William F. Sharpe
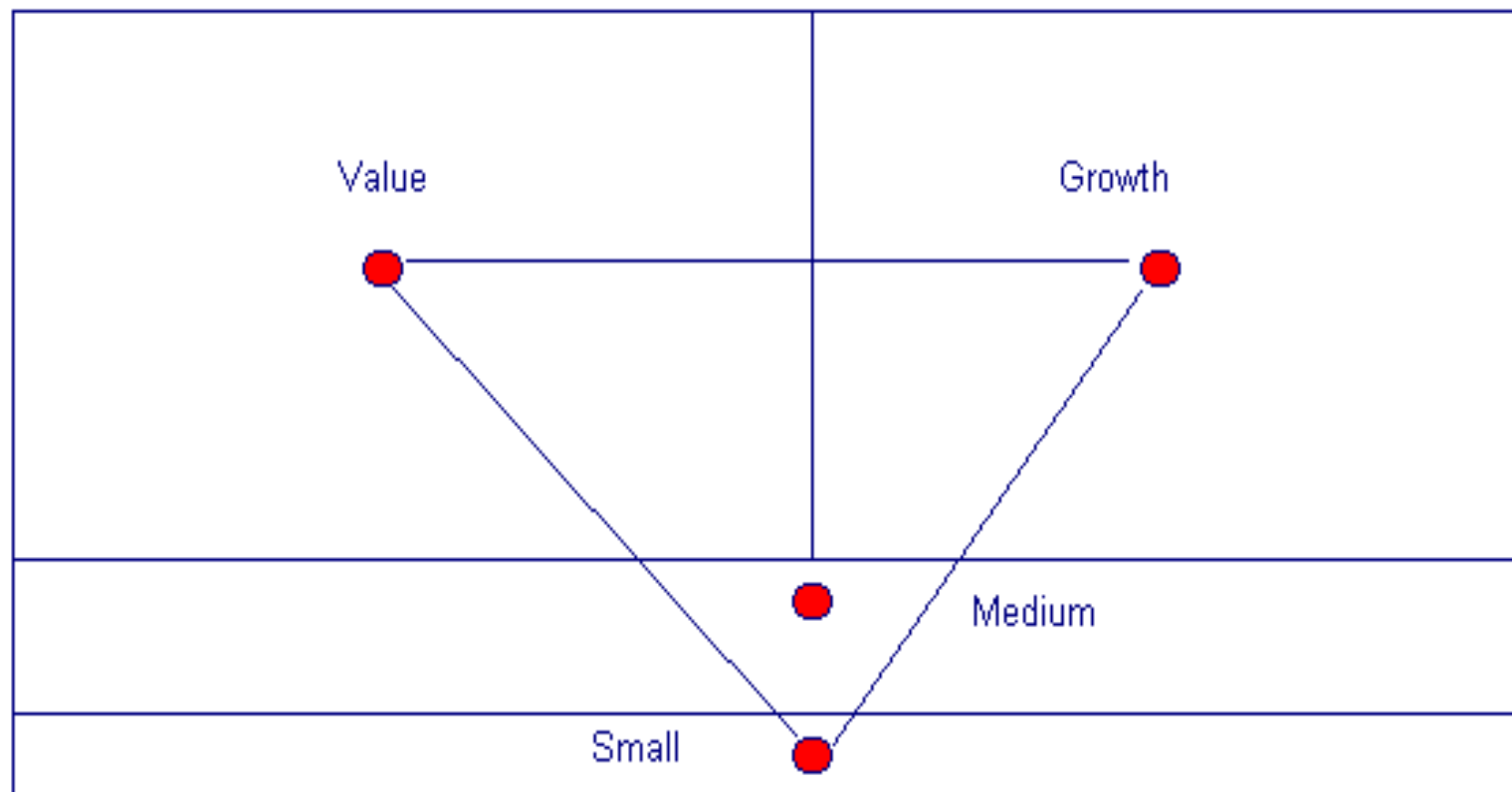# Style Analysis

May 20, 2016

A Multi-factor Model

$$\tilde{R}_i = [b_{i1}\tilde{F}_1 + b_{i2}\tilde{F}_2 + ... + b_{in}\tilde{F}_n] + \tilde{e}_i$$
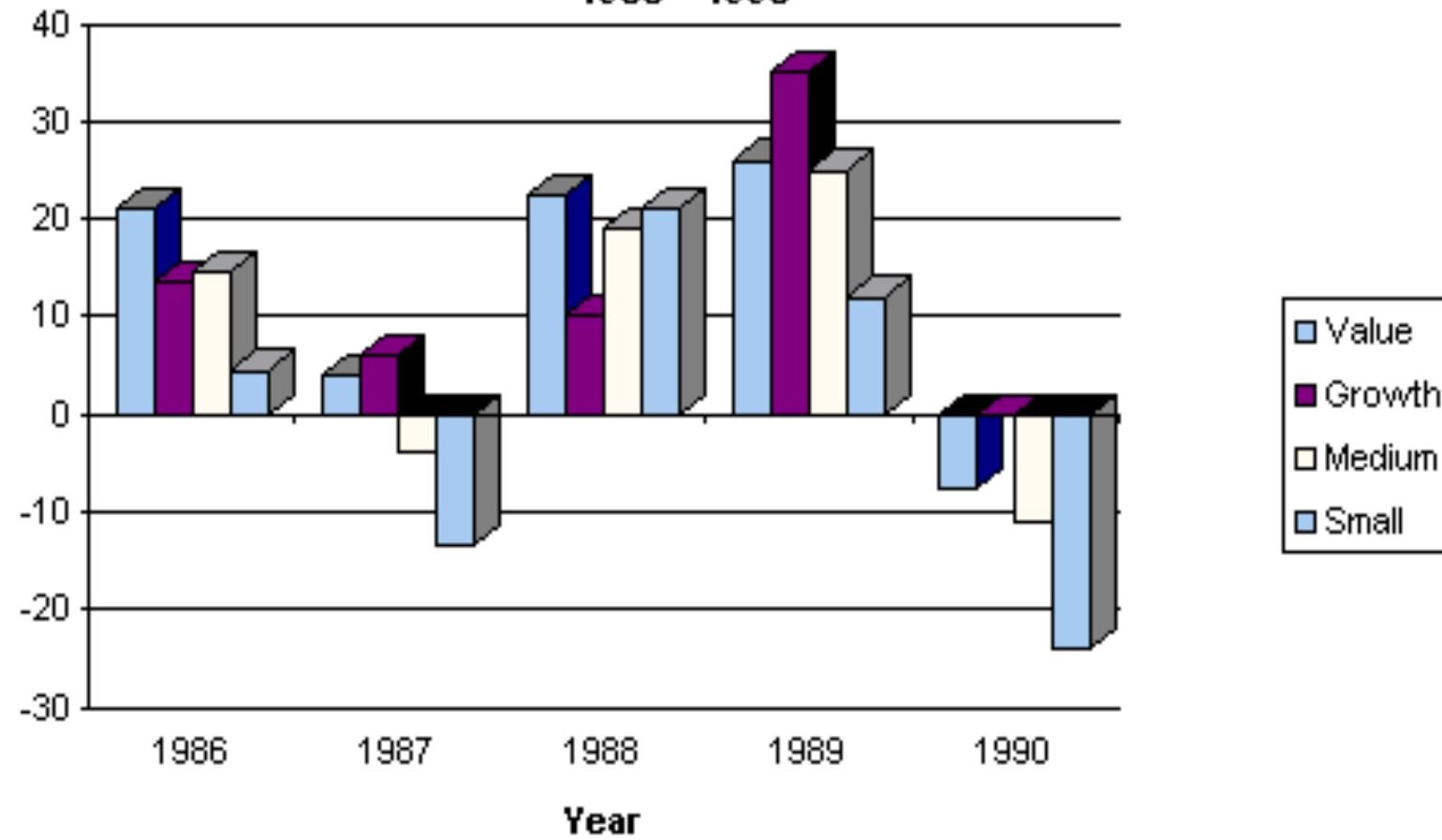
Factors:

Returns on mutually exclusive and exhaustive market capitalization-weighted portfolios

U.S. Stock Indices

Barra U.S. Stock Index Performance

FIGURE 2
ANNUAL EQUITY RETURNS
1986 - 1990

Regression Analysis

Trustees' Commingled Fund - U.S. Portfolio
January 1985 through December 1989

	Unconstrained Regression
Bills	14.69
Intermediate Bonds	-69.51
Long-term Bonds	-2.54
Corporate Bonds	16.57
Mortgages	5.19
Value Stocks	109.52
Growth Stocks	-7.86
Medium Stocks	-41.83
Small Stocks	45.65
Foreign Bonds	-1.85
European Stocks	6.15
Japanese Stocks	-1.46
Total	72.71
R-squared	95.20

Regression Analysis with a Constraint

Trustees' Commingled Fund - U.S. Portfolio
January 1985 through December 1989

|	Unconstrained Regression	Constrained Regression
Bills	14.69	42.65
Intermediate Bonds	-69.51	-68.64
Long-term Bonds	-2.54	-2.38
Corporate Bonds	16.57	15.29
Mortgages	5.19	4.58
Value Stocks	109.52	110.35
Growth Stocks	-7.86	-8.02
Medium Stocks	-41.83	-43.62
Small Stocks	45.65	47.17
Foreign Bonds	-1.85	-1.38
European Stocks	6.15	5.77
Japanese Stocks	-1.46	-1.79
Total	72.71	100.00
R-squared	95.20	95.16

Quadratic Programming

Trustees' Commingled Fund - U.S. Portfolio
January 1985 through December 1989

	Unconstrained Regression	Constrained Regression	Quadratic Programming
Bills	14.69	42.65	0
Intermediate Bonds	-69.51	-68.64	0
Long-term Bonds	-2.54	-2.38	0
Corporate Bonds	16.57	15.29	0
Mortgages	5.19	4.58	0
Value Stocks	109.52	110.35	69.81
Growth Stocks	-7.86	-8.02	0
Medium Stocks	-41.83	-43.62	0
Small Stocks	45.65	47.17	30.04
Foreign Bonds	-1.85	-1.38	0
European Stocks	6.15	5.77	0.15
Japanese Stocks	-1.46	-1.79	0
Total	72.71	100.00	100.00
R-squared	95.20	95.16	92.22

"An Algorithm for Portfolio Improvement"

Advances in Mathematical Programming and Financial Planning, 1987
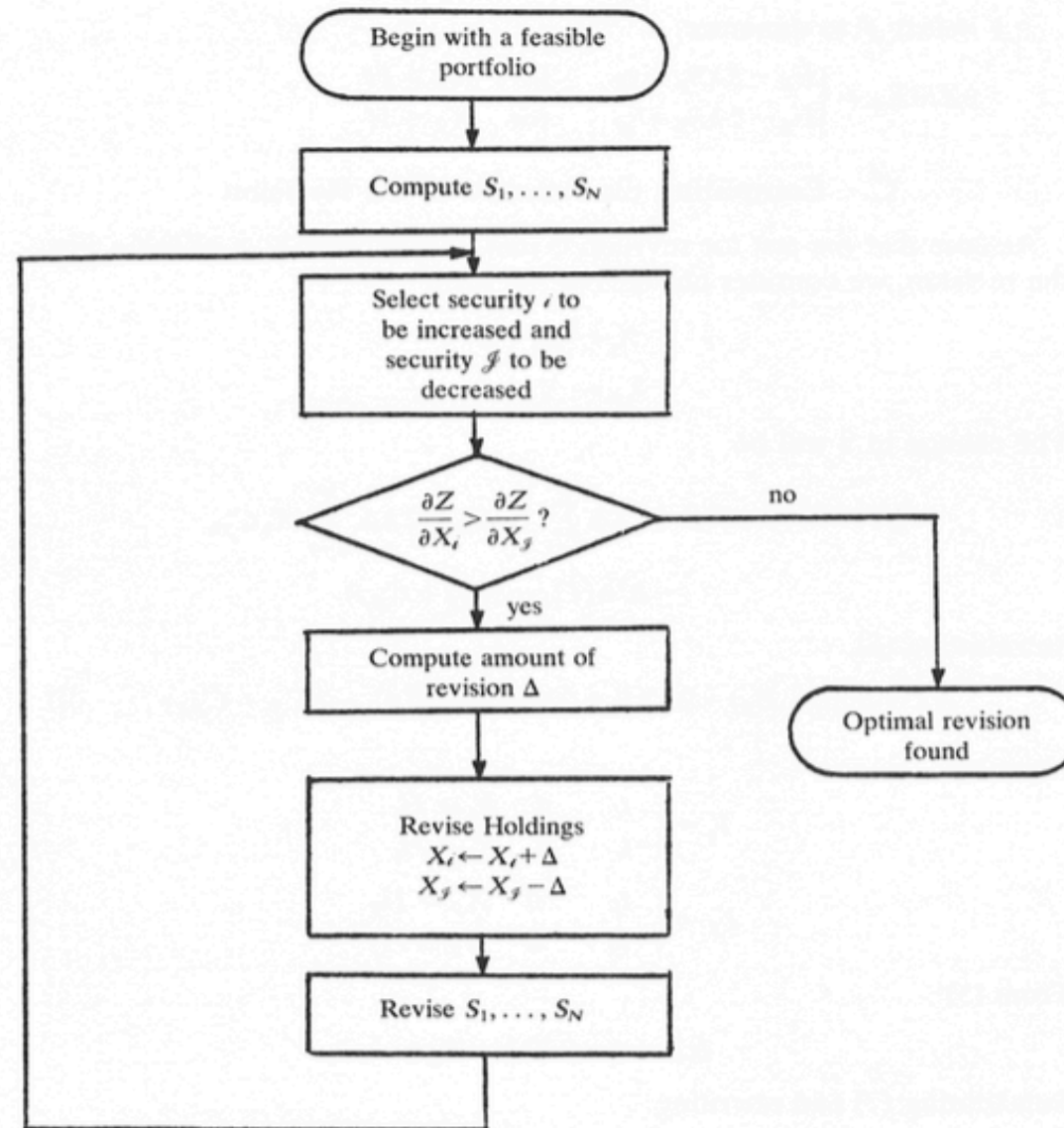
Asset Classes
"Determining a Fund's Effective Asset Mix"
(Dec. 1988)

Bills
Salomon Brothers' 90-day Bill Index

Intermediate Government Bonds
Shearson-Lehman Intermediate Government
Bond Index

Long-term Government Bonds
Shearson-Lehman Long-term Government Bond
Index

Corporate Bonds
Shearson-Lehman Corporate Bond Index

Mortgages
Shearson-Lehman Mortgage-backed Securities Index

Large Value Stocks
The Russell Price-driven Stock Index ™

Large Growth Stocks
The Russell Earnings-growth Stock Index ™

Small Stocks
The Russell 2000 Small Stock Index ®

Foreign Bonds
Salomon Brothers' Non-U.S. Government Bond
Index

Foreign Stocks
Financial Times Actuaries Euro-Pacific Index

In-sample R2 Values
388 Pension Fund Manager Accounts
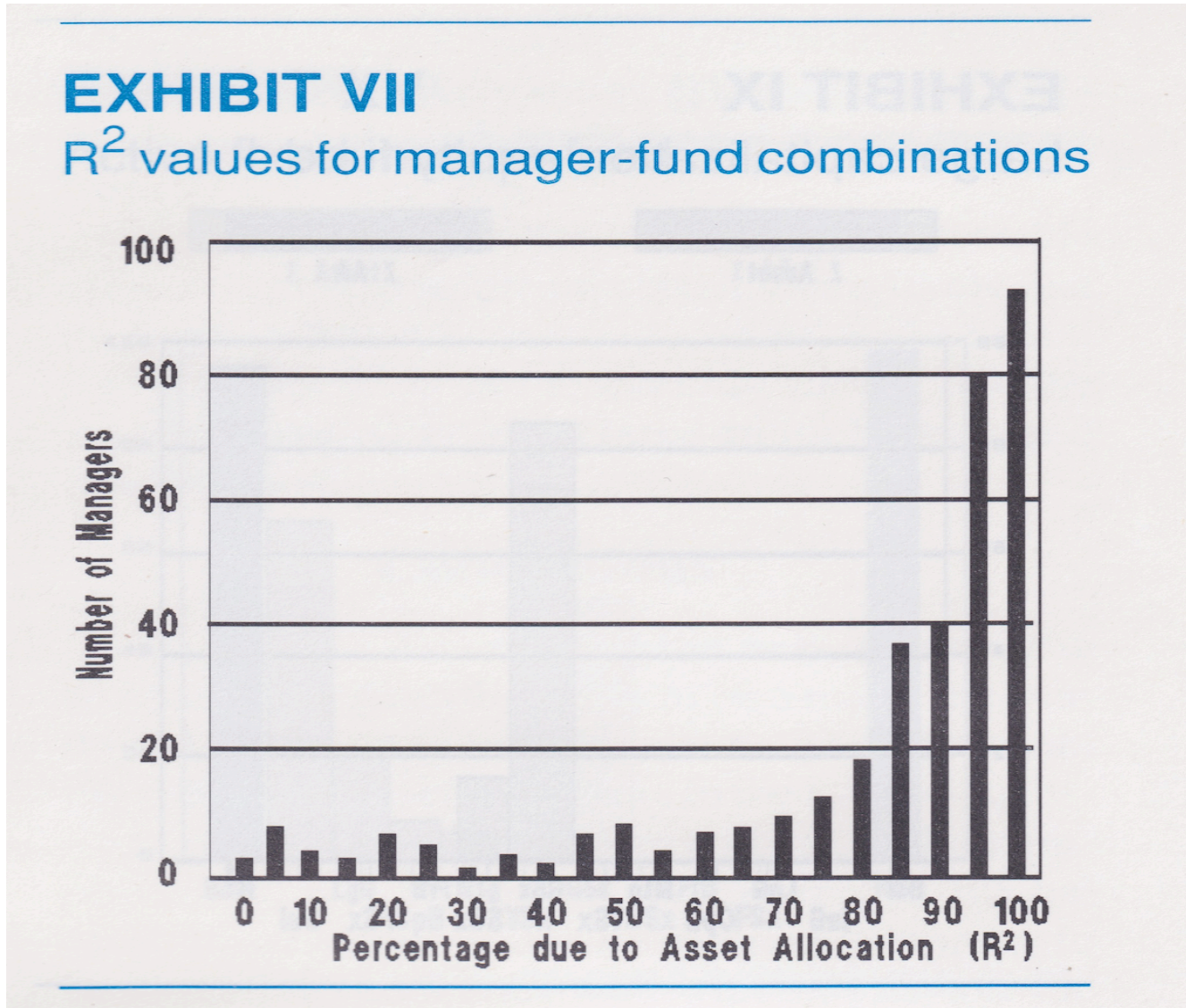
EXHIBIT VII
R^2 values for manager-fund combinations

Asset Classes

Bills

Intermediate-Term Government Bonds

Long-Term Government Bonds

Corporate Bonds

Mortgage-Related Securities

Large-Capitalization Value Stocks

Large-Capitalization Growth Stocks

Medium-Capitalization Stocks

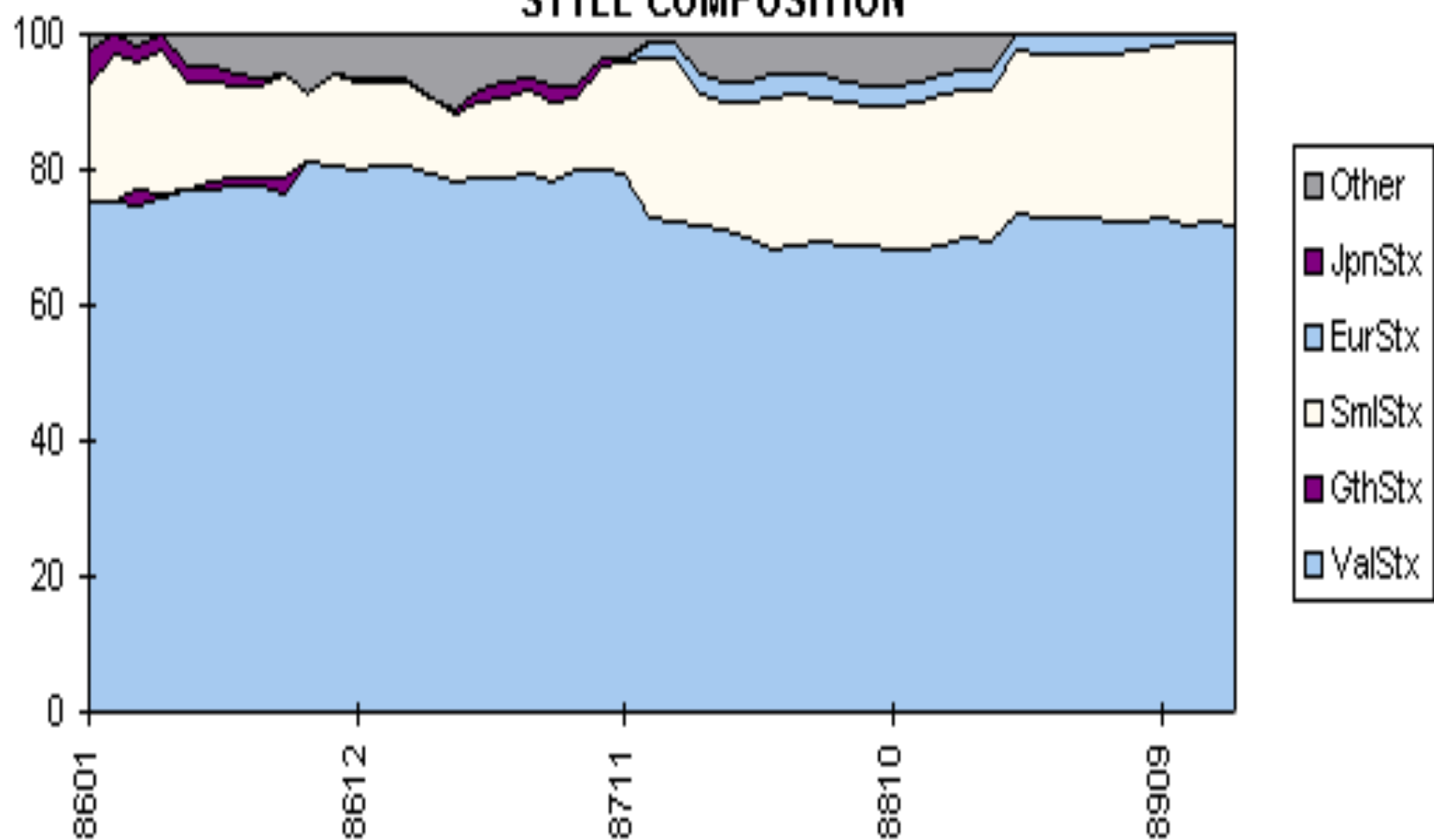Small-Capitalization Stocks

Non-U.S. Bonds

European Stocks

Japanese Stocks

Figure 4
TRUSTEES' COMMINGLED- U.S. PORTFOLIO
STYLE COMPOSITION

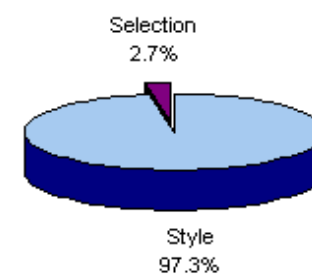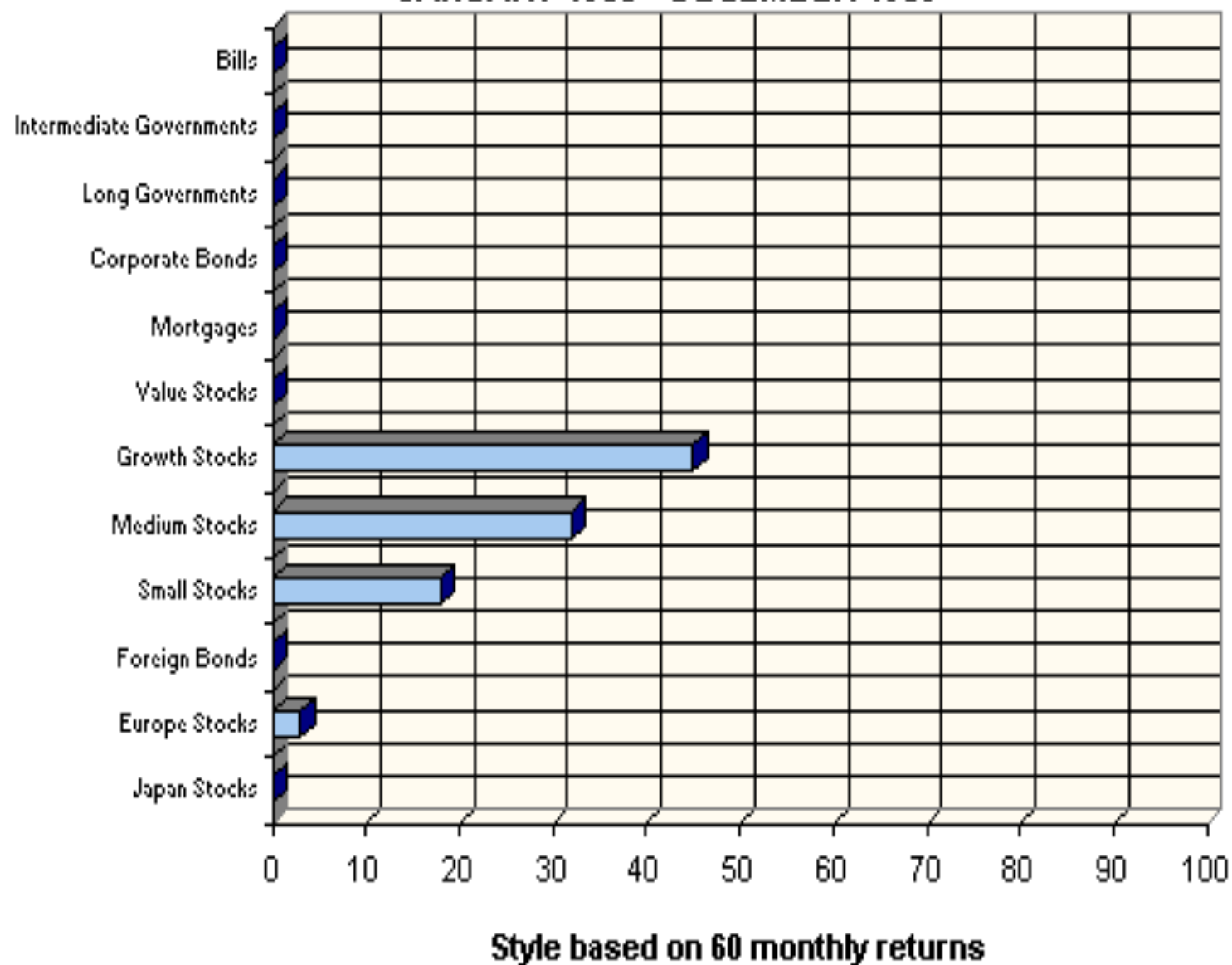FIGURE5
FIDELITY MAGELLAN FUND
JANUARY 1985 - DECEMBER 1989
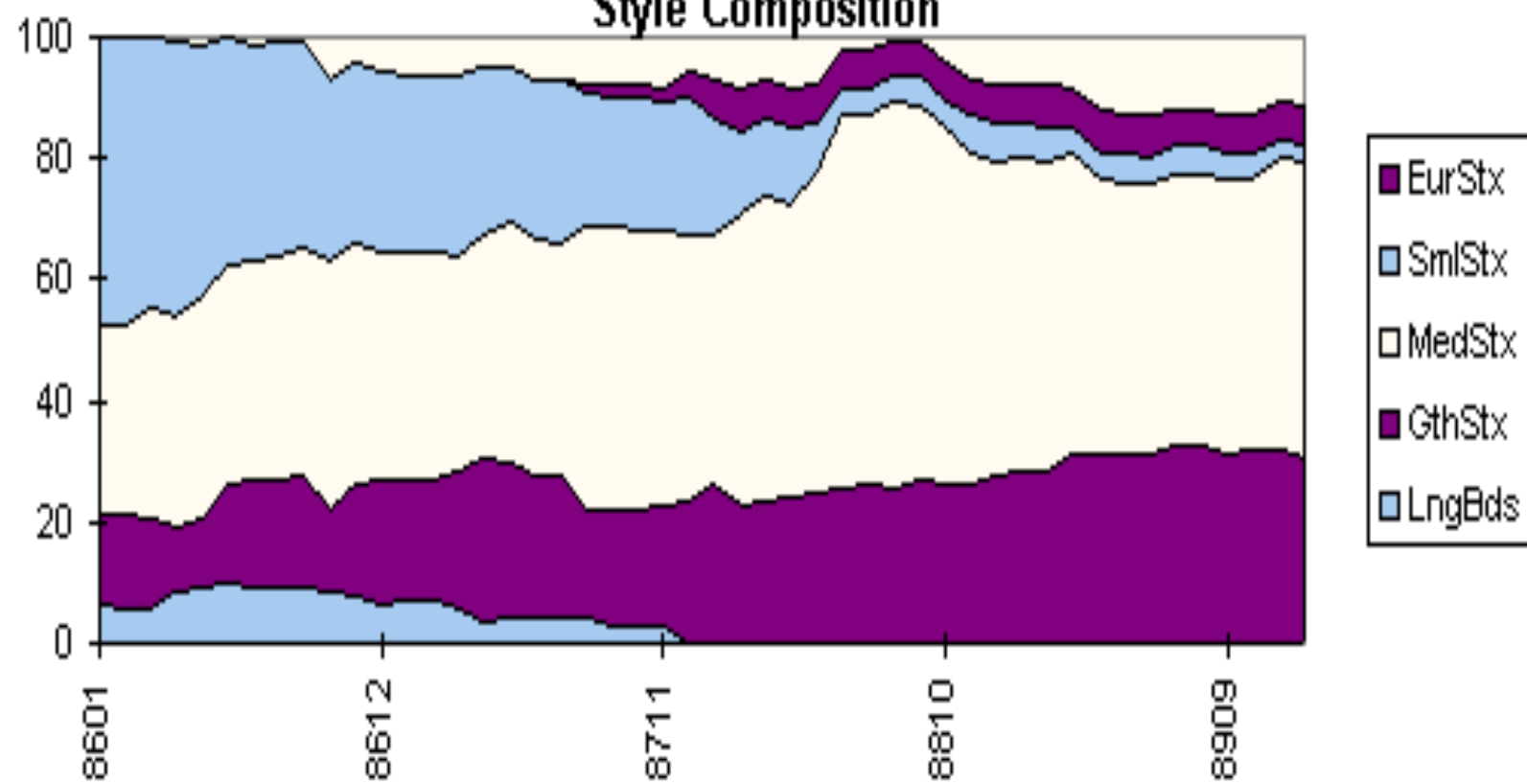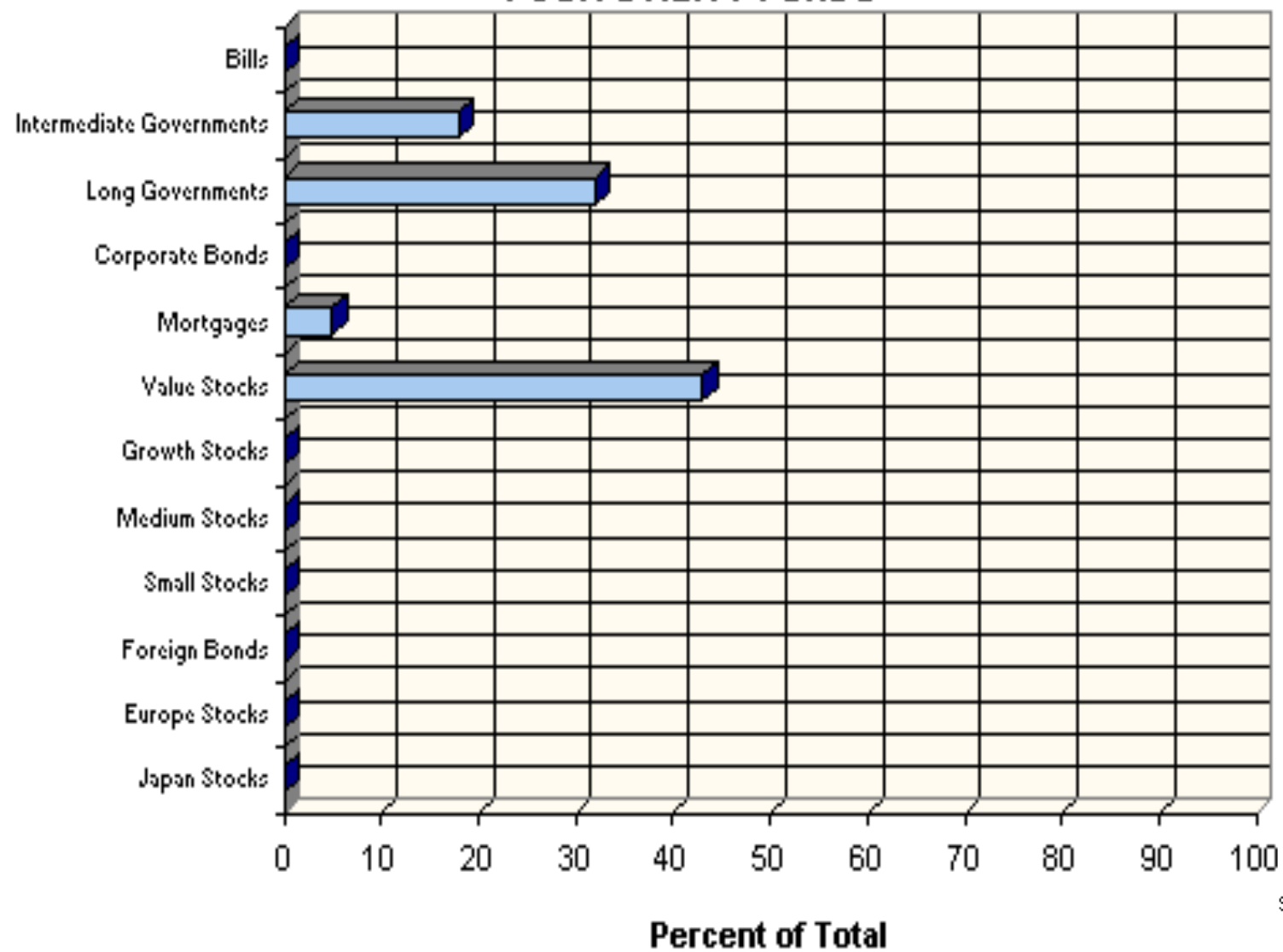
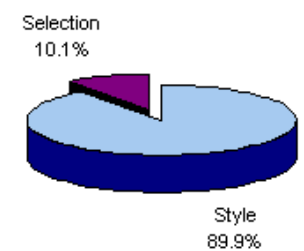Style based on 60 monthly returns

Selection 2.7%
Style 97.3%

Figure 6
Fidelity Magellan Fund
Style Composition

FIGURE 7
STYLES, 1985-1989
FOUR UTILITY FUNDS

Percent of Total

Category	
Bills	
Intermediate Governments	
Long Governments	
Corporate Bonds	
Mortgages	
Value Stocks	
Growth Stocks	
Medium Stocks	
Small Stocks	
Foreign Bonds	
Europe Stocks	
Japan Stocks	

Selection 40.7%
Style 59.3%

FIGURE 8
STYLES, 1985-1989
161 GROWTH EQUITY FUNDS

Category	
Bills	
Intermediate Governments	
Long Governments	
Corporate Bonds	
Mortgages	
Value Stocks	
Growth Stocks	
Medium Stocks	
Small Stocks	
Foreign Bonds	
Europe Stocks	
Japan Stocks	

0 10 20 30 40 50 60 70 80 90 100

Percent of Total

Selection
10.1%

Style
89.9%

FIGURE 8
STYLES, 1985-1989
161 GROWTH EQUITY FUNDS

Horizontal bar chart with categories (top to bottom):
- Bills
- Intermediate Governments
- Long Governments
- Corporate Bonds
- Mortgages
- Value Stocks
- Growth Stocks
- Medium Stocks
- Small Stocks
- Foreign Bonds
- Europe Stocks
- Japan Stocks

X-axis: **Percent of Total** (0 to 100)

Pie chart:
- Selection 10.1%
- Style 89.9%

FIGURE 9
STYLES, 1985-1989
118 GROWTH AND INCOME EQUITY FUNDS

Percent of Total

Selection
9.1%
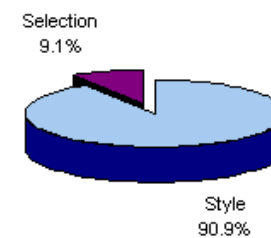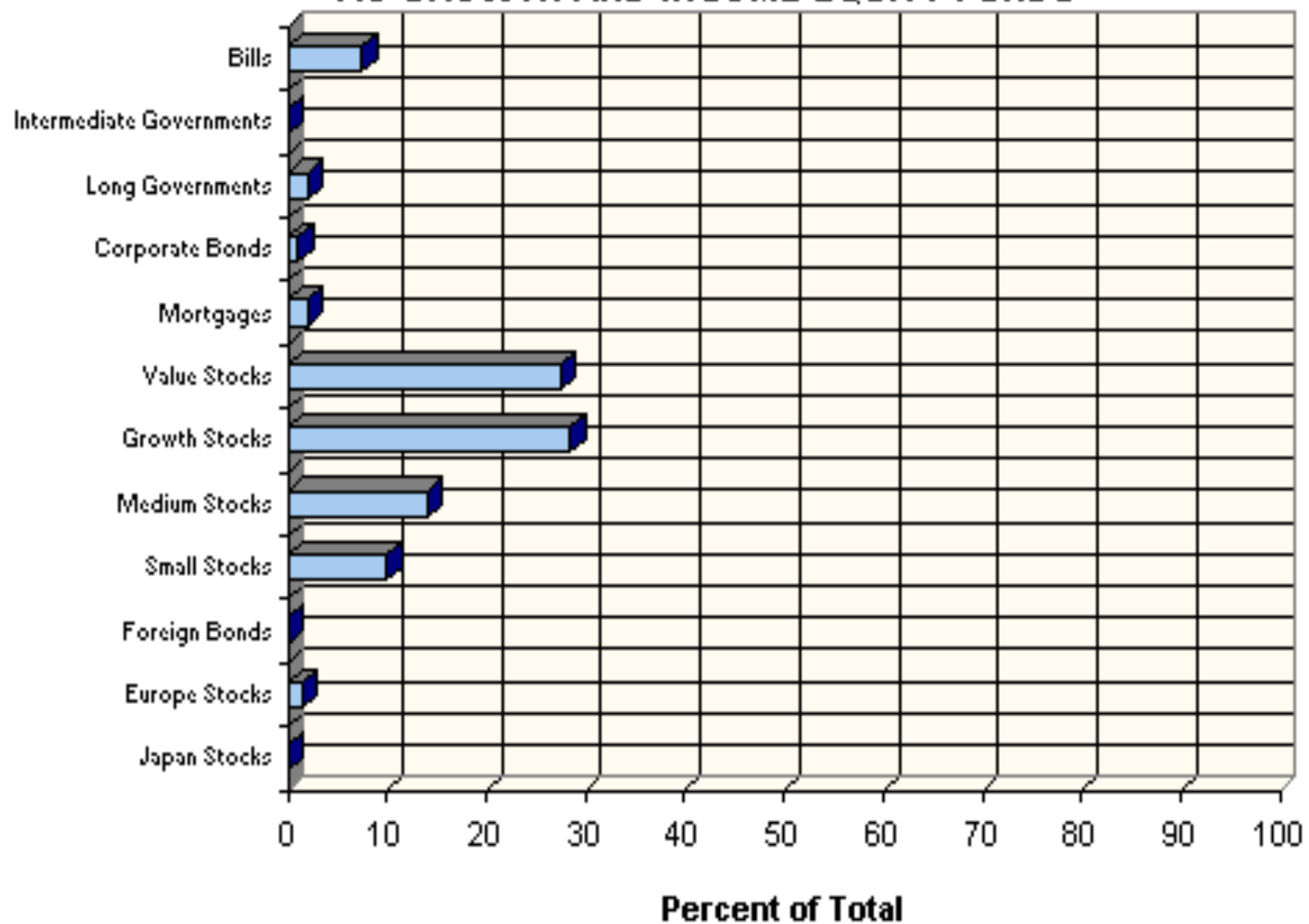
Style
90.9%

FIGURE 10
STYLES, 1985-1989
THIRTY-FOUR SMALL STOCK FUNDS

Percent of Total

Selection 12.4%

Style 87.6%
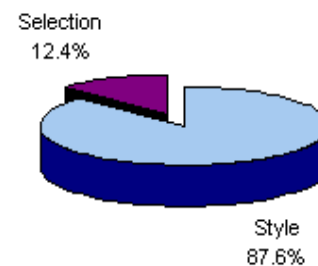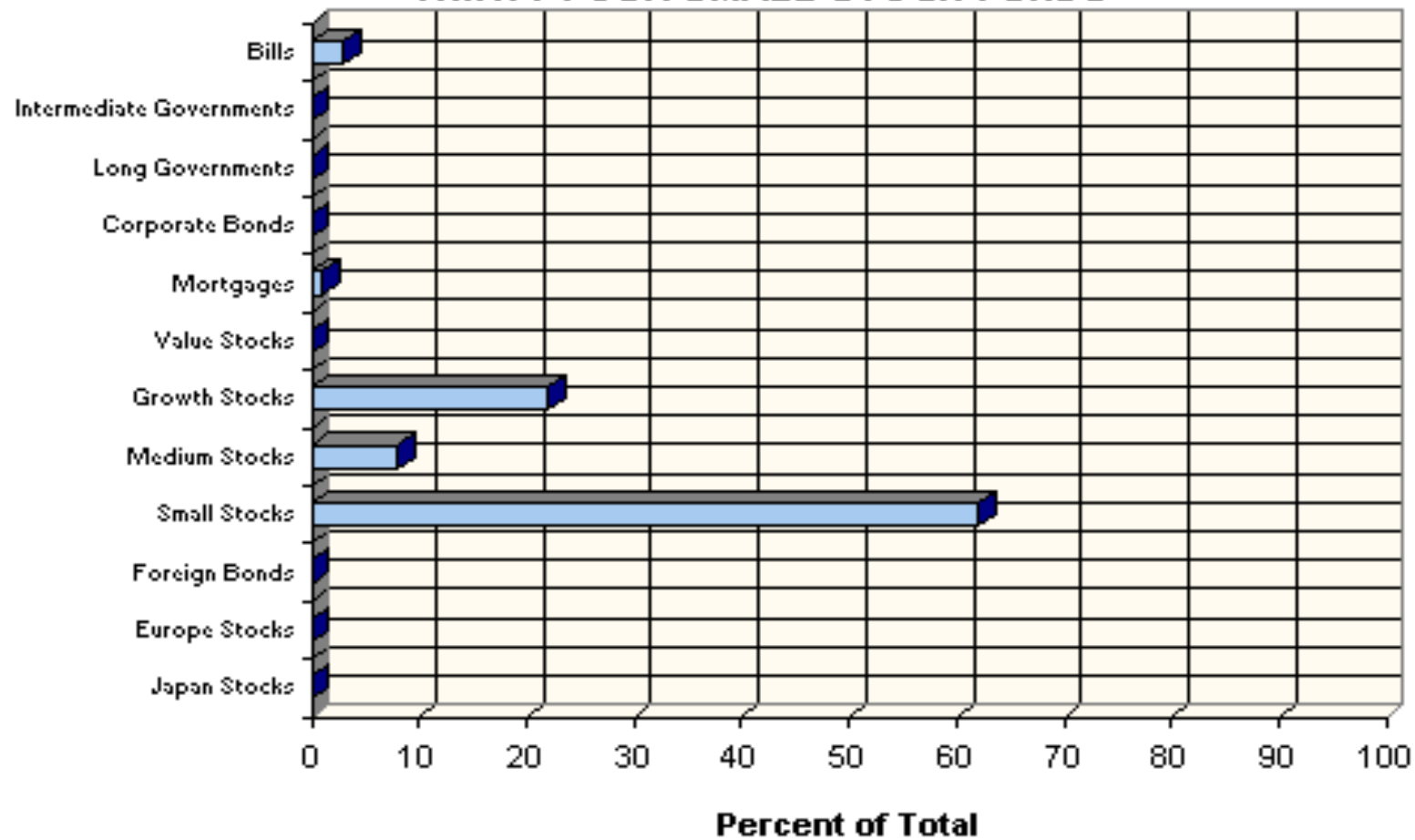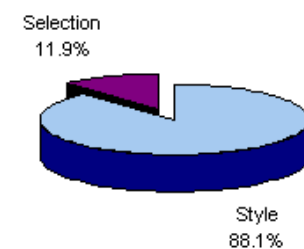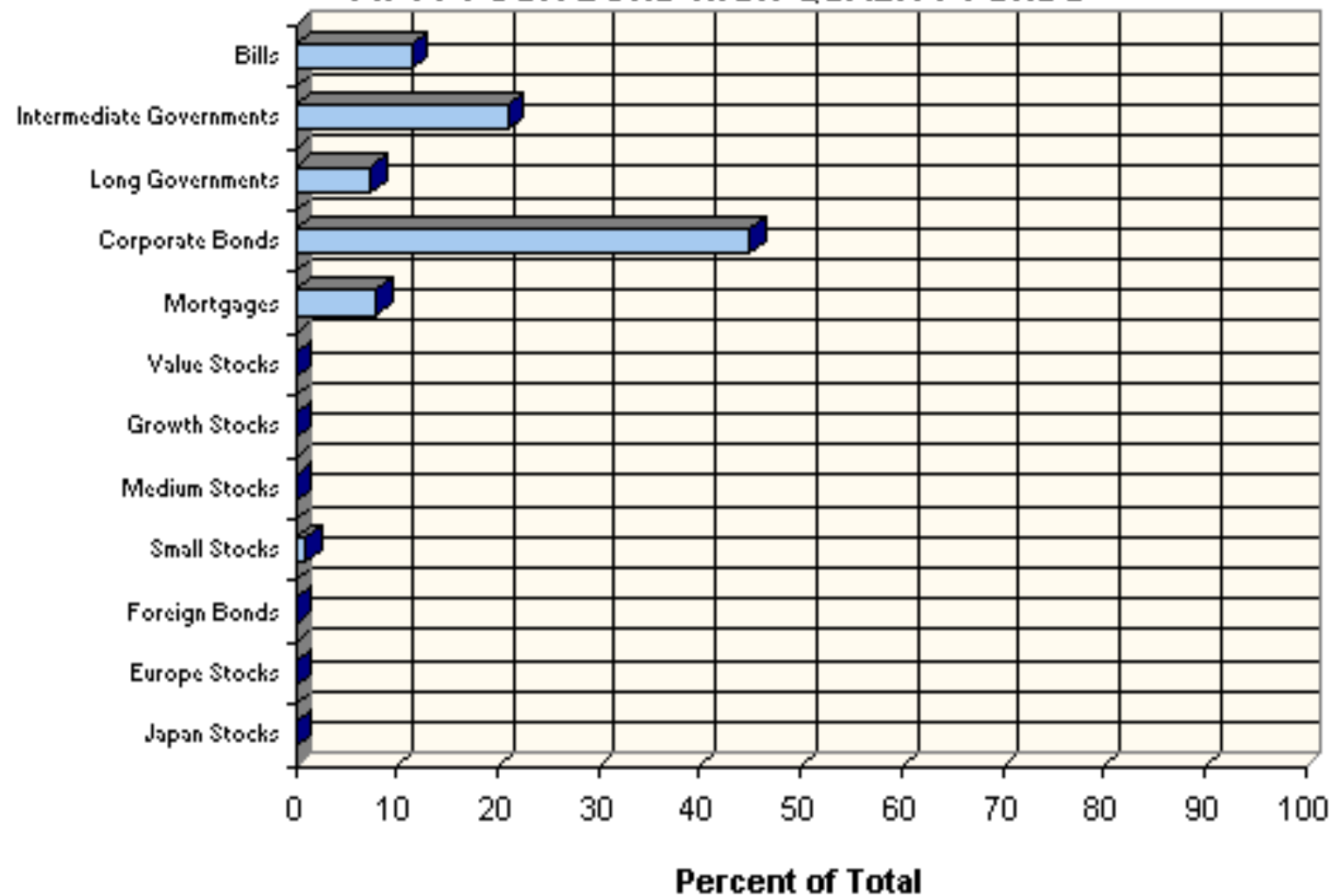
FIGURE 11
STYLES, 1985-1989
NINETEEN BALANCED FUNDS
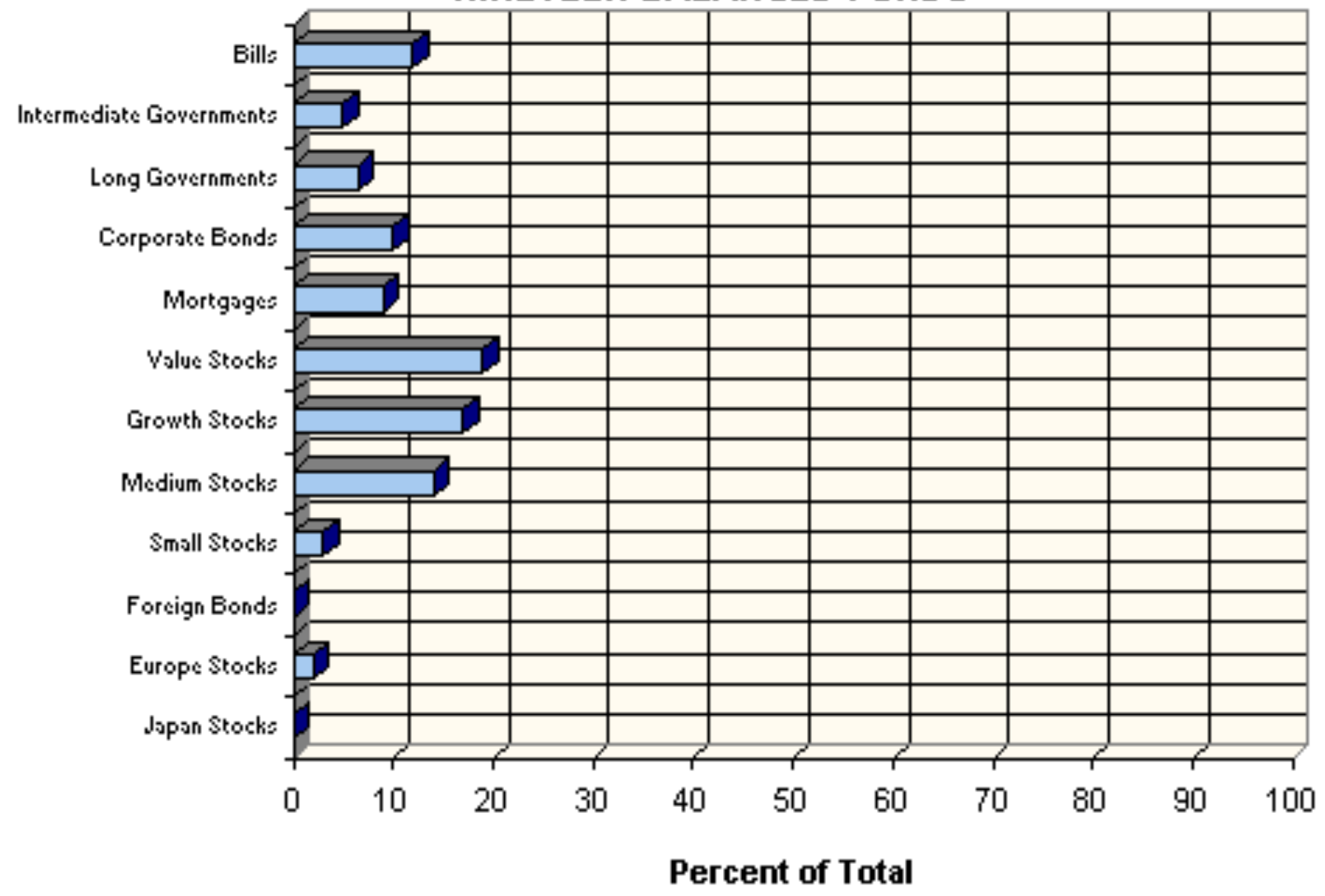
R2 = 89.0 %
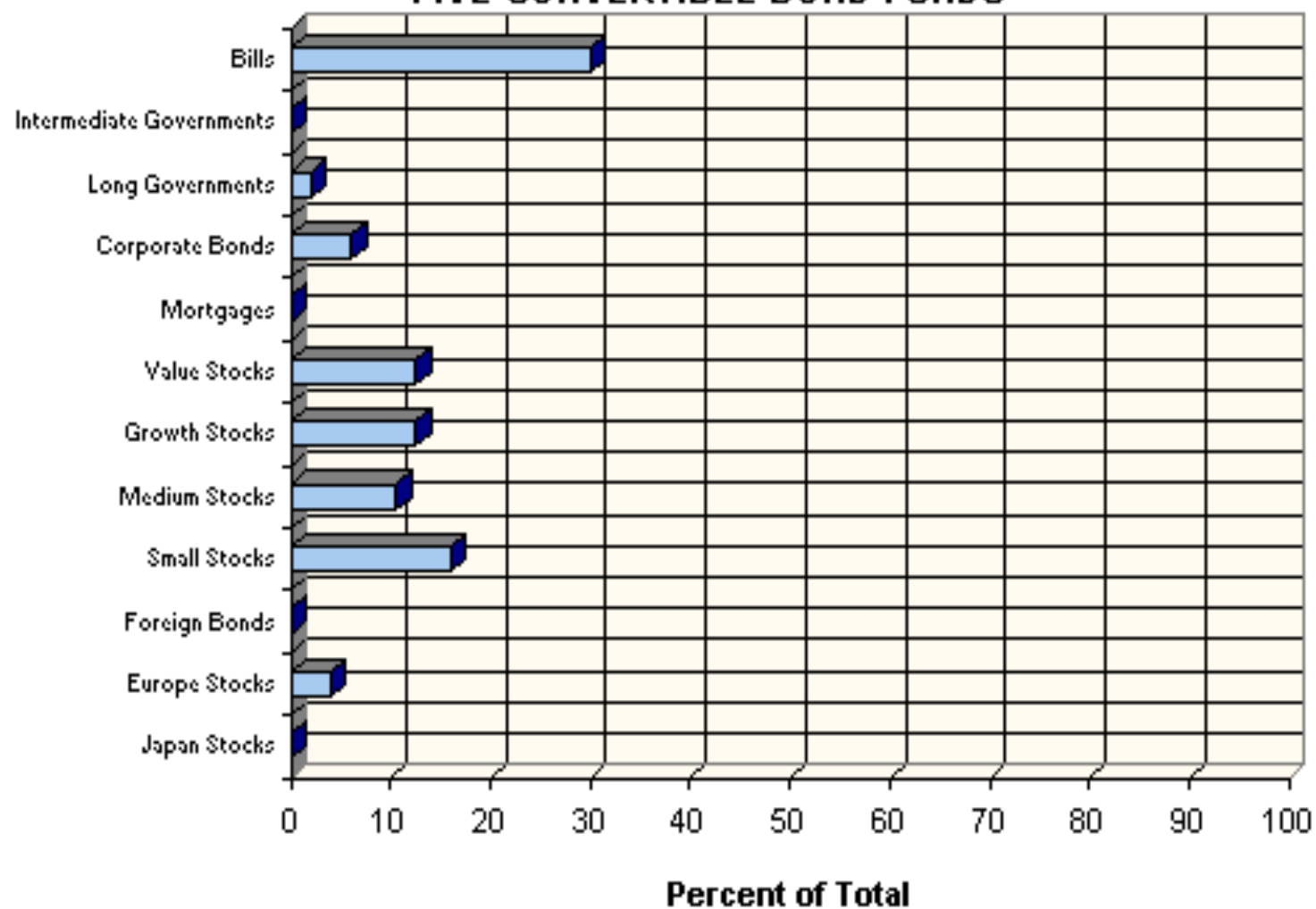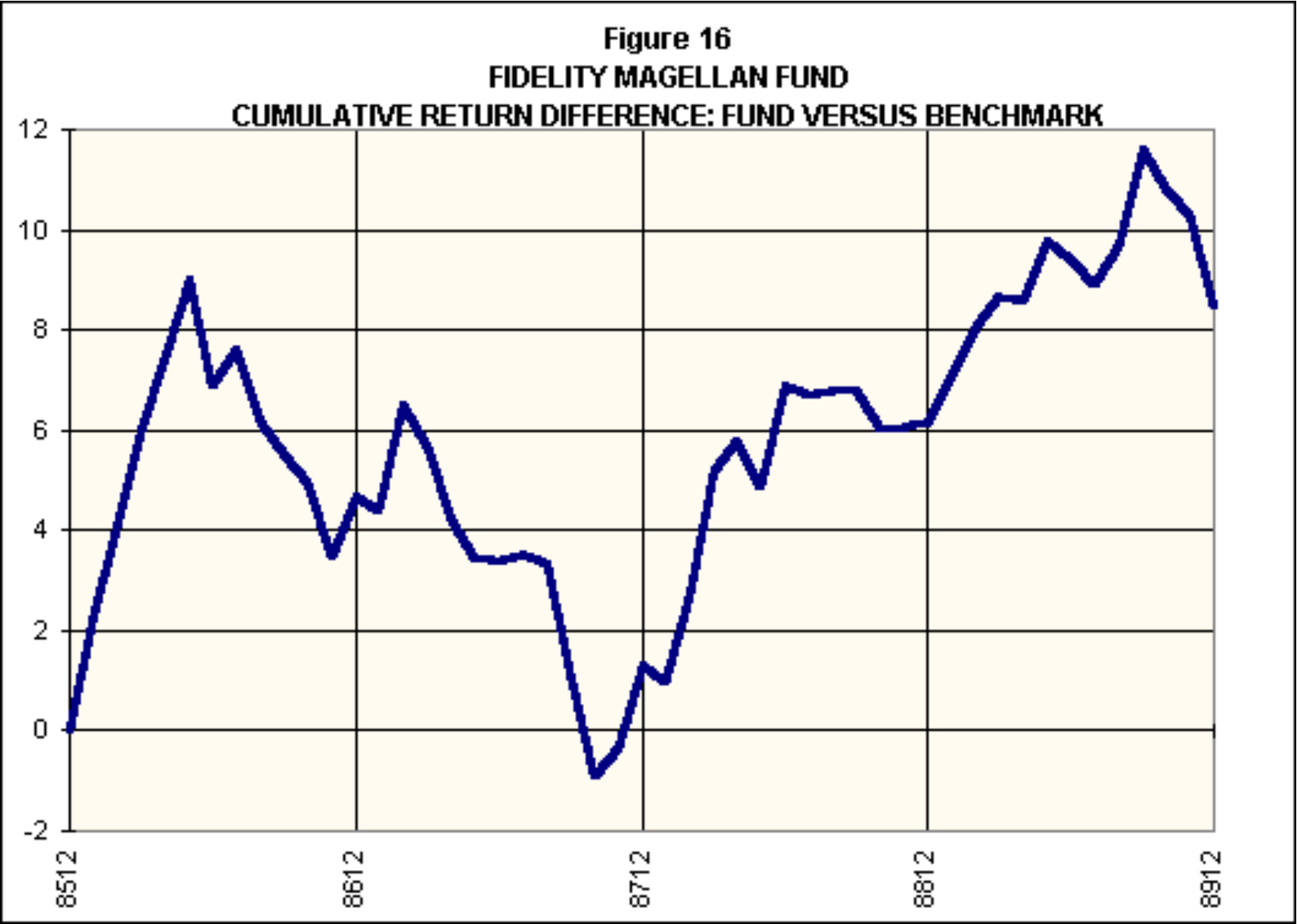
FIGURE 12
STYLES, 1985-1989
FIFTY-FOUR BOND HIGH-QUALITY FUNDS

Percent of Total

Selection 11.9%
Style 88.1%

FIGURE 13
STYLES, 1985-1989
FIVE CONVERTIBLE BOND FUNDS

Bills
Intermediate Governments
Long Governments
Corporate Bonds
Mortgages
Value Stocks
Growth Stocks
Medium Stocks
Small Stocks
Foreign Bonds
Europe Stocks
Japan Stocks

0   10   20   30   40   50   60   70   80   90   100

Percent of Total

Selection
11.2%

Style
88.8%

Figure 16
FIDELITY MAGELLAN FUND
CUMULATIVE RETURN DIFFERENCE: FUND VERSUS BENCHMARK
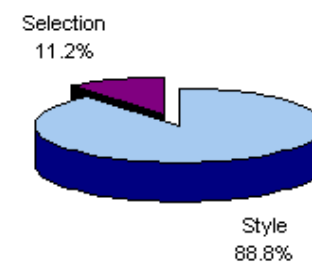
Mean: 0.18 %/mo   Standard Deviation = 1.48 %/mo   t(avg) = 0.84

Figure 17
FIDELITY MAGELLAN FUND
CUMULATIVE RETURN DIFFERENCE: FUND VERSUS STYLE
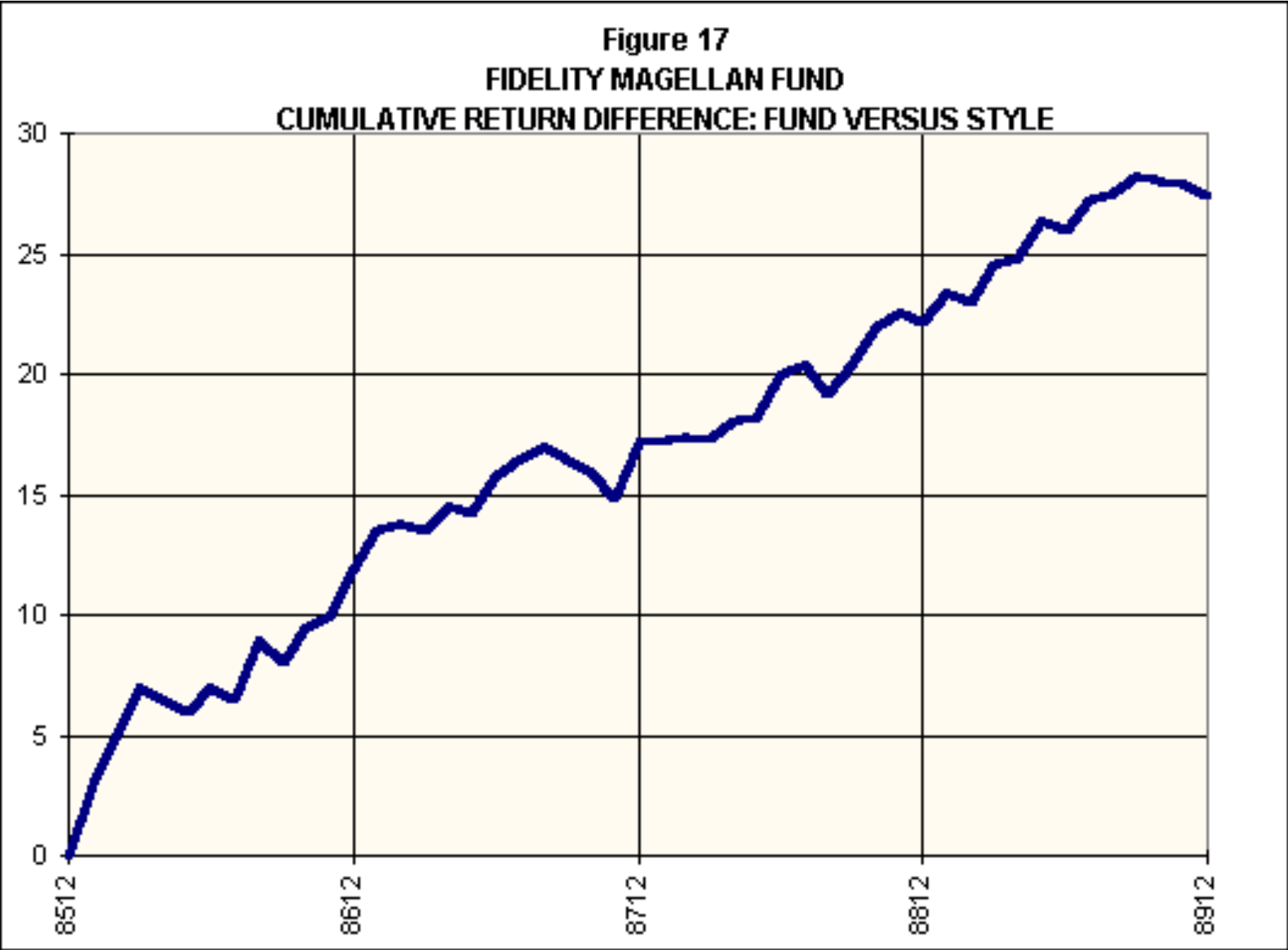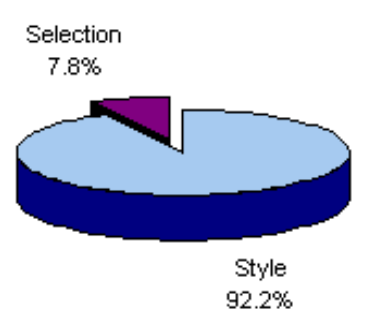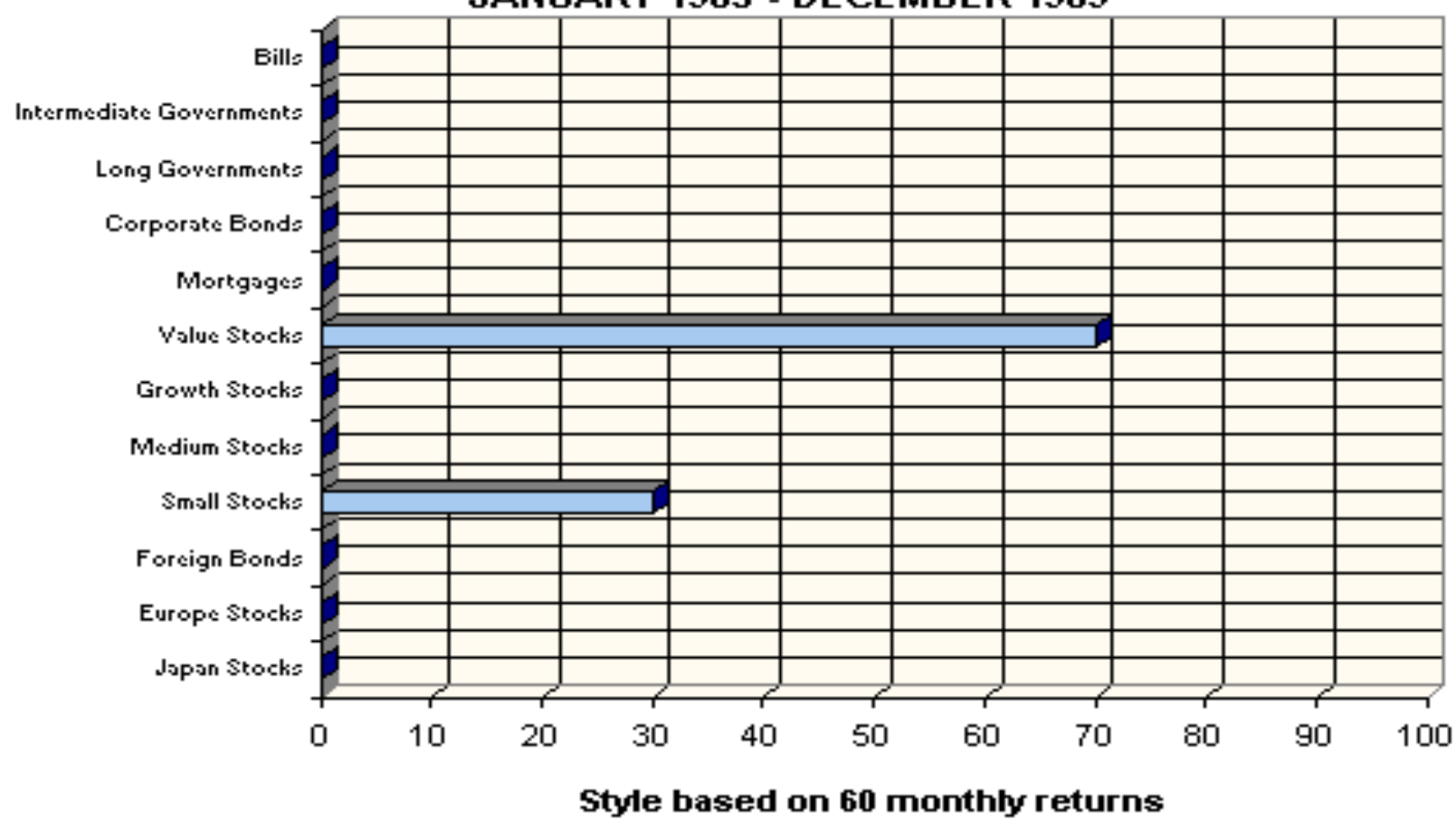
Mean: 0.57 %/mo   Standard Deviation = 1.05 %/mo   t(avg) = 3.76

FIGURE 3
TRUSTEE'S COMMINGLED - U.S. PORTFOLIO
JANUARY 1985 - DECEMBER 1989

Categories (top to bottom): Bills, Intermediate Governments, Long Governments, Corporate Bonds, Mortgages, Value Stocks, Growth Stocks, Medium Stocks, Small Stocks, Foreign Bonds, Europe Stocks, Japan Stocks

X-axis: 0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100

Style based on 60 monthly returns

Selection
7.8%

Style
92.2%

Figure 18
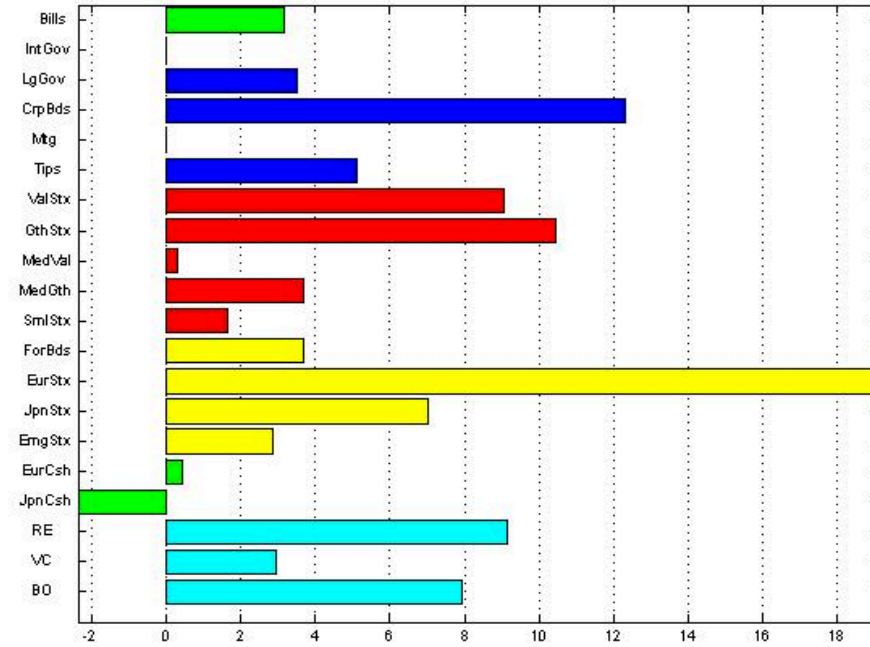**AVERAGE TRACKING ERROR**
636 MUTUAL FUNDS, 1985-1989
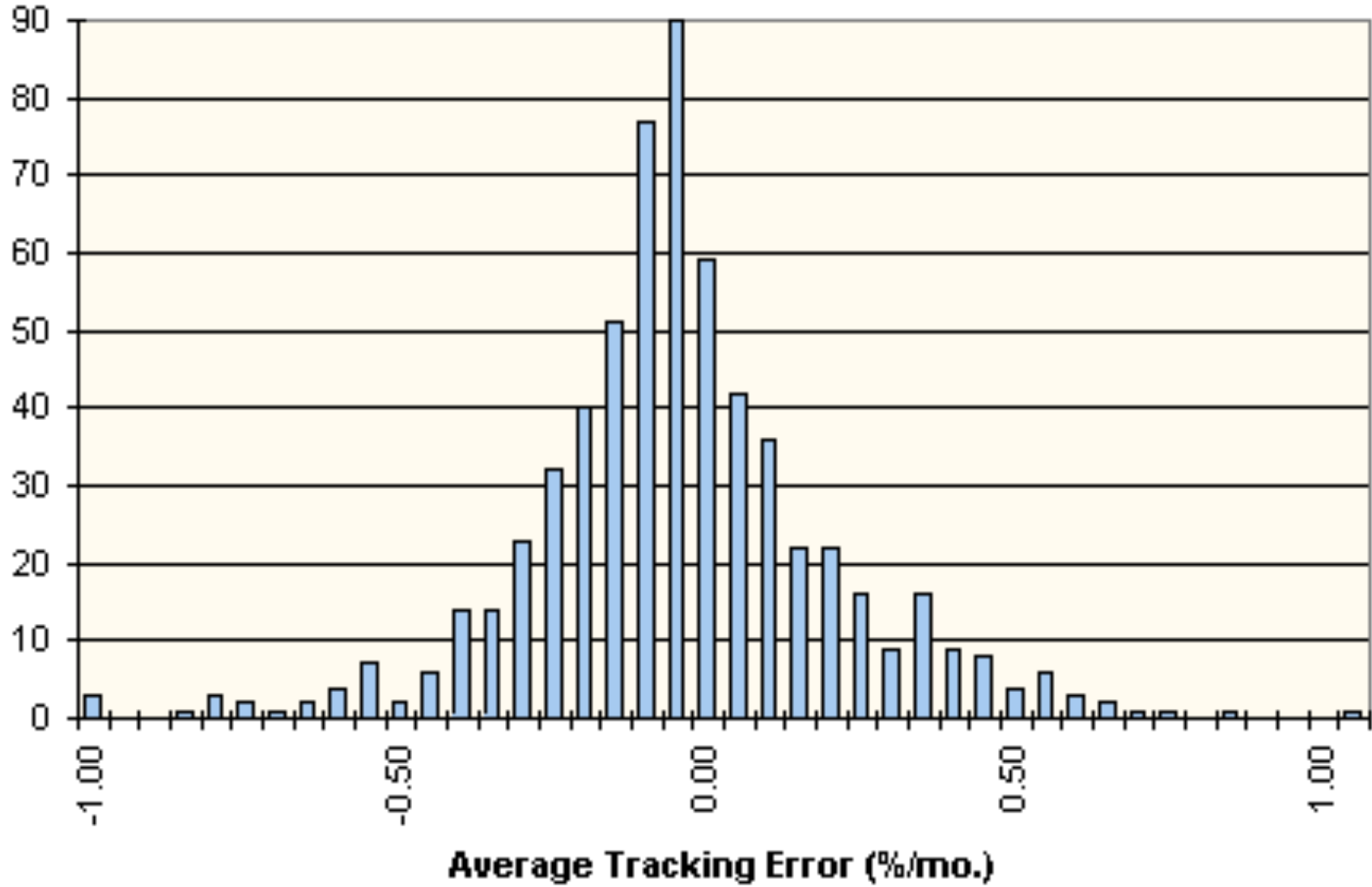
Mean = -0.074 %/mo (annualized: 0.888% /year)

Style and Performance Analysis

- Performance in month t vs. Style at end of month $t-2$

- Out-of-sample $R2$ values

- Style Analysis

  - number of months utilized

  - exponential weighting of monthly observations

- Aggregate results for individual funds

Total Fund
Style, 200909

Domestic Market-valued
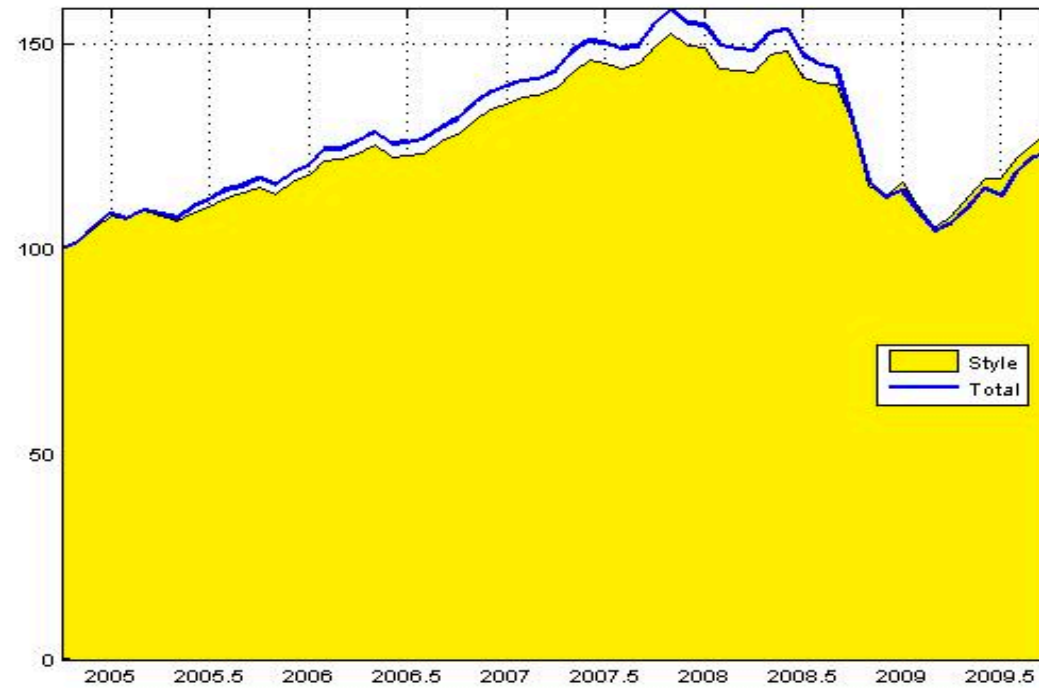
	Bills	IntGov	LgGov	CrpBds	Mtg	Tips	ValStx	GthStx	MedVal	MedGth	SmlStx
Style	3.18	0.00	3.50	12.32	0.00	5.11	9.05	10.44	0.29	3.66	1.66

Foreign and Appraised

	ForBds	EurStx	JpnStx	EmgStx	EurCsh	JpnCsh	RE	VC	BO
Style	3.66	19.19	7.00	2.87	0.43	-2.37	9.13	2.95	7.92

A Large Pension Fund

Total Fund
Compound Return, 200909
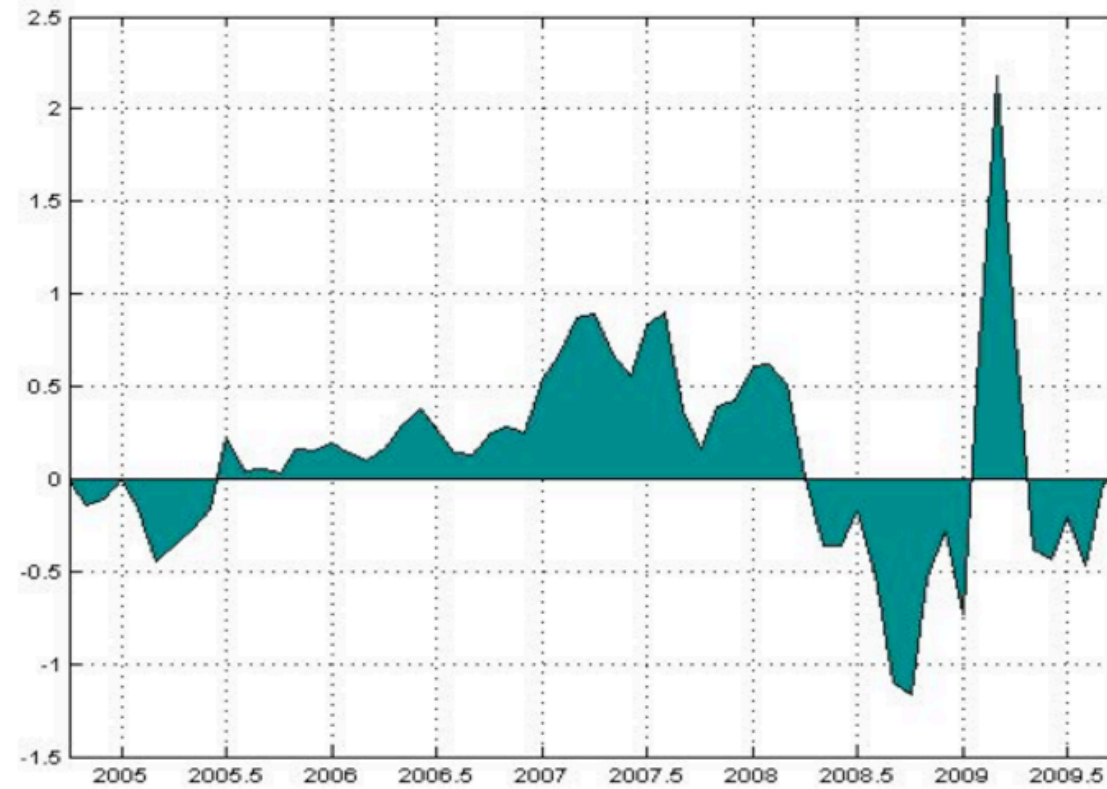
	Value of $100
Total	123.34
Style	128.81
Difference	-5.47

Total Fund
Value, 200909
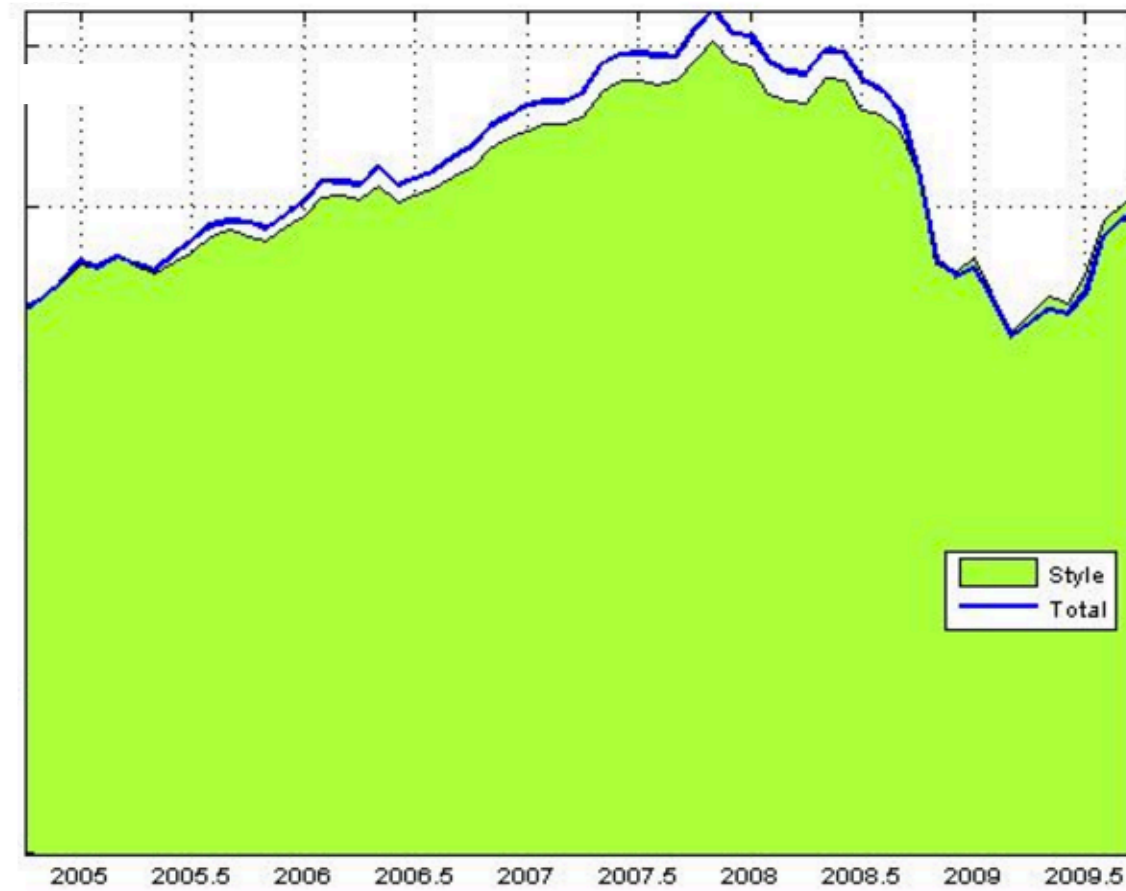
SH4KA1: TOTAL DOMESTIC EQUITY
Performance, 200909
#

	FirstMth	LastMth	NumMths	PctStyle	SelMn	SelSD	t-stat	SelPctl
Statistics	200410	200909	60	99.1	0.00	1.47	0.00	50.2

Holdings-based vs. Returns-based Style Analysis Models
(from Morningstar website)

Holdings-based
    - Uses characteristics of underlying securities

Returns-based
    - More widely used among financial professionals, because
      the input data (monthly returns) is (*sic*) widely available

Morningstar has long been a proponent of holdings-based style analysis but recognizes that there may be situations where returns-based analysis can also be helpful.

The company's institutional research platform … combines advanced holdings-based and returns-based style analysis.

Ideally, practitioners should use both approaches.