Monte Carlo Simulation
of
A Simple Equity Growth Model

by

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What is Monte Carlo Simulation?

- A computer program simulating thousands of outcomes of a mathematical model.
- This estimates the probability distribution of outcomes.
- Useful when the model cannot be studied analytically.

What is an Equity Growth Model?

- A company retains earnings for investing in new assets.
- The retained earnings are accumulated as equity capital.
- Assume future earnings are related to the equity capital.
- A simple model resamples the historical Return on Equity (ROE) and the historical fraction of earnings retained, and uses this to Monte Carlo simulate the future earnings and equity.

Equity & Retained Earnings

Starting equity is normalized to one: $Equity_0 = 1$

Equity at the end of year t is the previous equity plus retained earnings:

$$Equity_t = Equity_{t-1} + Earnings_t \cdot (Retain/Earnings)_t$$

Retained earnings are those not paid out as dividends or used for share buyback net of issuance:

$$\left(\frac{Retain}{Earnings}\right)_t = 1 - \left(\frac{Dividends}{Earnings}\right)_t - \left(\frac{Net\ Share\ Buyback}{Earnings}\right)_t$$

Earnings

Earnings for year t are found by multiplying the year's starting equity by the Return on Equity (ROE):

$$Earnings_t = Equity_{t-1} \cdot ROE_t$$

Price

The price (or market-cap) for time t is calculated from the simulated equity at that time, multiplied by a sample of the historical P/Book (aka Price/Equity):

$$Price_t = (P/Book) \cdot Equity_t$$

Share Buyback and Issuance

Starting number of shares is normalized to one: $Shares_0 = 1$

The number of shares after a share buyback and issuance is:

$$Shares_t = Shares_{t-1} \cdot \left(1 - \frac{Net\ Share\ Buyback_t}{Price_t}\right)$$

Per Share

The per-share numbers are:

$$Equity\ Per\ Share_t = Equity_t / Shares_t$$

$$Earnings\ Per\ Share_t = Earnings_t / Shares_t$$

$$Dividend\ Per\ Share_t = Dividend_t / Shares_t$$

$$Price\ Per\ Share_t = Price_t / Shares_t$$

Value Yield

Assume the shares are held for n years and then sold. The Value Yield is the discount rate that makes the present value of future dividends and present value of the selling share-price equal to the current share-price:

$$Price\ Per\ Share = \sum_{t=1}^{n} \frac{Dividend\ Per\ Share_t}{(1 + Value\ Yield)^t} + \frac{Price\ Per\ Share_n}{(1 + Value\ Yield)^n}$$

The value yield is the annualized rate of return on an investment over its holding period, given the current share-price.

Historical Financial Data

All we need for the Monte Carlo simulation of this simple equity growth model is the historical financial data for ROE, $Dividends/Earnings$, and $Net\ Share\ Buyback/Earnings$. For the pricing model we also need the historical $P/Book$.

Wal-Mart, Financial Data

USD Millions	Equity	Earnings	Dividends	Net Share Buyback
1994	10,753	2,333	299	0
...	...	...	...	...
2010	70,468	14,335	4,217	7,276
2011	68,542	16,389	4,437	14,776
2012	71,315	15,699	5,048	6,298
2013	76,343	16,999	5,361	7,600
2014	76,255	15,918	6,139	6,683

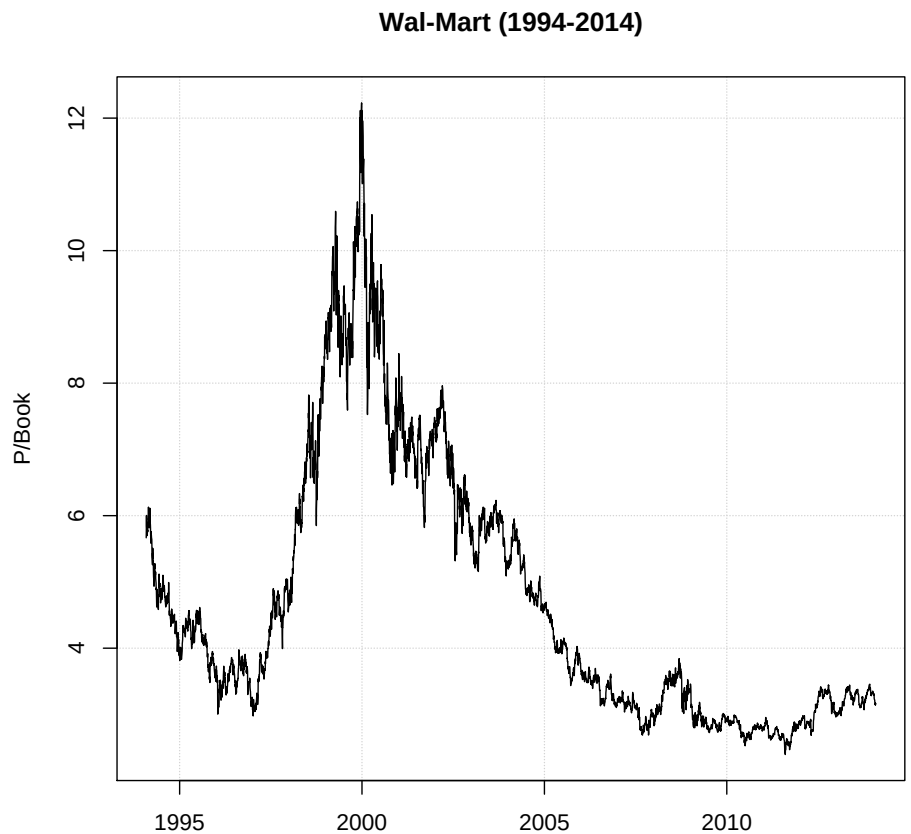
Data from financial reports (SEC Form 10-K).

Wal-Mart, Financial Ratios

Year	ROE	Dividends/ Earnings	Net Buyback/ Earnings	Retain/ Earnings
1995	25%	15%	0%	85%
…	…	…	…	…
2010	22%	29%	51%	20%
2011	23%	27%	90%	(17%)
2012	23%	32%	40%	28%
2013	25%	32%	45%	24%
2014	22%	39%	42%	19%

The ratios used in simulation. Calculated from the raw financial data.

Wal-Mart, P/Book



Statistics for 1994-2014:

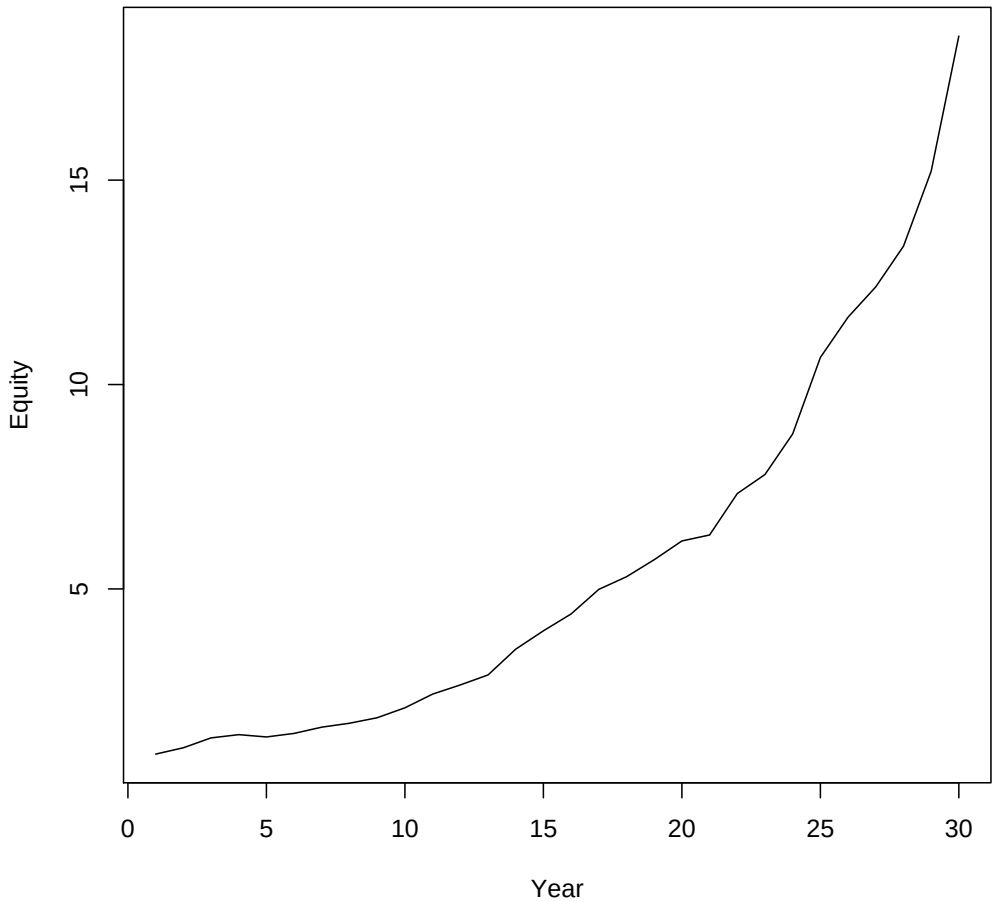
Mean: 4.7

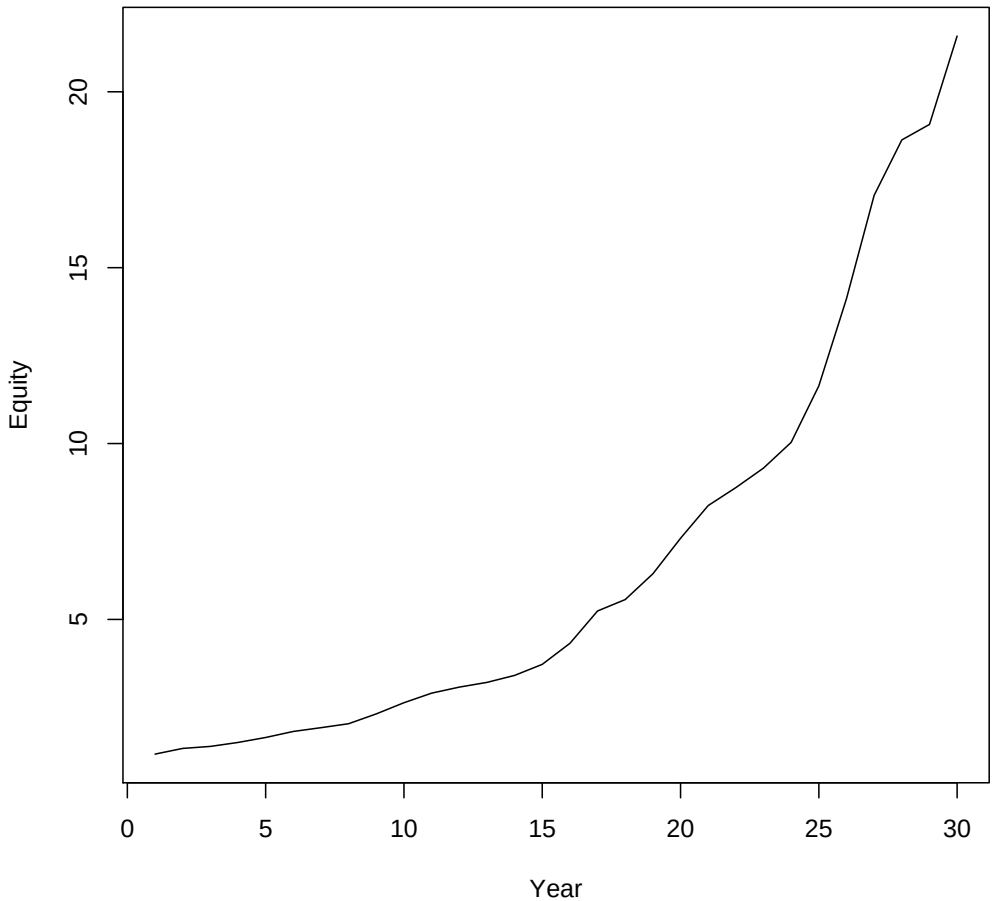
Stdev: 2.0

Min: 2.4

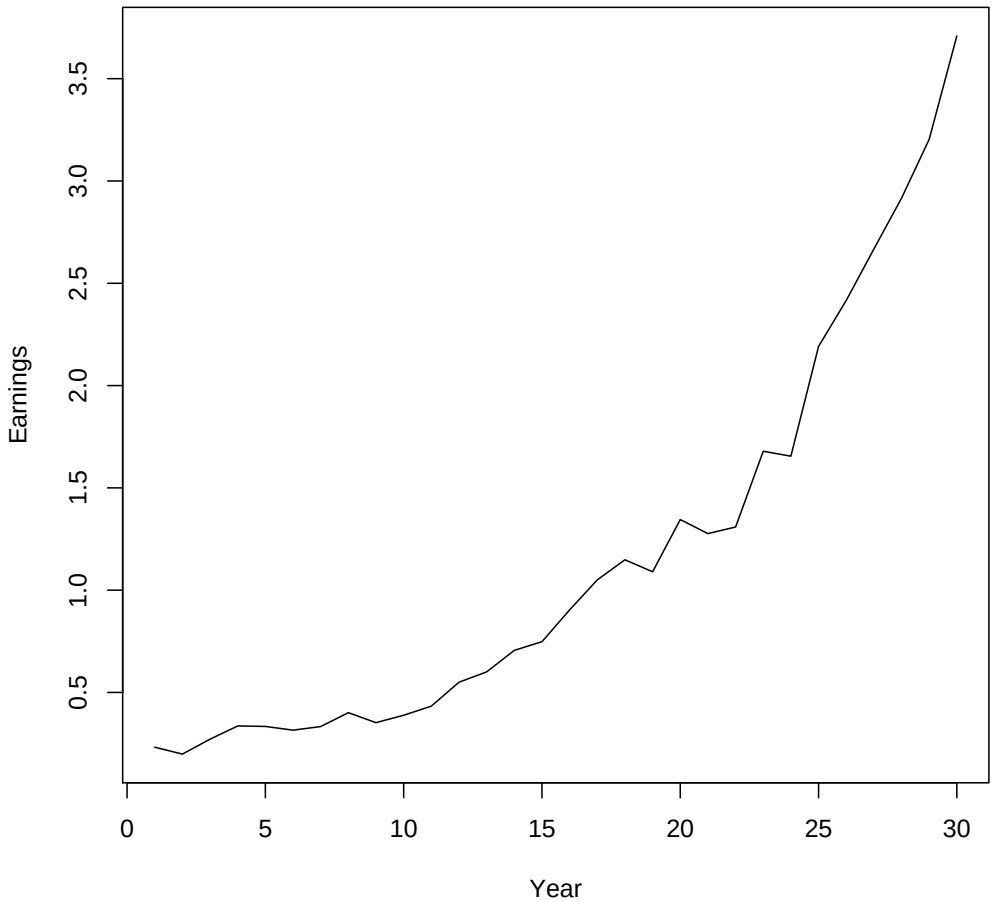
Max: 12.2

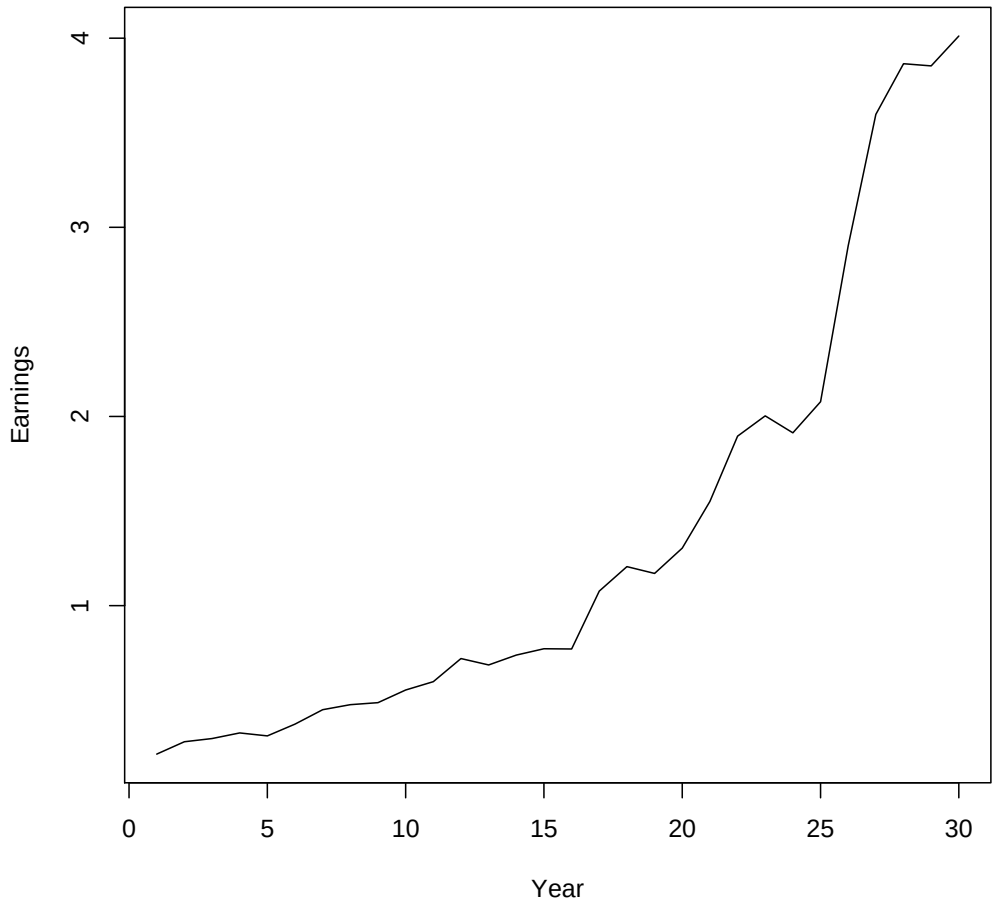
Wal-Mart, Simulated Equity



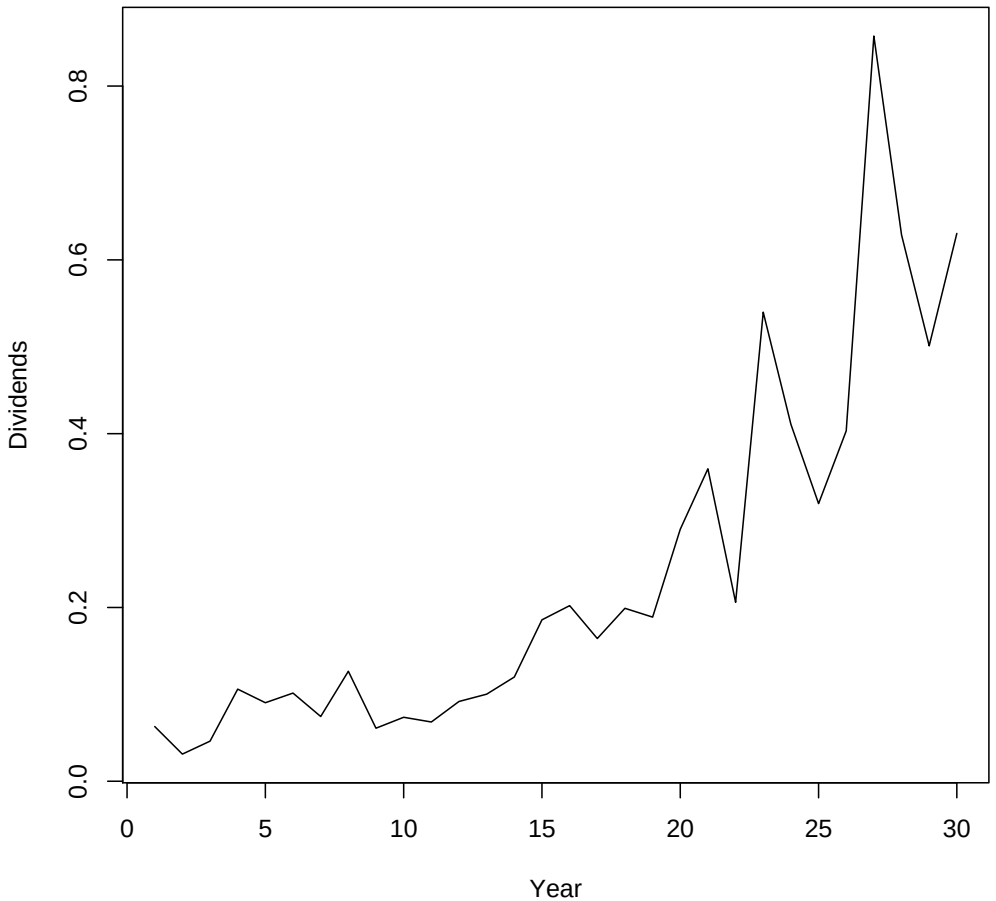


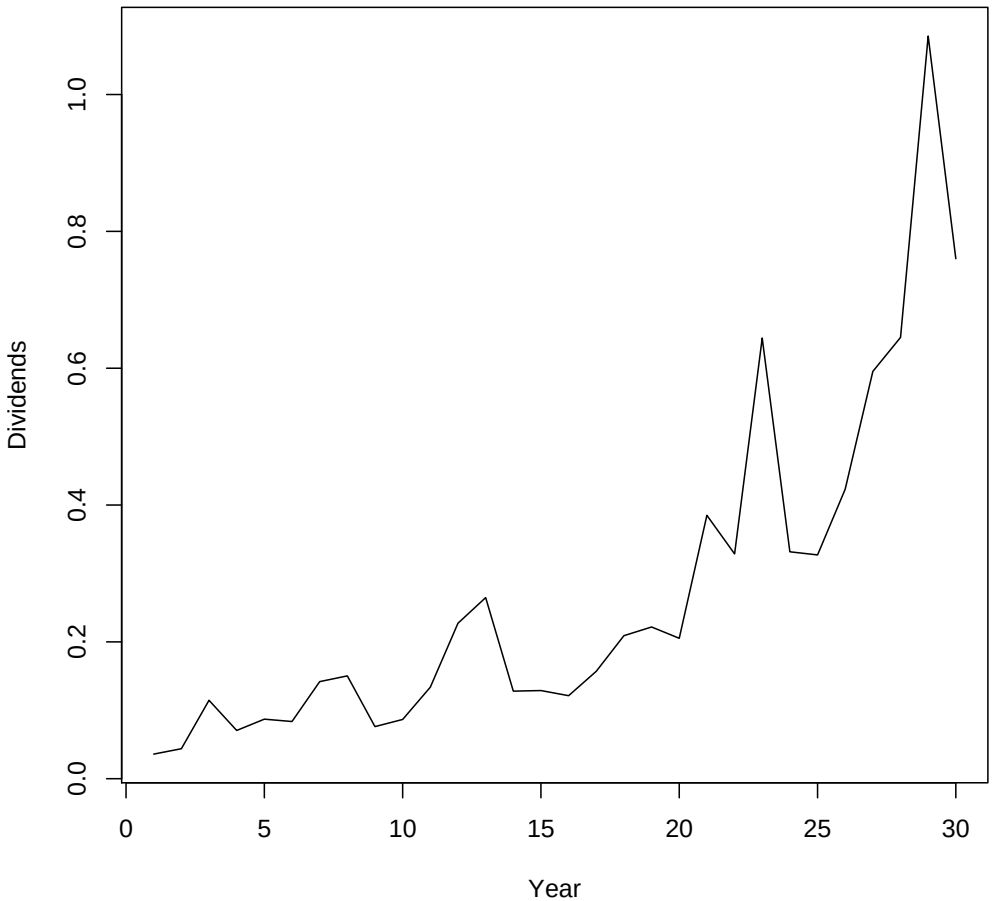
Wal-Mart, Simulated Earnings



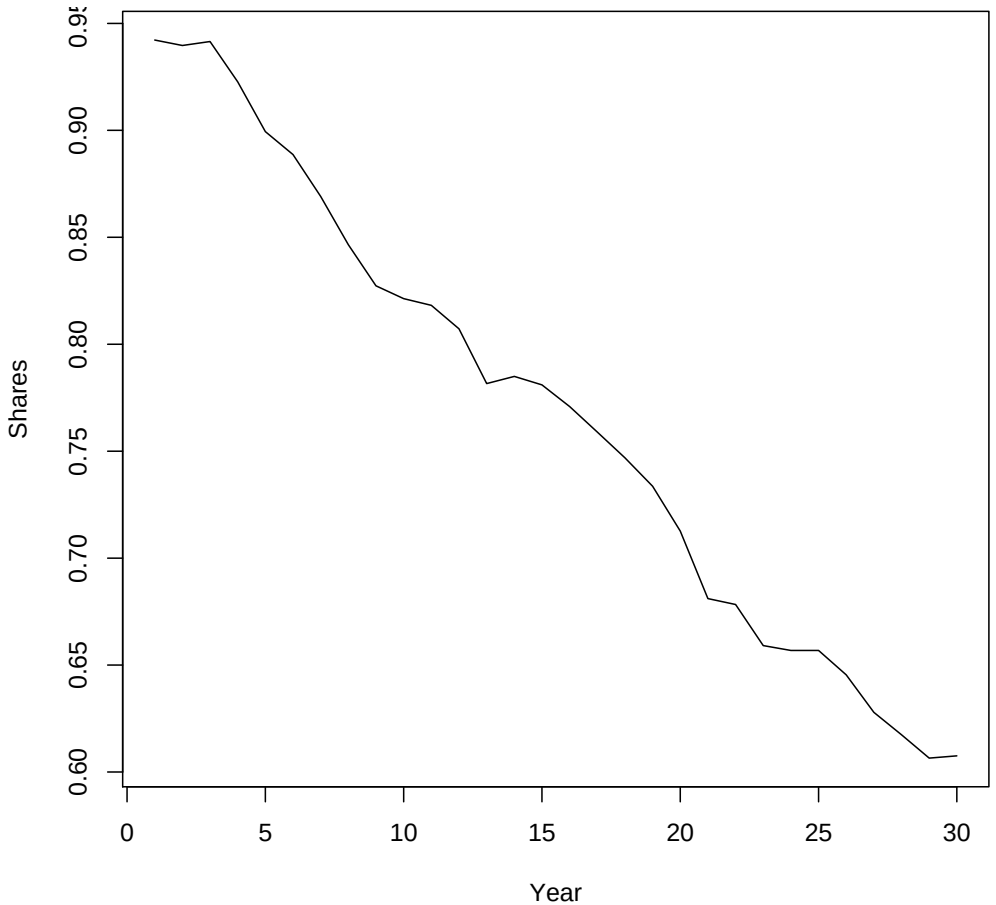


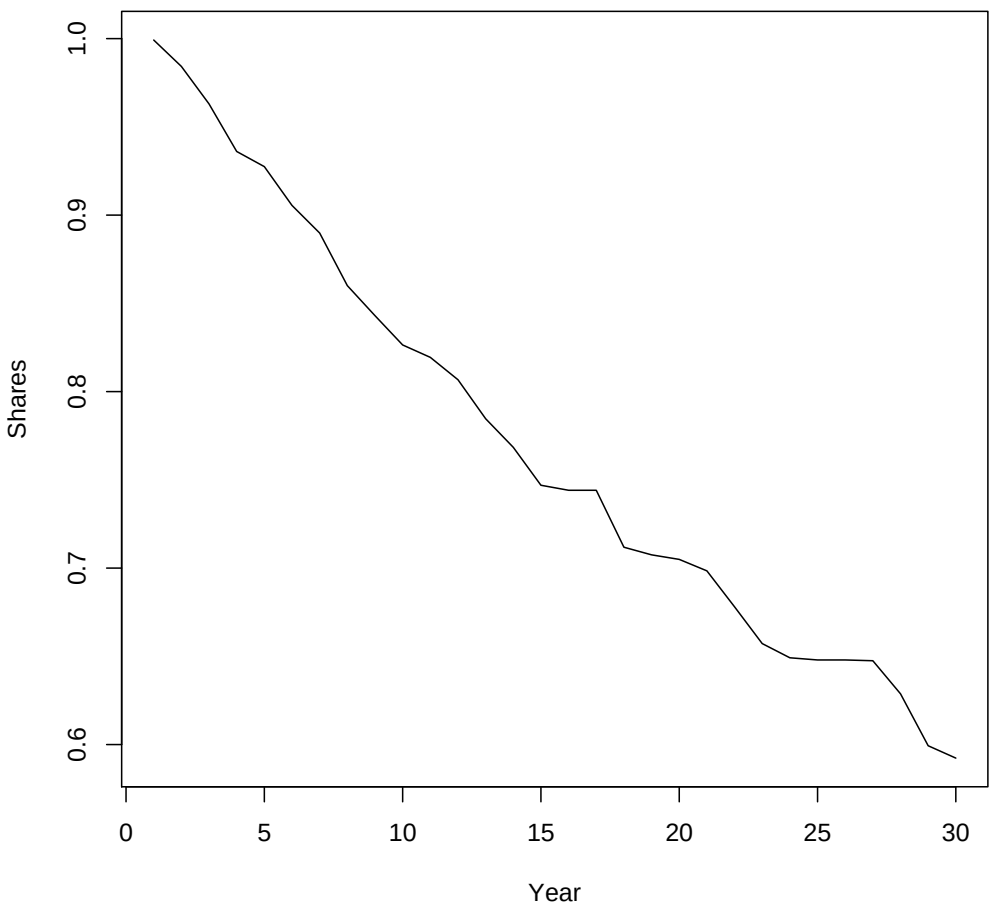
Wal-Mart, Simulated Dividends



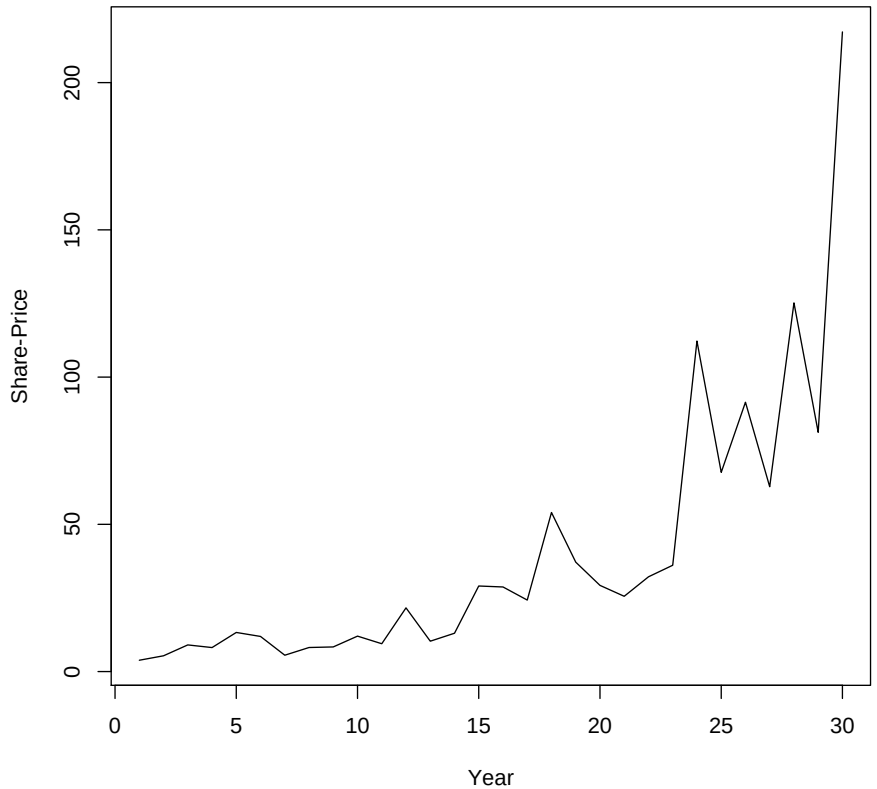


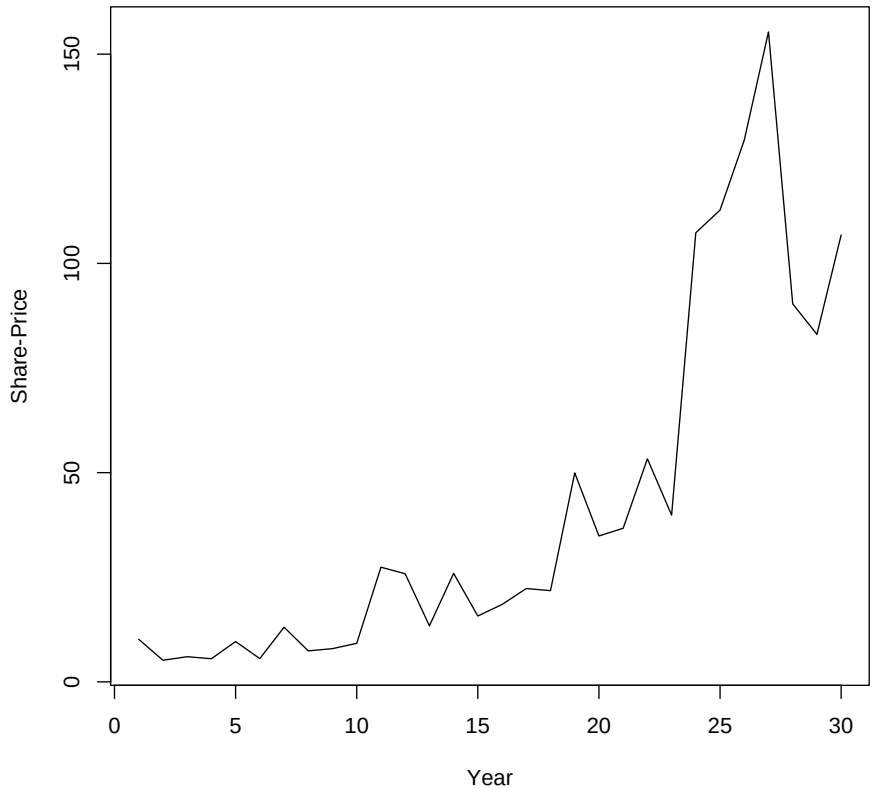
Wal-Mart, Simulated Number of Shares





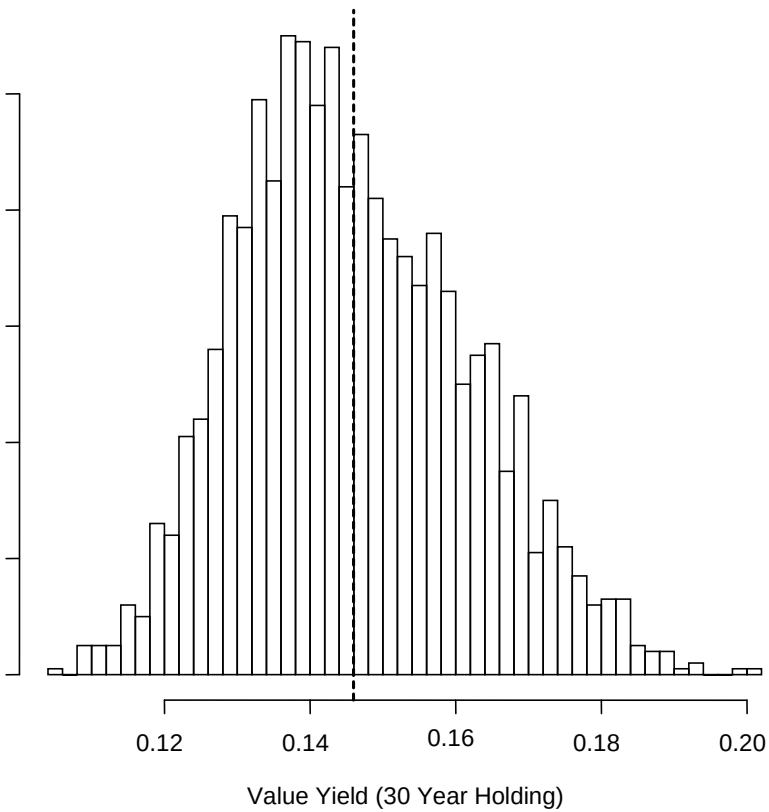
Wal-Mart, Simulated Price Per Share

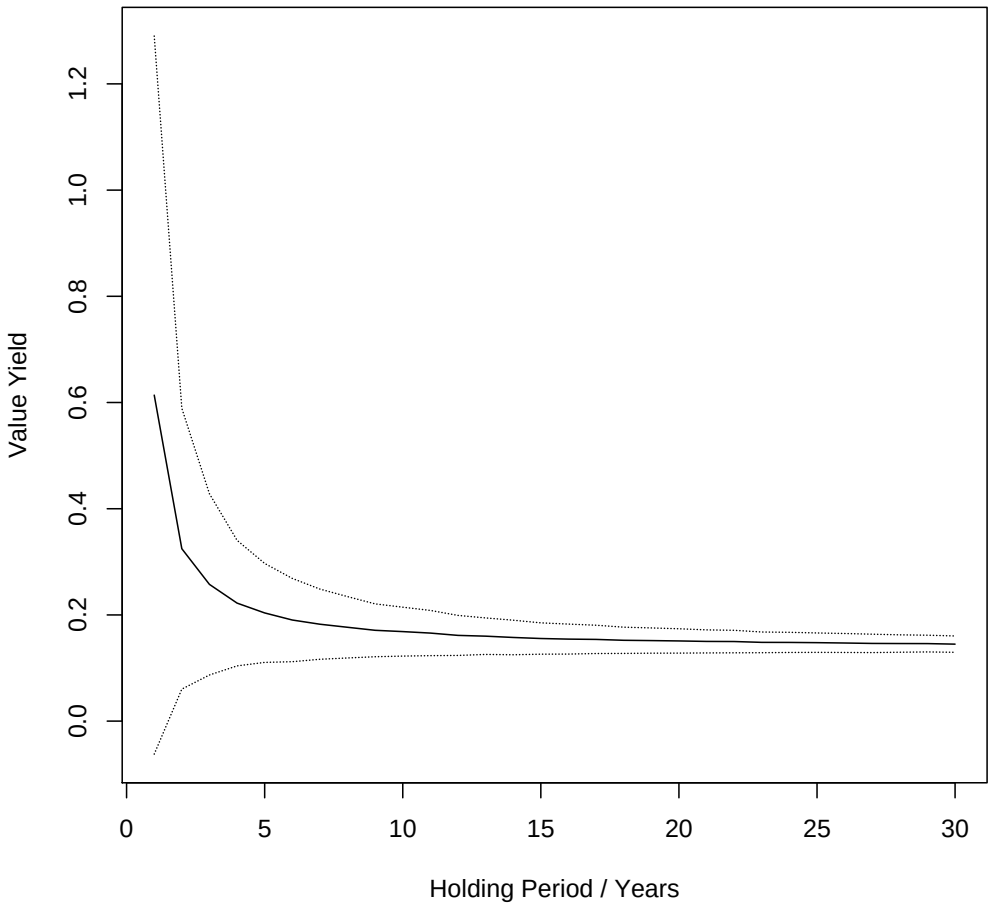




Remember this is normalized and must be multiplied by starting equity per share.

Wal-Mart, Value Yield





Warning

There are several limitations of the equity growth model, including:

- The model is simple and may not be suitable for a given company.
- Growth decline should also be modelled or the company may grow bigger than all the combined companies of the S&P 500 index.
- Financial data for more years may be needed.
- Older financial data should perhaps be sampled less frequently.
- The pricing model is crude.

So the simulation results should be interpreted with caution!

Conclusion

- The equity growth model uses historical financial data to simulate future equity, earnings, dividends, etc.
- The simulated equity is used with samples of the historical P/Book to estimate future stock-prices.
- This is a new paradigm for Monte Carlo simulation in finance.
- The model has several limitations and should be used with caution.
- The model can be extended – please do so and share your results!

Further Reading

This talk is based on the papers:

- **Monte Carlo Simulation in Financial Valuation**
- **Portfolio Optimization and Monte Carlo Simulation**

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Available on the internet:

www.Hvass-Labs.Org