What is risk?

- Uncertainty: Not knowing the future
- Unpredictability?
- Most important and problematic concept in finance

Finance concepts discussed

- Ex-post and ex-ante returns
- Holding-period returns
- Treasury bond returns
- Return statistics—mean, variance, and standard deviation

Excel functions used

- **AVERAGE**
- **SQRT**
- **VAR.P**
- **STDEV.P**
- **FREQUENCY**
- **COUNT**

Before we start: Do you know what the following financial assets are?

- A Treasury bill
- A money market fund
- A bank CD
- A bond
- A stock

Three risk characteristics of financial assets

- Horizon: How long does it take to get your money back?
- Safety: Is there a guarantee?
- Liquidity: Can you sell the asset or are you stuck with it?

Horizons can be long, short infinite, zero

- Zero horizon: A checking account; money market account
- Short horizon: A one-year certificate of deposit
- Long horizon: A ten-year bond
- Infinite horizon (almost): A stock
  - McDonalds will be around for a long time

Horizon risk

DISCOVER BANK

CD Rates & Calculator

As of: April 28, 2009

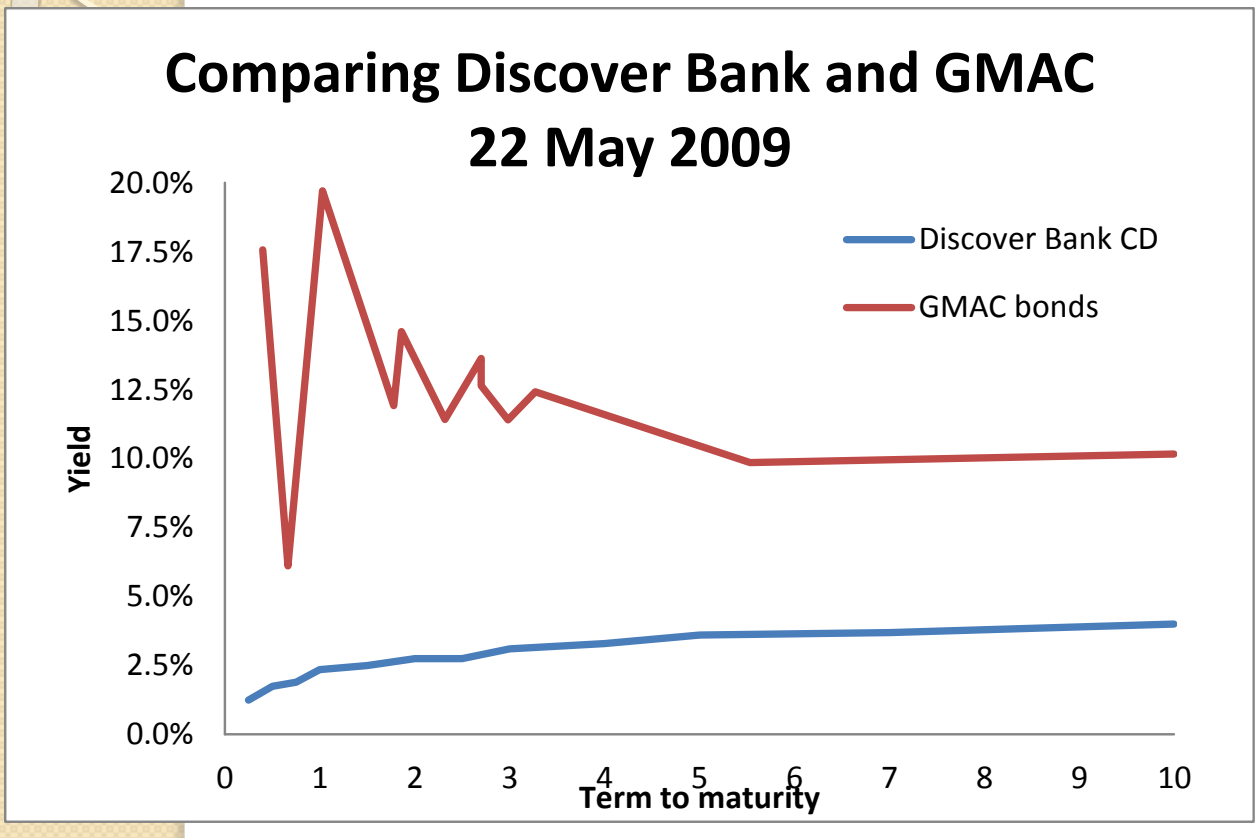
Term	Interest Rate	APY[4]
3 months	1.25%	1.25%
6 months	1.74%	1.75%
9 months	1.89%	1.90%
1 year	**2.33%**	**2.35%**
1½ years	2.47%	2.50%
2 years	2.72%	2.75%
2½ years	2.72%	2.75%
3 years	3.06%	3.10%
4 years	3.25%	3.30%
5 years	3.54%	3.60%
7 years	3.64%	3.70%
10 years	3.93%	4.00%

The Discover Bank CD is guaranteed by the U.S. government. But *horizon risk* makes the interest rate paid higher for longer maturities.

Safety

- A U.S. Treasury bill: The government will always keep its promise
- A bank certificate of deposit (CD): Only in the most unusual circumstances will bank back out of its promise. And … guaranteed by government up to $100,000

Discover Bank vs GMAC May 22, 2009



GMAC is a bank associate with General Motors. In May 2009 it is perceived to be riskier than Discover Bank …

Look at the yields!

Liquidity: Sometimes its hard to sell an asset

- Very liquid: Treasury bill, McDonalds stock
- Less liquid: A Discover Bank CD
  - Maybe only Discover will buy it back before maturity
  - Maybe it has to be held until maturity
- Much less liquid: Your time-share apartment in Boca Raton

A safe asset can be risky!

- We will give an example of Treasury Bill
- Riskless if held to maturity
- When risky? Maybe you don't hold bill to maturity.

Treasury bill example

- Buy bill 1 June 2008 for $977.04
- Horizon: Pays you back $1,000 in one year
- Safety: Payment guaranteed by U.S. government
- Liquidity: Highly liquid

Learn some Latin!

- **Ex-ante**: In the financial world, the *ex-ante return* is the expected return of an investment portfolio (Wikipedia)
- **Ex-post**: A measure of past performance (Wikipedia)

One year yield on T-bill

	A	B	C
1	**INTEREST ON THE TREASURY BILL**		
2	Purchase price	977.04	
3	Payoff on maturity	1,000.00	<-- This is the Treasury bill's face value
4	Interest	2.35%	<-- =B3/B2-1

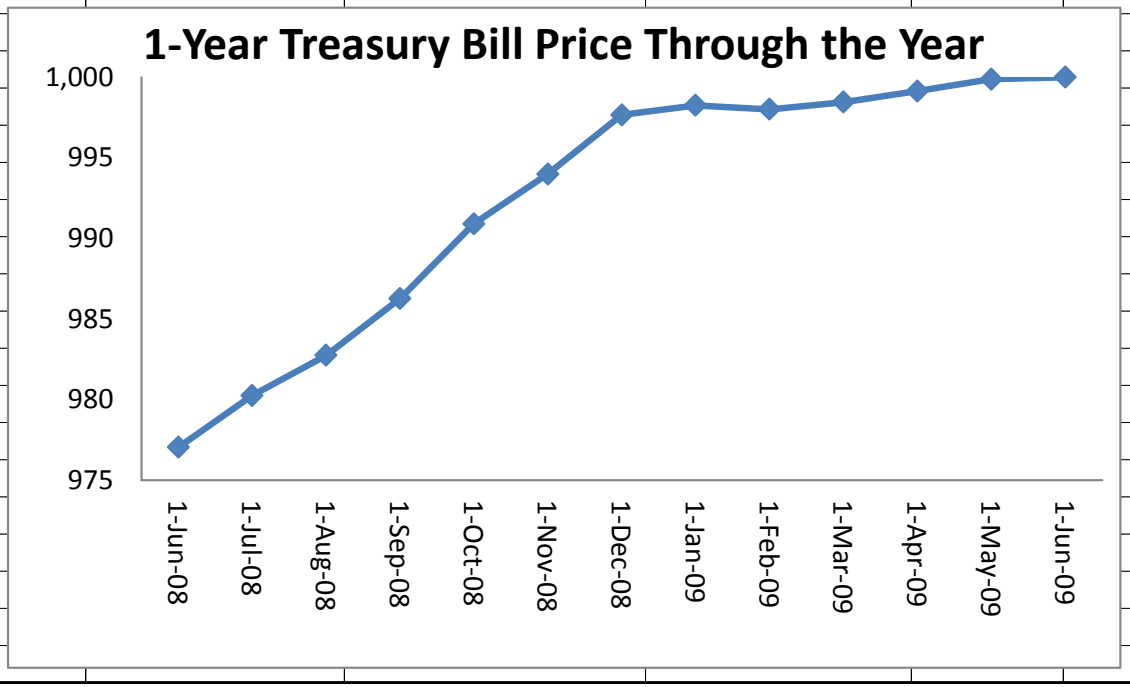
If you hold the Bill for one year, you will absolutely get the 2.35% yield. It is totally safe!

This 2.35% yield is both ex-ante and ex-post:

- Ex-ante: It is the predicted yield for holding the T-bill when you buy it
- Ex-post: It is the yield you will get after one year if you hold the T-bill to maturity

Track T-bill prices throughout the year

	A	B	C	D	E	F	G	H
1	THE PRICE OF THE TREASURY BILL THROUGHOUT THE YEAR							
2	**Date**	**Bill price**						
3	1-Jun-08	977.04						
4	1-Jul-08	980.25						
5	1-Aug-08	982.75						
6	1-Sep-08	986.27						
7	1-Oct-08	990.90						
8	1-Nov-08	993.98						
9	1-Dec-08	997.66						
10	1-Jan-09	998.26						
11	1-Feb-09	998.01						
12	1-Mar-09	998.46						
13	1-Apr-09	999.14						
14	1-May-09	999.88						
15	1-Jun-09	1,000.00						
16								
17								
18								
19								
20								



Suppose you sell T-Bill in September 2008

$$1 + \textit{ex-post monthly rate of return} = \left(\frac{\textit{Price on 1 September 2008}}{\textit{Initial price on 1 June 2008}} \right)^{1/3}$$

$$= \left(\frac{986.27}{977.04} \right)^{1/3} = 1.0031$$

The exponent of 1/3 is there because of the 3-month interval between June and September. If we raise this to the 12th power, we will get an annual rate of return of 3.83%.

	A	B	C
1	**ANNUALIZED EX-POST RETURN, June-September**		
2	Bought 1 June 2009	977.04	
3	Sold 1 September 2009	986.27	
4	Monthly return	0.31%	<-- =(B3/B2)^(1/3)-1
5	Annualized return	3.83%	<-- =(1+B4)^12-1

3.83% is the ex-post return: The actual return realized upon the sale of the asset.

If you had sold one month earlier?

If, instead, you had sold the Treasury bill on August 1, 1 month earlier, you would have made 3.56% in annual terms.

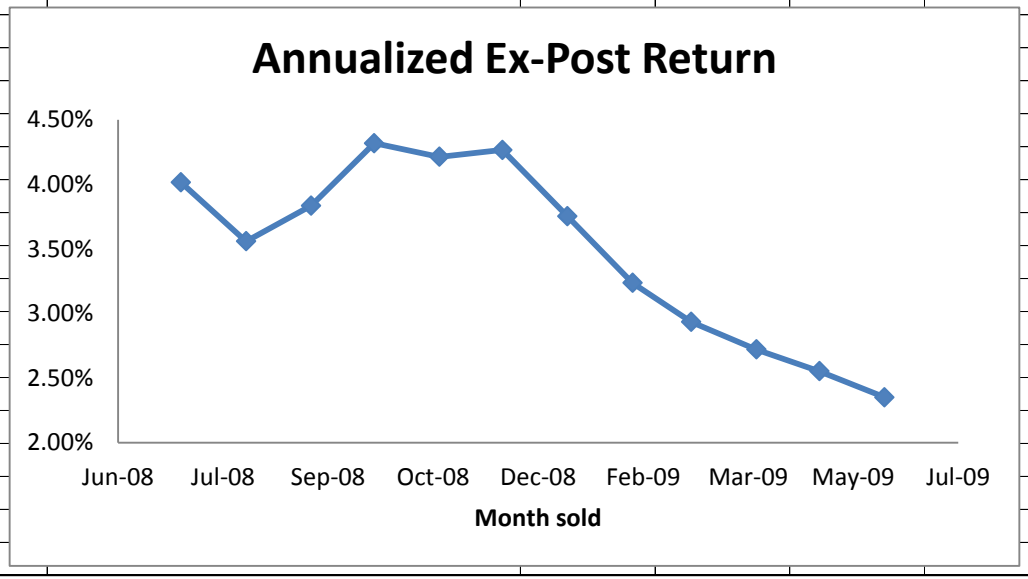
	A	B	C
1	**ANNUALIZED EX-POST RETURN, June-August**		
2	Bought 1 June 2009	977.04	
3	Sold 1 August 2009	982.75	
4	Monthly return	0.29%	<-- =(B3/B2)^(1/2)-1
5	Annualized return	3.56%	<-- =(1+B4)^12-1

You'd bought the T-bill on 1 June 2009 for $977.04

- If you sold it 1 August: 3.56%
- If you sold it 1 September: 3.83%

- Message: The ex-post return depends on
  - Market conditions
  - Holding period

	A	B	C	D	E	F	G	H
1	**EX-POST ANNUALIZED RETURN, MONTH BY MONTH**							
2	**Date**	**Bill price**	**Annualized return if sold at beginning of month**					
3	Jun-08	977.04						
4	Jul-08	980.25	4.01%	<-- =(B4/$B$3)^(12/COUNT($A$4:A4))-1				
5	Aug-08	982.75	3.56%	<-- =(B5/$B$3)^(12/COUNT($A$4:A5))-1				
6	Sep-08	986.27	3.83%	<-- =(B6/$B$3)^(12/COUNT($A$4:A6))-1				
7	Oct-08	990.90	4.32%					
8	Nov-08	993.98	4.21%					
9	Dec-08	997.66	4.27%					
10	Jan-09	998.26	3.75%					
11	Feb-09	998.01	3.24%					
12	Mar-09	998.46	2.93%					
13	Apr-09	999.14	2.72%					
14	May-09	999.88	2.55%					
15	Jun-09	1,000.00	2.35%					
16								
17								
18								
19								
20								
21								
22								
23								
24								



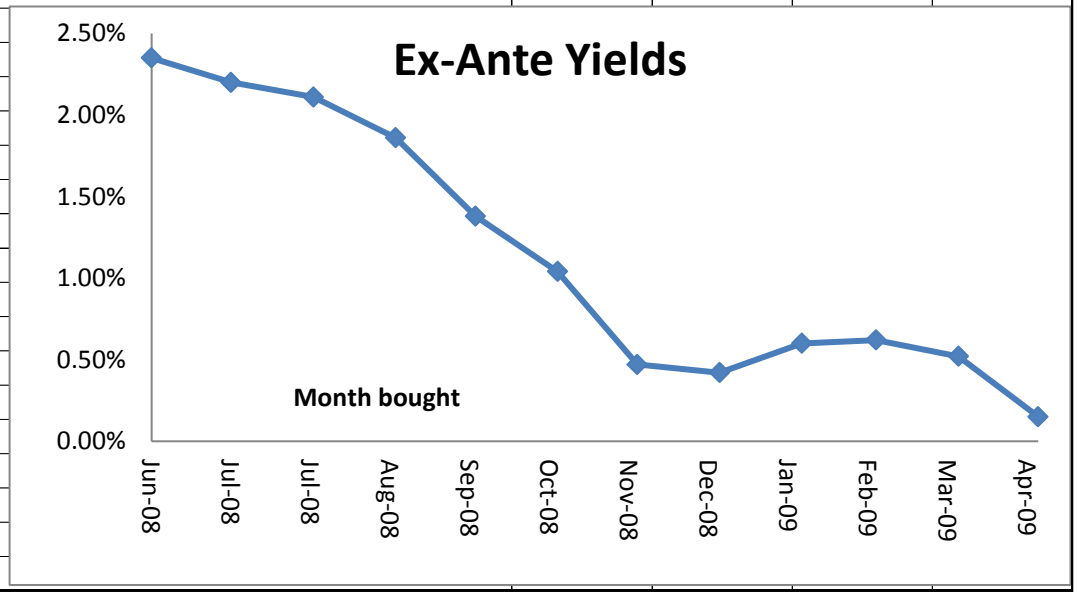
The ex-ante yield on the T-bill throughout the year

	A	B	C
27	**Computing the ex-ante yield**		
28	Month the T-bill is bought	1-Sep	
29	Price	986.27	
30	**Yield to maturity**		
31	Per month	1.0015	<-- =(1000/B29)^(1/9)
32	Annualized	1.86%	<-- =B31^12-1

If you bought the T-bill in September and plan to hold it until maturity, you will get 1.86% annualized. This is the ex-ante (expected) yield.

Good exam problem: You buy the T-bill in September and sell it in December. What's your annualized ex-post annualized yield?

	A	B	C	D	E	F	G	H
1	**EX-ANTE ANNUALIZED RETURN, MONTH BY MONTH**							
2	**Date**	**Bill price**	**Annualized ex-ante return if bought at beginning of month**					
3	Jun-08	977.04	2.35%	<-- =($B$15/B3)^(12/COUNT(A4:$A$15))-1				
4	Jul-08	980.25	2.20%	<-- =($B$15/B4)^(12/COUNT(A5:$A$15))-1				
5	Aug-08	982.75	2.11%	<-- =($B$15/B5)^(12/COUNT(A6:$A$15))-1				
6	Sep-08	986.27	1.86%	<-- =($B$15/B6)^(12/COUNT(A7:$A$15))-1				
7	Oct-08	990.90	1.38%					
8	Nov-08	993.98	1.04%					
9	Dec-08	997.66	0.47%					
10	Jan-09	998.26	0.42%					
11	Feb-09	998.01	0.60%					
12	Mar-09	998.46	0.62%					
13	Apr-09	999.14	0.52%					
14	May-09	999.88	0.15%					
15	Jun-09	1,000.00						
16								
17								
18								
19								
20								
21								
22								
23								
24								



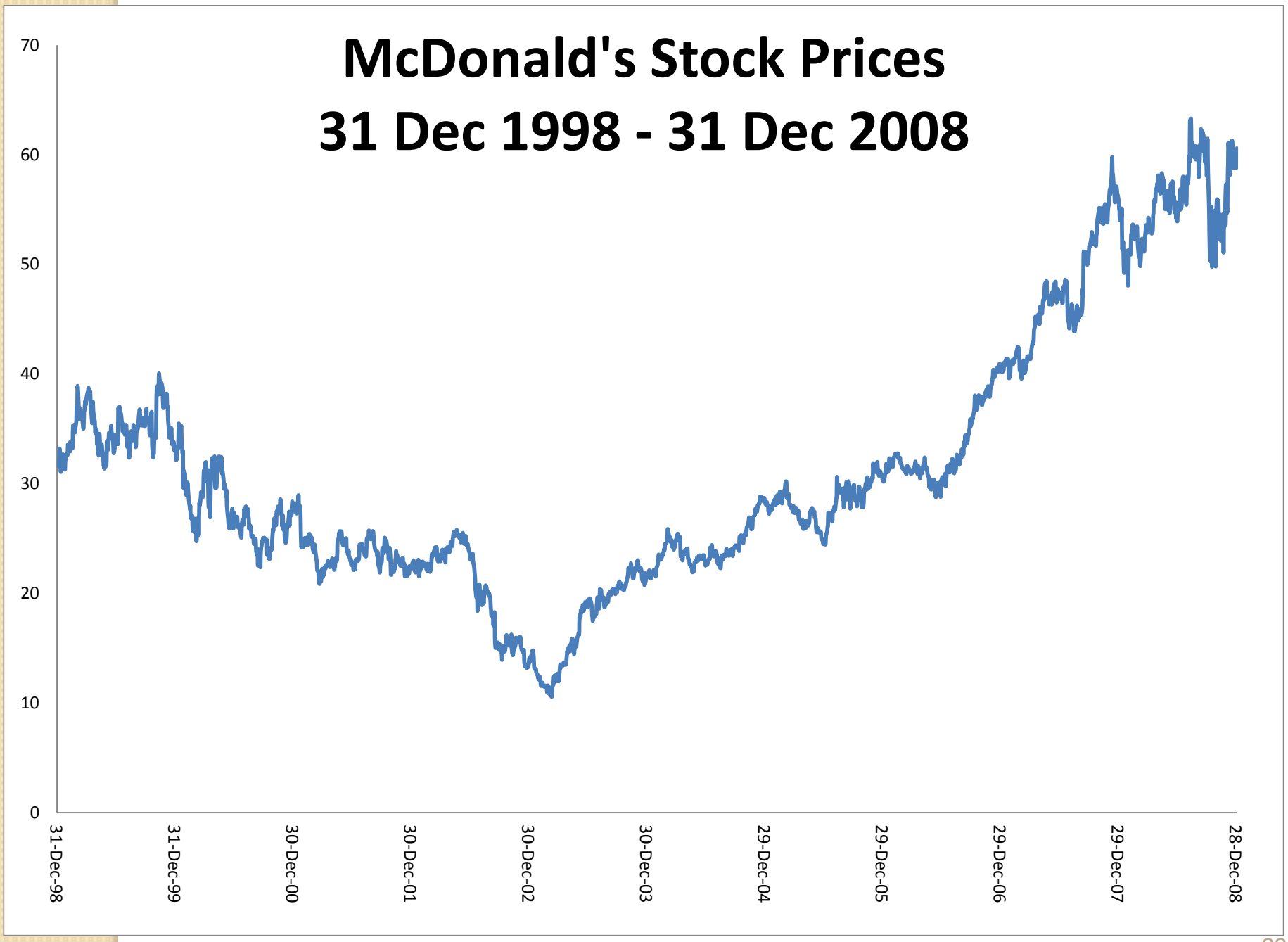
Message: Changing T-bill price over the year causes change (risk) in ex-ante yields.

T-bill example—the message

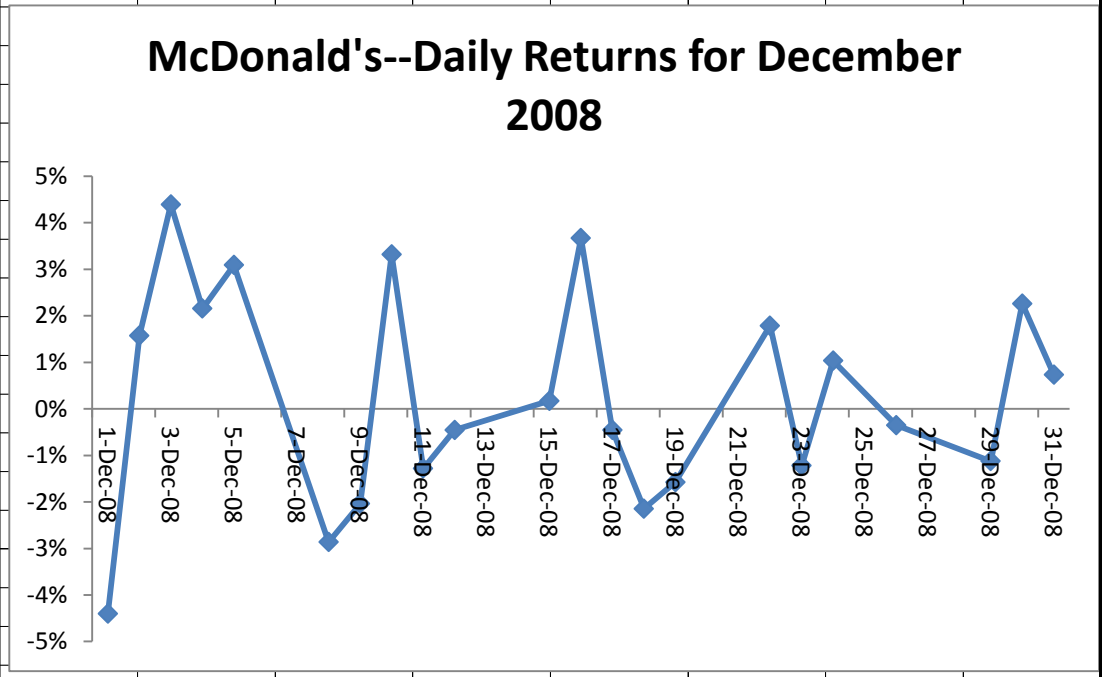
- A safe asset with no uncertainty as to payments (like a T-bill) can be risky because of horizon effects.
- If you want to sell the asset before maturity, market conditions may make the ex-post return risky.
- If you buy the T-bill during the year the ex-ante yield changes.

Stock price risk

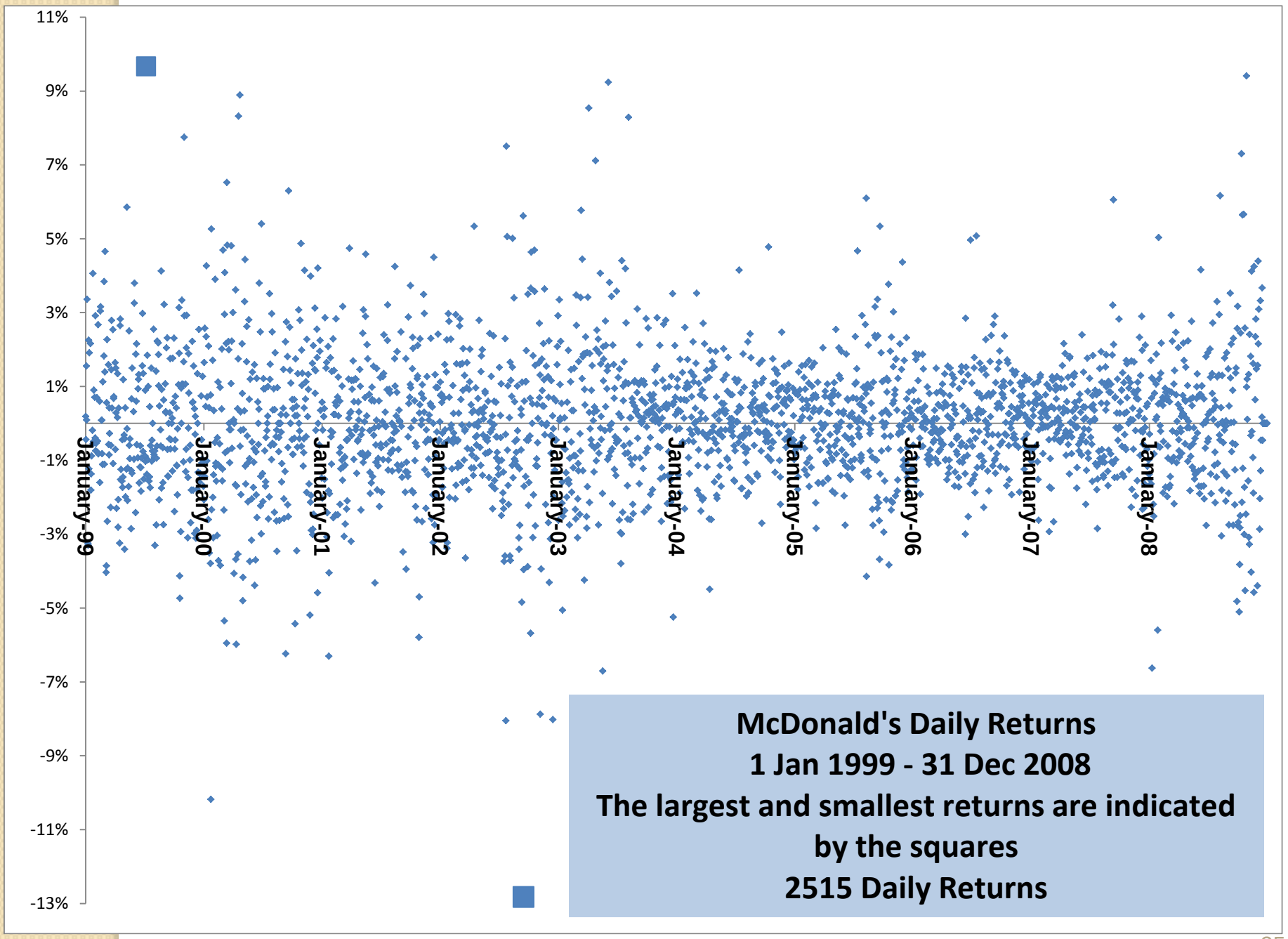
- McDonald's stock (MCD) is risky
  - Horizon risk: How long will you hold the stock?
  - Safety: stock is inherently unsafe
    - This doesn't mean it's not a good stock!
  - Liquidity risk: minimal—the volume of MCD traded daily is very large, so it should be easy to dispose of the stock.


McDonald's Stock Prices
31 Dec 1998 - 31 Dec 2008
70
60
50
40
30
20
10
0
31-Dec-98
31-Dec-99
30-Dec-00
30-Dec-01
30-Dec-02
30-Dec-03
29-Dec-04
29-Dec-05
29-Dec-06
29-Dec-07
28-Dec-08

	A	B	C	D
1	McDONALD'S--DAILY STOCK PRICES DURING DECEMBER 2008			
2		Stock price	Daily return	
3	28-Nov-08	57.23		
4	1-Dec-08	54.71	-4.40%	<-- =B4/B3-1
5	2-Dec-08	55.57	1.57%	<-- =B5/B4-1
6	3-Dec-08	58.01	4.39%	<-- =B6/B5-1
7	4-Dec-08	59.26	2.15%	<-- =B7/B6-1
8	5-Dec-08	61.09	3.09%	<-- =B8/B7-1
9	8-Dec-08	59.34	-2.86%	
10	9-Dec-08	58.13	-2.04%	
11	10-Dec-08	60.06	3.32%	
12	11-Dec-08	59.29	-1.28%	
13	12-Dec-08	59.02	-0.46%	
14	15-Dec-08	59.12	0.17%	
15	16-Dec-08	61.29	3.67%	
16	17-Dec-08	61.01	-0.46%	
17	18-Dec-08	59.70	-2.15%	
18	19-Dec-08	58.76	-1.57%	
19	22-Dec-08	59.81	1.79%	
20	23-Dec-08	59.08	-1.22%	
21	24-Dec-08	59.69	1.03%	
22	26-Dec-08	59.48	-0.35%	
23	29-Dec-08	58.81	-1.13%	
24	30-Dec-08	60.14	2.26%	
25	31-Dec-08	60.58	0.73%	



$$Daily\ return = \frac{P_t}{P_{t-1}} - 1$$

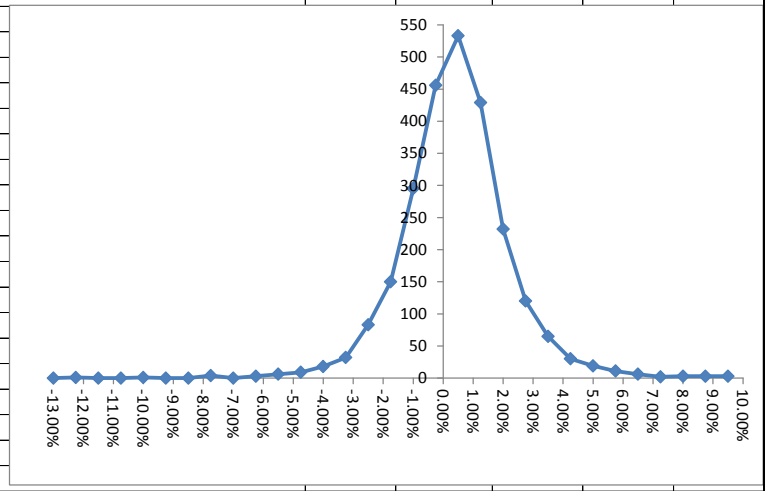

11%
9%
7%
5%
3%
1%
-1%
-3%
-5%
-7%
-9%
-11%
-13%
January-99
January-00
January-01
January-02
January-03
January-04
January-05
January-06
January-07
January-08
McDonald's Daily Returns
1 Jan 1999 - 31 Dec 2008
The largest and smallest returns are indicated by the squares
2515 Daily Returns

This looks like a big mess!

- But Excel can help you make order
- **Frequency** function
- **Count** function
- **Countif**
- **Index** and **Match** (advanced)

The big picture (hard to see)

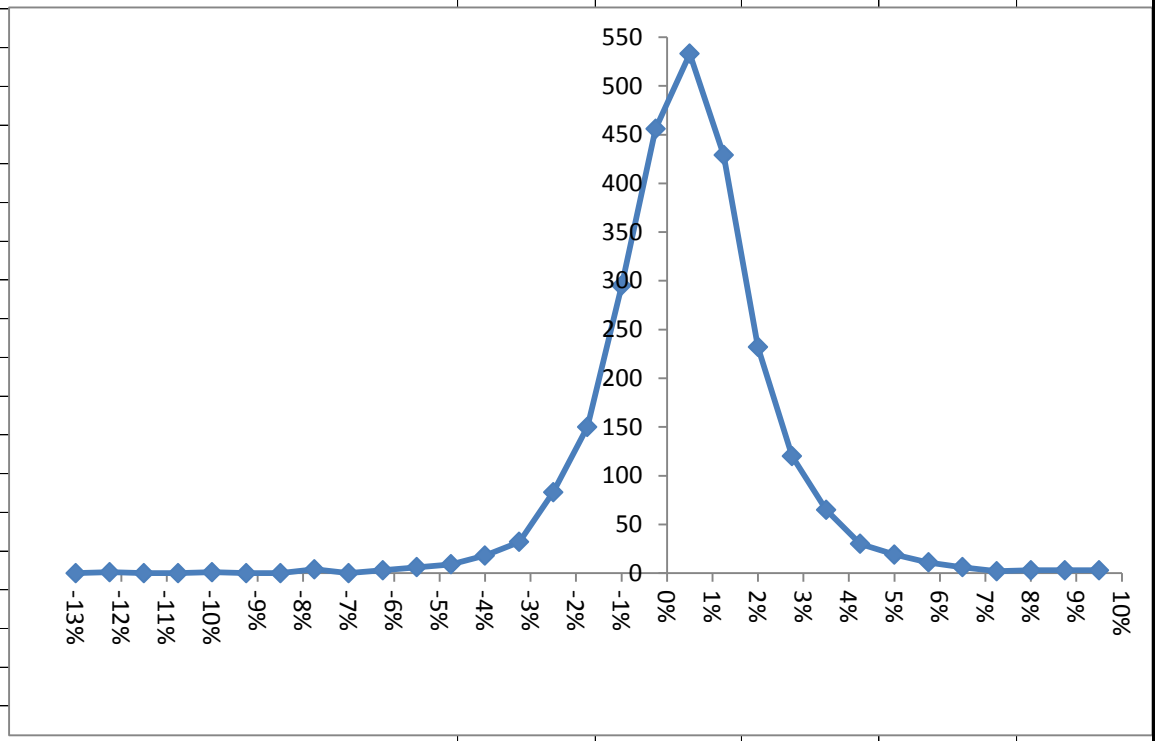
	A	B	C	D	E	F	G	H	I	J	K	L	M
1	McDONALD'S--DAILY STOCK PRICES AND RETURNS, 31 Dec 1998 - 31 Dec 2008												
2	**Date**	**Stock price**	**Daily return**			**Some statistics about McDonald's stock prices**							
3	31-Dec-98	31.69				Number of days	2515	<-- =COUNT(C4:C2519)					
4	4-Jan-99	31.75	0.19%	<-- =B4/B3-1		Minimum return	-12.82%	<-- =MIN(C4:C2519)					
5	5-Jan-99	31.61	-0.44%	<-- =B5/B4-1		Maximum return	9.67%	<-- =MAX(C4:C2519)					
6	6-Jan-99	32.1	1.55%	<-- =B6/B5-1		Date of minimum return	17-Sep-02	<-- =INDEX(A:A,MATCH(G4,C:C,0))					
7	7-Jan-99	32.13	0.09%	<-- =B7/B6-1		Date of maximum return	9-Jul-99	<-- =INDEX(A:A,MATCH(G5,C:C,0))					
8	8-Jan-99	33.21	3.36%	<-- =B8/B7-1		Number of zero-return days	43	<-- =COUNTIF(C:C,"=0")					
9	11-Jan-99	32.13	-3.25%										
10	12-Jan-99	31.07	-3.30%			**Computing the frequency distribution**							
11	13-Jan-99	31.77	2.25%			**Bin**	**How many?**						
12	14-Jan-99	31.38	-1.23%			-13.00%	0	<-- {=FREQUENCY(C4:C2518,F12:F43)}					
13	15-Jan-99	31.98	1.91%			-12.25%	1						
14	19-Jan-99	32.67	2.16%			-11.50%	0						
15	20-Jan-99	32.08	-1.81%			-10.75%	0						
16	21-Jan-99	31.64	-1.37%			-10.00%	1						
17	22-Jan-99	31.36	-0.88%			-9.25%	0						
18	25-Jan-99	31.3	-0.19%			-8.50%	0						
19	26-Jan-99	32.57	4.06%			-7.75%	4						
20	27-Jan-99	32.39	-0.55%			-7.00%	0						
21	28-Jan-99	32.23	-0.49%			-6.25%	3						
22	29-Jan-99	32.52	0.90%			-5.50%	6						
23	1-Feb-99	32.75	0.71%			-4.75%	9						
24	2-Feb-99	32.62	-0.40%			-4.00%	18						
25	3-Feb-99	33.57	2.91%			-3.25%	32						
26	4-Feb-99	33.32	-0.74%			-2.50%	83						
27	5-Feb-99	33.14	-0.54%			-1.75%	150						
28	8-Feb-99	33.37	0.69%			-1.00%	295						
29	9-Feb-99	33.11	-0.78%			-0.25%	456						
30	10-Feb-99	32.95	-0.48%			0.50%	533						
31	11-Feb-99	33.83	2.67%			1.25%	429						
32	12-Feb-99	33.55	-0.83%			2.00%	232						
33	16-Feb-99	33.75	0.60%			2.75%	120						
34	17-Feb-99	33.21	-1.60%			3.50%	65						
35	18-Feb-99	34.22	3.04%			4.25%	30						
36	19-Feb-99	35.3	3.16%			5.00%	19						
37	22-Feb-99	35.33	0.08%			5.75%	11						
38	23-Feb-99	35.36	0.08%			6.50%	6						
39	24-Feb-99	35.07	-0.82%			7.25%	2						
40	25-Feb-99	34.68	-1.11%			8.00%	3						
41	26-Feb-99	35.07	1.12%			8.75%	3						
42	1-Mar-99	35.71	1.82%			9.50%	3						
43	2-Mar-99	37.08	3.84%			10.25%	1						
44	3-Mar-99	36.67	-1.11%										



Some closeups

	F	G	H
2	**Some statistics about McDonald's stock prices**		
3	Number of days	2515	<-- =COUNT(C4:C2519)
4	Minimum return	-12.82%	<-- =MIN(C4:C2519)
5	Maximum return	9.67%	<-- =MAX(C4:C2519)
6	Date of minimum return	17-Sep-02	<-- =INDEX(A:A,MATCH(G4,C:C,0))
7	Date of maximum return	9-Jul-99	<-- =INDEX(A:A,MATCH(G5,C:C,0))
8	Number of zero-return days	43	<-- =COUNTIF(C:C,"=0")

	F	G	H	I	J	K	L	M
10	**Computing the frequency distribution**							
11	**Bin**	**How many?**						
12	-13.00%	0	<-- {=FREQUENCY(C4:C2518,F12:F43)}					
13	-12.25%	1						
14	-11.50%	0						
15	-10.75%	0						
16	-10.00%	1						
17	-9.25%	0						
18	-8.50%	0						
19	-7.75%	4						
20	-7.00%	0						
21	-6.25%	3						
22	-5.50%	6						
23	-4.75%	9						
24	-4.00%	18						
25	-3.25%	32						
26	-2.50%	83						
27	-1.75%	150						
28	-1.00%	295						
29	-0.25%	456						
30	0.50%	533						
31	1.25%	429						
32	2.00%	232						
33	2.75%	120						
34	3.50%	65						
35	4.25%	30						
36	5.00%	19						
37	5.75%	11						
38	6.50%	6						
39	7.25%	2						
40	8.00%	3						
41	8.75%	3						
42	9.50%	3						
43	10.25%	1						



Frequency function in Excel

- **Frequency** counts number of data points in specific ranges
- **Frequency** is an <u>array function</u>
  - Mark the range for the function
  - Put in the function
    - In this example: **Frequency(C4:C2518,F12:F43)**
  - Instead of [Enter]: [ctrl]+[Shift]+[Enter]

Computing the average and standard deviation of annual returns

	A	B	C	D	E	F	G	H
1	**McDONALD'S--BEGINNING-YEAR STOCK PRICES, Jan 1999-Jan 2009**							
2	**Date**	**Stock price**	**Return**			**Statistics**		
3	4-Jan-99	31.75				Largest annual return	52.12%	<-- =MAX(C3:C13)
4	3-Jan-00	32.85	3.46%	<-- =B4/B3-1		Smallest annual return	-36.65%	<-- =MIN(C3:C13)
5	2-Jan-01	27.95	-14.92%	<-- =B5/B4-1				
6	2-Jan-02	22.29	-20.25%			Average annual return	6.94%	<-- =(B13/B3)^(1/10)-1
7	2-Jan-03	14.12	-36.65%			Variance of annual returns	0.0723	<-- =VARP(C4:C13)
8	2-Jan-04	21.48	52.12%			Standard deviation of annual returns	26.88%	<-- =STDEVP(C4:C13)
9	3-Jan-05	28.09	30.77%					
10	3-Jan-06	30.19	7.48%					
11	3-Jan-07	40.48	34.08%					
12	2-Jan-08	55.02	35.92%					
13	2-Jan-09	62.10	12.87%					

Statistics review

	A	B	C	D
15	**STATISTICAL REVIEW**			
16		**MCD return**	**Return minus average, squared**	
17	3-Jan-00	3.46%	0.49%	<-- =(B17-$B$28)^2
18	2-Jan-01	-14.92%	6.45%	<-- =(B18-$B$28)^2
19	2-Jan-02	-20.25%	9.45%	
20	2-Jan-03	-36.65%	22.22%	
21	2-Jan-04	52.12%	17.34%	
22	3-Jan-05	30.77%	4.11%	
23	3-Jan-06	7.48%	0.09%	
24	3-Jan-07	34.08%	5.57%	
25	2-Jan-08	35.92%	6.47%	
26	2-Jan-09	12.87%	0.06%	
27				
28	Average	10.49%	<-- =AVERAGE(B17:B26)	
29	Variance	0.0723	<-- =SUM(C17:C26)/10	
30		0.0723	<-- =VARP(B17:B26)	
31	Standard deviation	26.88%	<-- =SQRT(B29)	

Statistical note: The only consistent way of computing annual average returns is to use the continuously compounded returns, illustrated on page 273. This Excel sheet uses discrete returns, but these give contradictory results. (Compare, for example 10.49% in cell B28 with 6.94% in cell G6 .)

For a discussion of average return versus standard deviation

AVERAGE RETURN VERSUS STANDARD DEVIATION OF RETURNS
A somewhat arbitrary list of assets, 1999-2008

	Average return	Standard deviation			Average return	Standard deviation
Abbott	4.25%	21.47%		Manpower	4.29%	32.37%
Alcoa	-3.43%	42.03%		Marriott	2.51%	27.70%
Altria	8.65%	29.51%		McGraw-Hill	0.71%	24.05%
American Airlines	-8.04%	75.72%		Microsoft	-5.79%	35.88%
anguard High-Yield	1.79%	8.59%		Nasdaq	-5.11%	30.98%
Boeing	4.49%	30.95%		Nicor	4.06%	27.34%
Cisco	-4.89%	43.06%		Nordstrom	-1.56%	42.24%
Coca Cola	0.10%	24.98%		Northrop	7.80%	25.31%
Dell	-15.50%	41.97%		Procter & Gamble	5.16%	22.31%
Exxon	10.60%	18.06%		PPG	1.24%	23.08%
Ford	-22.92%	48.67%		S&P 500	-3.22%	15.28%
GE	-4.89%	24.22%		Safeway	-8.13%	28.46%
Hershey	4.40%	23.17%		TEVA	21.33%	29.81%
IBM	0.43%	30.36%		U.S. Steel	6.11%	55.83%
Johnson & Johnson	5.30%	19.39%		Value Line Equity Fund	-5.14%	18.09%
Kellogg	3.79%	20.82%		Vanguard Long-Term Treasury	5.44%	13.37%
Kraft	0.74%	21.01%		Vanguard Windsor	1.93%	16.97%
Kroger	-1.42%	25.22%		Walmart	3.72%	22.89%