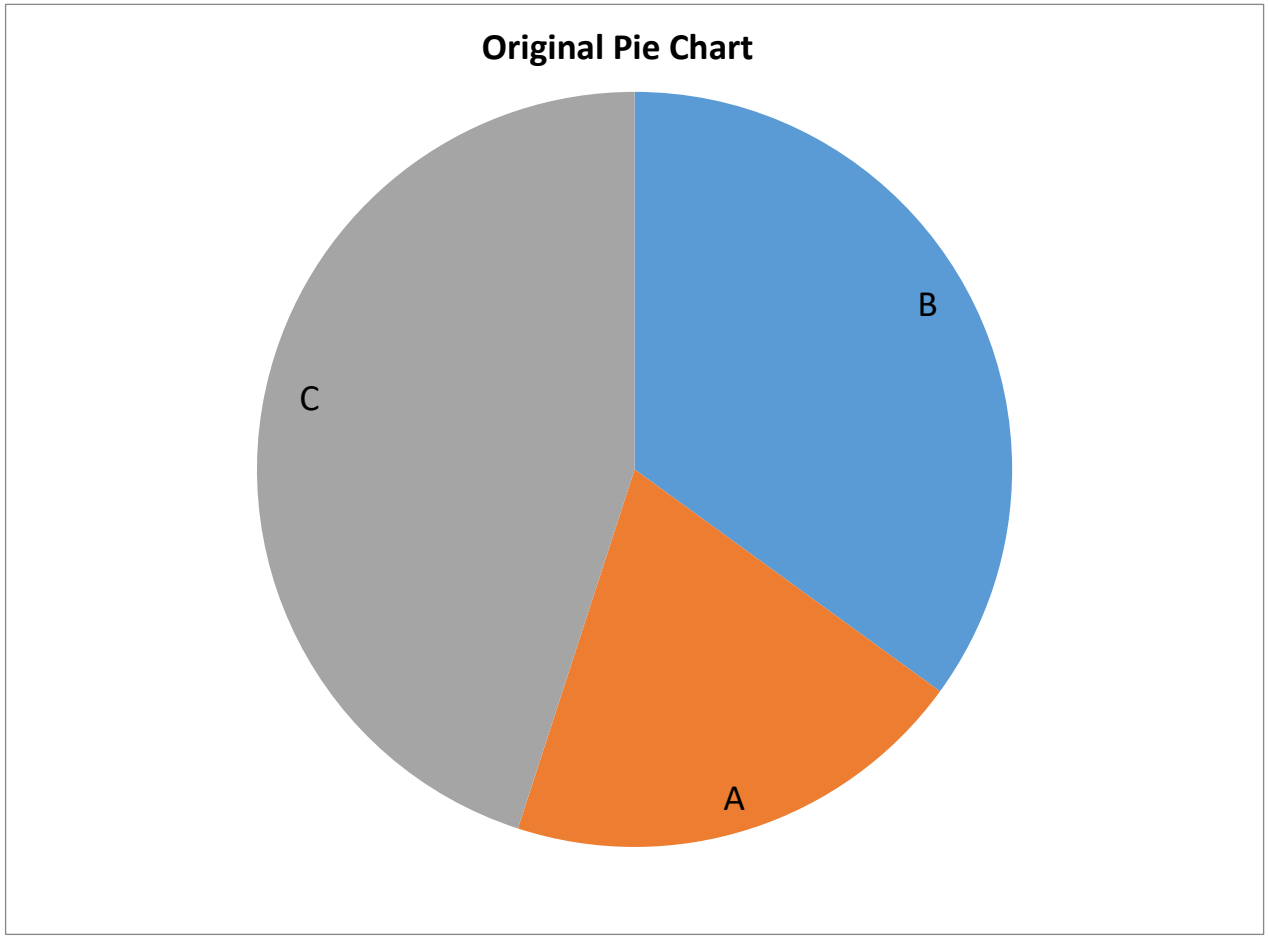
Trends are harder to detect in a vertical arrangement, so switch the axes.

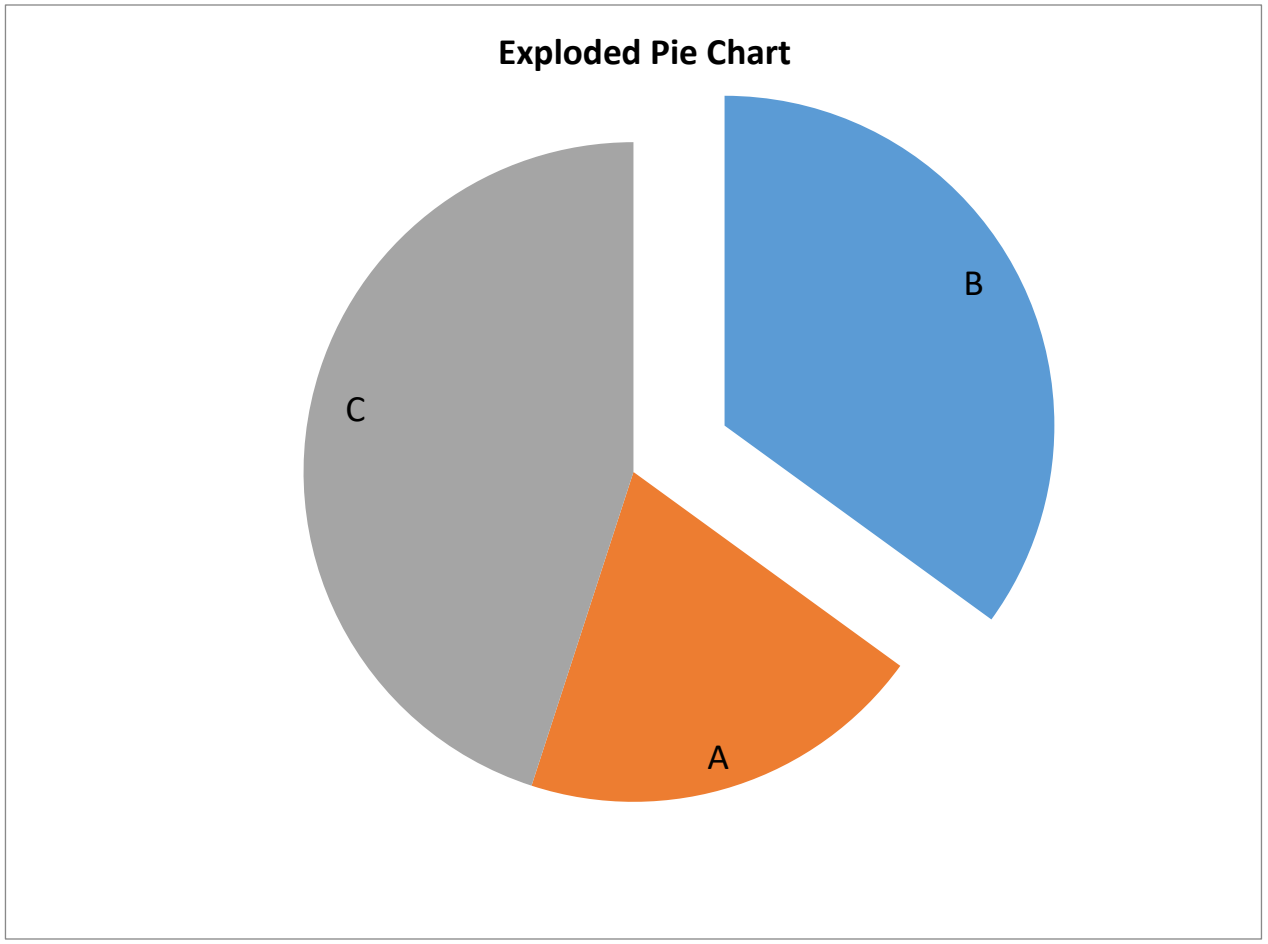


Reversing the horizontal axis turns a downward trend into an upward trend.

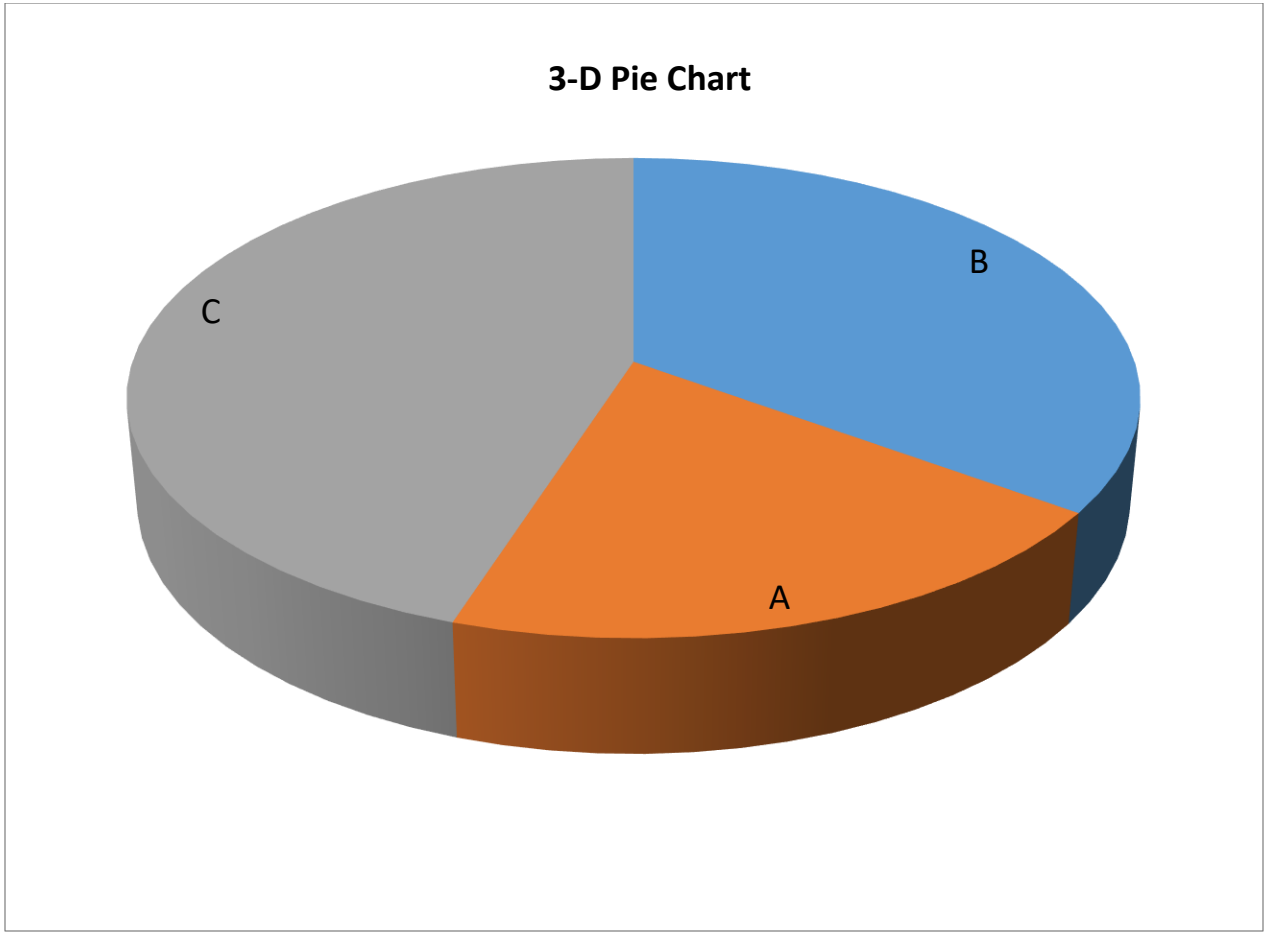

Amount of Misleading Graphs
4.7
15
10
5
25
24
Number of Graphs
2015
2013
2010
2011
2012
Year

Misleading Pie Chart





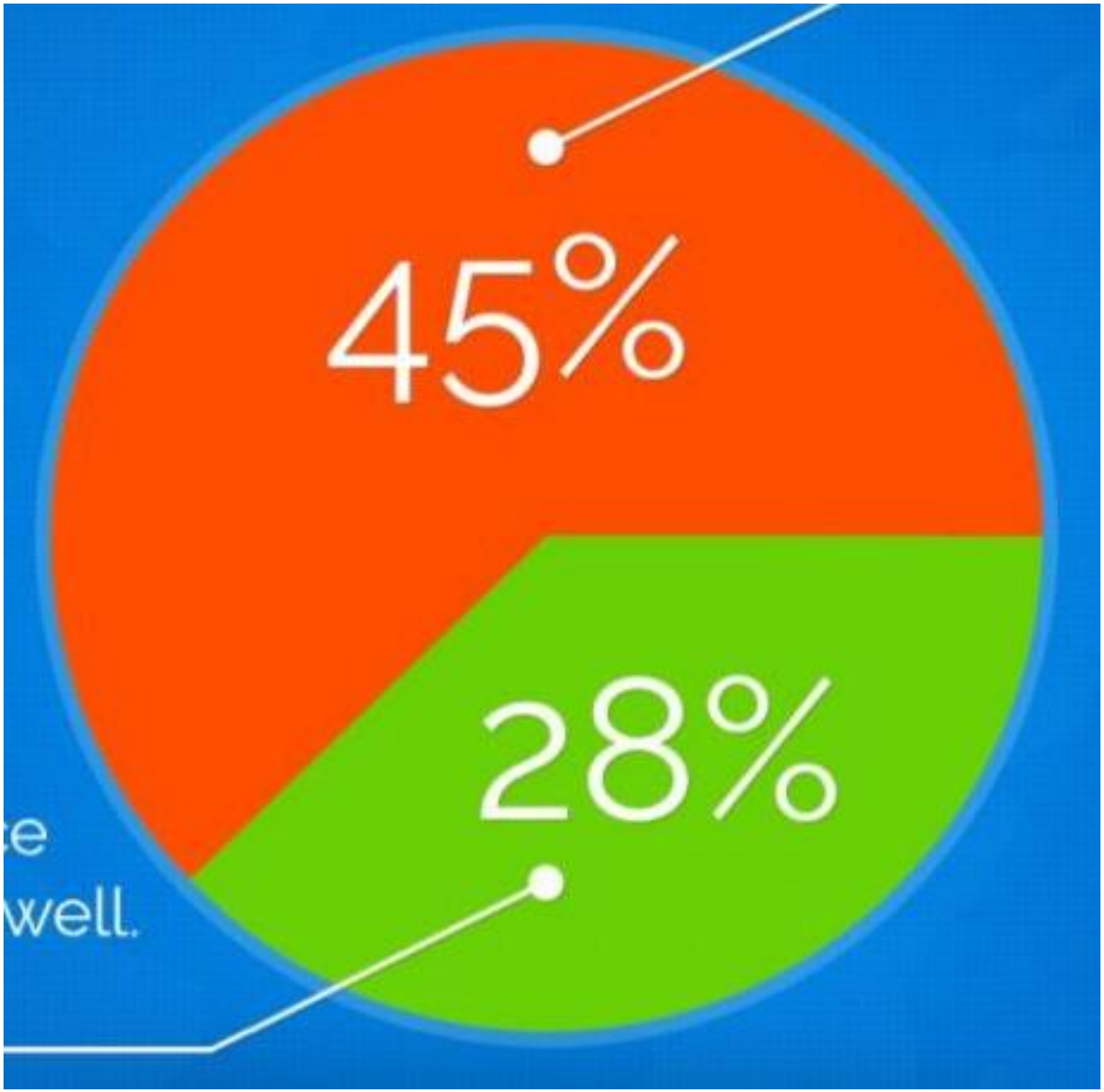
Emphasis is placed on the exploded piece.



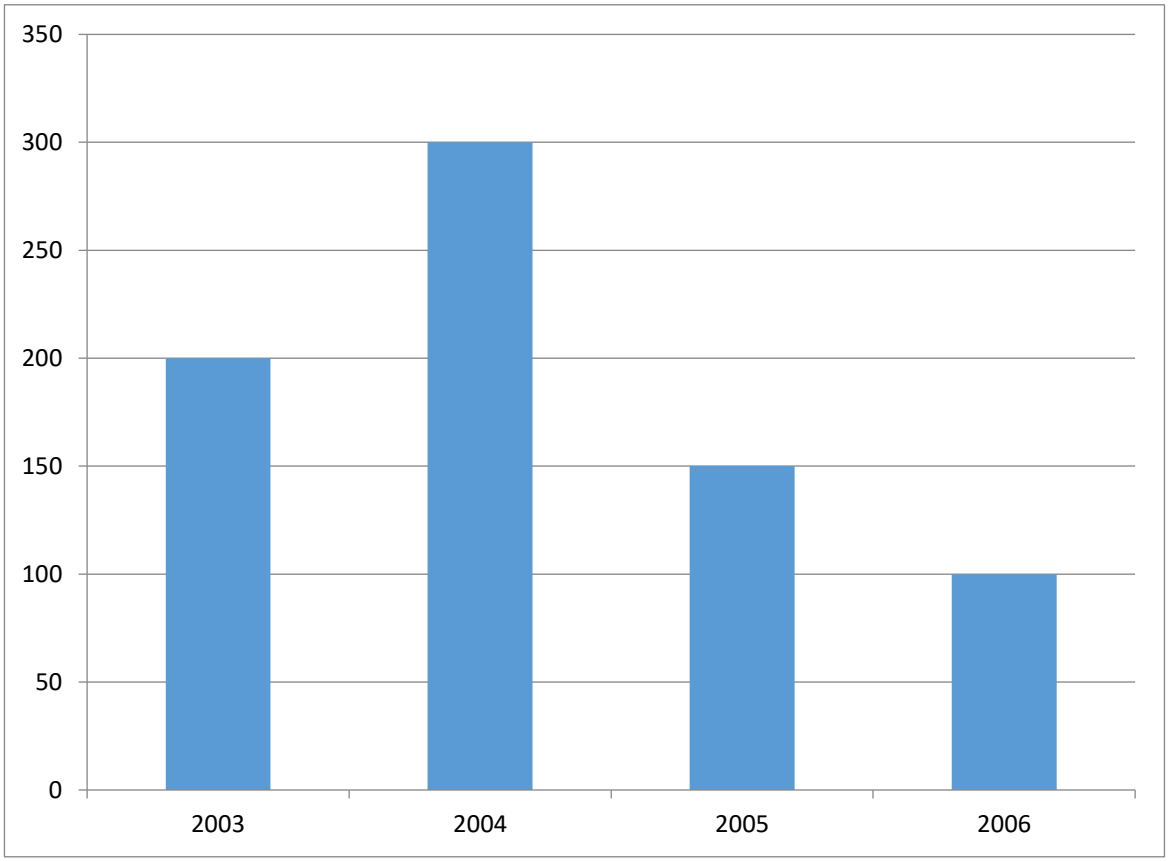
3-D can make comparisons more difficult.

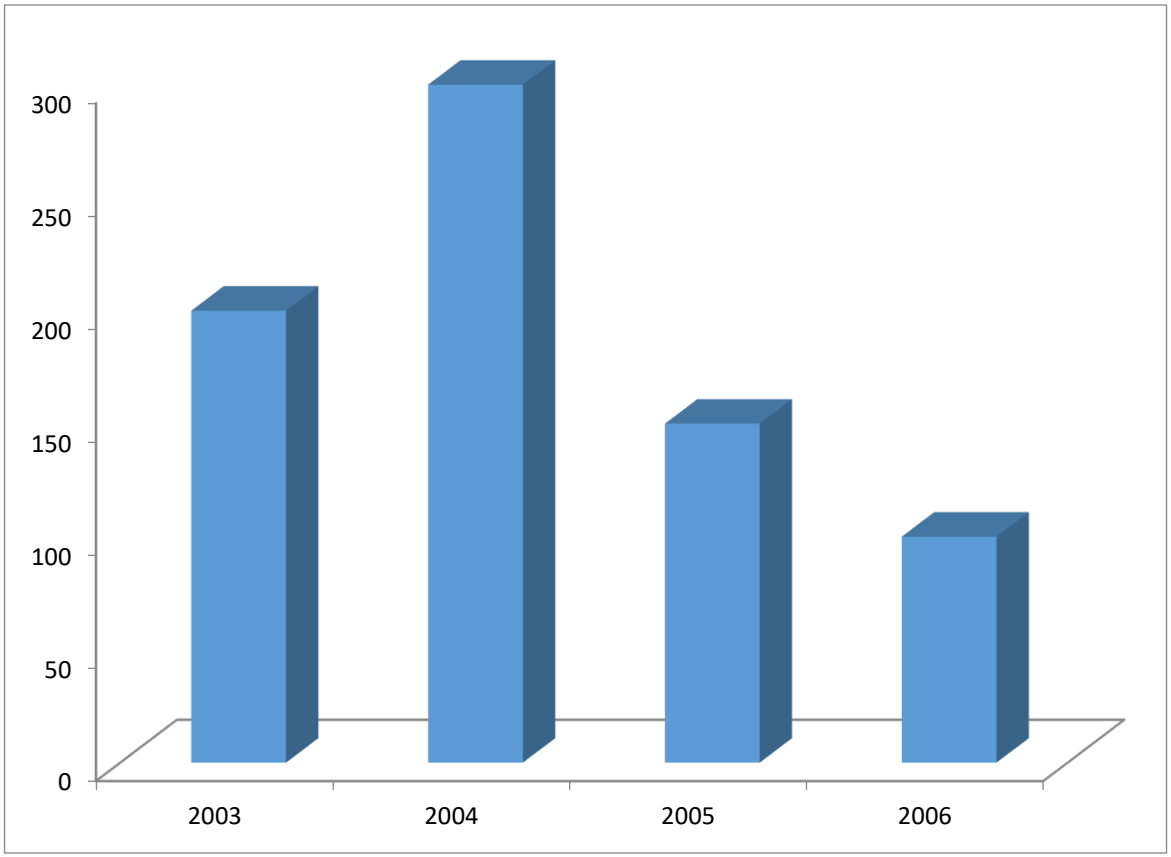
Pie charts are supposed to account for everything, so if percentages are displayed, they should add up to 100%. The percentage indicated should correspond to the amount of the circle shaded.

45% shouldn't take up more than half of the circle, and 28% should be closer to one-fourth of the circle. 45% + 28% is not 100%.

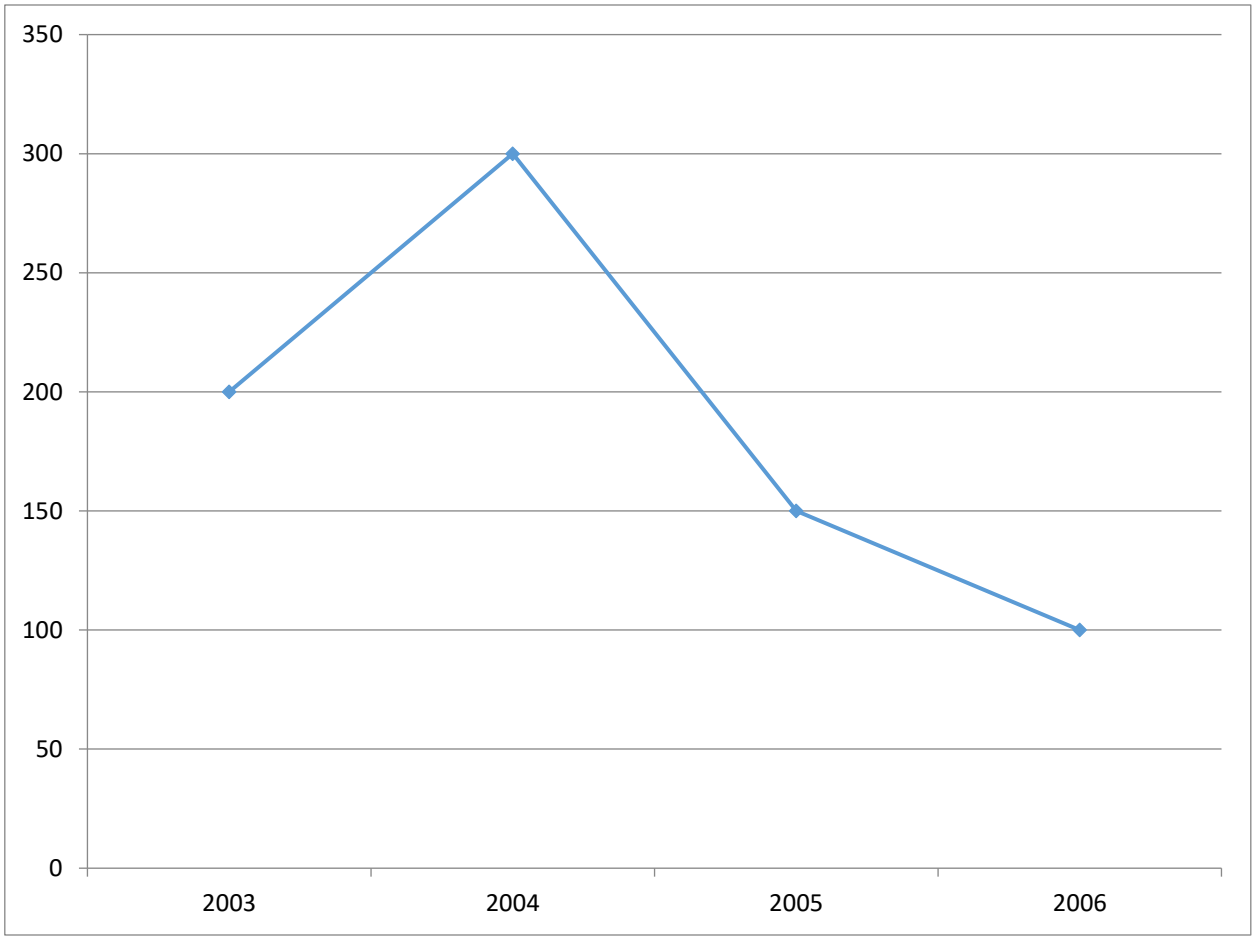


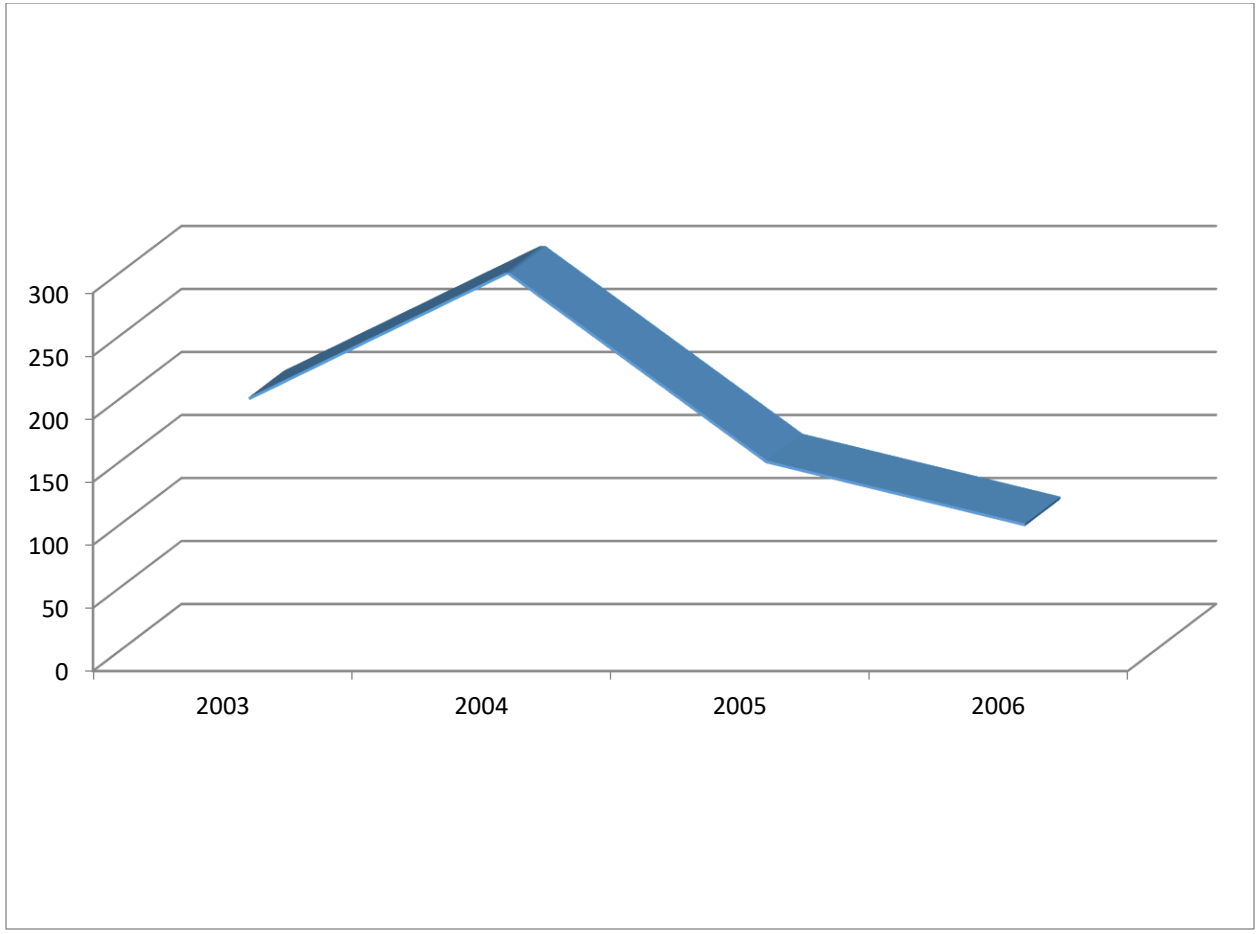
3-D Effects



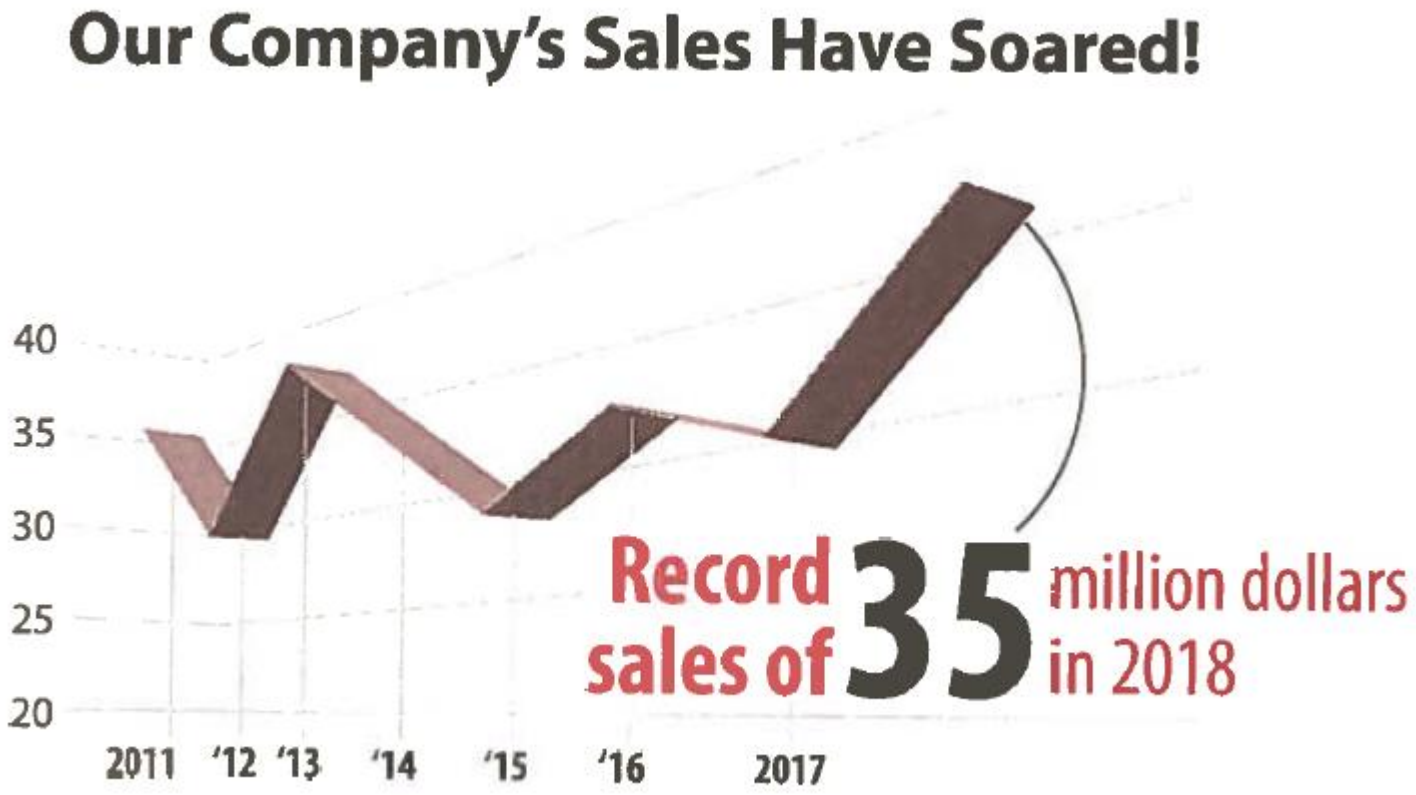


The 3-dimensional bars make it more difficult to read the actual values.


350
300
250
200
150
100
50
0
2003
2004
2005
2006



The surface makes it more difficult to read the actual values.



The orientation of the surface plot makes the 35 million dollars in 2018 seem like the largest amount of sales, but 2011 and 2013 actually had more sales.