Some Inspired Non-Parametric Portfolio Approaches of James R. Thompson

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Rice University

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Some Inspired Non-Parametric Portfolio Approaches of James R. Thompson

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Abstract
Security returns are an example of phenomena whose distributions defy parametric modeling. Jim Thompson used a variety of non-parametric approaches to develop workable investing solutions in such an environment. We review his ground-breaking exploration of the veracity of the capital asset pricing model (CAPM), and several non-parametric approaches to portfolio formulation including the Simugram™, variants of his Max-Median rule, and Tukey weightings

Key Words: Non-parametric statistics, simulation, portfolio construction, optimization, MaxMedian, power means

1. Introduction

We are honored and pleased to present this look at James Thompson's non-parametric market portfolio approaches. Professor James R. Thompson (1938-2017) earned his Ph.D. in Mathematics from Princeton in 1965 where John W. Tukey was his thesis advisor. Thompson was well-positioned for the age of Tukey, EDA and numerical solutions. He bridged the robustness/heavy math age of statistics with the bootstrap/computer age. He was one of the first to immediately realize the usefulness of the Bootstrap, back in the time of Julian Simon in 1969, and he became one of its evangelists, from the outset through the optimality phase of its development, to the present. We recall that the hardware processing at the time was accomplished on time-share machines or university computers such as the IBM 360, CDC-6600 or DEC PDP-8.

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Presented by

Katherine B. Ensor

2018 Joint Statistical Meetings (JSM)
Vancouver, BC

Papers in Honor of Professor James R Thompson (1938-2017)

July 30, 2018

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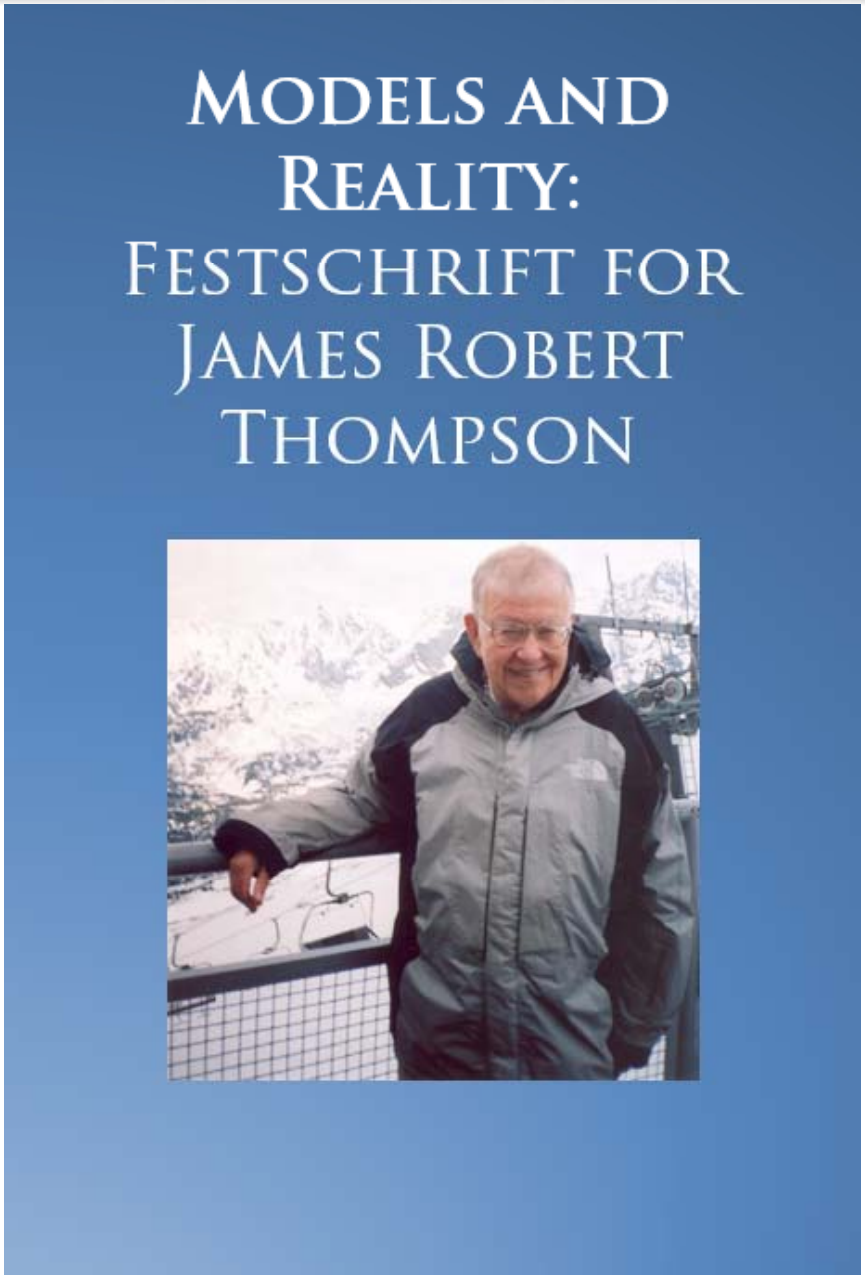
Thanks to All

- Reminiscences
- Mathematical biology
- SIMEST
- Empirical model-building
- Lymphocytes in semigroups
- Global financial crisis
- Fallacies of financial Economics
- The civic scientist



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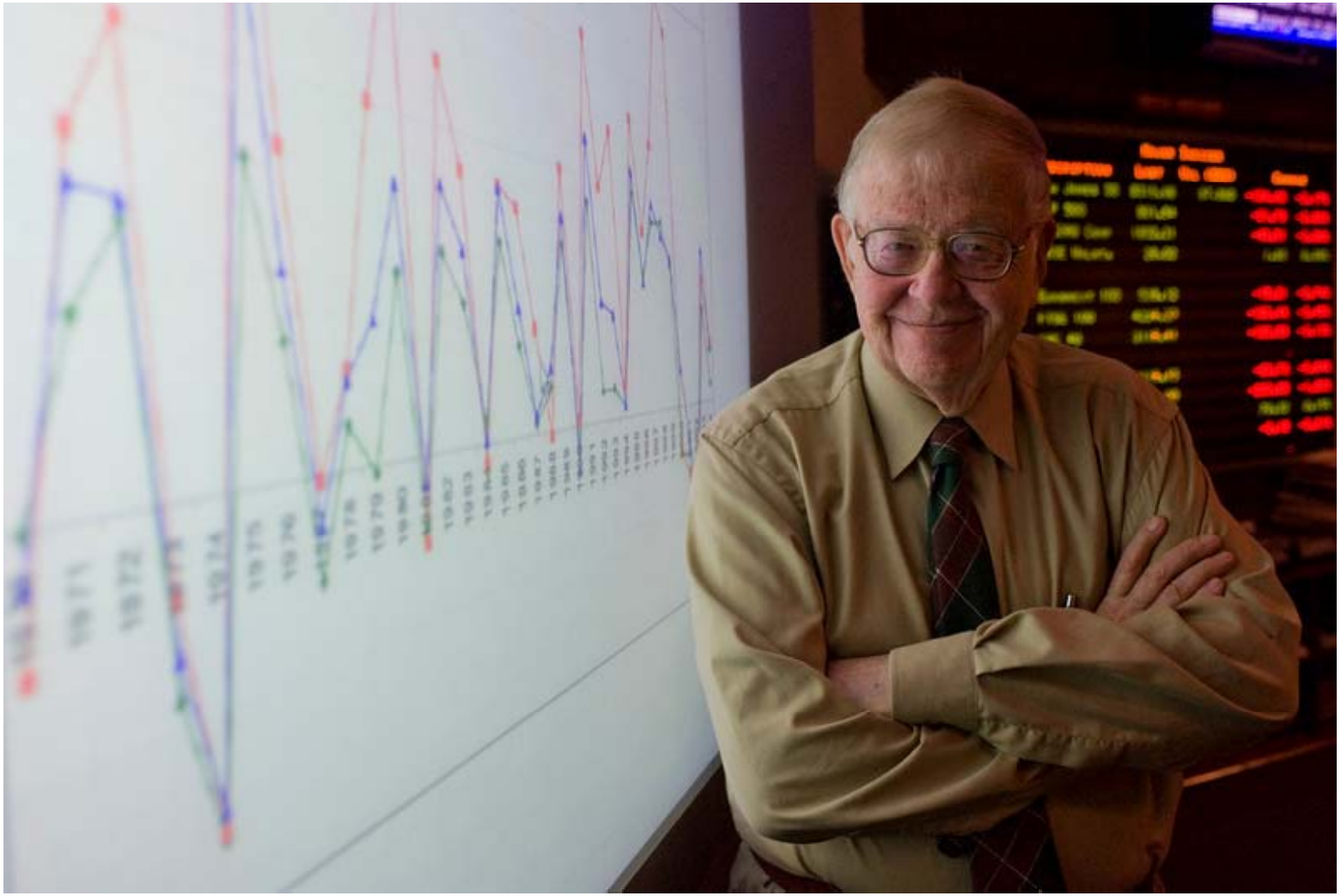
Computational Finance



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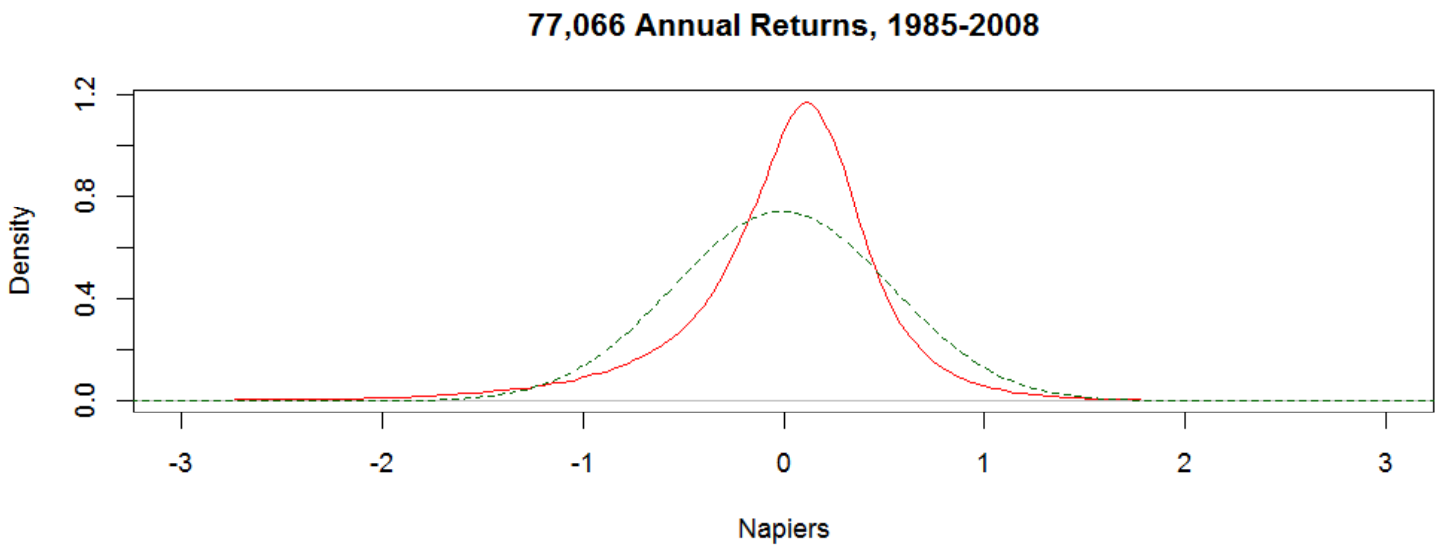
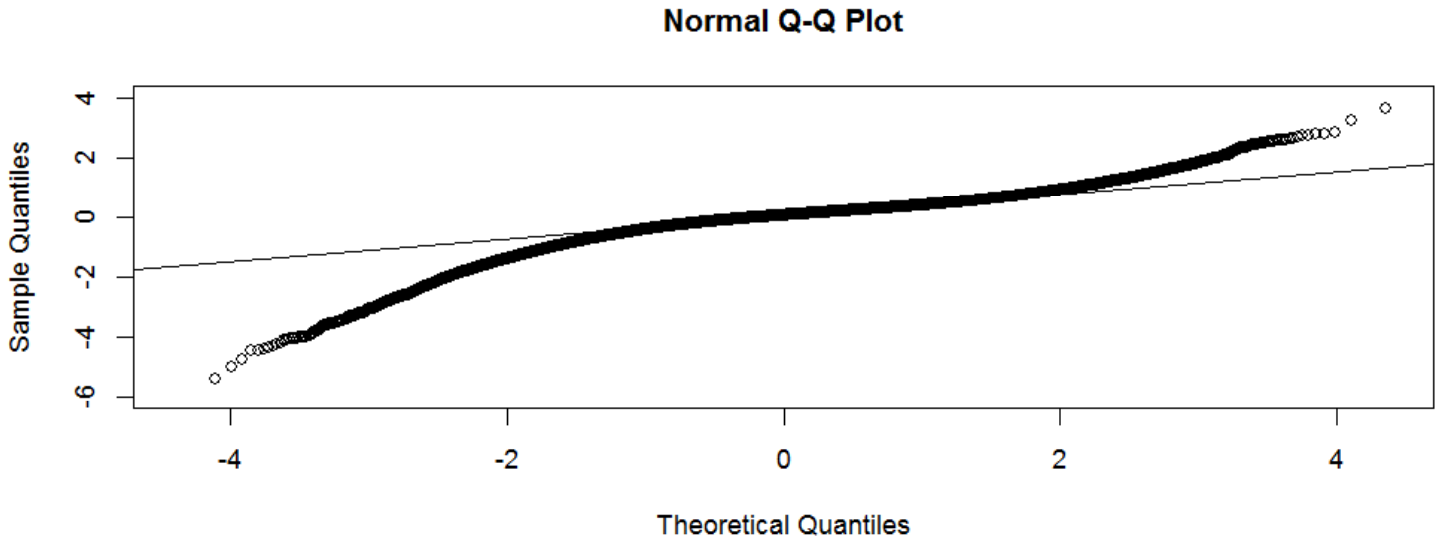
JRT Overview

- Almanac of security returns and market statistics
- Simugram™
- CAPM validation
- Max-Measures rule
- Alternate weights

Security returns





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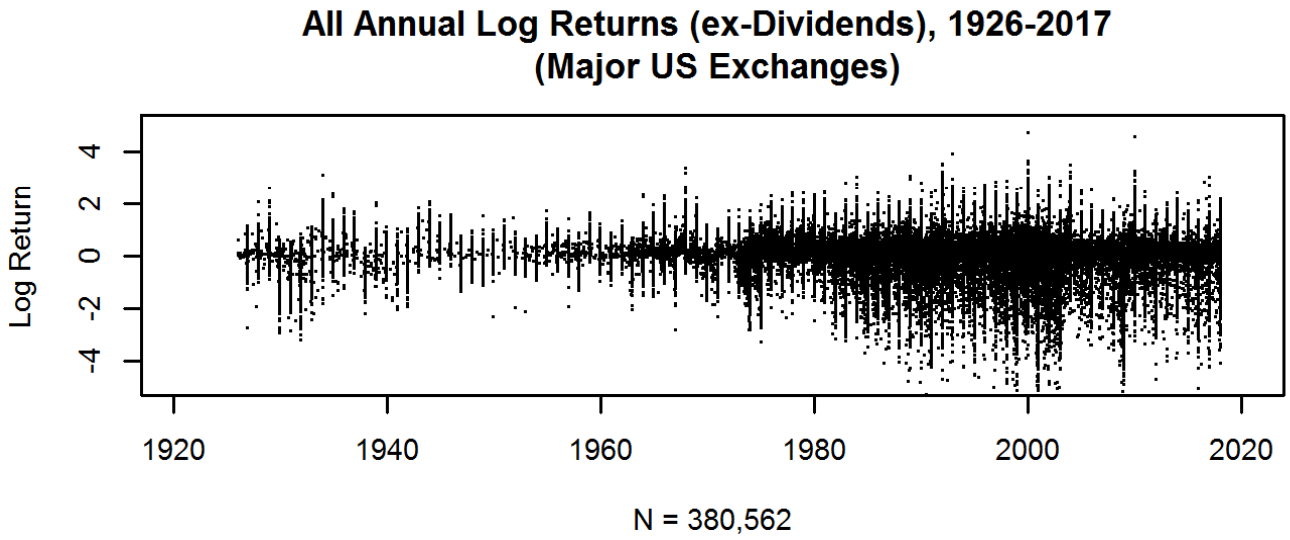
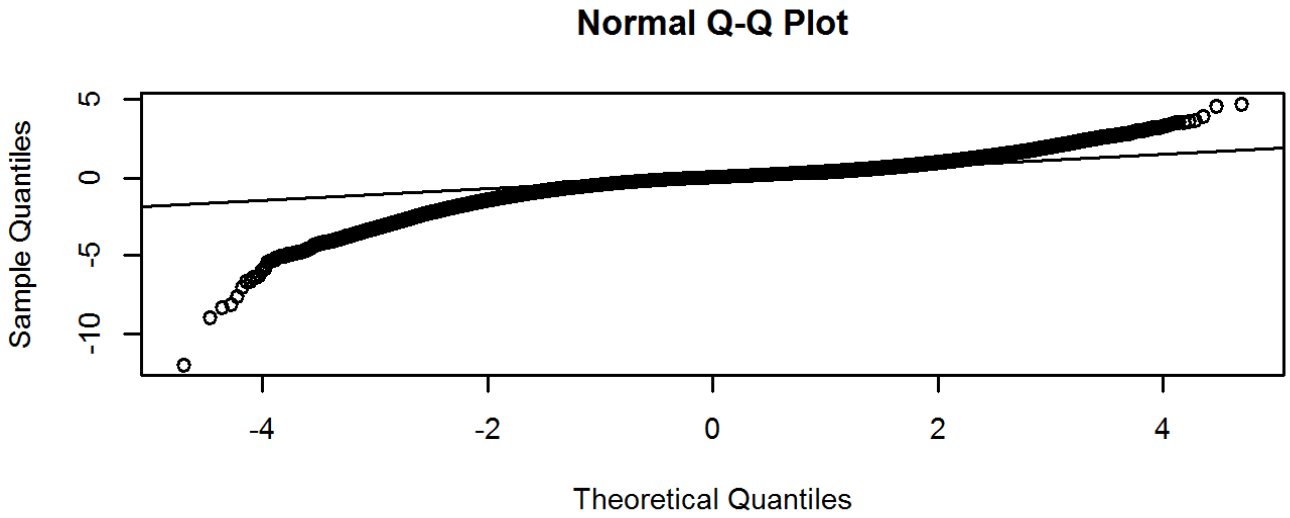
Annual returns





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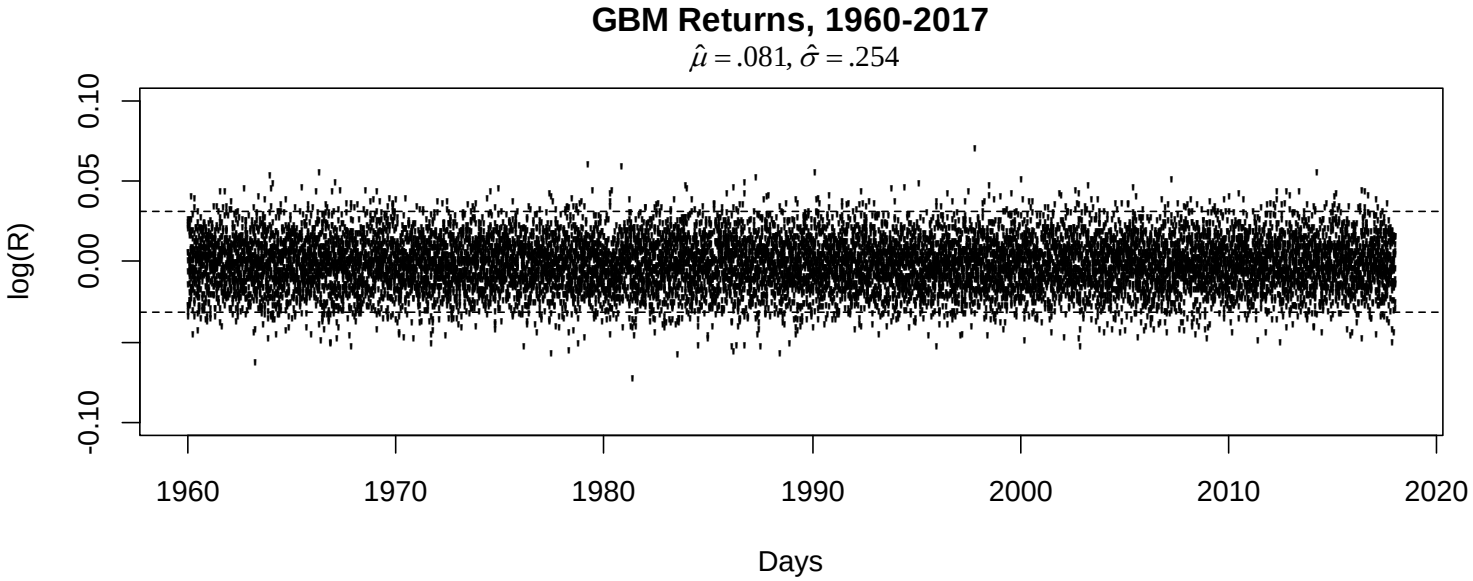
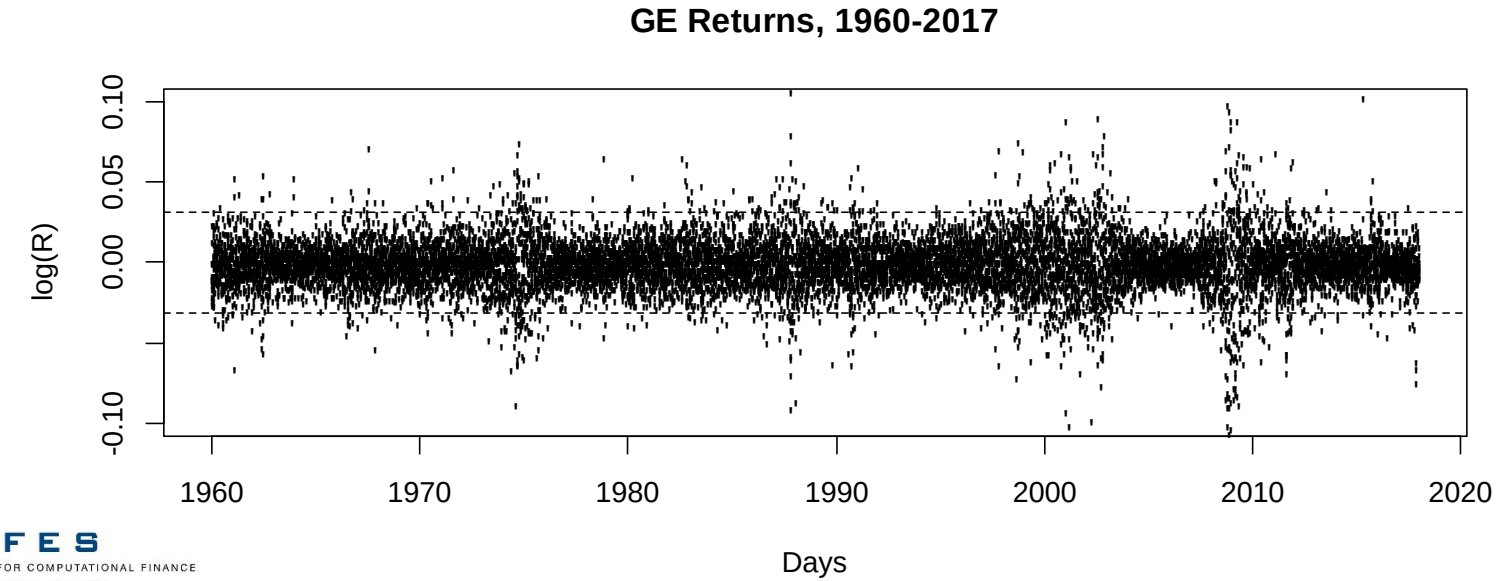
Security returns





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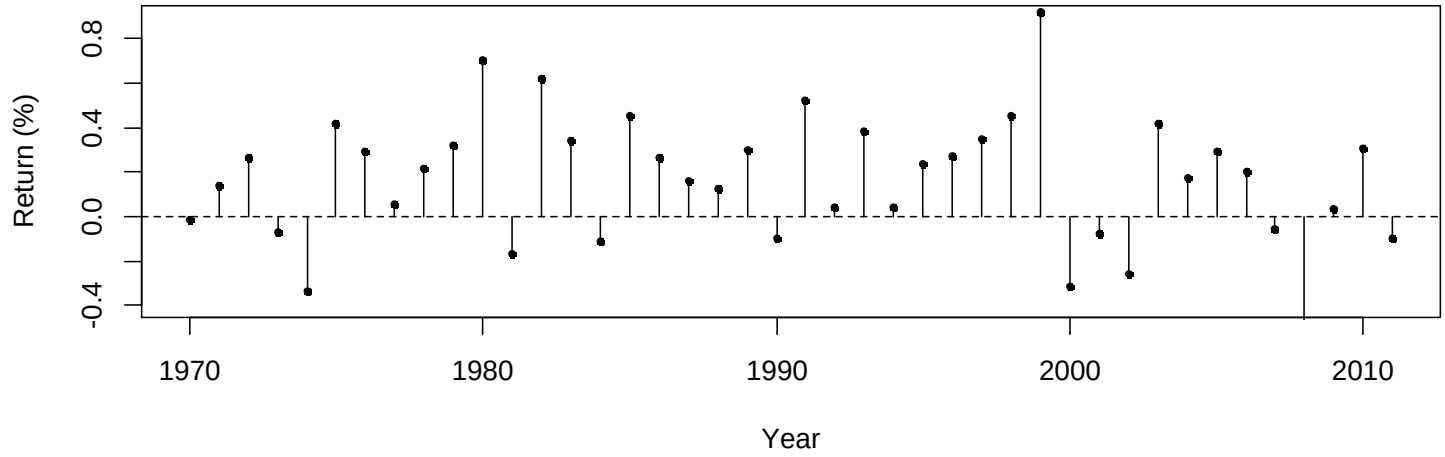
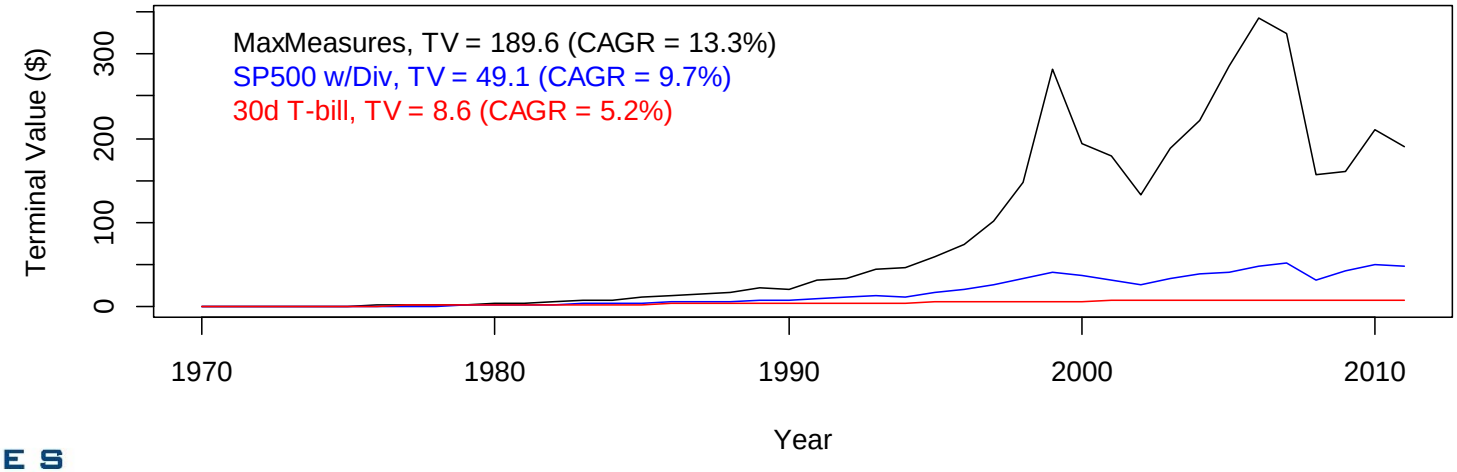
Summary Statistics

Enhanced MaxMedian Simple Return by Year



Growth of $1



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Index Benchmarks

Table 1: Compound annual growth rate (CAGR) of select major U.S. Stock Indexes. VW and EW are correspond to market-value weighted and equal-weighted, respectively. Dividends included or excluded as indicated by D or X. Source: The Center for Research in Security Prices (CRSP).

Current Date: 12/31/17

			CAGR			
Index	Begin Date	N	VWRETD	VWRETX	EWRETD	EWRETX
SP500	12/31/1925	92	0.100	0.059	0.118	0.078
NYSE	12/31/1925	92	0.098	0.057	0.123	0.081
AMEX	12/31/1962	55	0.077	0.053	0.126	0.103
NASDAQ	12/31/1972	45	0.106	0.089	0.131	0.116

2017 Returns

Table 2: One year return for major U.S. Stock Indexes for annual period ending December 31, 2017

Current Date: 12/31/17			CAGR			
Index	Begin Date	N	VWRETD	VWRETX	EWRETD	EWRETX
SP500	12/31/2016	1	0.220	0.195	0.187	0.165
NYSE	12/31/2016	1	0.177	0.148	0.148	0.113
AMEX	12/31/2016	1	0.042	0.019	0.056	0.033
NASDAQ	12/31/2016	1	0.289	0.274	0.186	0.173
	Average		0.182	0.159	0.144	0.121

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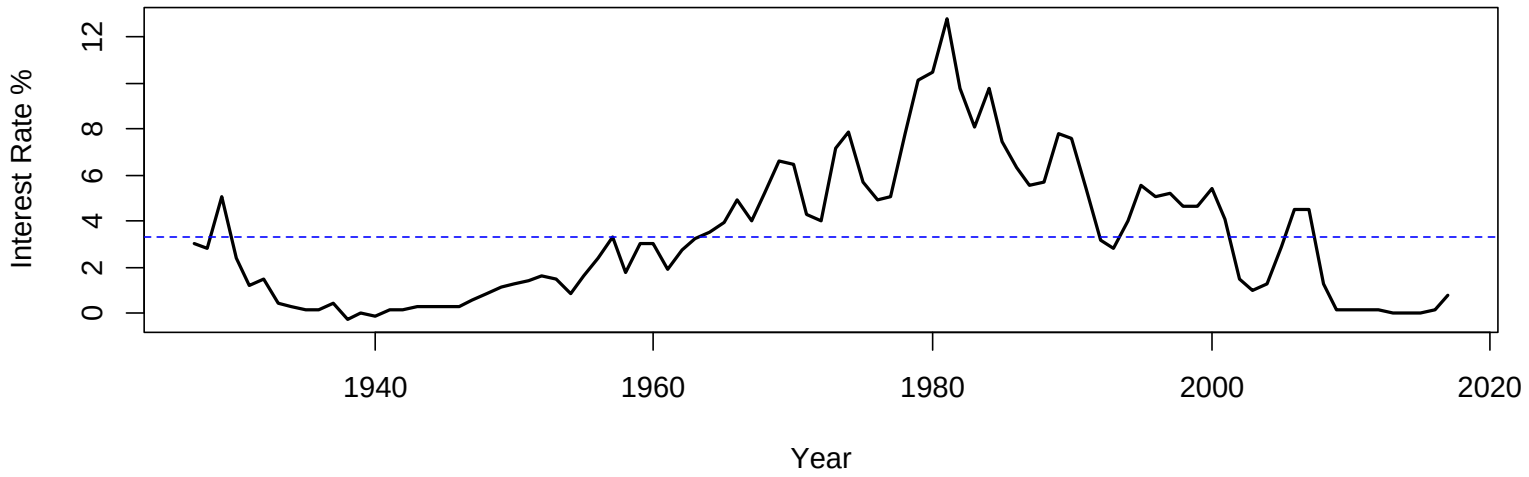
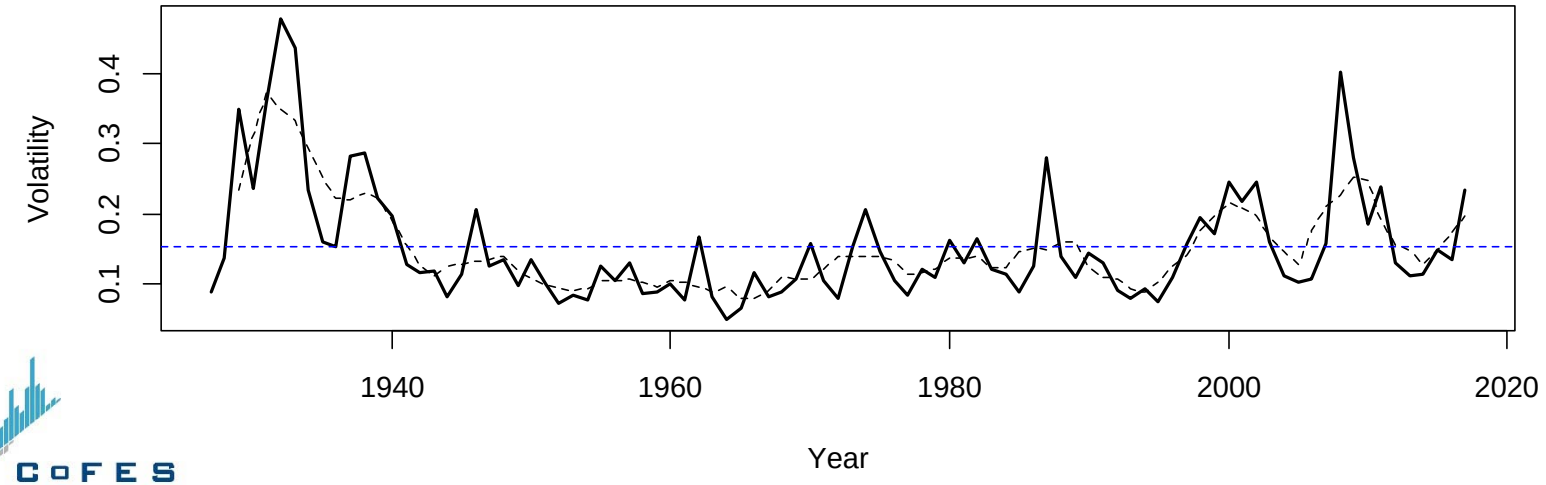
Market Parameters 1926-2017

- N=92 (2017-1926+1)
- NYSE Average annual return: 11.8%
- NYSE Compound annual growth rate (CAGR): 9.81%
- Average excess return: 8.5%
- Number of years with negative returns: 24 (26%)
- Number of years with return less than r_f: 29 (32%)
- GBM parameter estimates (.062, .174) 1896-2016
- Last Saturday trading: May 24, 1952
- Median company survival: 6.92 years

Risk Free Rate



Market Volatility



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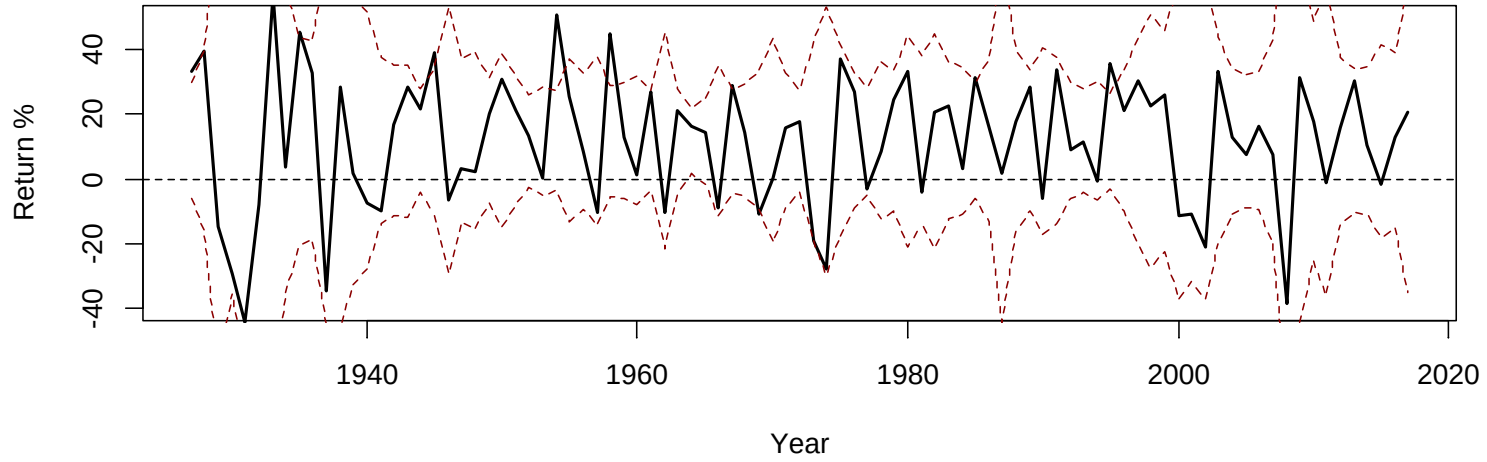
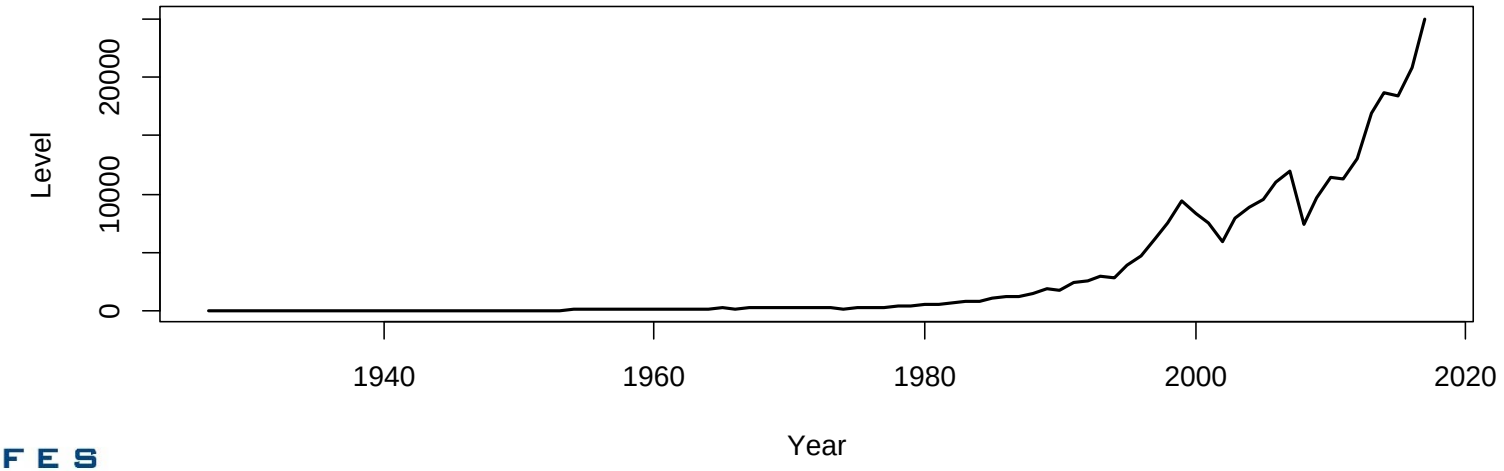
Market Returns



Representative Index Level



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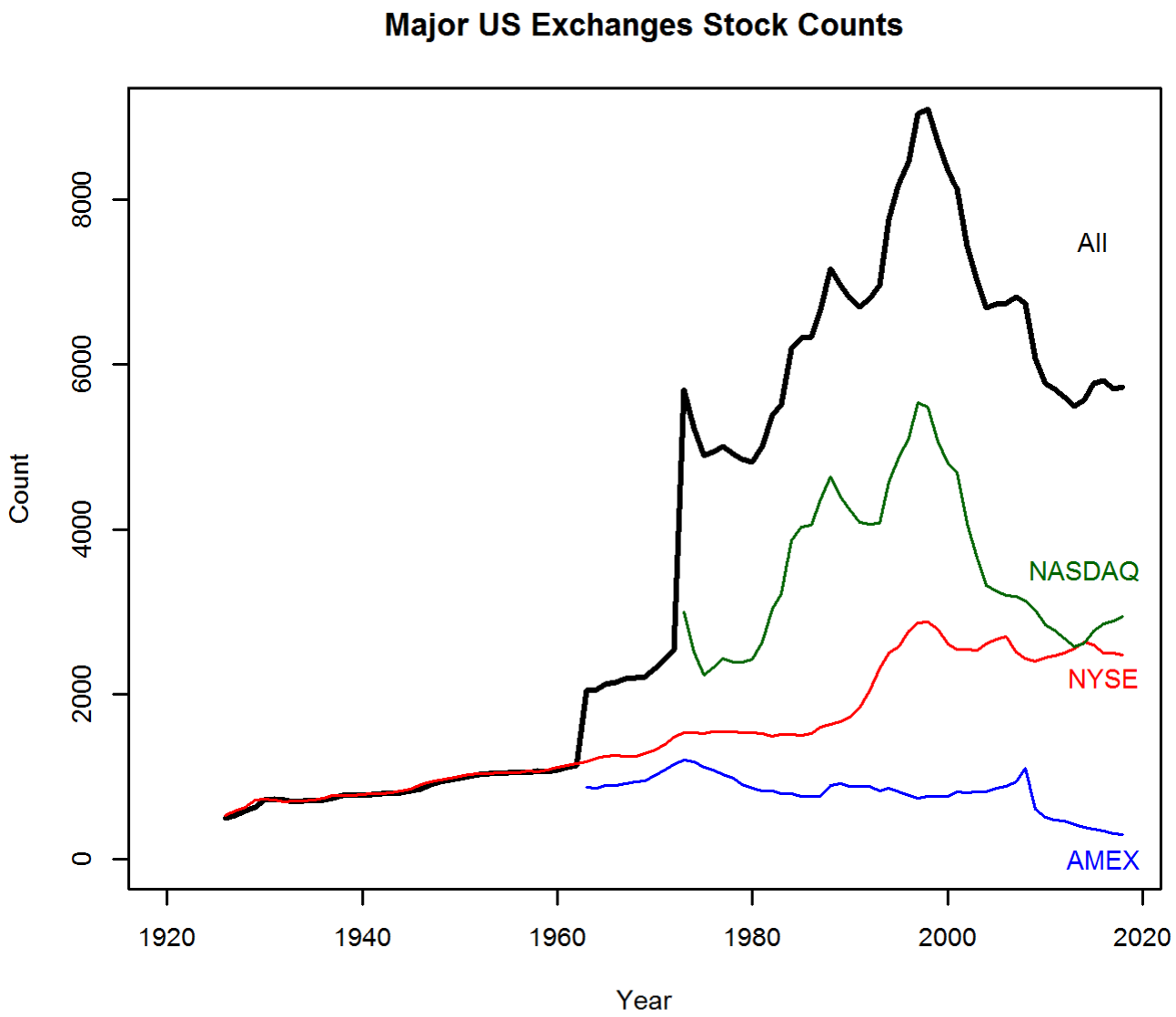
Company Counts



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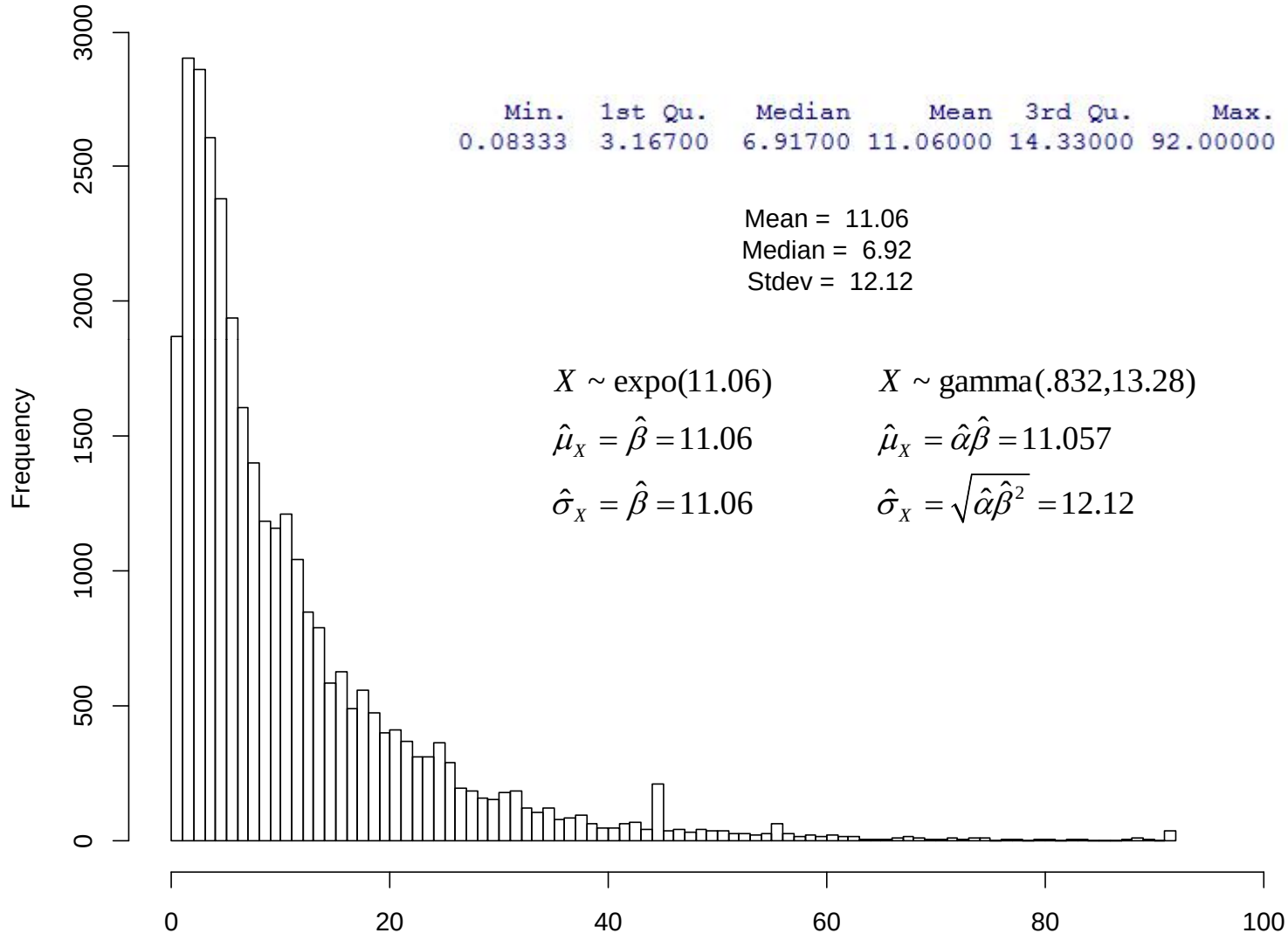
Survival of Big-Board listings

Survival of All Exchange-Traded Companies
1926-2017



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Simugram™

Portfolio Arithmetic

- *Sized portfolio* is a set of positions in a tradeable

$$\Pi = \{N_1 \cdot \text{IBM}, N_2 \cdot \text{CAT}\}$$

- Position values (in numeraire) come from total to invest (I) and the *weights*

$$P = I \cdot w = (P_1, P_2)$$

$$I = \$50{,}000 \text{ and } w = (.5,.5) \Rightarrow P = (\$25000, \$25000)$$

- N's come from each position value divided by price of each tradeable

$$(IBM, CAT) = (\$144, \$154) \Rightarrow N = (173.61, 162.34)$$

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- Value of portfolio is then sum of positions

$$P_0 = 1^T \Pi_{\$} = \$50{,}000$$

- Let return of each element at end of a period be

$$r_t = \frac{X_t}{X_{t-1}} - 1$$

- Return of the portfolio is $r_p = w^T r$
- Variance of the portfolio is

$$\sigma_p^2 = w^T \Sigma w$$

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It's all about the weights

- Random weight $w = (.3245, .212, \ldots)$
- Equal weight $w = \frac{1}{n} \cdot 1_n$

$$r_p = w^T r = \frac{1}{n} \sum_{i=1}^{n} r_i = \bar{r}$$

$$\sigma_p^2 = w^T \Sigma w = \frac{1}{n^2} \sum_{i,j} \sigma_{ij}$$

- Market capitalization weight

$$w_i = \frac{MC_i}{\Sigma MC}$$

- Non-causal (cheating)

$$w = (0,0,0,1,0,0 \ldots 0)$$

(12) **United States Patent**
Thompson

(10) **Patent No.: US 7,720,738 B2**
(45) **Date of Patent: May 18, 2010**

(54) **METHODS AND APPARATUS FOR DETERMINING A RETURN DISTRIBUTION FOR AN INVESTMENT PORTFOLIO**

(76) Inventor: **James R. Thompson**, 142 Stoney Creek, Houston, TX (US) 77024

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1945 days.

(21) Appl. No.: **10/336,173**

(22) Filed: **Jan. 3, 2003**

(65) **Prior Publication Data**

US 2004/0133490 A1 Jul. 8, 2004

(51) **Int. Cl.**
G06Q 40/00 (2006.01)

(52) **U.S. Cl.** ..... **705/36 R**; 705/35

(58) **Field of Classification Search** ..... 705/35, 705/36 R

See application file for complete search history.

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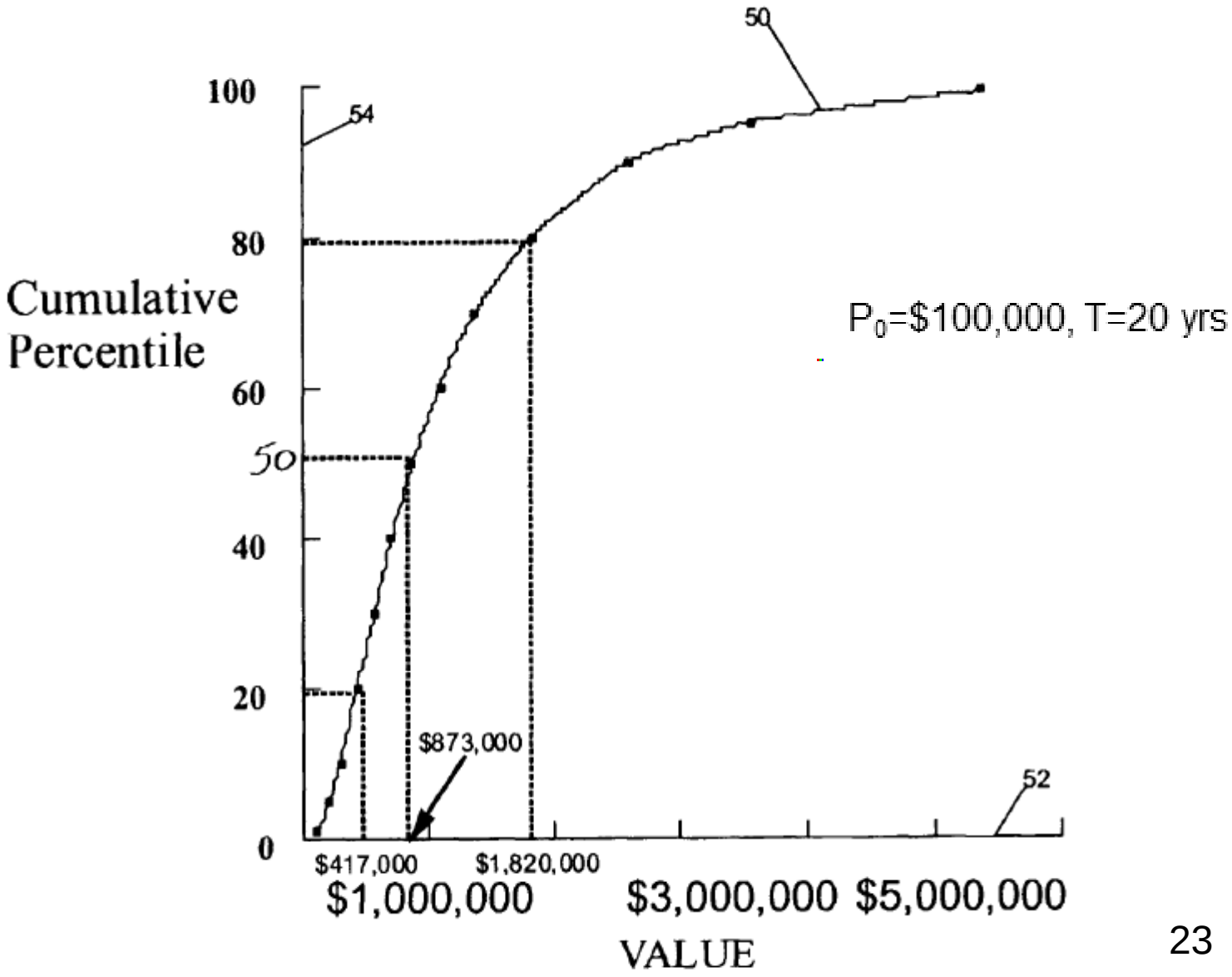
* cited by examiner

Primary Examiner—Jagdish N Patel
Assistant Examiner—Kenneth Bartley

E(Π) not that useful



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The problem

Decision variable is w

$$\text{Max } R_{T_C}(w, X, \psi)$$

s.t.

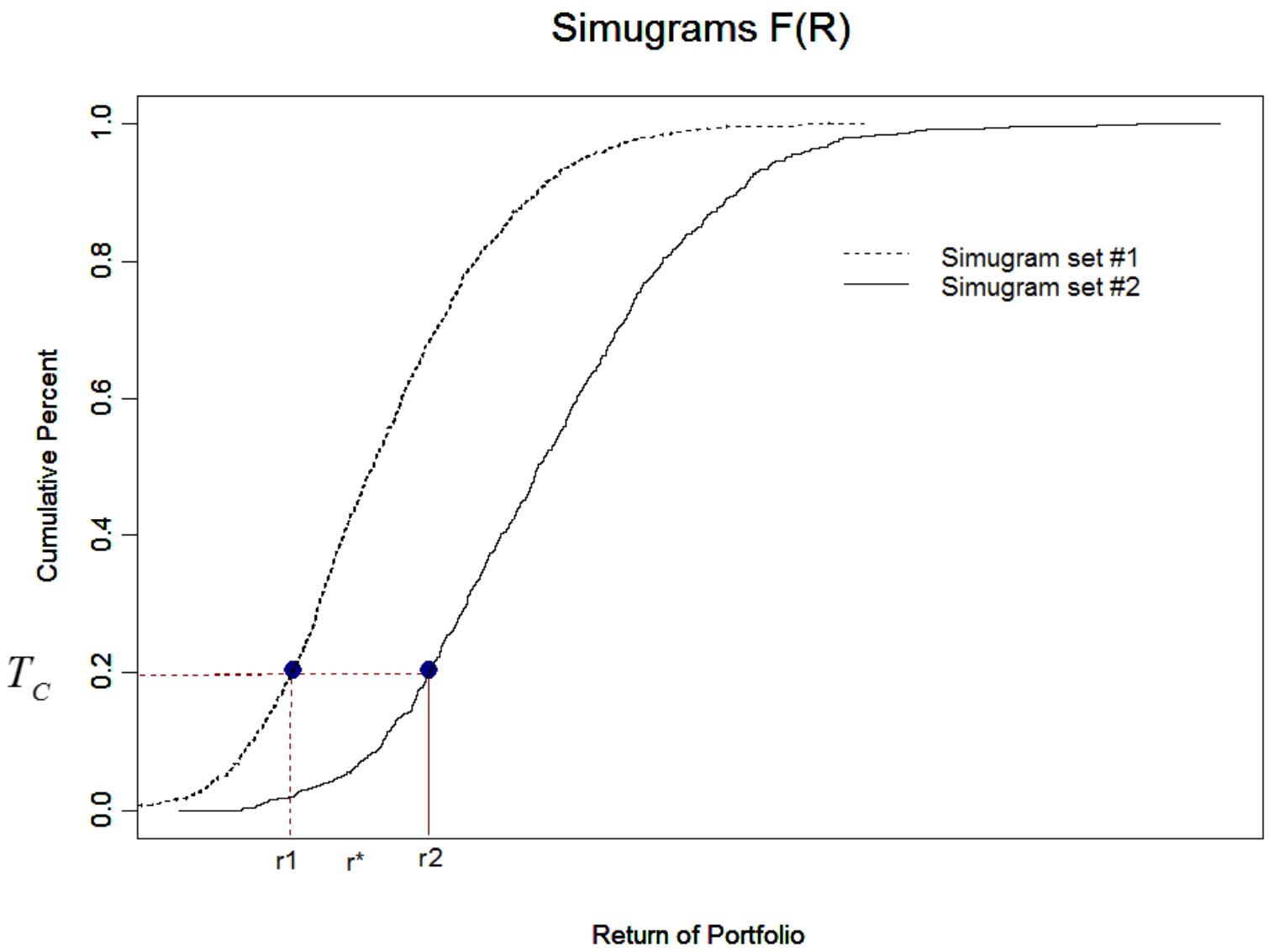
$$\psi_1 : w_T 1_k = \Sigma w = c$$

$$\psi_2 : w_i \geq L_w = 0$$

$$\psi_3 : w_i \leq U_w$$

$$\psi_{nlc} : \quad R_{T_C} \geq R^*$$

The approach



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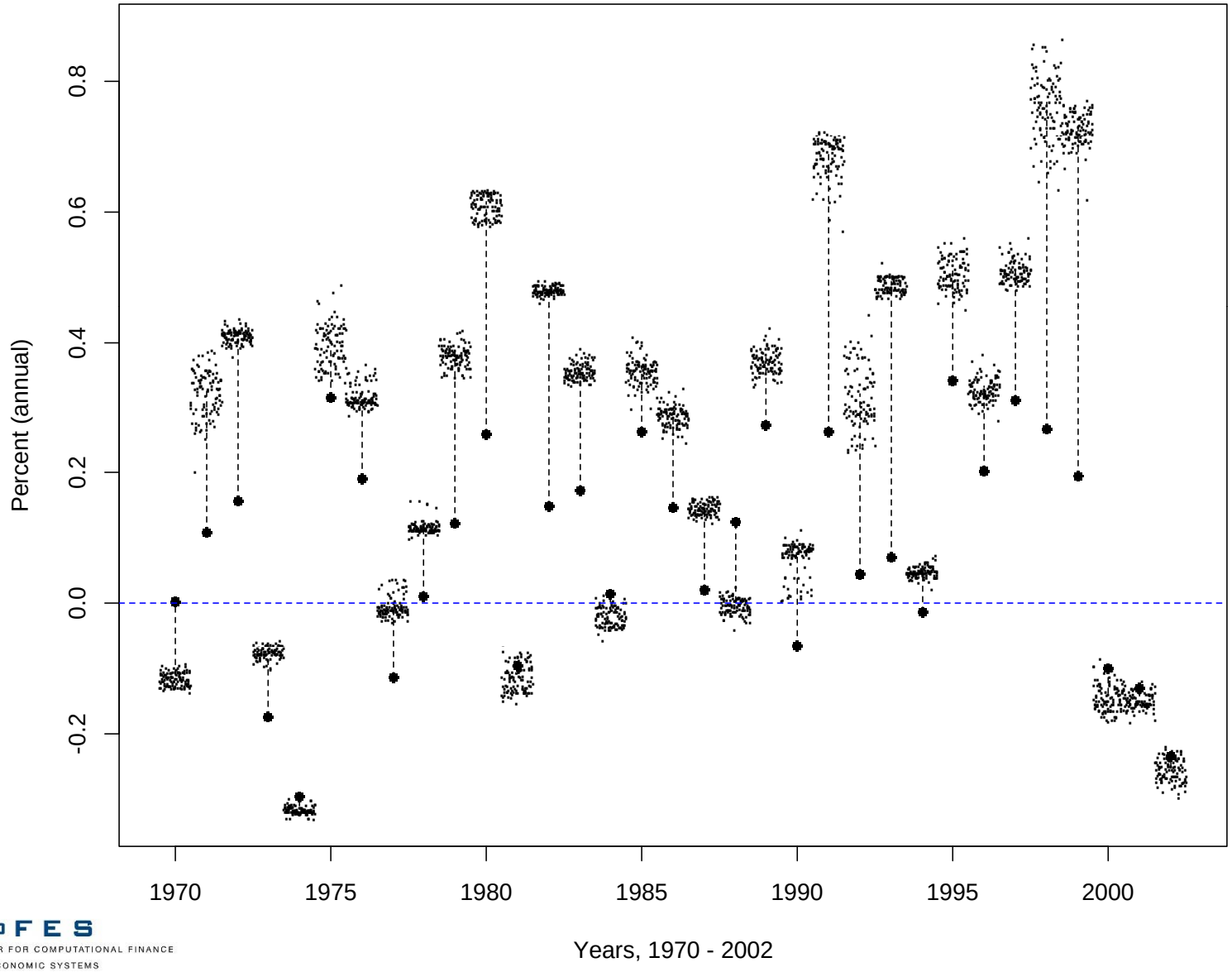
SP-100 Simugram Returns vs. SP-500



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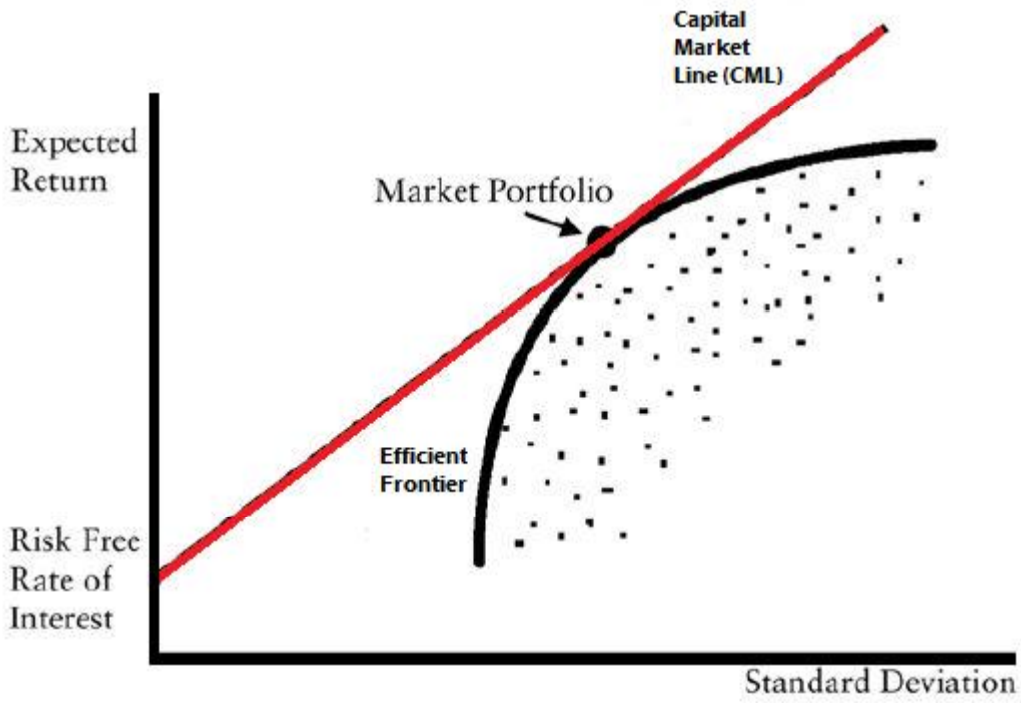
CAPM Validation


CAPM Validation



The CAPM of Sharpe (1964), Lintner (1965/Feb), Mossin (1966) and Treynor (1999)

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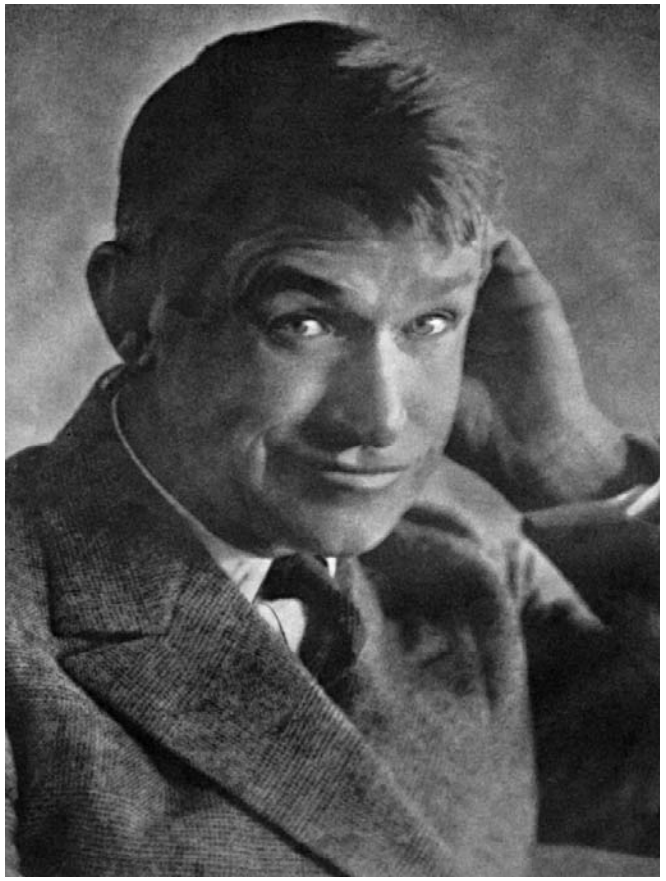
John Tukey, 1915-2000

Far better an approximate answer to the right question, which is often vague, than an exact answer to the wrong question, which can always be made precise.

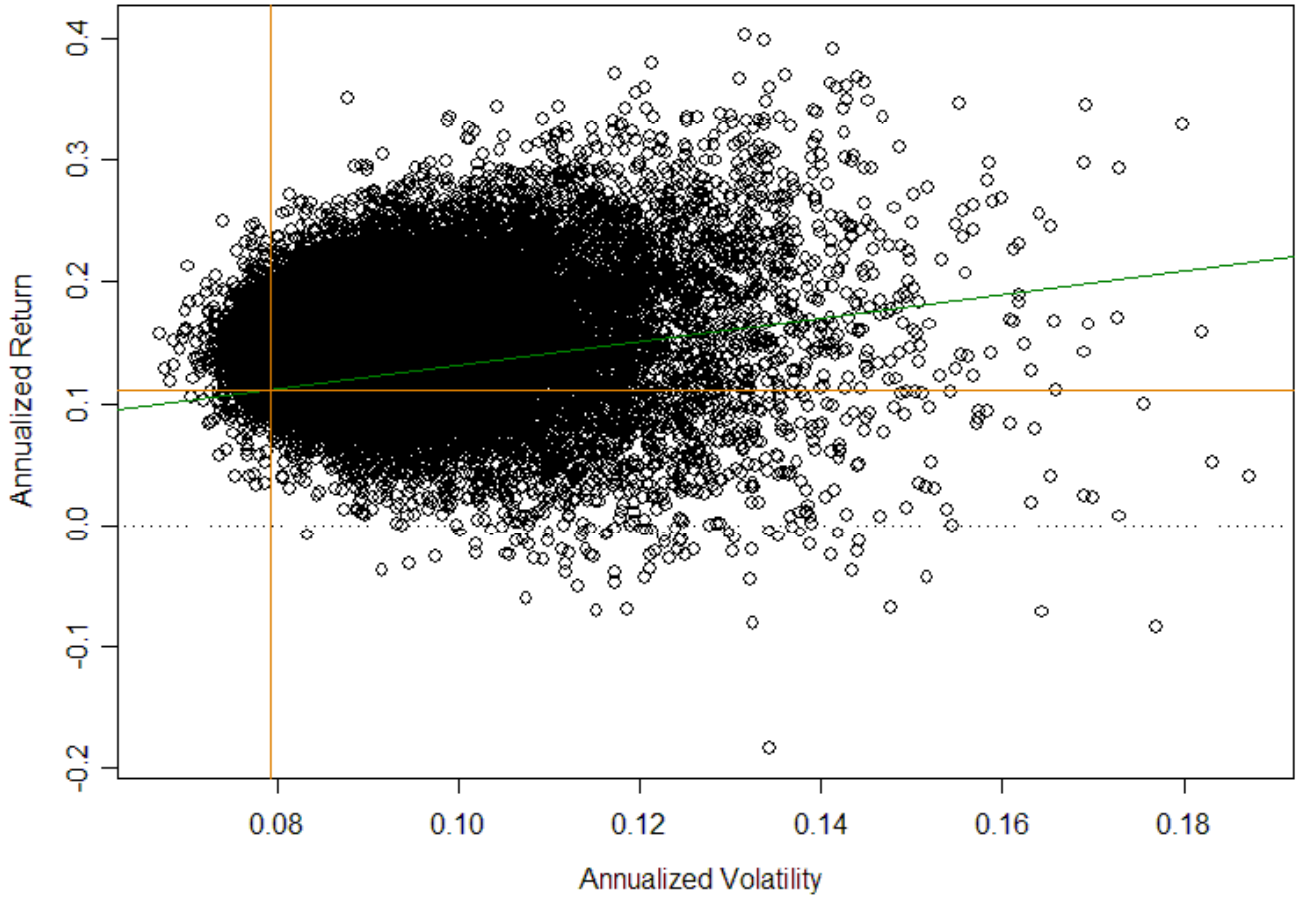


Will Rogers, 1879-1935

It isn't ignorance so much that hurts us. It's the things we know that just aren't so.

2005-2006

Orange:Market, Black:Random Portfolio, Green:CML, 1993



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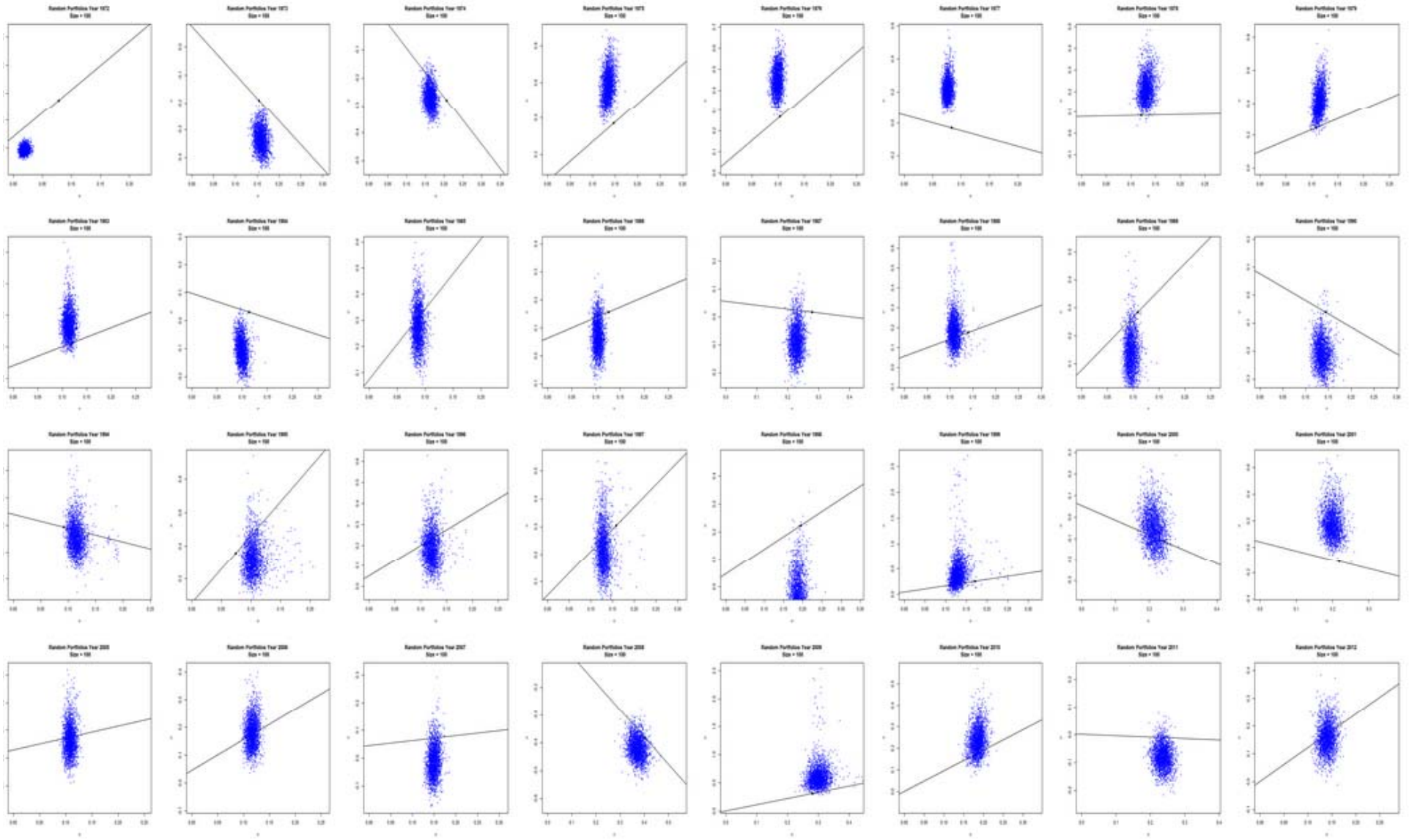
Revalidation

Portfolio N=100



“Everyman’s” Max-Median Rule

Max Median Rule

- Max-Median and Max Measures
  - Non-proprietary rule to enhance the return of ordinary investors not unwilling to do a little data crunching
  - Provide a tool easy to use without necessity of massive computing (i.e., using Excel or R)
  - MaxMedian portfolio results **meet or exceed** the equal-weighted SP500 benchmark performance with only 20 stocks.

Current Date:		12/31/17		CAGR		
CRSP	Begin Dates	N	vwretd	vwretx	ewretd	ewretx
SP500	12/31/1925	92	0.100	0.059	0.118	0.078
NYSE	12/31/1925	92	0.098	0.057	0.123	0.081
AMEX	12/31/1962	55	0.077	0.053	0.126	0.103
NASDAQ	12/31/1972	45	0.106	0.089	0.131	0.116

Max Median Pedigree

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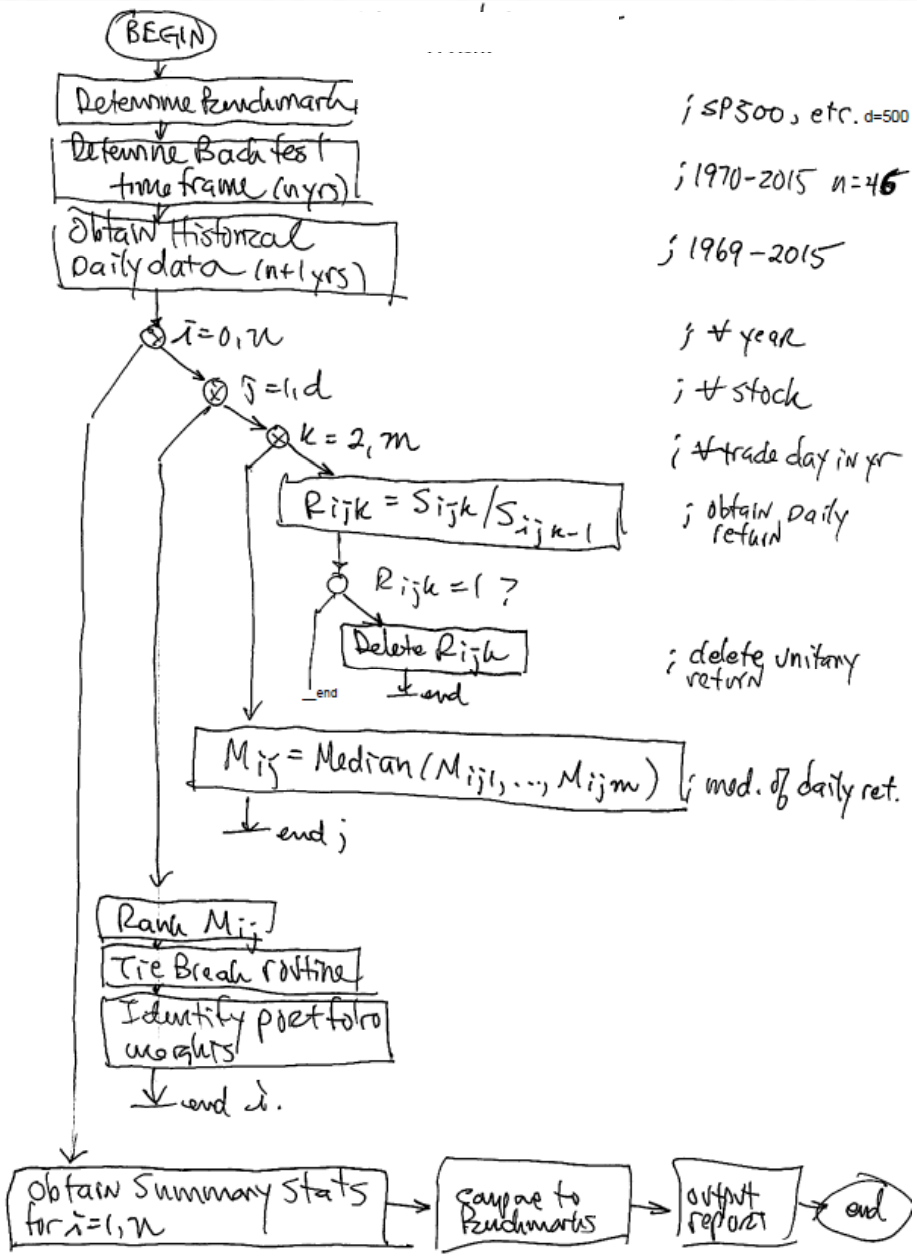
Concept

1. Collect the previous year's daily returns r(i,j) for all stocks in the S&P 500 at the time of portfolio formation.

2. Each year, calculate the 500 yearly median values for r(j,t)

3. Invest equally in the 20 stocks with the highest median returns.

4. Hold for one year (and one day), then liquidate.



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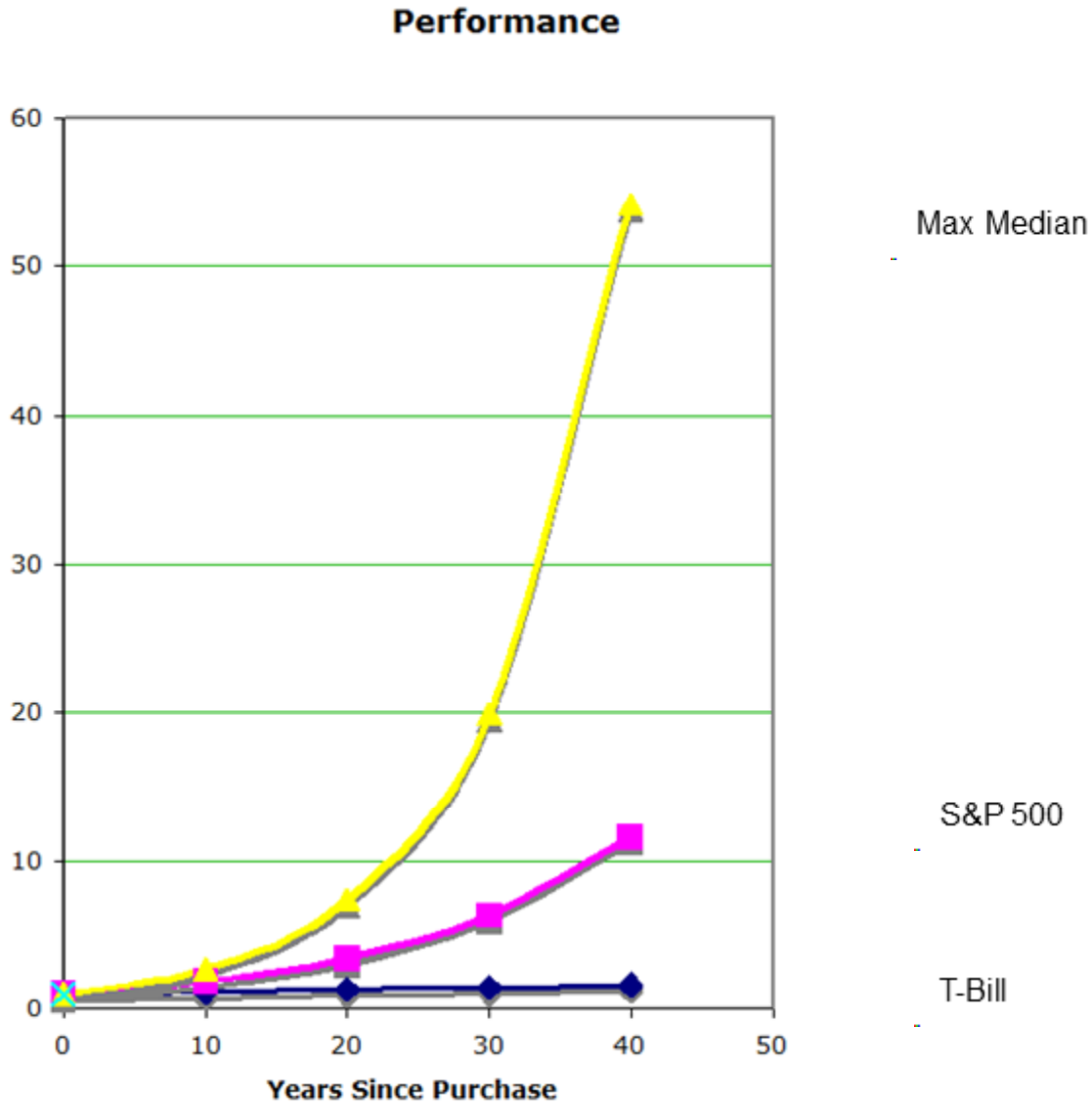
In real terms and w/taxes



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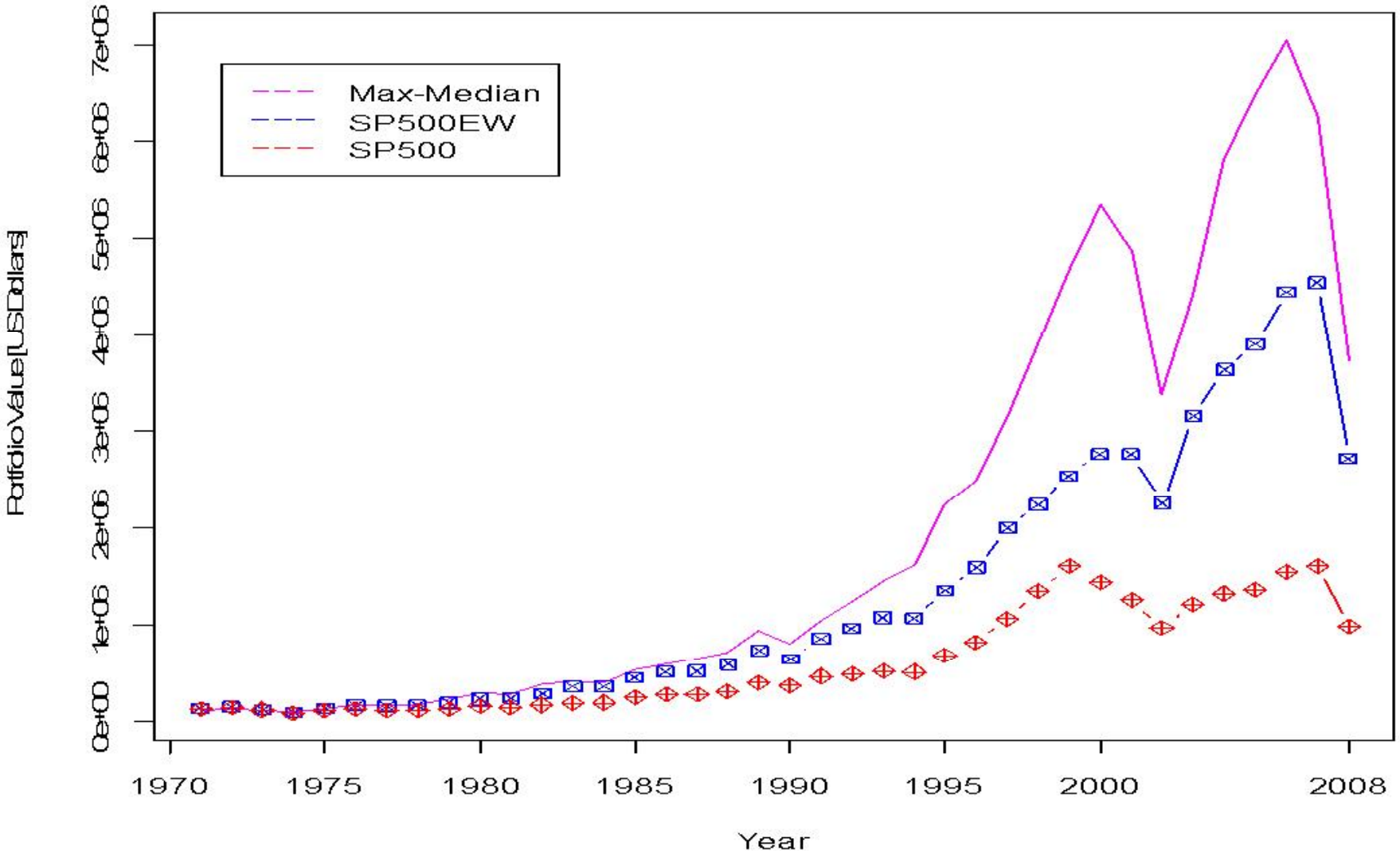
Affinito - 2008



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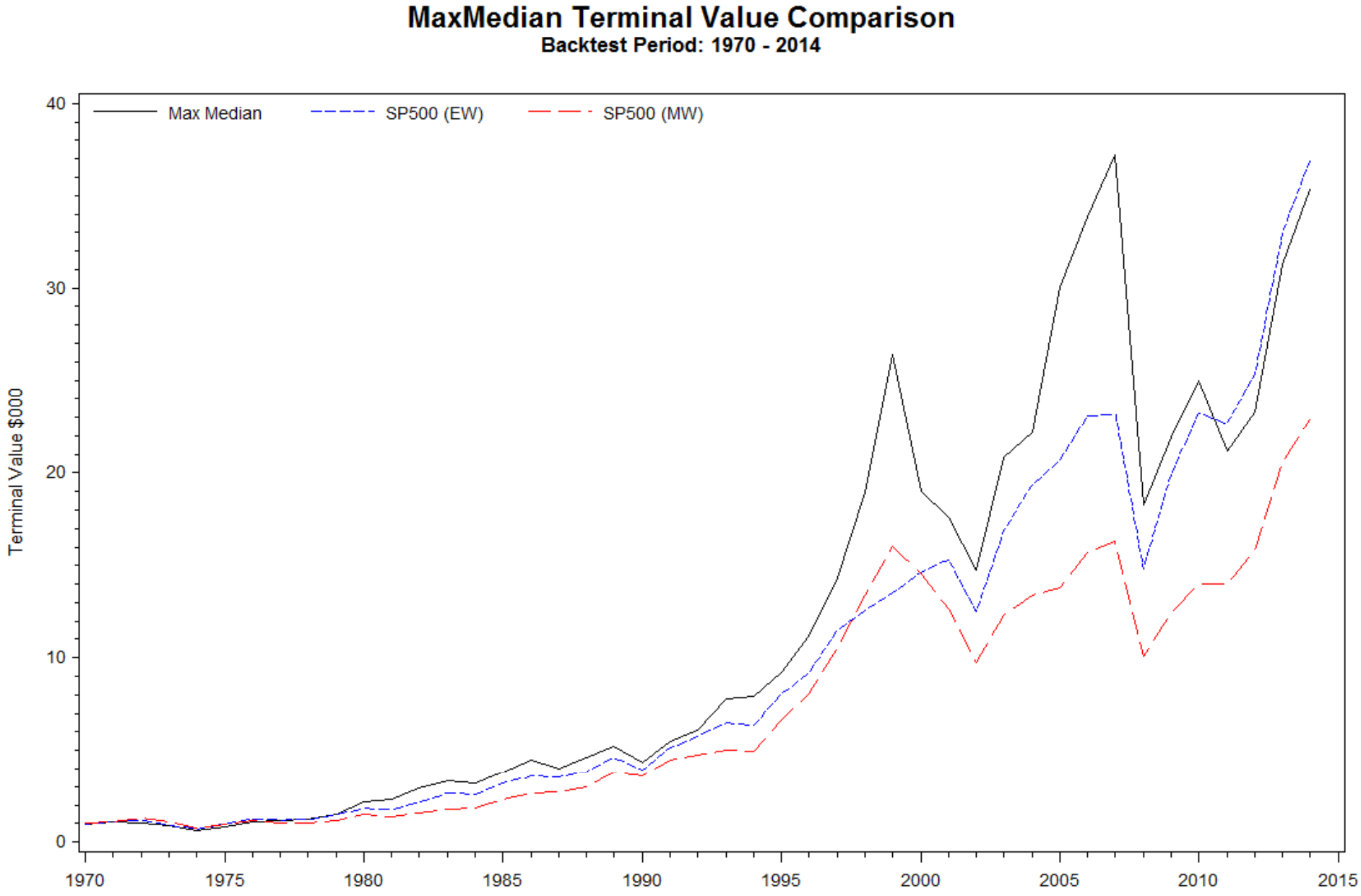
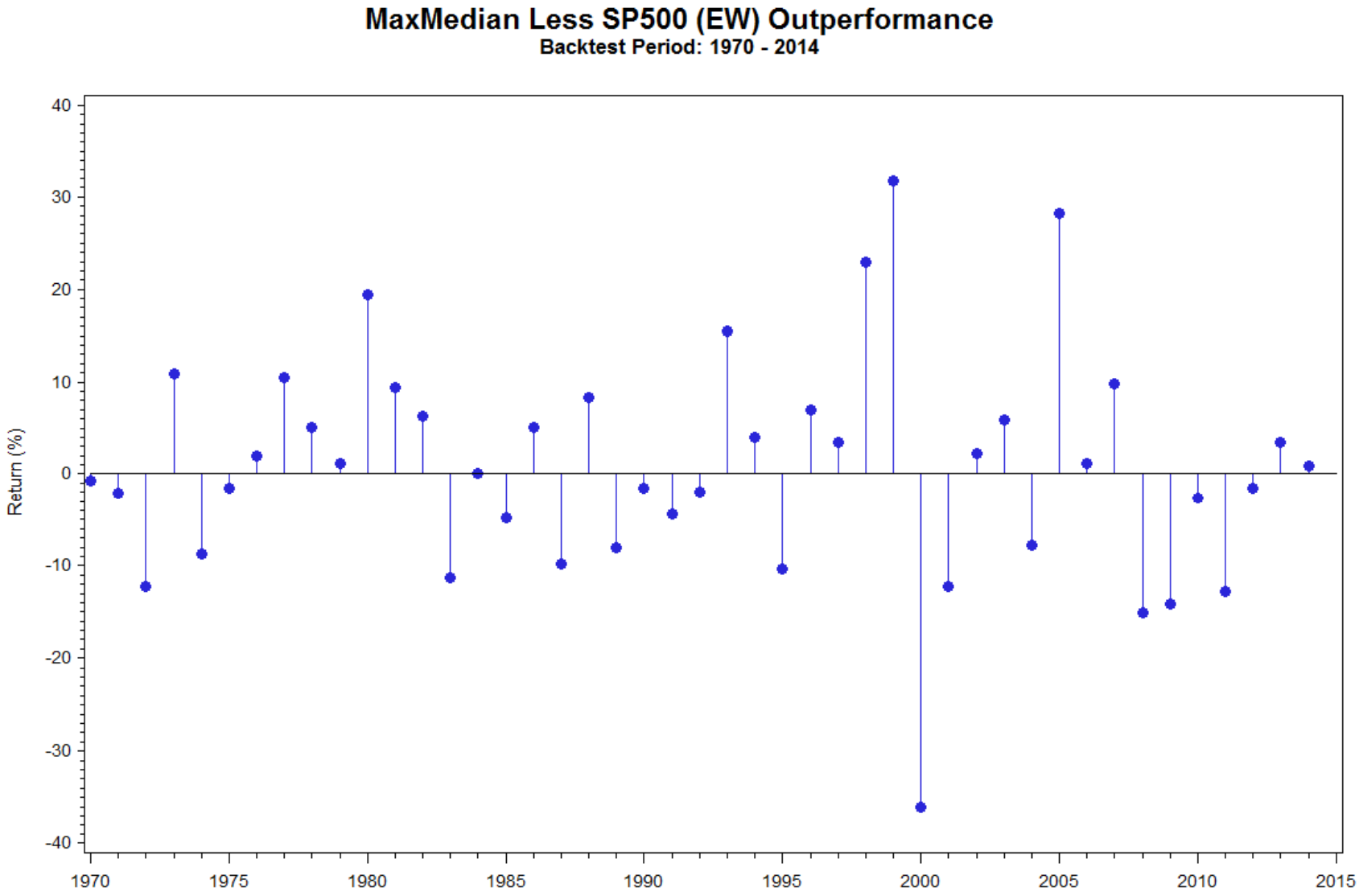
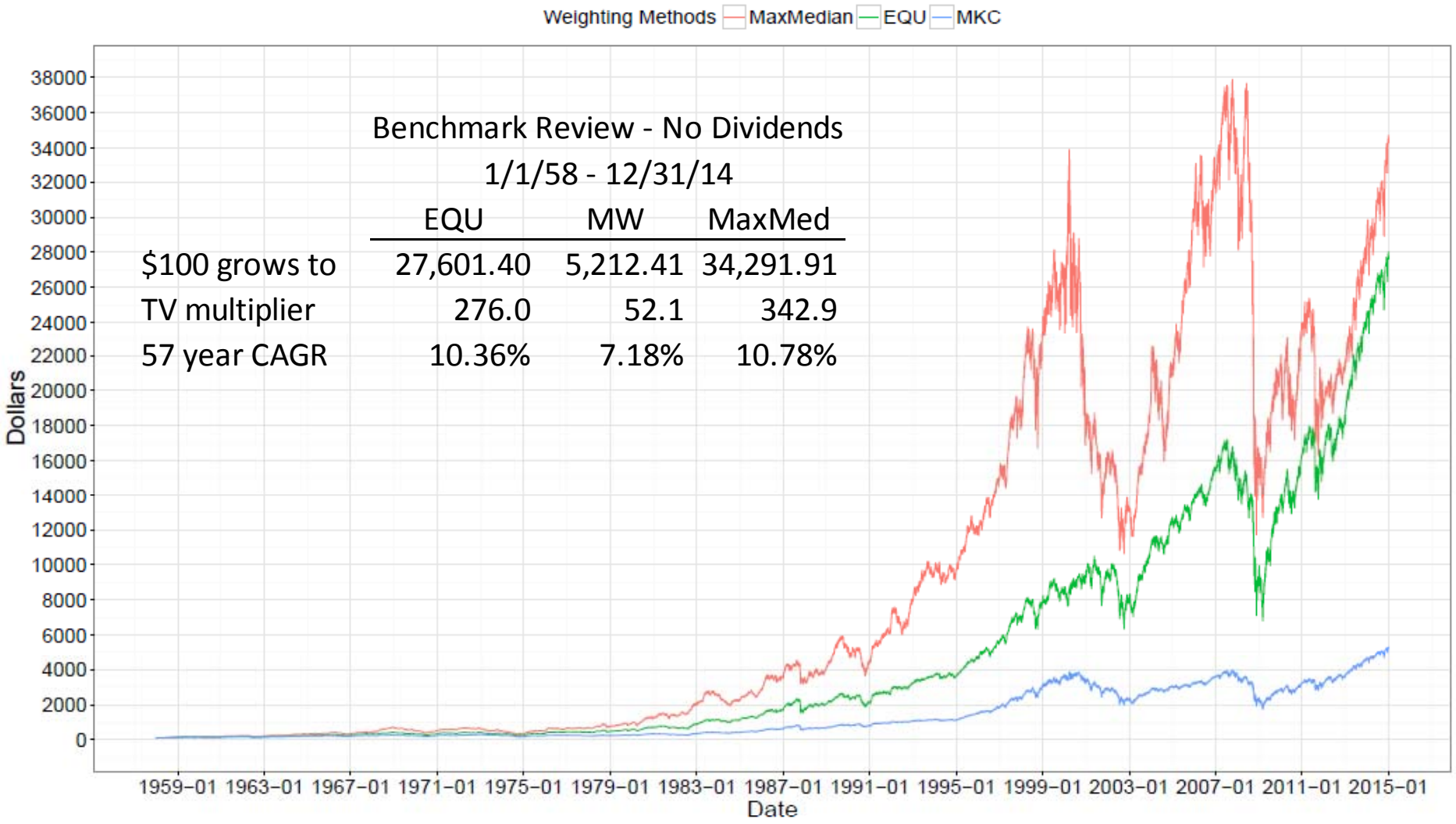

MaxMedian Terminal Value Comparison
Backtest Period: 1970 - 2014
Max Median
SP500 (EW)
SP500 (MW)
Terminal Value $000
40
30
20
10
0
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015

Difference Plot



Ernst, Thompson, Miao 58-14



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Max Measures

- Sarah M. Tooth (2012) d. 10/30/14
- Provides important extensions to basic Max Median methodology
  - Percentiles
    - Self explanatory
  - Power means

$$\text{For } x_i > 0 \,\forall i \text{ and } p \in \mathbb{R}$$

$$M_p(x) = \left(\frac{1}{N} \sum_1^N x_i^p \right)^{1/p}$$

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Power Means

- Named special cases of power means

Minimum	$\lim_{p \to -\infty}$
Harmonic mean	$p = -1$
Geometric mean	$\lim_{p \to 0}$
Arithmetic mean	$p = 1$
Quadratic mean (RMS)	$p = 2$
Maximum	$\lim_{p \to \infty}$

Implemented *p*'s

- Uses geometric sequence of *p*'s to better judge impact on ranking strategies

Positive p									
Value	$10^{-\frac{4}{4}}$	$10^{-\frac{3}{4}}$	$10^{-\frac{2}{4}}$	$10^{-\frac{1}{4}}$	$10^{\frac{0}{4}}$	$10^{\frac{1}{4}}$	$10^{\frac{2}{4}}$	$10^{\frac{3}{4}}$	$10^{\frac{4}{4}}$
Approx.	0.1	0.2	0.3	0.6	1	1.8	3.2	5.6	10
Negative p									
Value	$-10^{-\frac{4}{4}}$	$-10^{-\frac{3}{4}}$	$-10^{-\frac{2}{4}}$	$-10^{-\frac{1}{4}}$	$-10^{\frac{0}{4}}$	$-10^{\frac{1}{4}}$	$-10^{\frac{2}{4}}$	$-10^{\frac{3}{4}}$	$-10^{\frac{4}{4}}$
Approx.	- 0.1	-0.2	-0.3	-0.6	-1	-1.8	-3.2	-5.6	-10
Limits of p									
$p \to$	$-\infty$		0		∞				
Limit	$\min x$		$(\prod_i^n x_i)^{1/n}$		$\max x$				

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Results

- Benchmarks 1970-2011

	Overall	1970s	1980s	1990s	2000s
With Dividends					
Value Weighted S&P500	9.90	5.83	17.60	18.36	-0.69
Equal Weighted S&P500	12.40	8.91	19.97	15.54	6.02
Mean Return	12.66	10.18	18.70	16.02	6.53
Without Dividends					
Value Weighted S&P500	6.49	1.57	12.54	15.49	-2.51
Equal Weighted S&P500	9.10	4.50	15.41	12.88	4.20

System results

		CAGR	Mean	Med	σ	σ_i
S&P500		9.90	11.43	14.90	17.72	
Percentile						
	0.05	12.33	13.47	14.82	15.82	15.81
	0.25	12.58	13.80	14.97	16.12	18.02
→	0.50	12.67	15.50	18.21	23.61	35.01
	0.75	10.17	16.41	18.88	35.40	51.45
	0.95	11.54	18.42	17.50	40.53	56.32
Power						
	-10.0	14.63	16.53	19.69	20.54	25.09
HM	-1.0	14.44	17.88	18.65	27.83	36.11
GM	0.0	13.43	17.29	21.12	29.06	38.67
AM	1.0	12.99	16.92	21.32	28.73	40.58
	10.0	11.94	18.67	18.99	39.66	53.68

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(Real) risk

	Average	Max	Total	TNY	MNY
S&P500	-17.38	-38.44	-104.30	6	2
Percentile					
0.05	-12.59	-24.26	-75.56	6	2
0.25	-10.27	-29.06	-82.14	8	2
0.50	-18.38	-54.69	-183.78	10	3
0.75	-26.29	-63.96	-315.53	12	3
0.95	-23.30	-62.36	-302.96	13	3
Power					
-10	-9.94	-37.16	-99.45	10	3
-1	-15.55	-46.91	-186.57	12	3
0	-17.76	-51.89	-213.15	12	3
1	-19.65	-53.03	-235.77	12	3
10	-28.75	-62.62	-287.49	10	3

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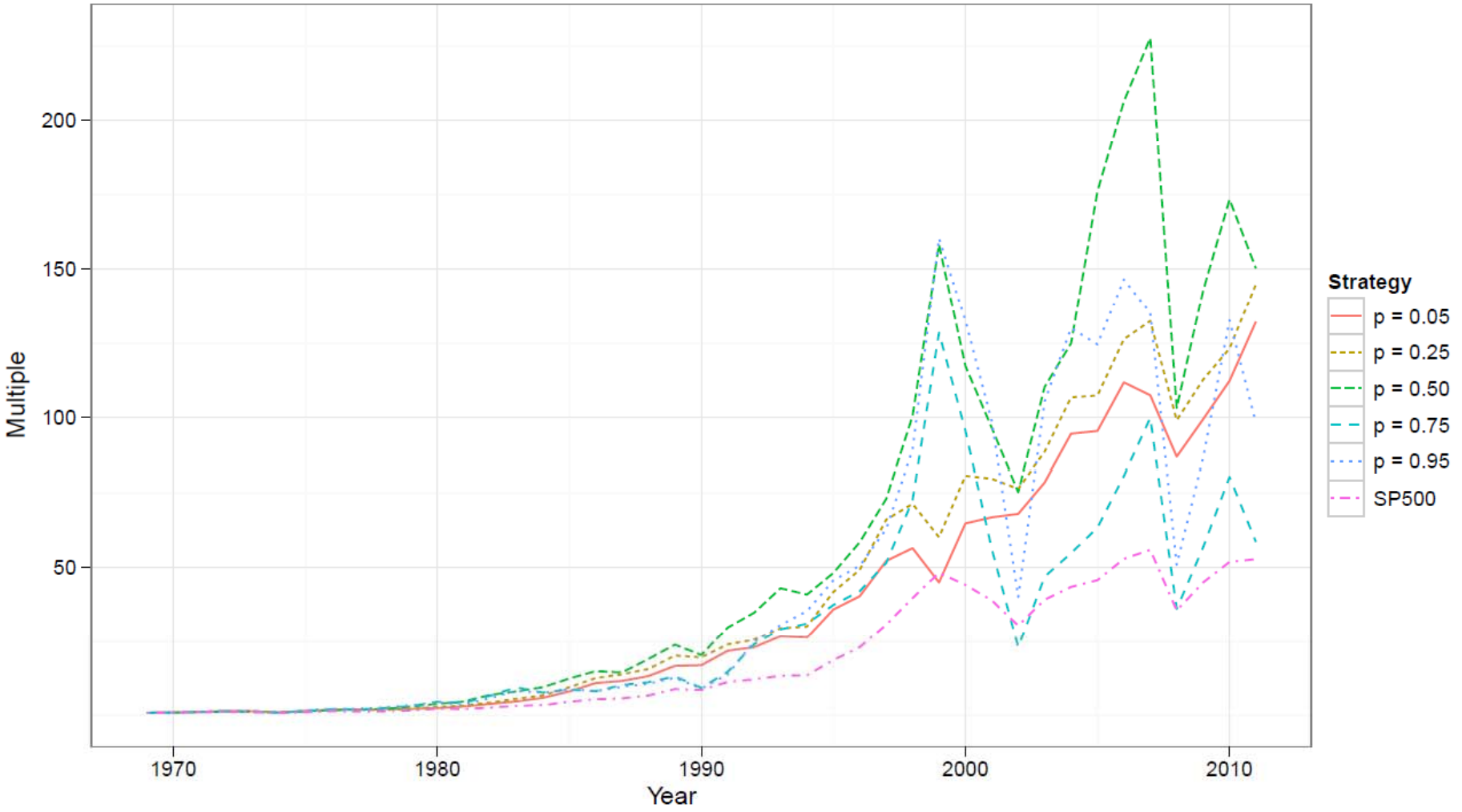
Tooth - 2012



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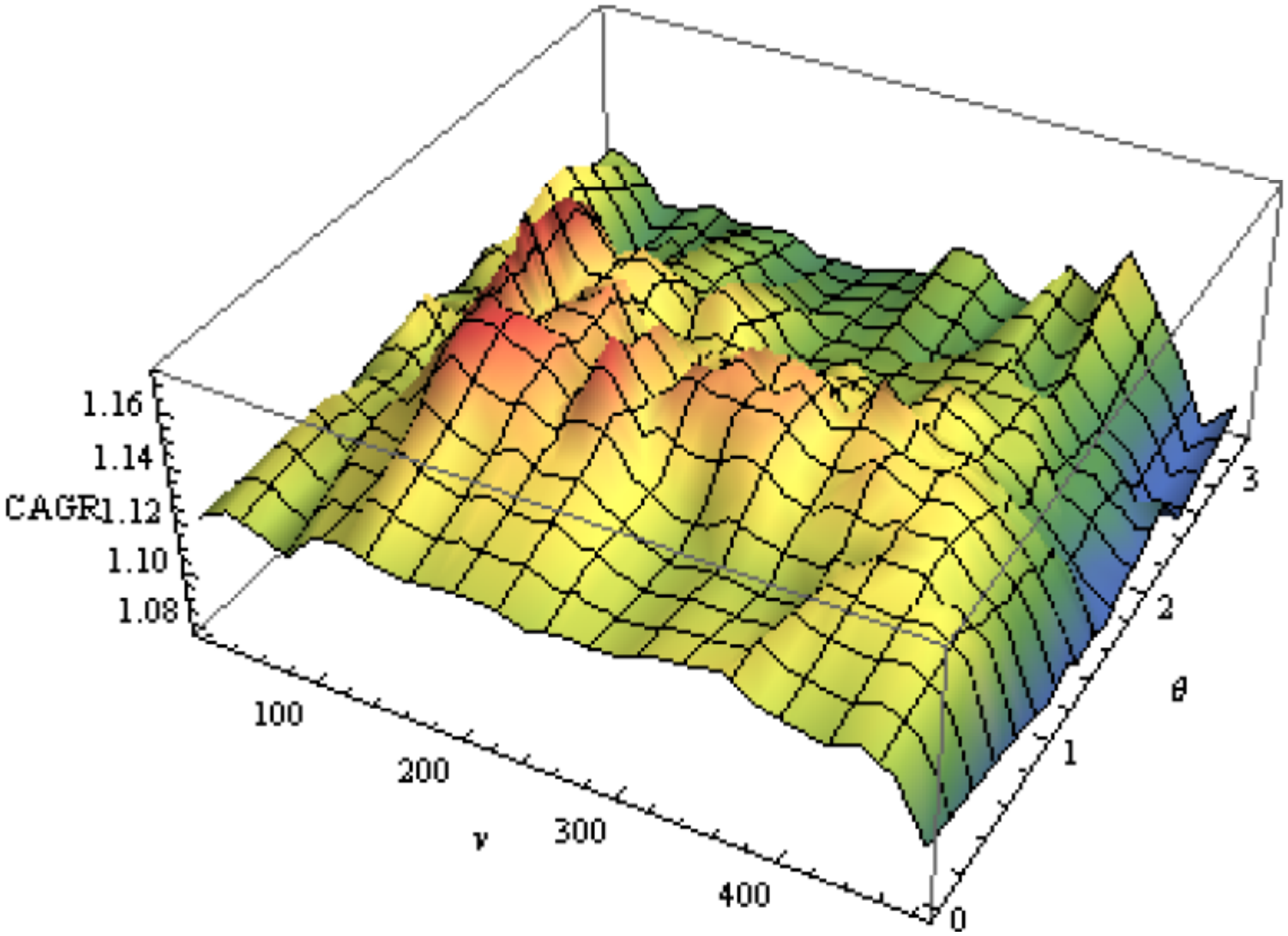
Mode searching



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Tukey Transformational Ladder

- John Tukey's transformational ladder of powers (FDA 1962, EDA 1970/1977)
- Let *X* be the Market Cap of a stock

$$\text{Market Cap} = \text{Price per share} \times \text{Shares outstanding}$$

- Tukey weights for each of N stocks would then be

$$w_i = \frac{T(x_i)}{\Sigma T(x_i)}$$

- The ladder is

$$1/x^2 \quad 1/x \quad 1/\sqrt{x} \quad \ln(x) \quad 1/n \quad \sqrt{x} \quad x \quad x^2$$

- Suppose 3 stocks market cap ($B) are (400,100,10)

$$w_i = \frac{T(x_i)}{\Sigma T(x_i)}$$

$1/x^2$	$w = (0.000618, 0.009895, 0.989487)$	
$1/x$	$w = (0.022222, 0.088889, 0.888889)$	
$1/\sqrt{x}$	$w = (0.107244, 0.214487, 0.678269)$	
$\ln(x)$	$w = (0.464483, 0.357012, 0.178506)$	
$1/n$	$w = (0.333333, 0.333333, 0.333333)$	EW
$\sqrt{x}$	$w = (0.603095, 0.301547, 0.095358)$	
x	$w = (0.784314, 0.196078, 0.019608)$	MW
x^2	$w = (0.940623, 0.058789, 0.000588)$	

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- CAGR's (including dividends and frictions)

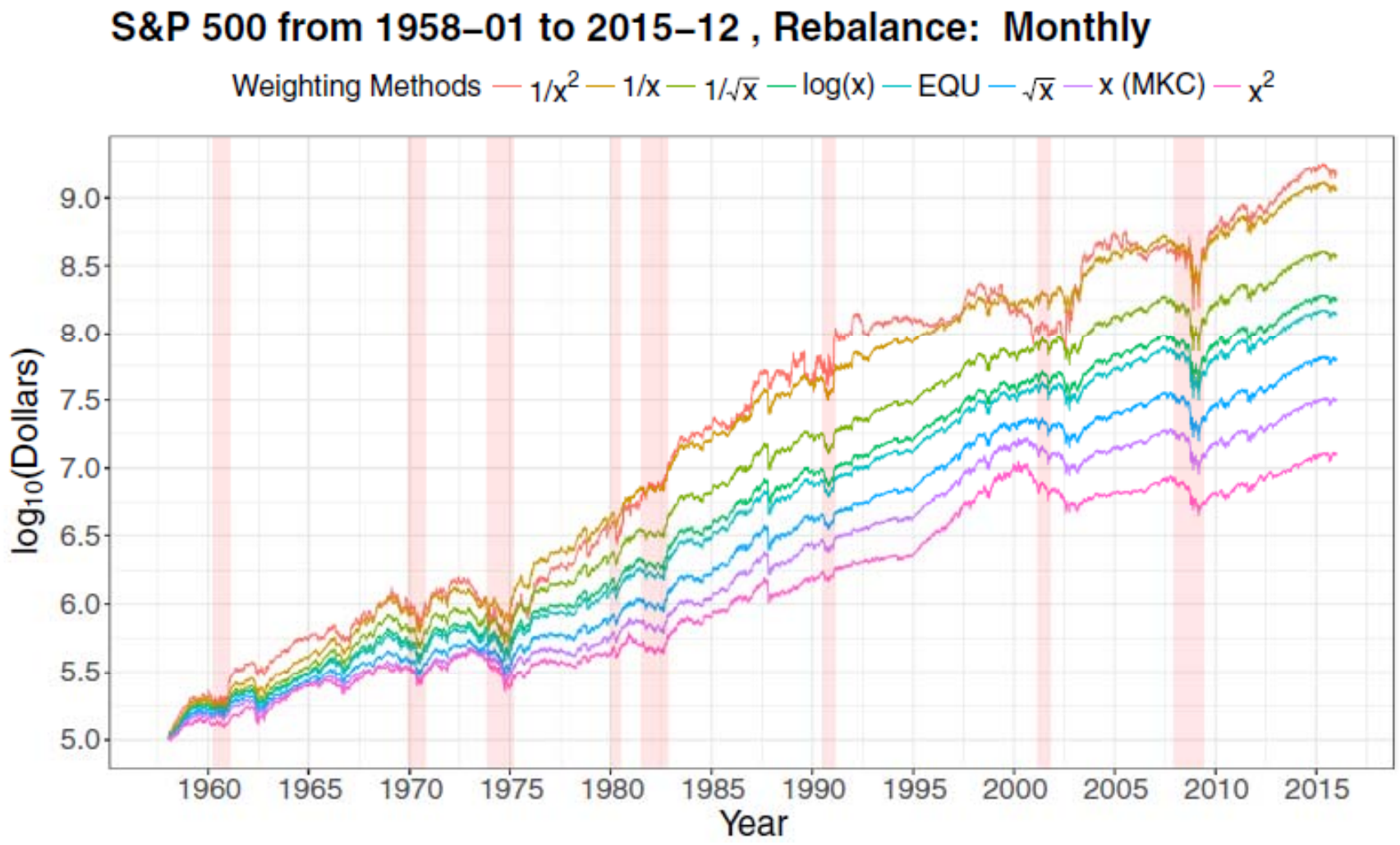
$1/x^2$	$1/x$	$1/\sqrt{x}$	$\log(x)$	EQU	$\sqrt{x}$	MKC	x^2
18.00%	17.53%	15.23%	13.80%	13.32%	11.73%	10.43%	8.69%

- Portfolio standard deviation

$1/x^2$	$1/x$	$1/\sqrt{x}$	$\log(x)$	EQU	$\sqrt{x}$	MKC	x^2
39.54%	26.44%	22.29%	20.01%	19.30%	17.52%	16.98%	18.05%

- Sharpe ratios

$1/x^2$	$1/x$	$1/\sqrt{x}$	$\log(x)$	EQU	$\sqrt{x}$	MKC	x^2
56.07%	70.35%	70.21%	69.31%	68.81%	65.24%	59.25%	47.09%



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- Terminal values of $1 compounded at the CAGR's over 58 years:

$1/x^2$	$TV = 14,762$	
$1/x$	$TV = 11,712$	
$1/\sqrt{x}$	$TV = 3,722$	
$\ln(x)$	$TV = 1,804$	
$1/n$	$TV = 1,412$	EW
$\sqrt{x}$	$TV = 622$	
x	$TV = 315$	MW
x^2	$TV = 125$	

James Robert Thompson

MathSciNet

Ph.D. Princeton University 1965 

Dissertation: *A Shrinking Technique for Modifying Minimum Variance Unbiased Linear Estimators*

Advisor: John Wilder Tukey

Students:

Name	School	Year	Descendants
Bennet, John		1973	
de Montricher, Gilbert	Rice University	1973	
Bennett, John	Rice University	1974	
Hokanson, James	University of Texas at Houston	1975	
Scott, David	Rice University	1976	23
Smith, Melvyn	Rice University	1980	
Atkinson, Neely	Rice University	1981	
Boswell, Steven	Rice University	1983	
Hathaway, Richard	Rice University	1983	
Sanchez, Rolando	Rice University	1990	
West, Ronald	Rice University	1994	4
Elliott, Mark	Rice University	1995	
Overley, Mark	Rice University	1995	
Lawera, Martin	Rice University	1999	
Schwalb, III, Otto	Rice University	1999	
Miller, John	Rice University	2003	
Dobelman, John	Rice University	2004	
Affinito, Ricardo	Rice University	2013	

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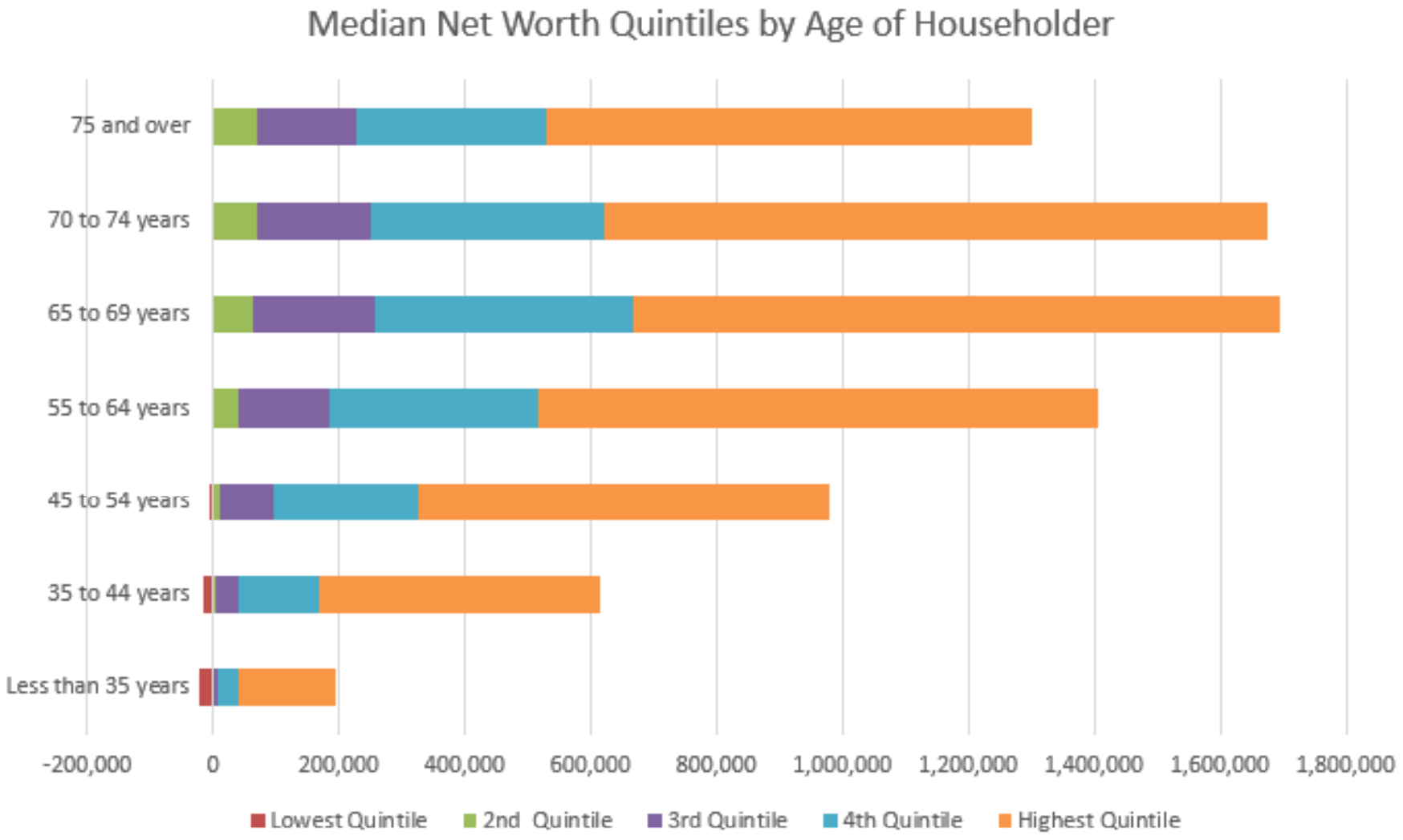
According to our current on-line database, James Thompson has 17 students and 45 descendants.
We welcome any additional information.



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Thank you Jim
(and Kathy)

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