Financial Disasters or The Saga of a "Black Swan"

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Overview

- What is a ‘Disaster’?
  - How do we define a ‘Disaster’ in general and a ‘Financial Disaster’ in particular?
  - Are there any parallels to a ‘regular’ Natural Cat?
- Do we have a scientific framework to assess the likelihood of a ‘major’ event?
  - Does the fact that financial events are all man-made make them more or less predictable?
  - Quick introduction to Black-Scholes theory
  - Can this theory be supported by actual data
- Should the recent financial crisis be considered a ‘Black Swan’ event?
  - How unexpected was it?
  - Will we have a different view if we consider ‘individual stock’ investors vs. ‘index’ investor?
  - What are long-term expectations about ‘winners’ and losers’?
- Q & A

What is a ‘Disaster’?

A calamitous event, especially one occurring suddenly and causing great loss of life, damage, or hardship, as a flood, airplane crash, or business failure

Financial Disasters are similar to Natural Disasters in many ways:

Relatively infrequent:

May be 1 in 10 years (at least)

Generates significant damages and effects many people:

$10k-$20k per capita is not uncommon

Sudden (*for the majority of people, anyway*) but expected in a ‘long run’.

Unlike a Natural disaster, there is a possibility for the ‘upside’ and damages, in many cases, are ‘paper losses’.

Just a few reference points:

- DJIA Market Cap is about $4T
- S&P 500 Market Cap is about $14T
- RUSSEL 3000 Market Cap is about $17T

- There are about 10,000 public companies in the 'universe' every year (+/- 10%). About half of them are very small (less than $50m in Market Cap)

- One way to think about 'unusual' events is in terms of the # of Standard Deviations from the Mean.
- Another way is to compare the number of 'big' events in terms of Actual vs. Expected. 'Big' Event – you know when you see it.

Do we have a scientific framework to assess the likelihood of the 'major' event?

Quick Overview of the Black-Scholes Theory:

- US Capital Markets are 'weakly' efficient
- Stock price follows 'Brownian Motion', which has 'no memory' – future movement are independent of the prior path.
- This 'motion' is described by a Wiener Process. Greatly simplified:

$$Y = a + b*X*N(\mu,\sigma).$$

Long story short: Future stock prices are Lognormally distributed. Changes in stock prices are Normally distributed with parameters (μ,σ). *The 'sigma' parameter is called 'volatility'.*

Market has 'No Memory'

Changes in DJIA Index from 'week 1' vs. 'week 2' for any subsequent week

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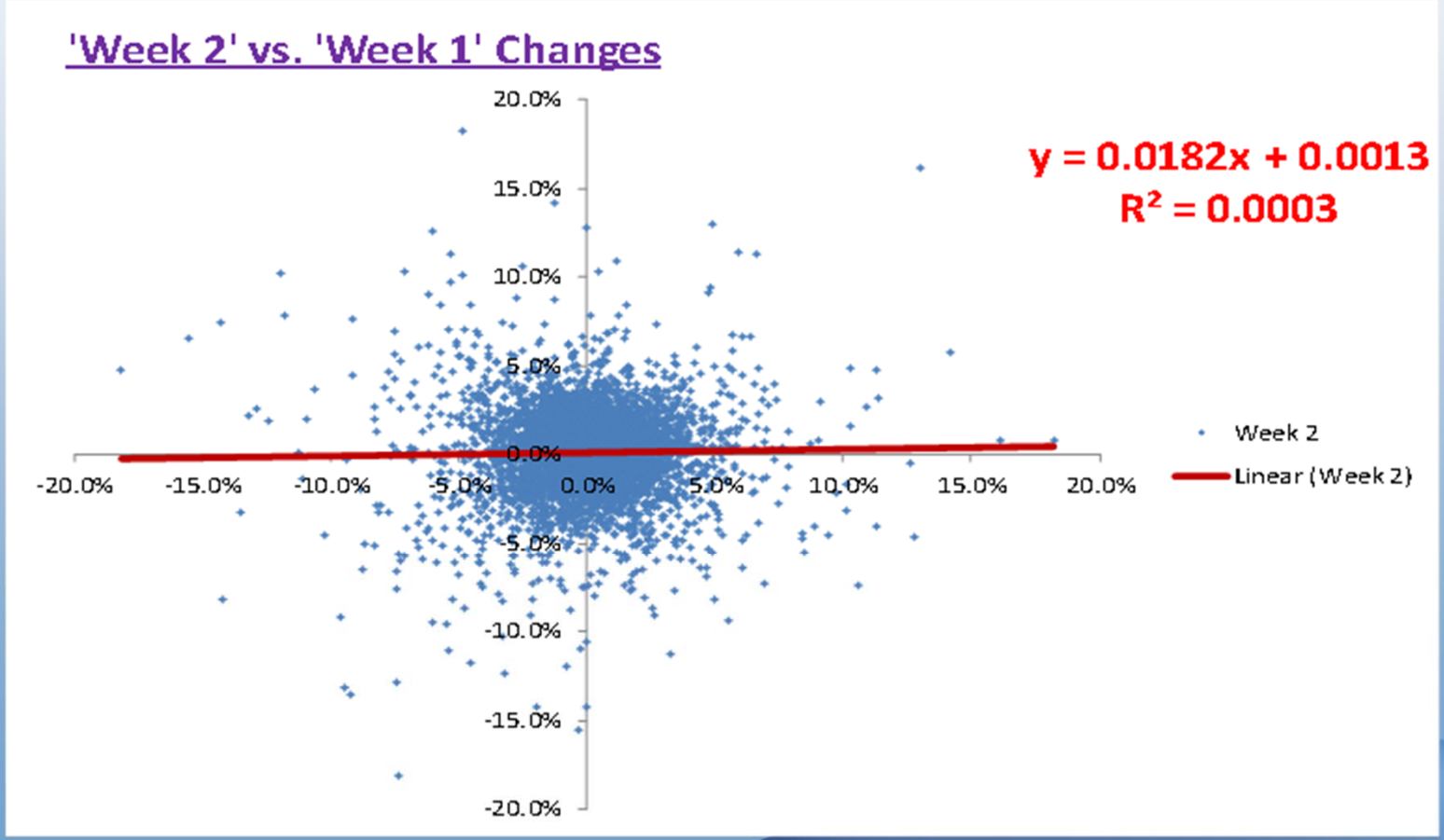
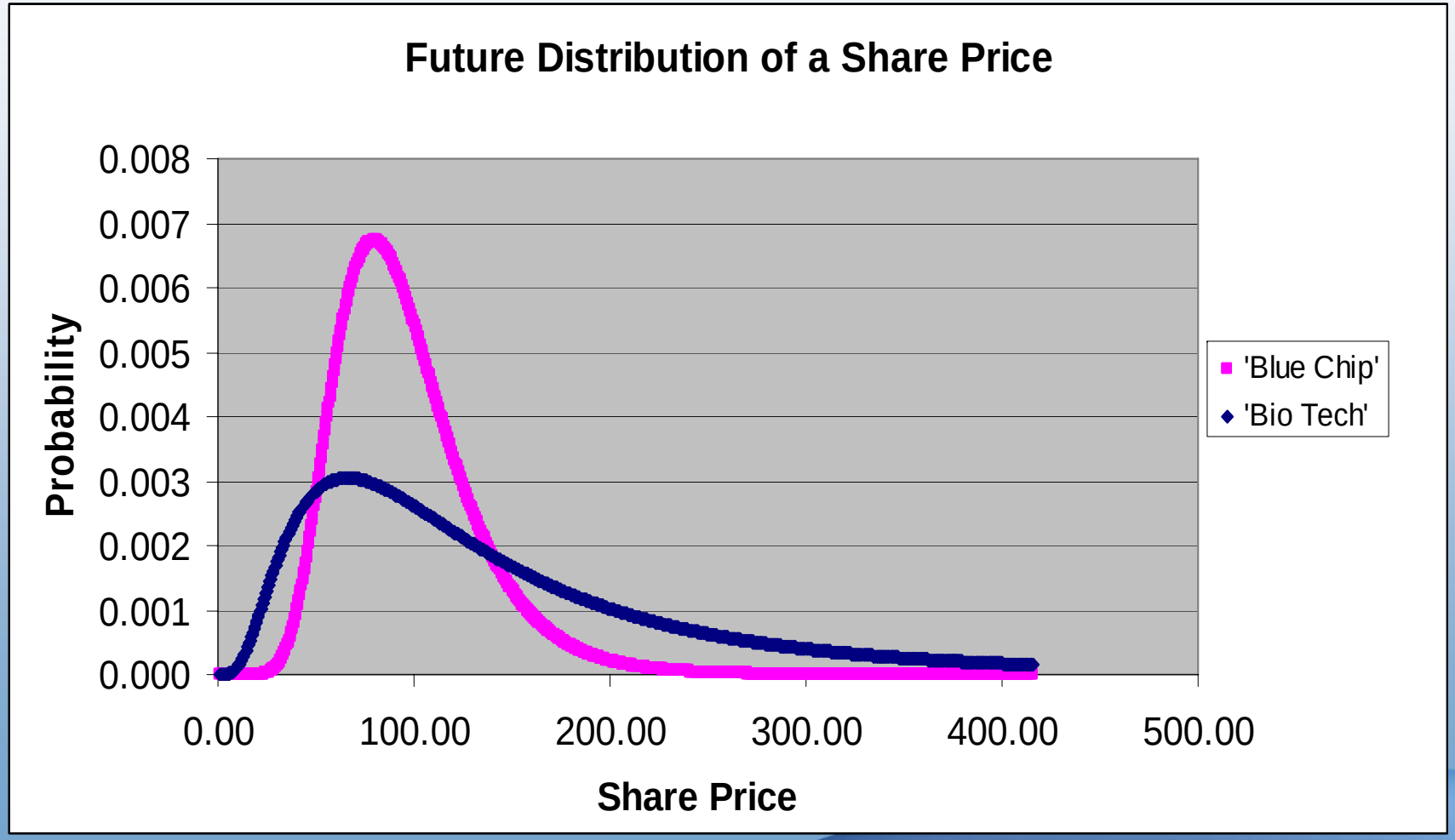
It appears that changes in any two subsequent weeks are completely *uncorrelated*. *We observe the same pattern for any period* (monthly, quarterly or yearly).



According to the Black-Scholes methodology, future share prices are Lognormally distributed. The skewness of this distribution depends on the expected volatility



Example

Estimating DJIA Volatility

We consider DJIA figures for the last 12 years. Based on B-S theory, the last column should follow a Normal Distribution with the mean of 1.3% and Standard Deviation of 15.6%

Date	Index	Change	Ln(Change)
01/06/2012	12,360	1.059	5.7%
01/07/2011	11,675	1.120	11.3%
01/01/2010	10,428	1.154	14.3%
01/02/2009	9,035	0.706	-34.8%
01/04/2008	12,800	1.032	3.2%
01/05/2007	12,398	1.131	12.3%
01/06/2006	10,959	1.034	3.3%
01/07/2005	10,604	1.019	1.8%
01/02/2004	10,410	1.210	19.1%
01/03/2003	8,602	0.838	-17.6%
01/04/2002	10,260	0.962	-3.8%
01/05/2001	10,662		

Mean	1.3%
St. Dev	15.6%

Estimated Annual Return >>>>>>>	2.6%

Estimated Return >>>>>>>	$EXP(\mu+\delta^2/2)-1$

Can we get a representative sample?

- We have fairly accurate market data (DJIA Index) for the last 100 years (give or take). This is not a 'huge' sample.
- We don't evaluate a possibility of 'really' big hurricane or the earthquake based on the last 100 years, do we?
- However, there is a way to increase sample size if we are willing to make a few simplifying assumptions:
  - There is nothing 'special' about January 1st
  - An 'average' investor could have entered the Market at any day in any year and exit a year later – this would constitute an 'annual' return for that particular investor.
  - Correlations could be ignored in a 'long run'. Average correlation between rolling four weeks return is about 2%

If we make these assumptions and consider weekly values => we will have about 5,000 annual observations (from 1915 to Present).

Historical Performance of DJIA

in terms of average returns and volatility (e.g. average of Ln(changes) and St. Dev of Ln(changes)

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Time Period 1915-2012 YTD

Time Period	Ln (of Changes)		Number of Observations	Estimated Annual Return
	Average	St. Dev.		
1915-1924	5.9%	21.3%	521	8.5%
1925-1934	-1.1%	40.6%	521	7.4%
1935-1944	3.4%	19.8%	522	5.5%
1945-1954	9.4%	13.0%	522	10.8%
1955-1964	7.0%	12.4%	522	8.1%
1965-1974	-1.2%	14.5%	521	-0.2%
1975-1984	4.9%	14.6%	522	6.2%
1985-1994	11.9%	13.0%	522	13.6%
1995-2004	8.3%	14.5%	522	9.8%
2005-2012	2.4%	19.7%	347	4.5%
Total	**5.2%**	**20.4%**	**5,042**	**7.5%**
Total 1915-2004	**5.4%**	**20.5%**	**4,695**	**7.8%**

Historical Performance of DJIA

in terms of average returns and volatility (e.g. average of Ln(changes) and St. Dev of Ln(changes)

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Time Period 1935-2012 YTD

Many changes have taken place after the Market Crash in 1932 (lowest observation of 41 was on 7/8/1932). WWII introduced a lot of distortions as well.

Time Period	Ln (of Changes)		Number of Observations	Estimated Annual Return
	Average	St. Dev.		
1935-1944	3.4%	19.8%	522	5.5%
1945-1954	9.4%	13.0%	522	10.8%
1955-1964	7.0%	12.4%	522	8.1%
1965-1974	-1.2%	14.5%	521	-0.2%
1975-1984	4.9%	14.6%	522	6.2%
1985-1994	11.9%	13.0%	522	13.6%
1995-2004	8.3%	14.5%	522	9.8%
2005-2012	2.4%	19.7%	347	4.5%
Total	**5.9%**	**15.7%**	**4,000**	**7.4%**
Total 1935-2004	**6.2%**	**15.3%**	**3,653**	**7.7%**
Total 1945-2004	**6.7%**	**14.3%**	**3,131**	**8.1%**

Time Period: 1945-2005…

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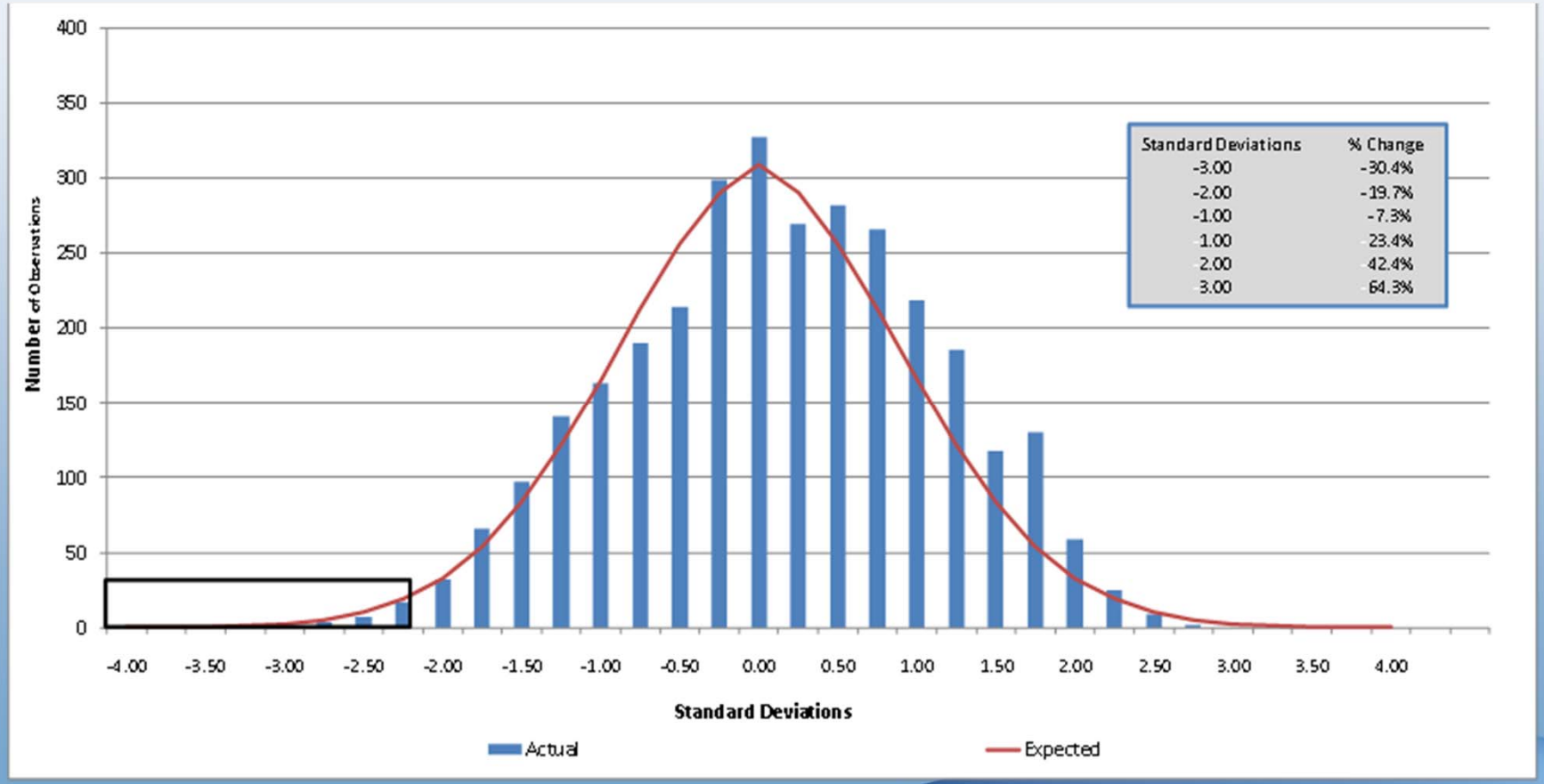
It appears that during this period, the changes in DJIA have in fact followed a Normal Distribution



Time Period: 1945-2005...

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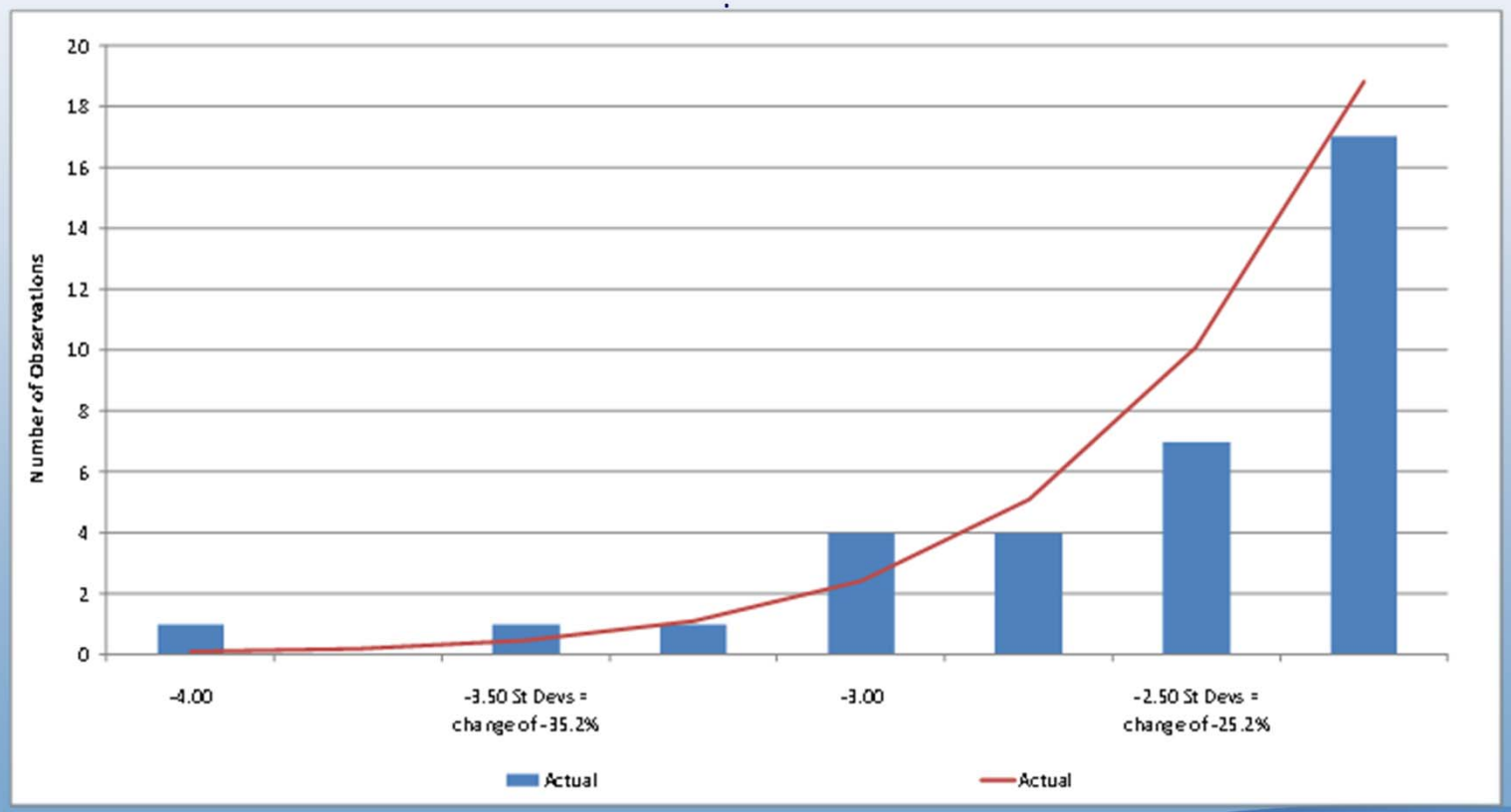
Tail of the distribution appears to fit reasonably well to the historical data



The Time period from 2005 till Present Clearly have introduced additional volatility and have lowered Average Return.

Was it a 'Black Swan' event?

Time Period	Ln (of Changes)		Number of Observations	Estimated Annual Return
	Average	St. Dev.		
1935-1944	3.4%	19.8%	522	5.5%
1945-1954	9.4%	13.0%	522	10.8%
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Total 1945-2004	**6.7%**	**14.3%**	**3,131**	**8.1%**
Total 1945-2012	**6.3%**	**15.0%**	**3,478**	**7.7%**

Time Period: 1945-2012…

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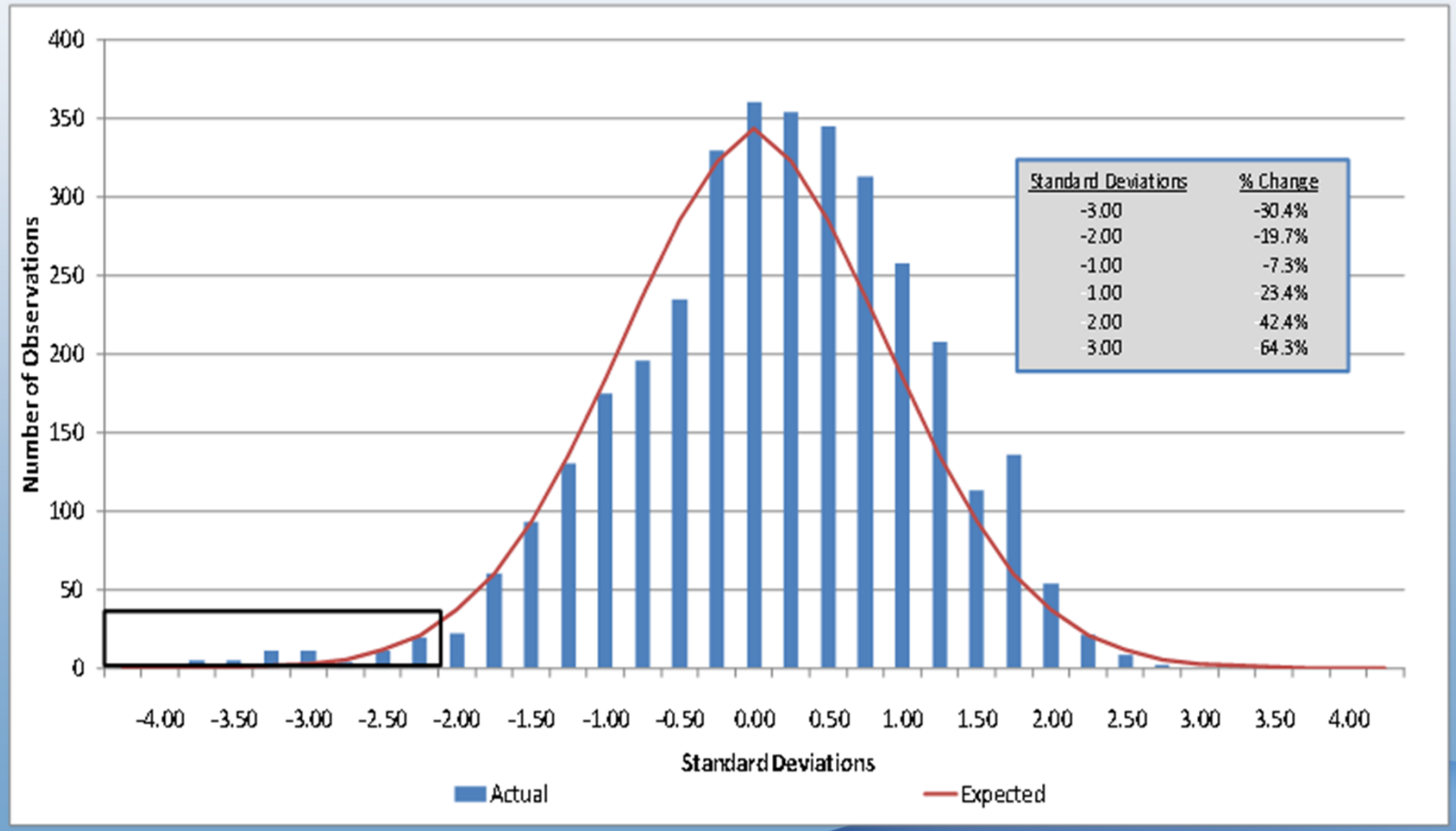
Normal Distribution does not look 'as good'



Time Period: 1945-2012…

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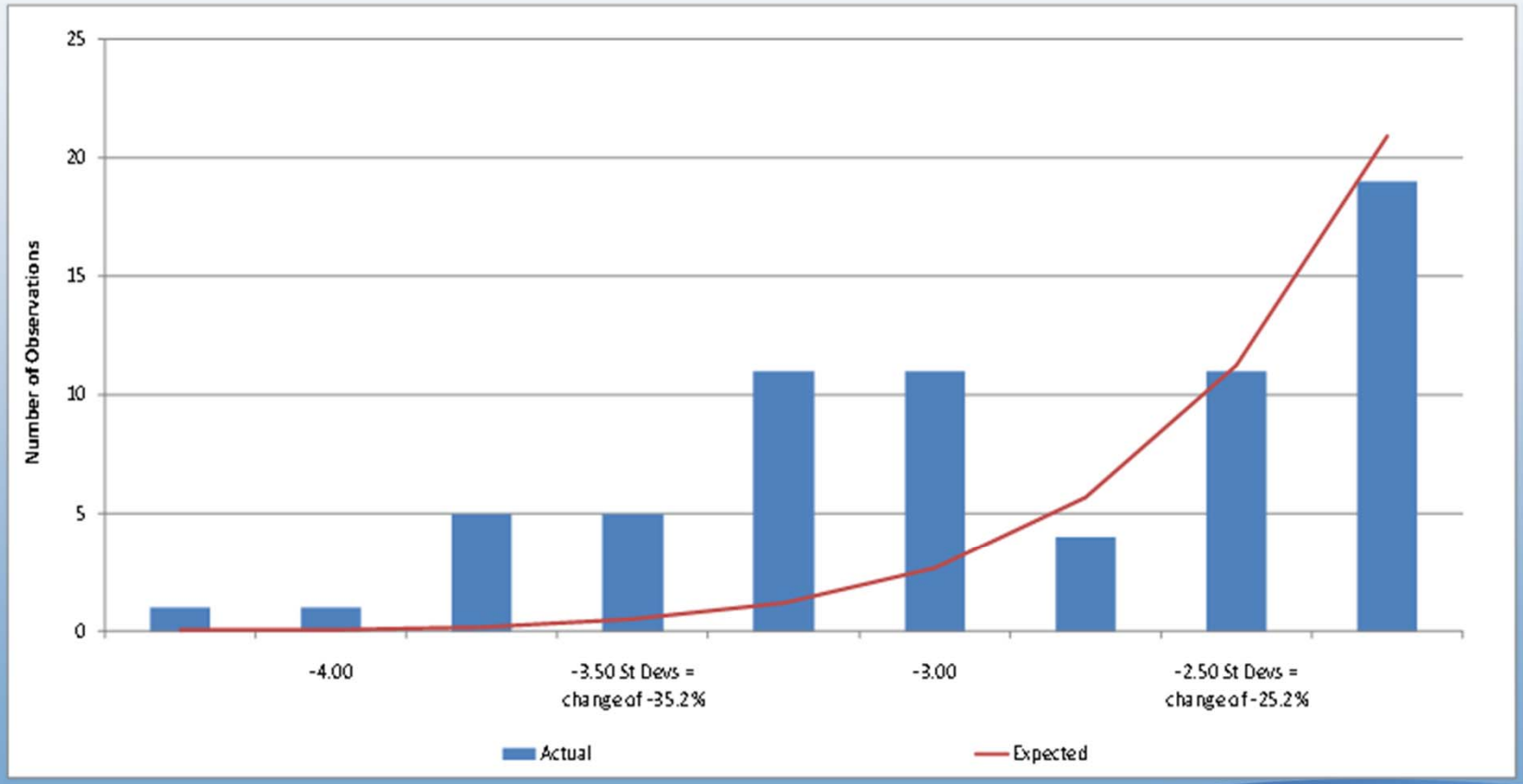
Tail does not fit at all.



However…

If we calculate our expectations based on a longer historical period then our Actual vs. Expected numbers look much more reasonable

Observation of Annual Returns for DJIA: Actual vs. Expected

All Observations		Number of Observations		
Range of Changes in the Index		Actual	Expected based on	
from	to	1945-2012	1945-2005 parameters	1935-2005 parameters
-50%	-25%	60	46	70
-25%	-15%	182	178	214
-15%	-5%	490	493	517
-5%	0%	330	393	384
0%	10%	921	943	890
10%	20%	746	809	762
20%	35%	593	531	536
35%	100%	156	84	104
100%	Up	0	0	0
Total		3,478	3,478	3,478

Even 'Tail' looks more reasonable

Utilizing parameters from the period1935-2004 seems to explain the observed 'tail' relatively well.

Observation of Annual Returns for DJIA: Actual vs. Expected
'Tail' Analysis

Just a Tail

Range of Changes in the Index		Number of Observations		
			Expected based on	
from	to	Actual 1945-2012	1945-2005 parameters	1935-2005 parameters
-50%	-45%	0	0	1
-45%	-40%	5	1	3
-40%	-35%	17	4	8
-35%	-30%	16	12	19
-30%	-25%	22	28	40
Total		60	46	70

VIX Index – Also Known as 'Fear Index'

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VIX is calculated as a function of implied volatilities in stock options

Lets Look at this from a different angle:
Winners vs. Losers

- Let's consider a completely different static: number of issues (stocks) that gained value vs. number of issues that lost value.
- This is a 'view' of an individual investor who has purchased 'A STOCK' – what is the chance that person will make money on his/her investment in any given annual period?
- Usually, all market stats consider weighted average return – out of 10 companies, 9 can 'lose' a little and 1 can 'gain' a lot. So, overall this portfolio will be a 'winner'.
- In the following analysis, we only consider the number of 'winners' and 'losers'. We want to examine the possibility of identifying 'a disaster' as an event of extreme correlation between stock performance – do we have an unexpectedly high number of losers during the financial disaster vs. the more 'regular' period of time.

Data Available:

- S&P Database: weekly stock prices from 1997 to 2012
- All companies which were listed at any point during the above-mentioned period.
- Around 10 million records. Average company will have around 780 weekly observations for 15 years. There are about 10,000 companies listed each year. However, some new companies are 'coming in' every year (IPOs, 'spin offs') and some companies get de-listed (bankruptcy, mergers, go private). There are about 15,000 different 'names' (ticker symbols) in our database.

Calculations:

- We calculated year over year changes starting in September of 1998.
- Percent of 'Winners' is calculated based on all companies which have gained in value vs. all companies in the database.
  - For Example: we counted how many 'stocks' have increased in value from 6/13/1997 to 6/19/1998. We record a percent of winners as of 6/19/1998. Then we 'shifted' one week forward and so on.
- We also have calculated the percent of companies which have gained over 5% - long term average return (give or take) vs. all companies in the database.
- We separated all companies in three groups based on their market Cap (roughly):
  - Large Companies – excess of $500m (on average)
  - Small Companies – less than $50m (on average)
  - Medium Companies – everything in between

Percent of Winners

Most of the stocks lose value in any given year (55%)
Only 41% of stocks gain more than 5% in any given year
Percentage of 'winners' is size-dependent – larger companies are more likely to gain value in any given year.

Percentage of Winners - Summary Statistics by Company Size

(Period 1997-2012 - 720 Observations)

	'Straight Up' Winners			
	Large	Medium	Small	Total
Average	56%	46%	36%	45%
St. Dev.	22%	18%	12%	16%
CV	38%	38%	34%	35%
Max*	97%	91%	67%	82%
Min**	4%	5%	7%	6%
#2-δ Events^	38	29	25	37

	'Over 5%' Winners			
	Large	Medium	Small	Total
Average	51%	41%	33%	41%
St. Dev.	21%	18%	12%	15%
CV	42%	42%	36%	38%
Max*	96%	89%	65%	80%
Min**	3%	4%	7%	5%
#2-δ Events^	36	13	15	33

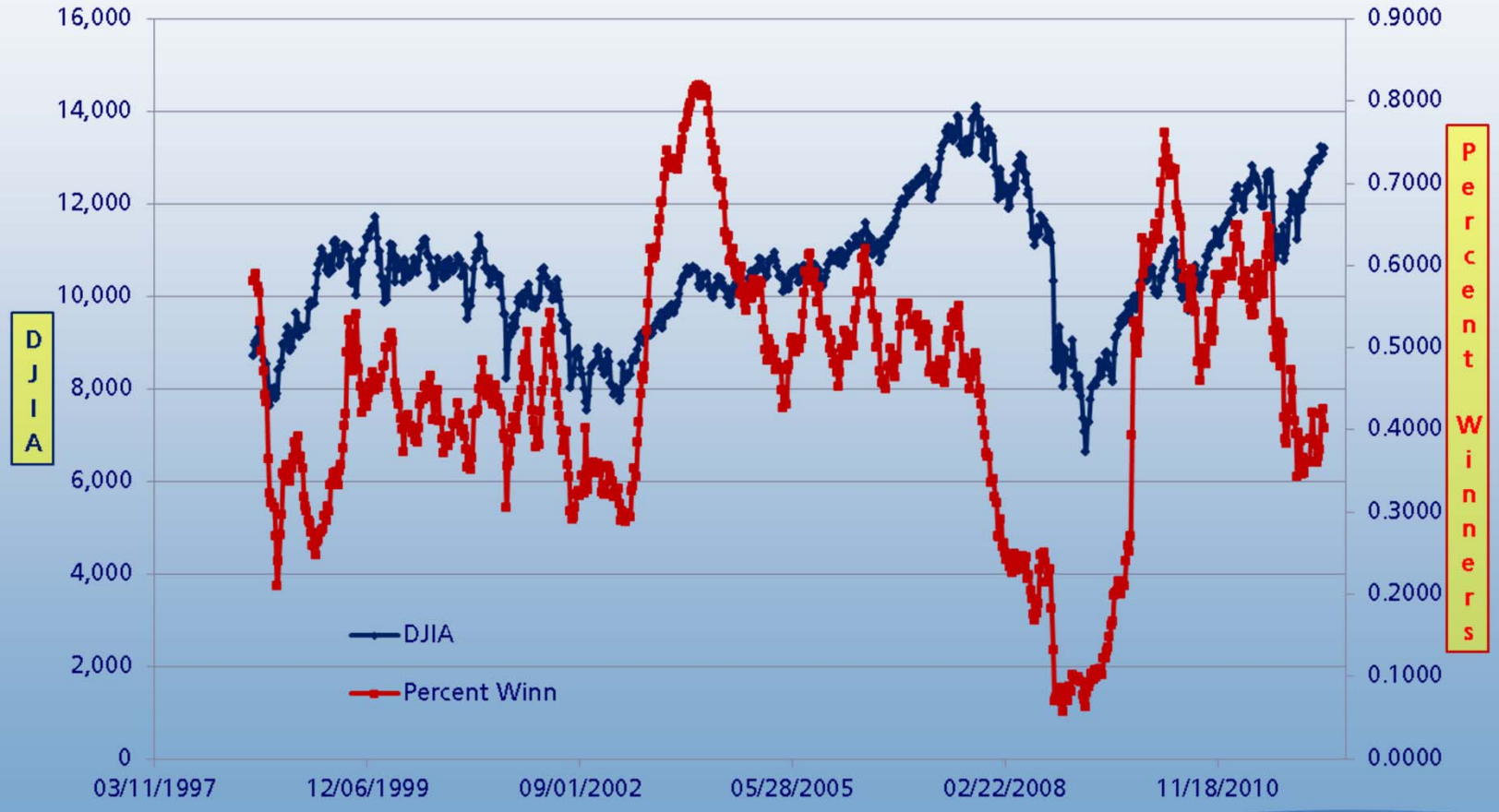
* Around March 2004

** Around March 2009

^ "To the Left"

How Percent of Winner is Correlated with DJIA?

Not very correlated – R^2 is only about 9%



Percent of 'Winners' during the 1997-2012 period

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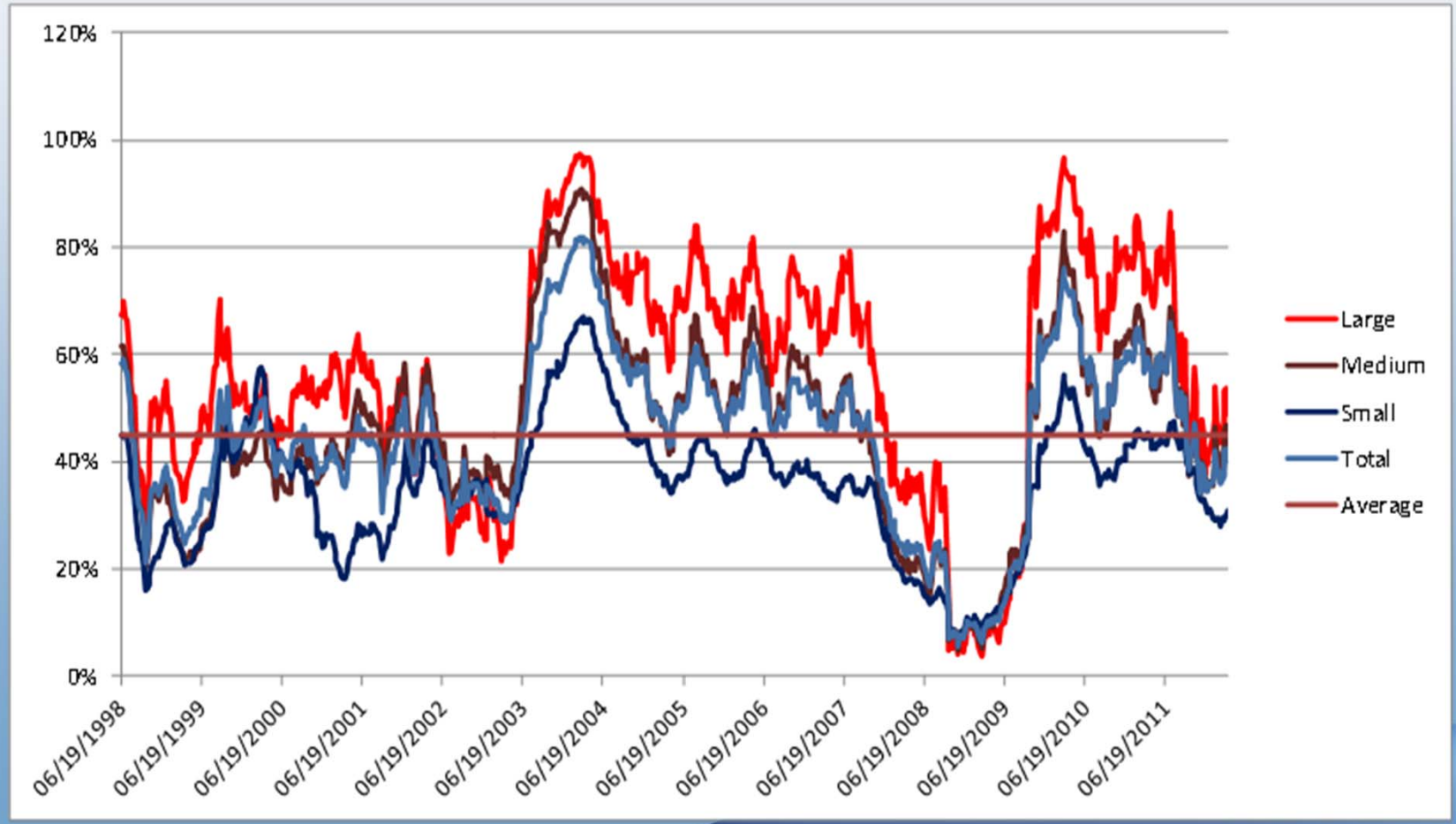
The percent of 'winners' appears to be fairly random.



Percent of 'Winners' during the 1997-2012 period

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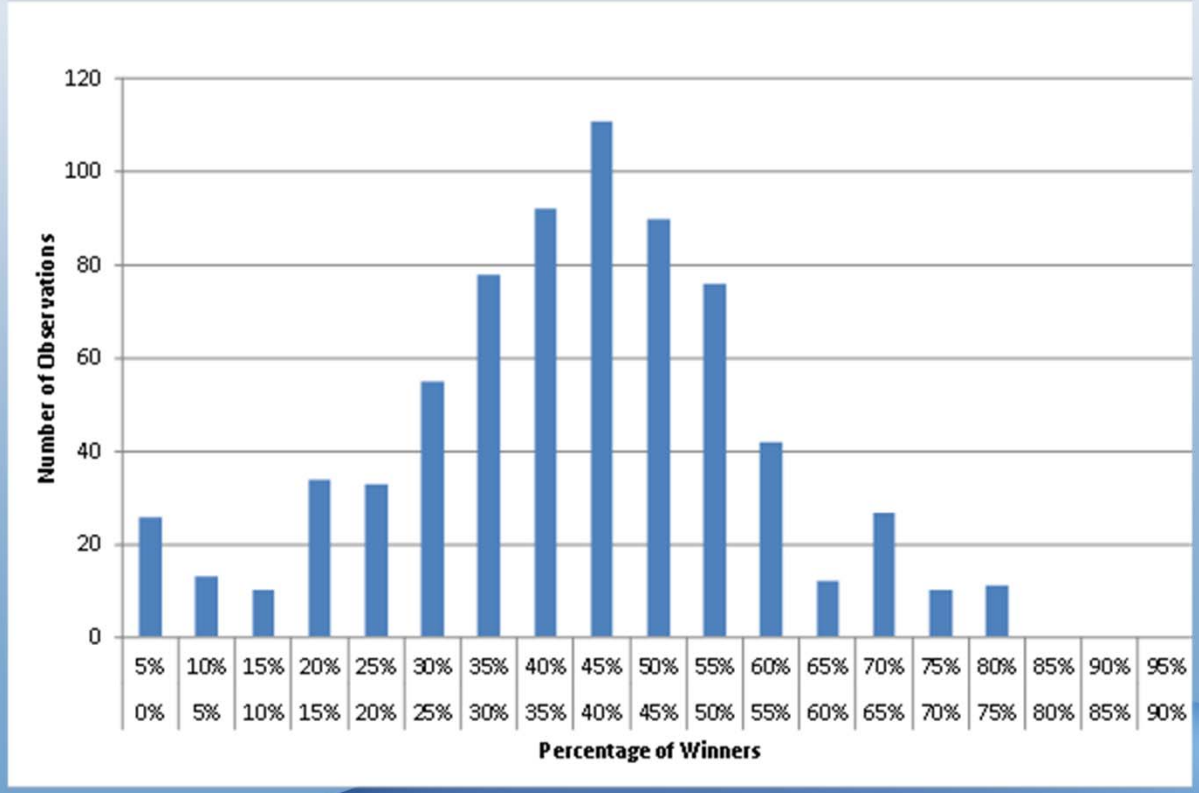
There were 720 observations – year over year changes for 780 weeks. Frequency diagram is presented below.

Example: There were 13 observation (annual periods) in which only 10%-15% of US stocks has gained value

Total Nuber of Observations: 720

Percentage Of Winners Range: from-to		Number of Observations
0%	5%	
5%	10%	26
10%	15%	13
15%	20%	10
20%	25%	34
25%	30%	33
30%	35%	55
35%	40%	78
40%	45%	92
45%	50%	111
50%	55%	90
55%	60%	76
60%	65%	42
65%	70%	12
70%	75%	27
75%	80%	10
80%	85%	11
85%	90%	
90%	95%	
95%	100%	



Percent of 'Winners' - Normalized

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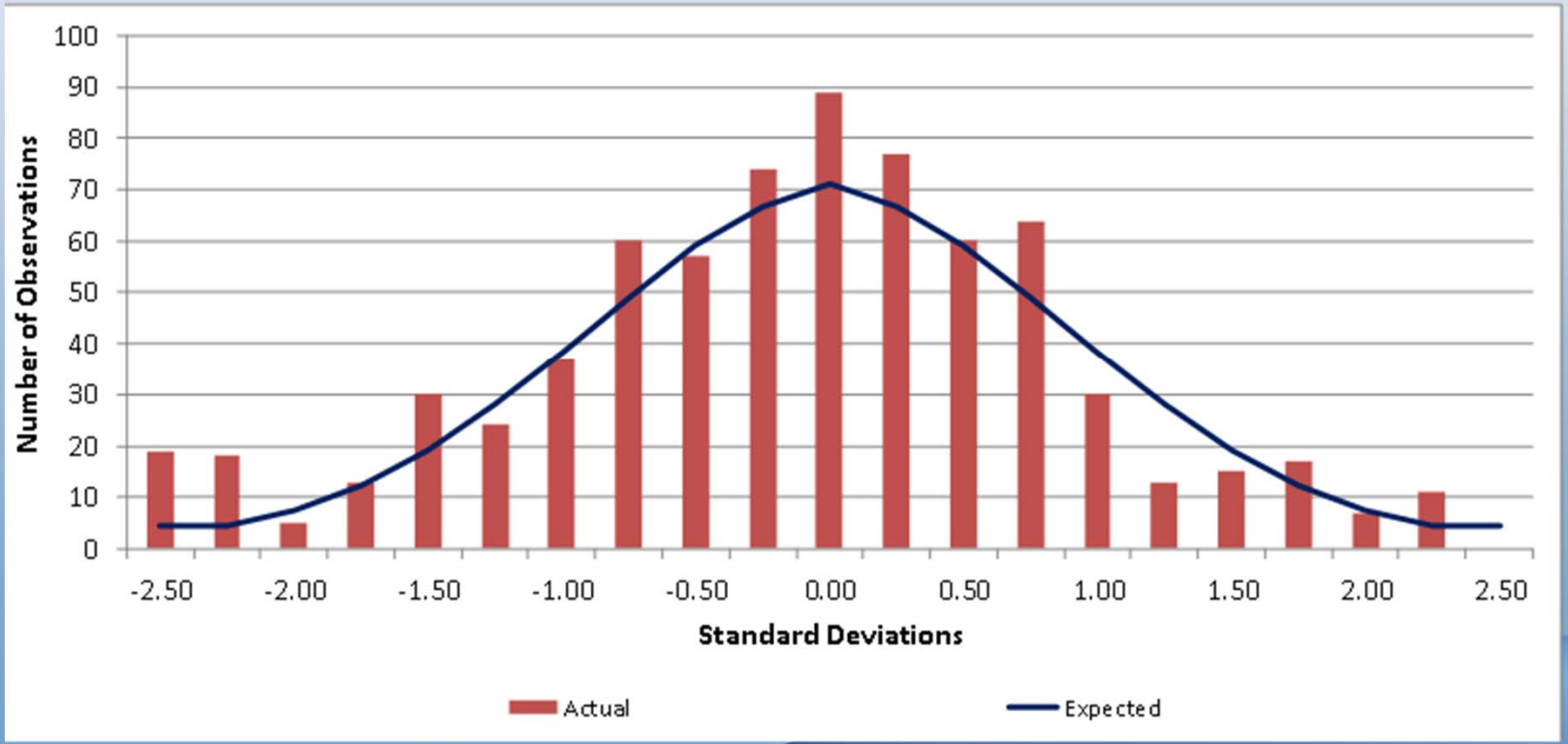
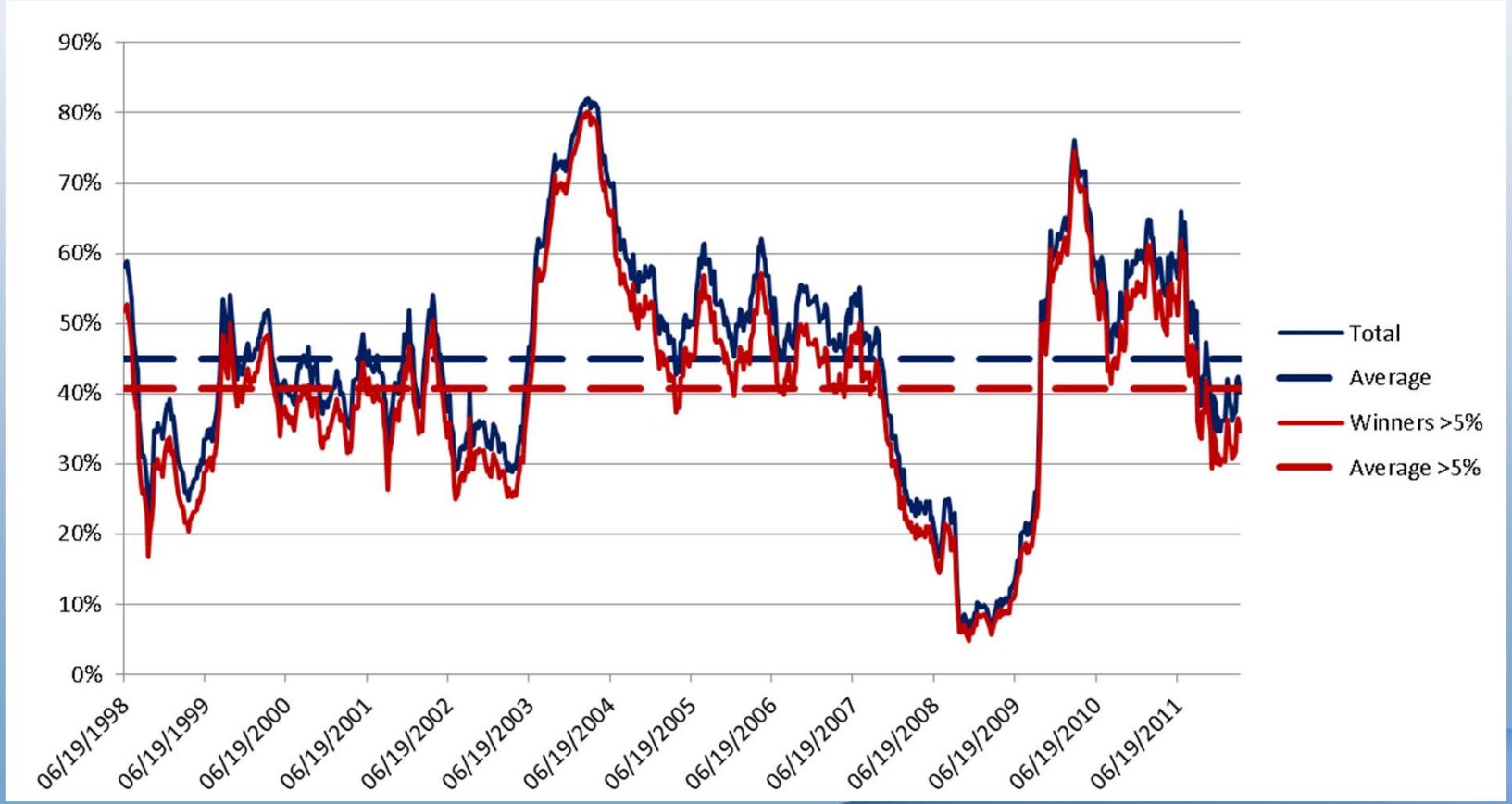
Normalized Percentage of 'Winners' (overall numbers)

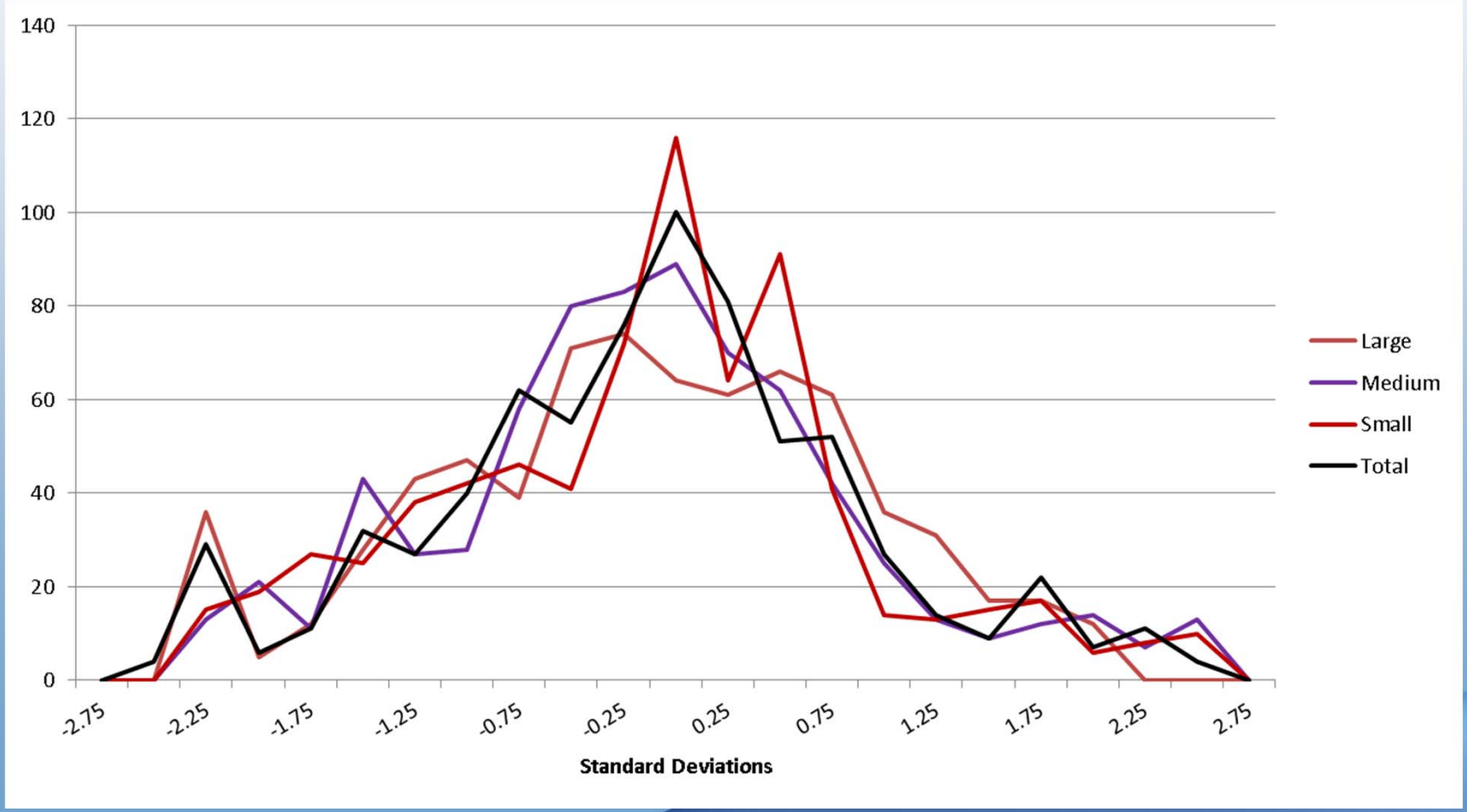
Average	45%
St. Dev.	16%
Number of Observations	720



Percent of Winners 'Straight Up' vs. '5% Winners'



Normalized Percent of Winners: Large vs. Medium vs. Small



‘Percent of Winners’ - Summary

- Very different statistics, almost uncorrelated with ‘Dollar Market Return’.
- Overall results, however, are fairly similar to a more ‘traditional’ analysis – the events at the end of 2008 and early 2009 were very unusual, but not totally unexpected
- We have only 15 years of data – if we study ‘rare’ events (less than 1 in 10 years), this time period is not sufficient to reach conclusions.
- In my opinion, the actual observations were ‘off’, but not ‘off enough’ to be considered a ‘Black Swan’.

Final Thoughts / Conclusions:

- Financial Theory is in its infancy:
  - Similar to 'Pre-Newton' physics
  - Multiple conflicting opinions by many world-renown economists
  - Mathematics of 'Utility Substitution' is not developed
- Major financial events appear to be fairly random:
  - Although the actions of individual participants are not random, the outcome of the entire process seems to be random. Similar to the number of car accidents.
  - Recent financial disasters were, in fact, very unusual events, but not outside of 'realm of possibility'
  - 'Utility Substitution' (e.g. monetary systems) is likely to continue to generate financial shocks. Financial 'bubbles' have a very long history (tulips any one?).
- Normal Distribution vs. Levy Process vs. Multiple Universes.
  - A lot of work ahead
  - Politics and Legal environment are the 'wild cards'.

It is possible that movement in Asset Pricing is governed by two (three, many…) distributions – one for every day 'regular' movements and one for rare shock losses. This is not that dissimilar to 'regular' property damage vs. hurricane damage.

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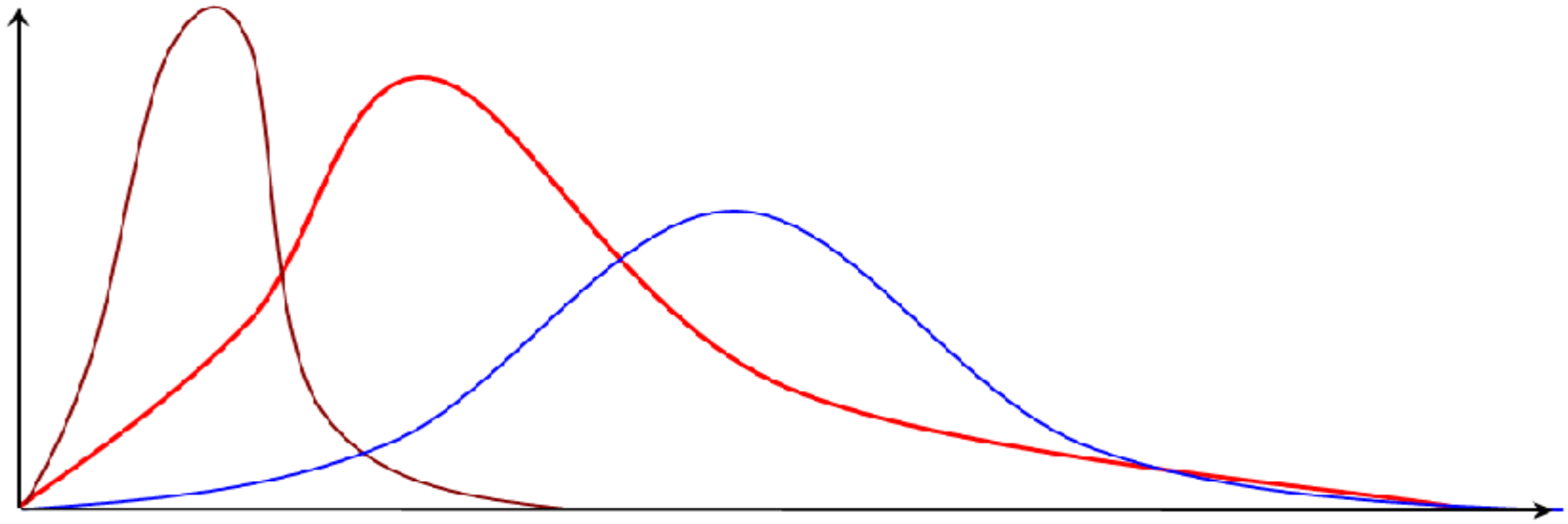
Losses may give an appearance of a single distribution, but it may be a combination of several distinct distributions.



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