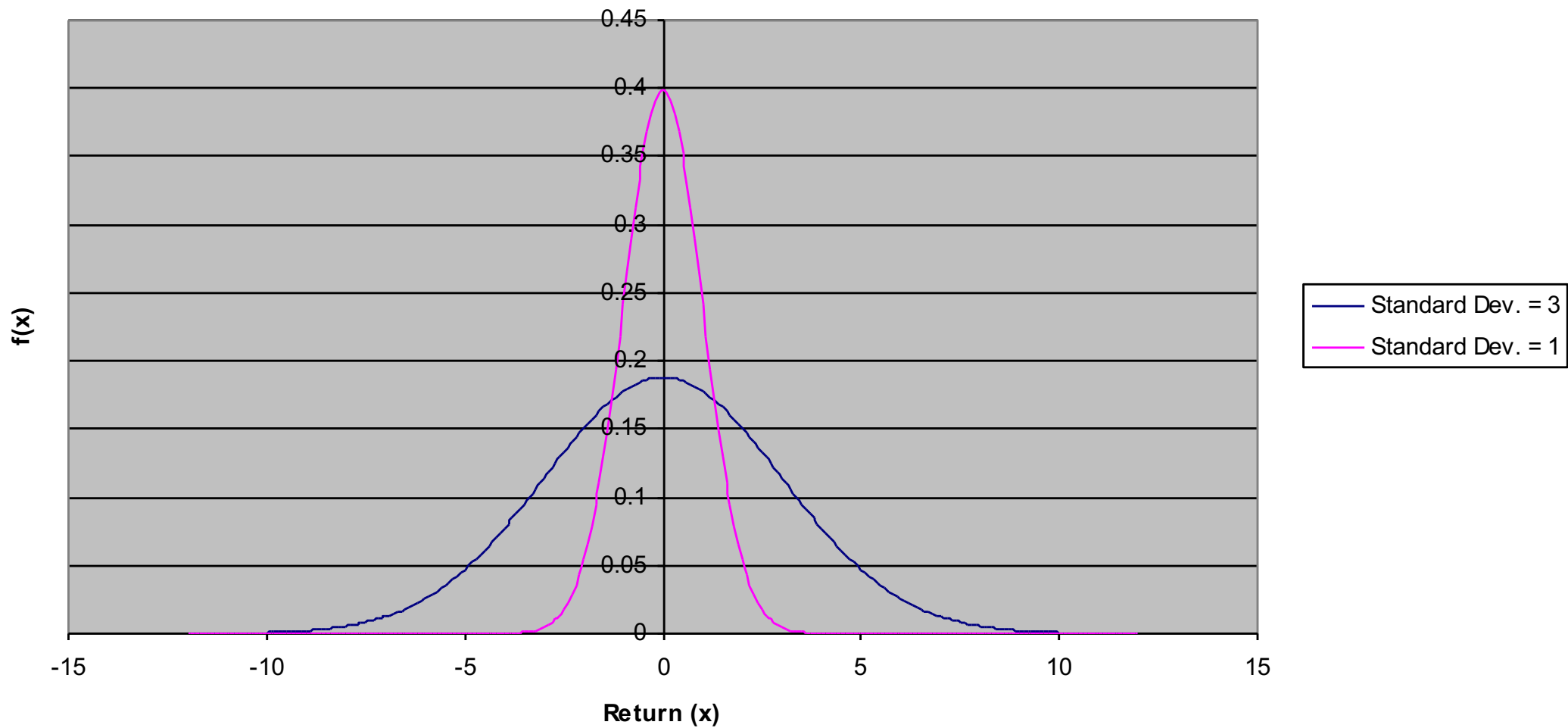
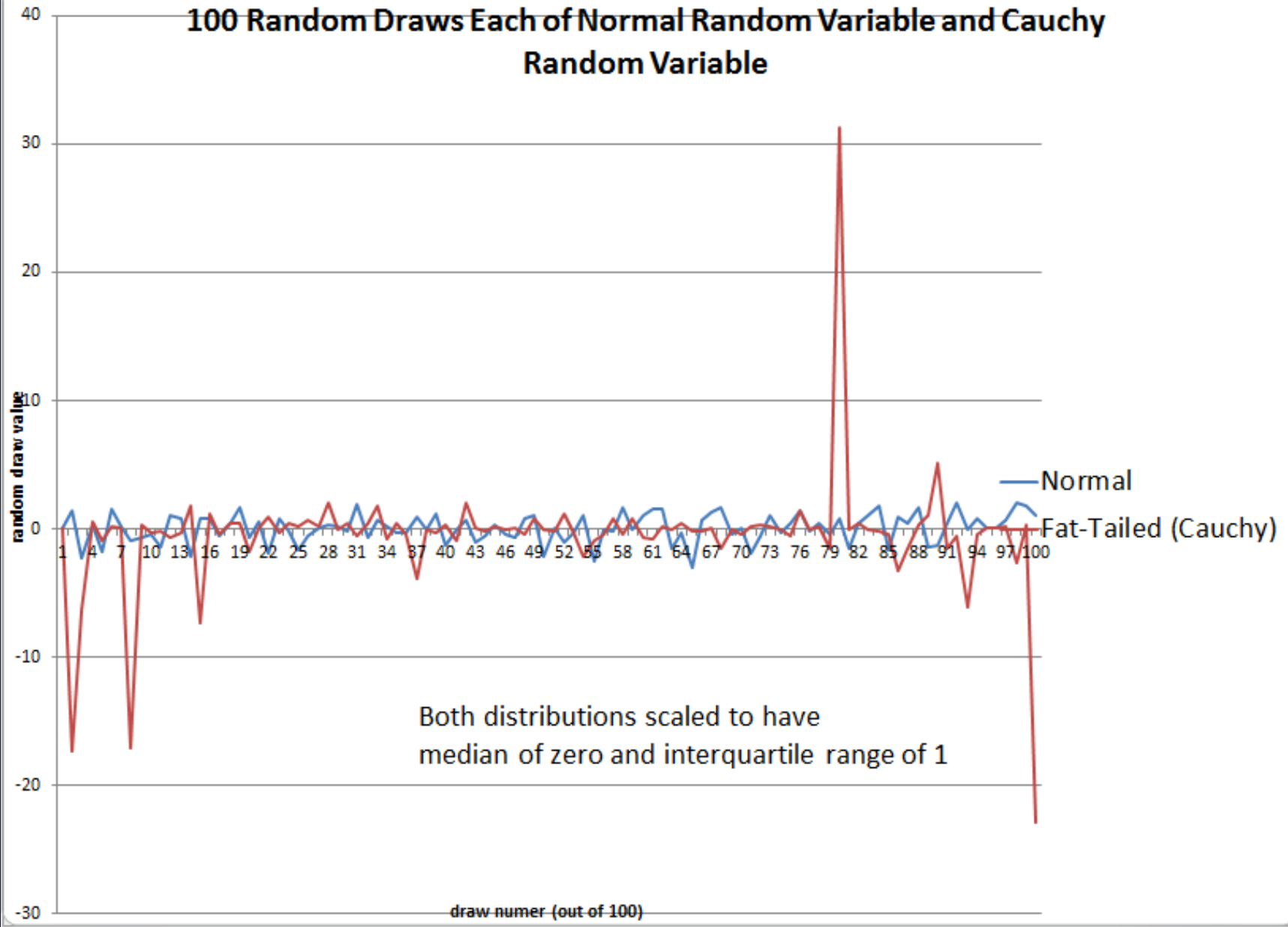


Normal Distribution with Zero Mean



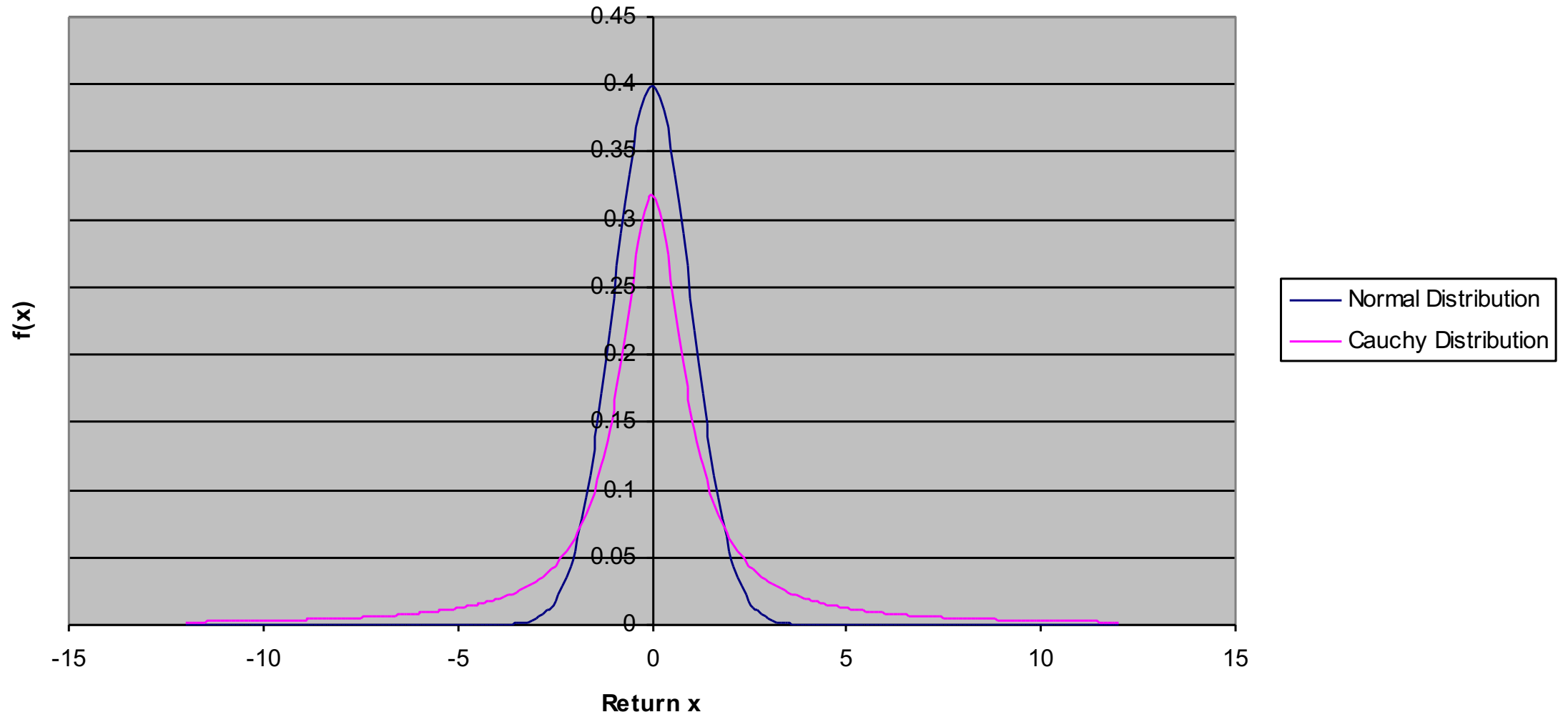
# 100 Random Draws Each of Normal Random Variable and Cauchy Random Variable



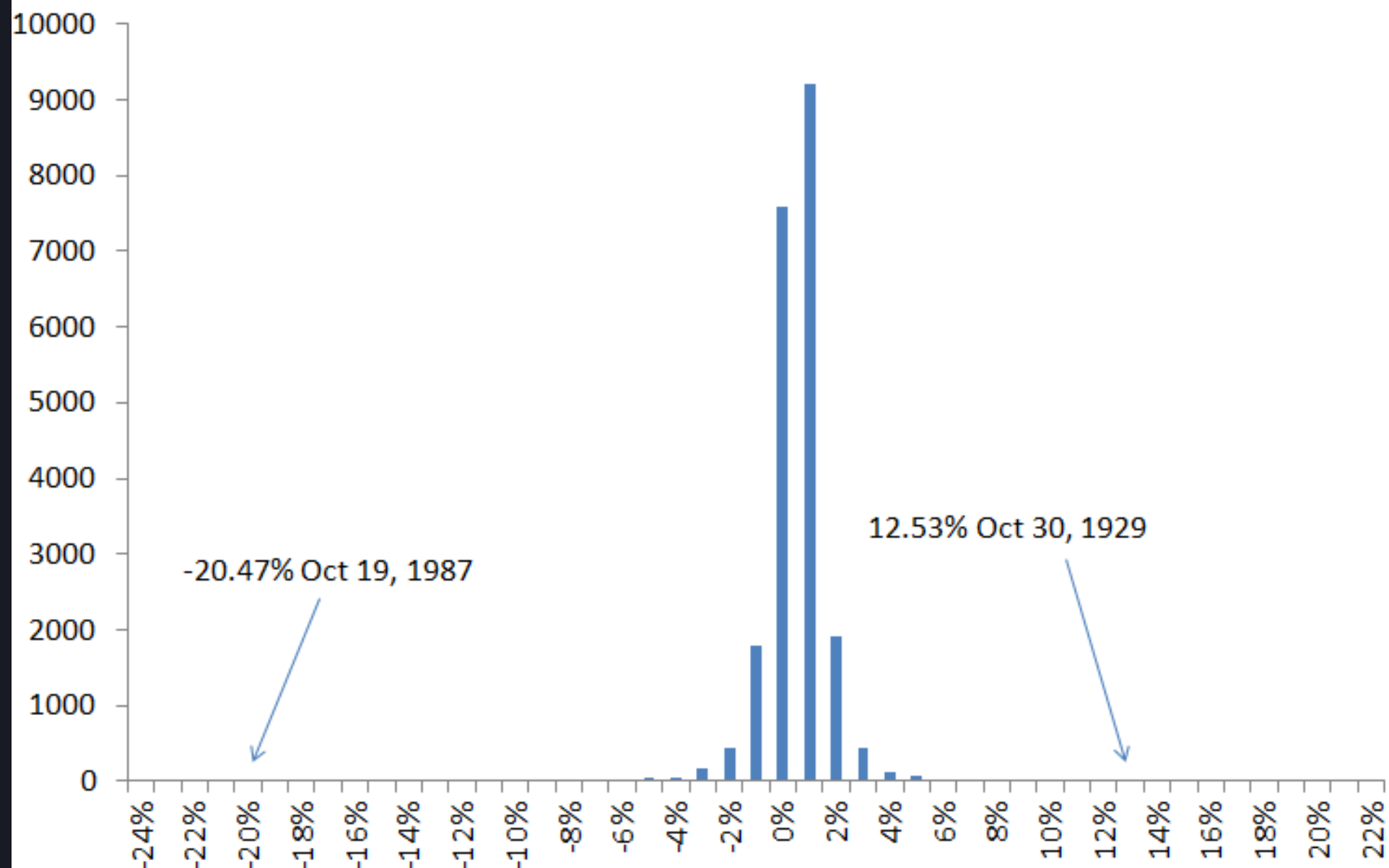
# Central Limit Theorem

- Averages of a large number of independent identically distributed shocks (whose variance is finite) are approximately normally distributed
- Can fail if the underlying shocks are fat tailed
- Can fail if the underlying shocks lose their independence

### Normal Versus Fat Tailed Distributions



### Histogram of Daily Stock Price Changes since 1928



# Outliers

- Normal distribution with same mean and standard deviation as the histogram shown has a probability of a drop greater than 20% equal to  $3 \times 10^{-71}$