

# Testing the Efficient Market Hypothesis

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## Outline:

- Definition and Rationale
- Role in Option Pricing
- Historical EMH Tests
- Our Basic Test

## Outline continued:

- Example Output
- Categories of Stocks Tested
- Results of the Basic Test
- Testing Technical Indicators
- Are Positive Results Exploitable

# Definition

In 1900 Louis Bachelier stated that stock prices moved randomly, like the steps taken by a drunk, and are therefore unpredictable. Thus was born the "random walk hypothesis" of stock price movements.

How can this be explained? Bachelier and, in greater detail, Eugene Fama offered the efficient market hypothesis as the explanation.

The efficient market hypothesis (EMH) states that financial markets are "efficient" in that prices already reflect all known information concerning a stock. Information includes not only what is currently known, but also future expectations, such as earnings or dividends.

Only new information will move stock prices significantly, and since new information is presently unknown and occurs at random, good or bad, future movements in stock prices are also unknown and, thus, move randomly.

The basis of the efficient market hypothesis is that the market consists of many rational investors who are constantly reading the news and react quickly to any new significant information about a security.

## Role in Option Pricing

The random walk hypothesis is at the heart of the Black-Scholes equation for pricing options. The starting point for the theory is that a stock's (relative) price changes from moment-to-moment, randomly, according to a normal distribution. This means the price could go up or down equally likely but small movements are more likely than large ones\*.

## Footnote \*

The Black-Scholes model is

$$\frac{dS}{S} = \mu dt + \sigma \sqrt{dt} Z$$

where  $Z$  is a normal, mean 0, variance 1, random variable. This shows that if  $dt$  is an infinitesimal period of time, then the “jump size” of the price movement has standard deviation equal to  $\sigma \sqrt{dt}$  and is also infinitesimal.



# Historical EMH Tests

One of the strongest proponents of the EMH is Burton Malkiel in the book "Random Walk Down Wall Street." In his book Malkiel cites many tests of EMH e.g.:

- Fama and Blume (1966)
- Van Horne and Parker (1967)
- Jensen and Benington (1970)

All these studies conclude that no advantage can be gained by Technical Analysis.

However, some studies, not cited in Malkiel, claim to have shown that there is an edge to be had in certain technical systems. For example:

- Brock, W., Lakonishock, J. and LeBaron, B. (1992)

propose that moving average and trading range breakout trading shows consistent, positive results.

An excellent run-down of tests of the EMH can be found

in, “What do we know about the profitability of Technical Analysis?” by Park and Irwin (2004) and available on the internet for free.

## Our Basic Test

Taking moment-to-moment in option pricing theory to mean day-to-day, we first test the extent to which the price of a stock tomorrow is up or down relative to today.

The test can be conducted on a restricted range of stocks or dates.

We do this:

- a stock and a date are randomly selected compliant with

## the restrictions

- the closing price of that stock on that date is noted, and
- this price is compared with the closing price on the next market day
- if they are the same, the sample is discarded; otherwise the result is tabulated up or down

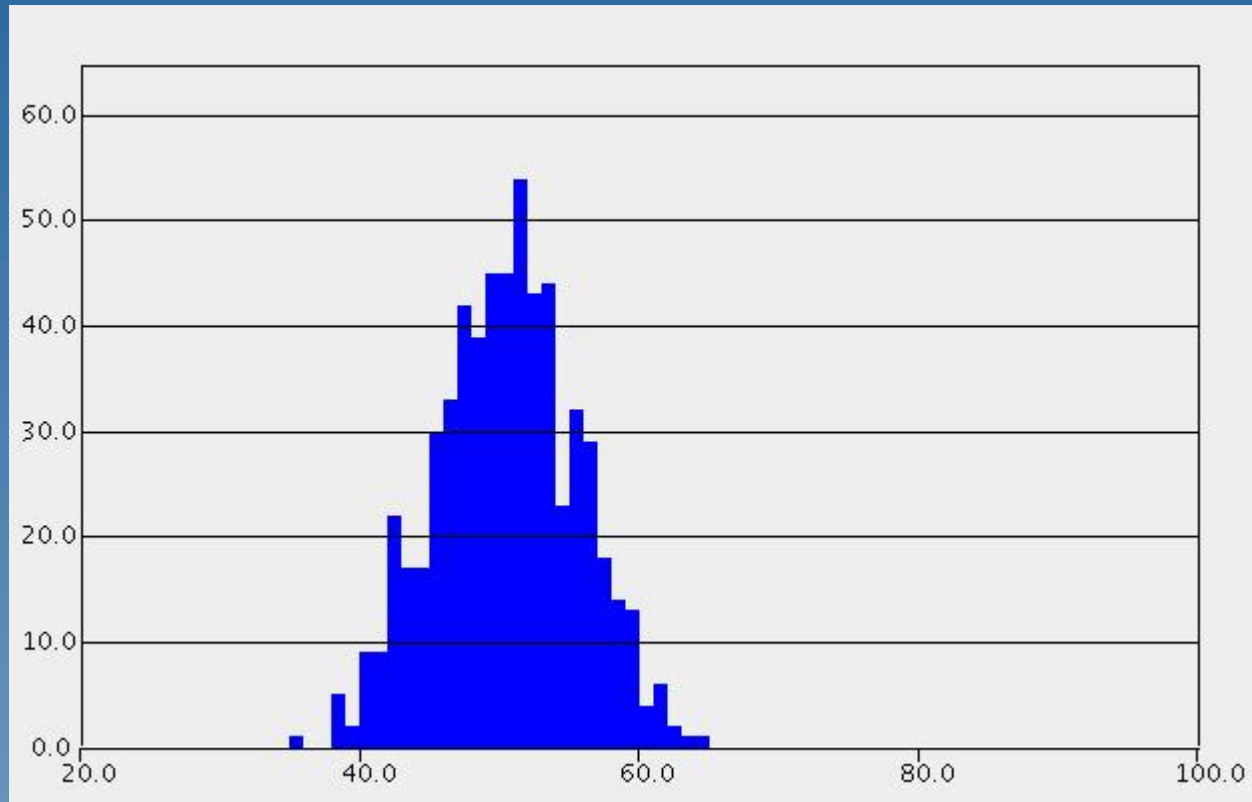
The statistic calculated is the probability  $p$  that a stock's price will be up tomorrow relative to today.

To generate confidence intervals for  $p$ , the samples are batched 100 at a time. The batches are therefore normally distributed. A run consists of 1,000 batches typically. (Altogether then a run consists of 100,000 samples.)

Here is an example run:

NYSE, 1990 – 2008, 95.4% confidence interval (CI)  
 $p = 49.91 \pm .32$

In addition, the batches are histogrammed,



# Will Tomorrow be Up or Down?

- NYSE 1990 – 2008,  $49.91 \pm .32$
- NASDAQ 1990 – 2008,  $48.86 \pm .156$  (down 1.14)
- NYSE 1996 – 2000,  $49.64 \pm .160$
- NASDAQ 1996 – 2000,  $47.75 \pm .16$  (down 2.25)
- NYSE 2001 – 2003,  $49.59 \pm .22$



- NASDAQ 2001 – 2003,  $48.74 \pm .23$  (down 1.26)
- NYSE 1971 – 1990,  $50.6 \pm .32$

Here is a sample of the processing performed; thousands of prices and dates are sifted through.

TRR, 8/12/1999, price 4.58 cf. 4.67 on 8/13 (+)

KBH, 6/21/2006, price 42.30 cf. 41.64 on 6/22 (−)

ATG, 4/27/1998, price 10.72 cf. 10.95 on 4/28 (+)

IRM, 6/14/2005, price 18.67 cf. 18.69 on 6/15 (+)

CHP, 3/14/1996, price 6.53 cf. 6.71 on 3/15 (+)

# Testing Categories

Tests were conducted on the following categories:

- exchanges: NYSE / NASDAQ

- dates:

1990 – 2008 / 1996 – 2000 / 2001 – 2003 / 1971 – 1990

- sectors:

basic materials, conglomerates, consumer goods, financials, healthcare, services, technology, and utilities.

## Noteworthy Exceptions

Mostly the results were very close to 50/50. The largest deviations:

- nasdaq, 1996–2000,  $p = 47.75$  (down 2.25% more likely than up)
- technology sector, 1996–2000,  $p = 47.11$  (down 2.89% more likely)

A surprise? Exploitable?

## What About in a Week?

Mostly the price tomorrow is as likely to be up as down. But what about prices in the next week? Of course this is not strictly an EMH test since one week is not such a short time and the drift will have an effect.

- NYSE, 1990–2008,  $52.47 \pm 0.416$  (2.47% over)
- NASDAQ, 1990–2008,  $48.79 \pm 0.406$  (1.21% under)

## What About the Days of the Week?

Are stock prices up on Monday relative to Friday? They are  $p = 50.29\%$  of the time.

More generally we have the following: (NYSE data for 1990 to 2008):

- Monday,  $50.29 \pm 0.332$
- Tuesday,  $50.04 \pm 0.313$
- Wednesday,  $51.35 \pm 0.297$  (up 1.35%)

- Thursday,  $50.50 \pm 0.313$
- Friday,  $50.29 \pm 0.392$

# Conclusion

So as far as the assumption about prices being randomly up or down from moment-to-moment is concerned, it is approximately correct with only small deviations in certain situations.

What about the assertion that patterns in past and current stock prices and sales volume have no predictive value?



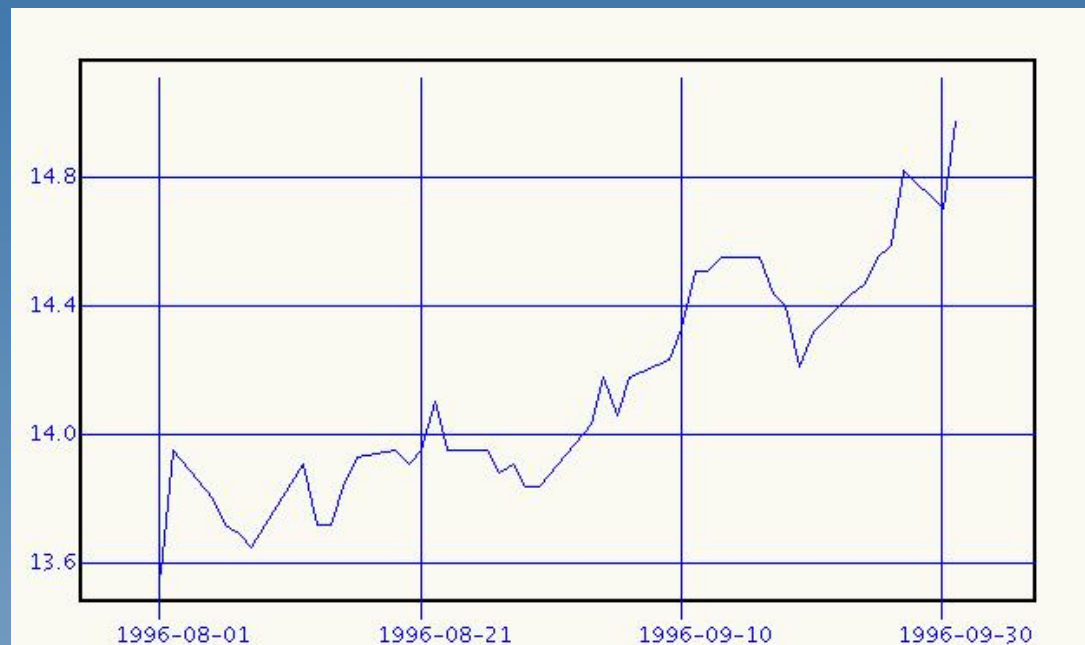
# Technical Indicators

The EMH implies that Technical Analysis is of no value, all information available in charts is already incorporated into the stock's price; future price movement is due to news.

Is it true?

# Momentum

Take momentum to mean that a stock's price make steady and not excessively oscillatory gains over a period of at least 3 weeks, for example.



And later ...



## Do Stock Prices Have Momentum?

- NYSE, 1990–2008, gain 7cents/day over 20 days: up tomorrow 50.9%
- NYSE, 1990–2008, gain 7cents/day over 45 days: up tomorrow 52.2%
- NYSE, 1990–2008, gain 7cents/day over 45 days: up next week 50.6%

## Direction Movement Indicator (DMI)

OptionVue's Steve Lenz suggests DMI generates a good signal. "The amount by which today's price is higher than yesterday's is  $dm+$ . Conversely, the amount by which today's price is below yesterday's is (numerically)  $dm-$ . Whichever is smallest on a given day is reset to 0. The DMI indicator is the moving average of the difference typically over 14 days. A signal is generated when the 14 day  $dm+$  crosses above the 14 day  $dm-$ ."

# DMI Results

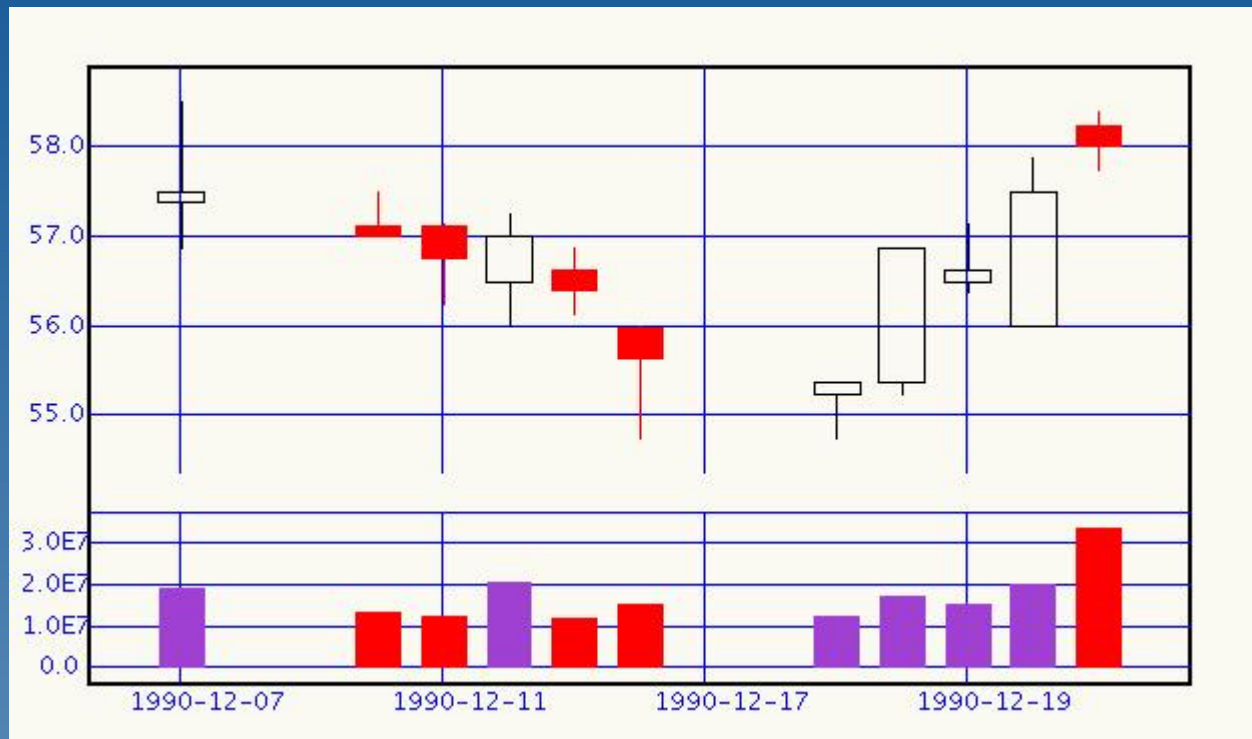
- NYSE, 1990–2008,  $50.11 \pm 0.424$
- NASDAQ, 1990–2008,  $49.21 \pm 0.432$

Sectors of note:

- basic materials, 1/2001–3/2003,  $47.11 \pm 0.407$

# The Hammer

“The Hammer is comprised of one candle identified by the presence of a small body with a shadow at least two times greater than the body. Found at the bottom of a downtrend, this shows evidence that the bulls started to step in. The color of the small body is not important but a white candle has slightly more bullish implications than the black body.”



Here is what we found, using 6,000 trials for added accuracy:



- $46.48 \pm 0.128$  (down 3.52%)

It would appear that the hammer is a fairly good *anti-predictor*. The same goes for the inverted hammer which yielded the prediction:

- $p = 46.81 \pm 0.129$  (down 3.19%)

## Two at a Time

I also tested some combinations of two at a time. Suppose both dmi and momentum indicate the price will rise.

- NYSE 1990–2008, 30 day gain of at least 3cents/day,  $51.18 \pm 0.407$  (up 1.18%)

## Moving Average Convergence/Divergence (MACD)

“MACD is the difference between a short term moving average and a long term moving average. When the short term exceeds the long term by a certain amount, then the stock is overbought, the stock price is predicted to fall. Conversely when the short term is less than the long term by more than a certain amount then the stock is oversold, the price will rise.”

## MACD Results

- NYSE 1990–2008, 12/26 day MA,  $55.64 \pm 0.414$
- NASDAQ 1990–2008, 12/26 day MA,  $52.80 \pm 0.410$

Recall we are testing whether or not the price tomorrow is up relative to today if and when a signal is generated, the data show that 55.6% of the time the stock price agreed with the prediction when a MACD signal was generated.

As pointed out at the beginning of the talk, this result confirms that of Brock, Lakonishock, and LeBaron.

Can it be exploited ... ?

# Some Recent Results

s/	reco	sig-	adv	start	date	date	date	date	max/min	%	
f	tkr	date	nal	dec	price	+1	+2	+3	+4	week 2	chng
*	SR	10/12	0.14	dec	7.65	7.48	7.75	7.75	7.87	6.84*	-10.6
*	LEE	10/12	0.14	dec	3.79	3.74	4.01	4.01	3.89	3.27*	-13.7
*	SRI	10/12	0.13	dec	8.82	8.63	8.70	8.67	8.55	8.13*	-7.8
	ETM	10/12	0.13	dec	7.63	7.95	8.73	9.00	9.11	8.23	7.9
*	GCI	10/12	0.12	dec	13.24	13.15	13.48	13.19	13.00	11.57*	-12.6
*	AM	10/12	0.12	dec	23.19	23.68	24.00	23.17	22.24	21.47*	-7.4
	PER	10/12	0.11	dec	29.84	29.92	29.92	29.91	29.89	29.90	0.2
*	TLB	10/12	0.11	dec	11.58	11.61	11.80	11.66	11.20	10.03*	-13.4
	NTL	10/12	0.10	dec	14.50	14.90	14.90	14.75	15.19	16.00	10.3
	OMN	10/12	0.10	dec	7.51	7.81	7.92	7.80	7.59	7.24*	-3.6
	PIR	10/12	0.09	dec	4.41	4.85	4.83	4.77	4.65	3.64*	-17.5

s/	reco	sig-	adv	start	date	date	date	date	max/min	%	
f	tkr	date	nal	dec	price	+1	+2	+3	+4	week 2	chnng
*	MGS	10/12	0.09	dec	2.44	2.56	2.52	2.35	2.58	2.30*	-5.7
*	MNI	10/12	0.09	dec	3.36	3.63	4.02	3.50	3.24	3.23*	-3.9
*	GAP	10/12	0.09	dec	10.29	10.01	10.44	10.62	11.03	9.18*	-10.8
*	GY	10/12	0.08	dec	6.69	6.64	7.05	7.13	7.13	7.35	9.9
	MIC	10/12	0.08	dec	9.33	9.34	9.75	10.22	9.64	8.05*	-13.7
*	SBP	10/12	0.08	dec	11.81	11.73	11.94	11.86	11.83	11.16*	-5.5
	BLC	10/12	0.08	dec	5.12	5.33	5.47	5.61	5.51	5.39	5.3
*	LIZ	10/12	0.08	dec	6.82	6.68	7.45	7.49	7.05	6.10*	-10.6
*	OXM	10/12	0.07	dec	23.09	22.82	23.57	23.53	22.91	19.72*	-14.6
*	TMS	10/12	0.07	dec	2.04	2.07	2.08	2.02	1.98	1.48*	-27.5
*	WNC	10/09	0.07	dec	2.75	2.73	2.83	2.78	2.87	2.34*	-14.9



s/	reco	sig-	adv	start	date	date	date	date	max/min	%	
f	tkr	date	nal	dec	price	+1	+2	+3	+4	week 2	chnng
*	TGS	10/12	0.07	dec	3.31	3.27	3.35	3.10	3.07	2.92*	-11.8
*	BTN	10/09	0.07	dec	3.72	3.71	3.72	3.62	3.51	3.38*	-9.1
*	ITP	10/08	0.07	dec	2.23	2.19	2.30	2.25	2.26	1.82*	-18.4
	CDE	10/12	0.07	dec	23.31	23.85	24.29	23.78	23.48	21.99*	-5.7
*	BVN	10/09	0.07	dec	38.38	37.84	38.46	39.05	39.12	35.79*	-6.7
*	HL	10/08	0.07	dec	5.02	4.76	4.71	4.82	4.91	4.74*	-5.6
	BZ	10/12	0.07	dec	5.73	6.01	6.29	6.29	6.23	5.52*	-3.7
*	CPY	10/12	-0.09	adv	10.13	9.99	10.03	10.02	10.37	13.24*	30.7
*	CBC	10/12	-0.10	adv	2.91	2.99	3.12	3.20	2.83	2.90	-0.3
*	BBX	10/12	-0.13	adv	2.13	2.17	2.33	2.33	2.15	2.01	-5.6

## Summary

advance predictions 3 out of 3 (100.0%)

decline predictions 20 out of 29 (69.0%)

overall 23 out of 32 (71.9%)

advance predictions on week 2, 1 out of 3 (33.3%)

decline predictions on week 2, 24 out of 29 (82.8%)

overall 25 out of 32 (78.1%)

**Over Aug/Sept/Oct**

