

# Practical Risk Models

## Overview

- Why use a Risk model?
- What is the basis of a Risk model?
- Types of Risk models
- What are the strengths and weaknesses?
- Illustration of Market Model and Equity Style Model with Mutual Fund Shares

# Why Use a Risk Model?

- ***Asset Pricing***: determine the normal return of for a given level of risk
- ***Benchmark***: represent the return of a *passive* portfolio that is similar to the evaluated portfolio
- ***Security Analysis***: determine the Risks that are relevant for security prices
- ***Industry/Market Analysis***: determine whether any subset of assets have outperformed other subsets or outperformed the market as a whole
- ***Portfolio Attribution***: to attribute the returns of an actively managed portfolio to exposure in various market segments
- ***Forecasting***: estimate expected return
- ***Quantitative Risk Management***: simplify the number of risk Risks in building a portfolio (most textbooks focus on this motivation)

# What is the basis of a Risk model?

## *Key Assumption:*

There are a limited number of factors,  $K$ .

(  $K=1$  for market model,  $K=6$  in style example,  $K=68$  for *BARRA model* )

There is a linear relationship between the  $K$  Factors and returns

$$R_{it} = \mathbf{I}_i + b_{i1} F_{1t} + b_{i2} F_{2t} + \cdots + b_{iK} F_{Kt} + \mathbf{e}_{it}$$

- the key assumption is that you have enough Factors to do the job but not too much to add noise to the model
- generally speaking considerable statistical work finds that there are between five to ten Factors driving the market but nobody can agree on *which* five to ten Risks. We know there are more than one but that the “market Risk” is the most important.

# Statistical Assumptions of Risk Models

Statistical assumptions vary depending on the purpose of the model.

***Strict Statistical Assumptions:*** (the same as a regression model)

- Think of each error term,  $\varepsilon_{it}$  as the effect of all the omitted variables on stock  $j$  at date  $t$
- *assumption 1:*  $E(\varepsilon_{it})=0$ , means the average effect of omitted variables is zero
- *assumption 2:*  $COV(\varepsilon_{it-i}, \varepsilon_{it})=0$ , means the omitted variables from date  $t-i$  do not cause errors on date  $t$
- *assumption 3:*  $COV(\varepsilon_{it}, F_{jt})=0$ , means that the omitted variables do not affect the Risks
- *assumption 4:*  $COV(F_{it}, F_{jt})=0$ , means that the Factors do not affect each other

***Firm Specific Risk Model: (BARRA)***

- the Risks are related to each other so that  $COV(F_{it}, F_{jt})$  is not zero

***Style Analysis Risk Model: (Zephr Associates)***

- allow Factors (ie. indices) to be correlated,  $COV(F_{it}, F_{jt}) > 0$
- force  $\sum_{j=1}^K b_{ij} = 1$  so that each “b” can be interpreted as the % invested in the strategy represented by the index (e.g. small growth)

# Types of Risk Models

- *Pure Statistical Model*

The only input is the correlation matrix of returns. The statistical technique of “Factor analysis” (from psychology) is used to determine the “significant Factors”

- *Pre-specified economy-wide variables*

Value of the Factors ( $F_{it}$ ) are the same across all firms. (Examples are interest rates, inflation, unemployment.) The model allows different responses to these variables for each firm.

- example: Roll and Ross Asset Management allow the investor to specify the economy-wide risk that he wants hedged.

- *Pre-specified firm variables*

Value of the Factors ( $F_{it}$ ) are different for each firm. (Examples are leverage, size growth in earnings). The model assumes that each firm has a constant response to these variables over some time period.

- *Style Model*

Value of the Factors ( $F_{it}$ ) are the same across all firms. Factors are chosen to represent an asset class. The model allows different responses to these variables for each firm.

## What are the strengths and weaknesses of Risk models?

- **Strengths**
  - Objective determinant of alpha (the value added) and risk
  - assumptions are clear
  - flexible (can add whatever variables are needed)
  - risk analysis and portfolio management is simplified
  - good basis for discussion (will discuss style analysis as a management tool at the end of the course)
  - cheaper than hiring a group of analysts
- **Limitations**
  - must know the Factors!
  - some firms may have non-linear relationships with Factors
  - difficult to incorporate judgment
    - Factors change
    - firm-specific events cannot be incorporate
  - impossible to incorporate non-quantitative information

# Risk Adjustment & Style Analysis

## The Case of Mutual Fund Shares

*Illustrates:*

- Why a risk model is important in evaluating equity investments
- Different ways that risk-adjustment can be used
- How a Risk model can be used to examine portfolio allocations
- Strengths and limitations of the tool

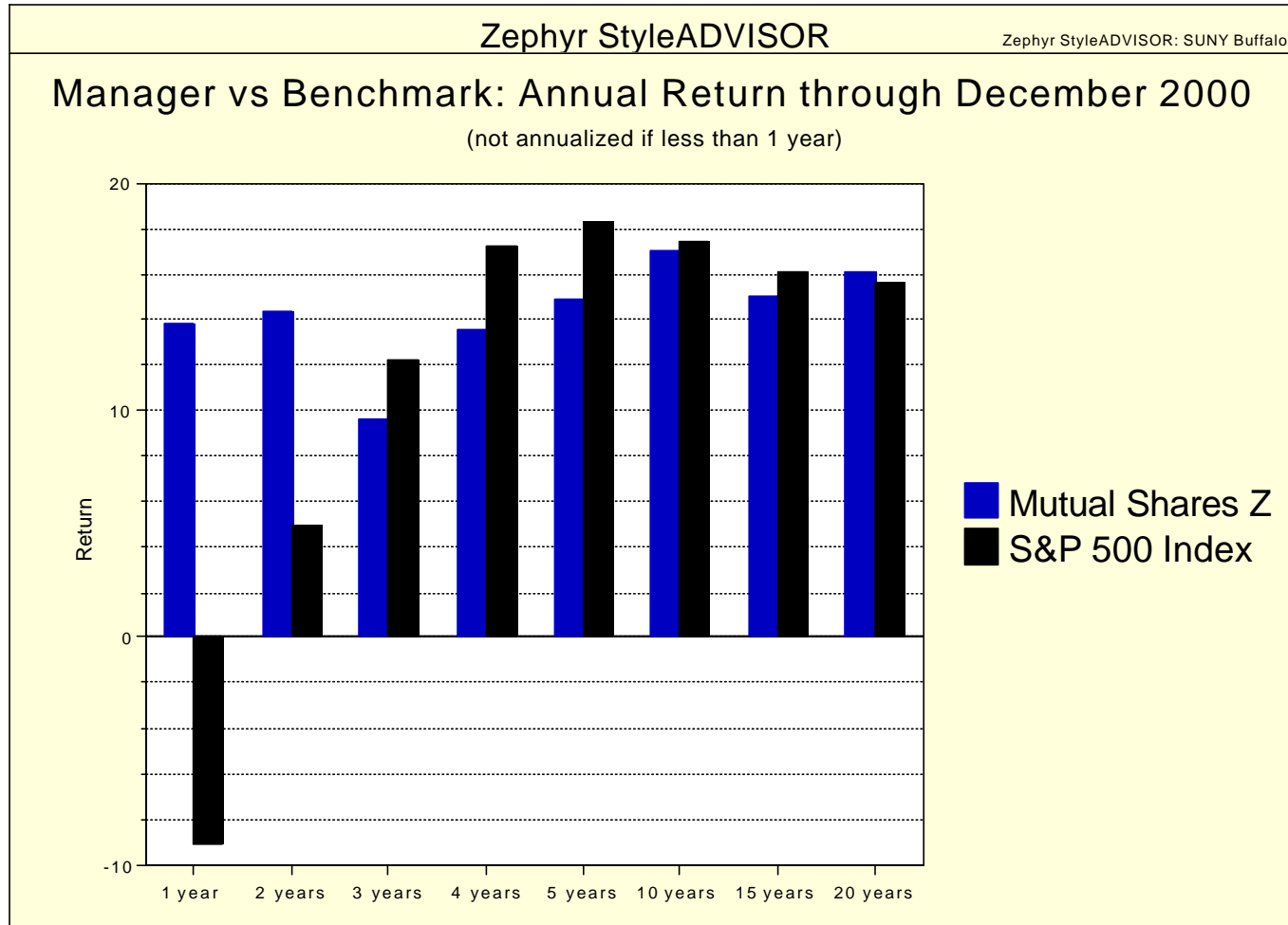
## Facts About Mutual Fund Series Fund Family

<u>Fund (Ticker)</u>	<u>Birth Date</u>	<u>Assets (\$bill)</u>		<u>Expense Ratio</u>		<u>Turnover</u>		<u>Morningstar Classification</u>
		<u>6/97</u>	<u>12/00</u>	<u>6/97</u>	<u>12/00</u>	<u>6/97</u>	<u>12/00</u>	
Beacon_(BEGRX)	8/61	5.3	3.0	73bp	78bp	76	68	Mid Cap Value
Discovery (MDISX)	1/93	3.8	2.0	96	103	80	88	World Stock Fund
Qualified (MQIFX)	9/80	4.7	2.9	75	77	65	60	Mid Cap Value
<b>Shares (MUTHX)</b>	<b>7/49</b>	<b><u>7.2</u></b>	<b><u>5.5</u></b>	<b>70</b>	<b>75</b>	<b>58</b>	<b>66</b>	<b>Mid Cap Value</b>
		21.0	13.4					

From about 1976 to the Fall 1998, Micheal Price ran all four of these funds. He sold the fund group to the Franklin group in the summer of 1996 and agreed to run the funds for two years. Lawrence Sondike is now the portfolio manager.

We will analyze the largest fund: **Mutual Fund Shares.**

# Return Distributions 1980:1 to 2000:12



# One- Factor Model

## Example: The Market Model

- Data Monthly Returns from Morningstar: 1979:01-2000:09
- $R_t$  = total return from mutual fund shares in month  $t$
- $R_{mt}$  = total return of the SP500 (includes dividends) in month  $t$
- $R_{Ft}$  = Salomon Brothers 90 day tbill total return in month  $t$
- Model:

$$R_t - R_{Ft} = \alpha + \beta (R_{mt} - R_{Ft}) + \varepsilon_t$$

estimate the model using ordinary least squares

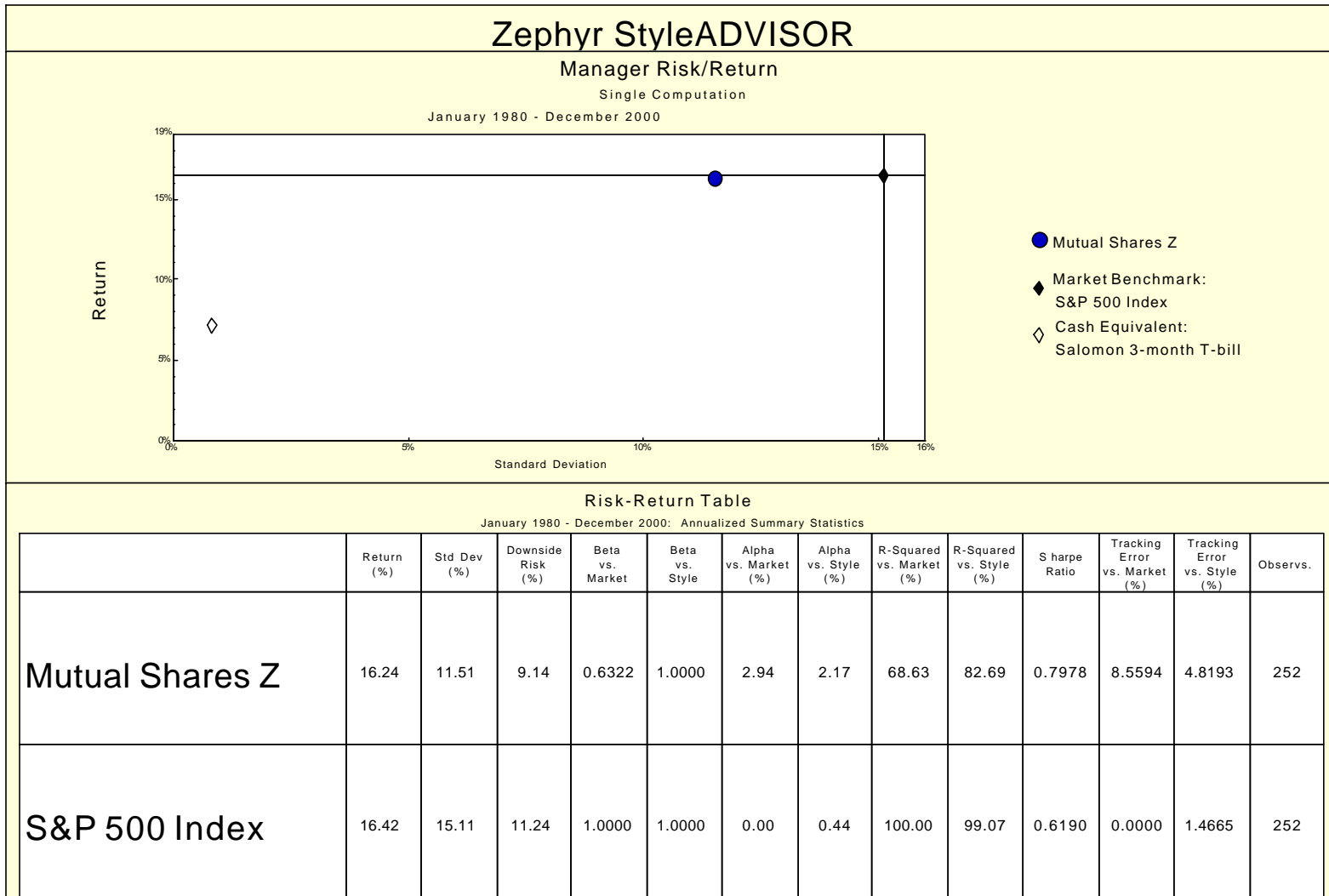
- Justification is the CAPM:
  - if the manager has information or abilities that are not available through passive management then  $\alpha > 0$
  - if the market is efficient and the CAPM is true then  $\alpha = 0$

# Other Measures of Risk

Define:  $\sigma(R)$  = standard deviation of the returns of the portfolio, then

- **Downside**  $\sigma(R)$  = standard deviation of all negative  $R_t - R_{mt}$ , i.e. downside risk
  - problem: Investors need to only be compensated for systematic risk not total risk.
  - The ranking of portfolios by  $\sigma(R)$  or by  $SEMI\sigma(R)$  will not be the same as the ranking by  $\alpha$
- **Sharpe Ratio** =  $[Avg(R - R_F)] / \sigma(R)$
- **Information Ratio** =  $\alpha / \sigma(\epsilon)$

# Controlling For Risk Using the CAPM



# Style Analysis Risk Model

(William Sharpe, “Asset Allocation, Management Style and Portfolio Performance” *Journal of Portfolio Management*, Winter 1992)

- Ultimately, investors do not - or should not - care about the type of stocks a manager is selecting, what matters is how they act together in a portfolio
- use a set of indices that represent the “style” of the manager by computing the computing the weights of the managed return on each index

- The basic idea:

Use a set of indices to construct a passive portfolio that captures the “style” of an actively managed portfolio

The difference in returns, Active portfolio returns - passive style portfolio returns is the manager’s value-added over the passive style.

- If the investors are only interested in the “style” of investing, that is only interested in the subset of stocks satisfying the style, then the value-added over the passive style is equivalent to the “alpha” of the manager.
- If the investors are interested in the larger universe of stocks, then the manager’s value added over the style is a positive signal of ability. Even if the style is down, the manager may be a good one.

# Implementing the Style Analysis Risk Model

- use a set of indices that represent the “style”
- Indices should be chosen so that they represent real investment alternatives to the actively managed portfolio

- For this example:

$I_1$  = Russell 1000 value (large “value” index, low market to book)

$I_2$  = Russell 1000 growth (large “growth” index, high market to book)

$I_3$  = Russell 2000 value (small value index)

$I_4$  = Russell 2000 growth (small growth)

$I_5$  = Salomon Brothers Treasury Bill Return

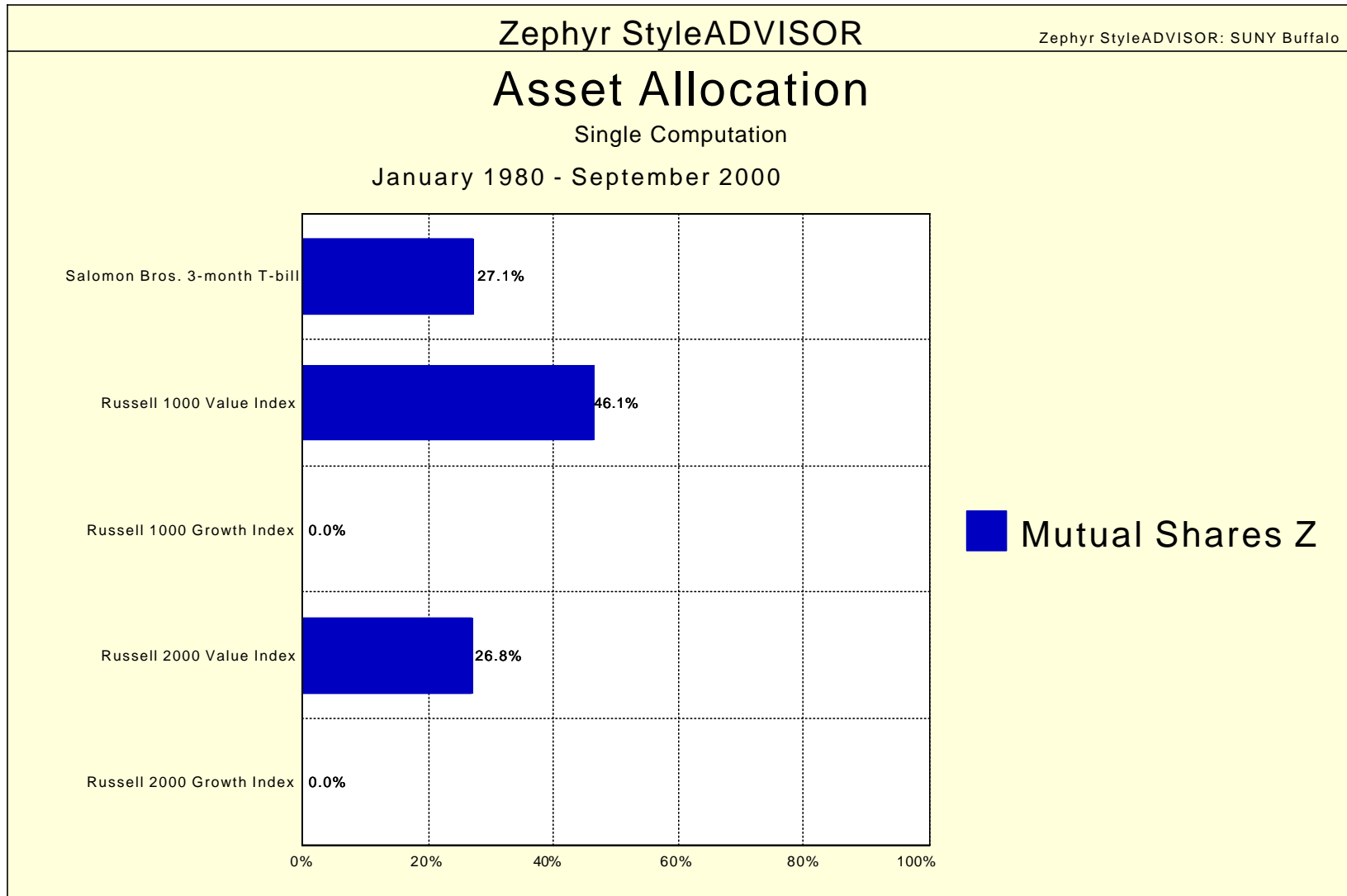
$I_6$  = MSCI EAFE (Morgan Stanley Europe, Australia and Far East)

# Implementing the Style Analysis Risk Model

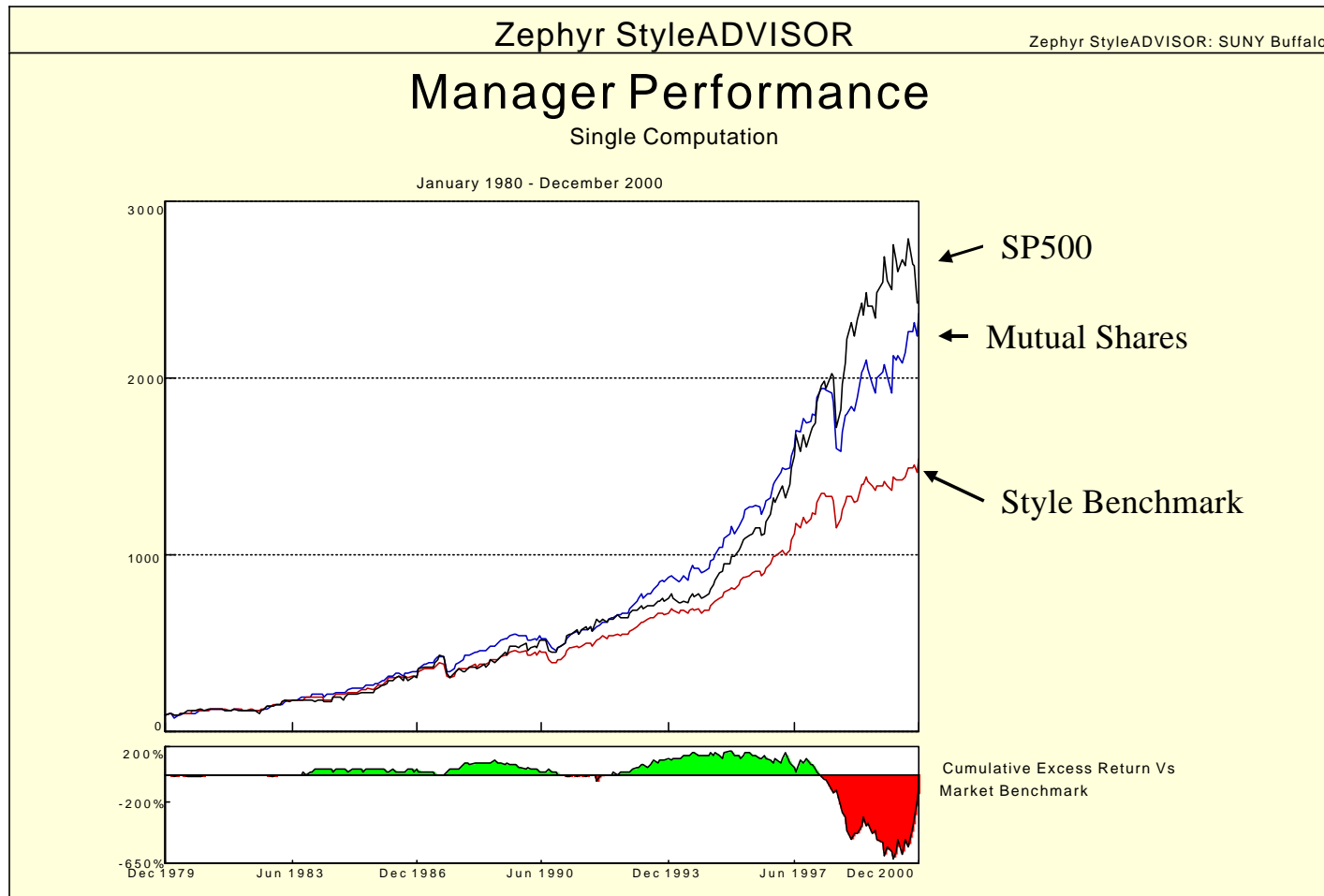
- model:  $\mathbf{R}_t = \mathbf{a} + \mathbf{b}_1 \mathbf{I}_{1t} + \mathbf{b}_2 \mathbf{I}_{2t} + \mathbf{b}_3 \mathbf{I}_{3t} + \mathbf{b}_4 \mathbf{I}_{4t} + \mathbf{b}_5 \mathbf{I}_{5t} + \mathbf{b}_6 \mathbf{I}_{6t} + \mathbf{e}_t$
- if this represents a passive strategy the weights must sum to one: Estimate the weights so that so that the b's sum to 1
- If you cannot go short on the indices, then the weights are  $>0$
- The constraints on our model are:  $b_j > 0$  and  $b_1 + b_2 + b_3 + b_4 + b_5 = 1$
- How to choose the weights?
  - note that ordinary least squares cannot be used since the model places restrictions on the coefficients
  - use an optimizer!

# Graph of Coefficients of Style Analysis Model

Estimated with returns 1979:01--2000:09

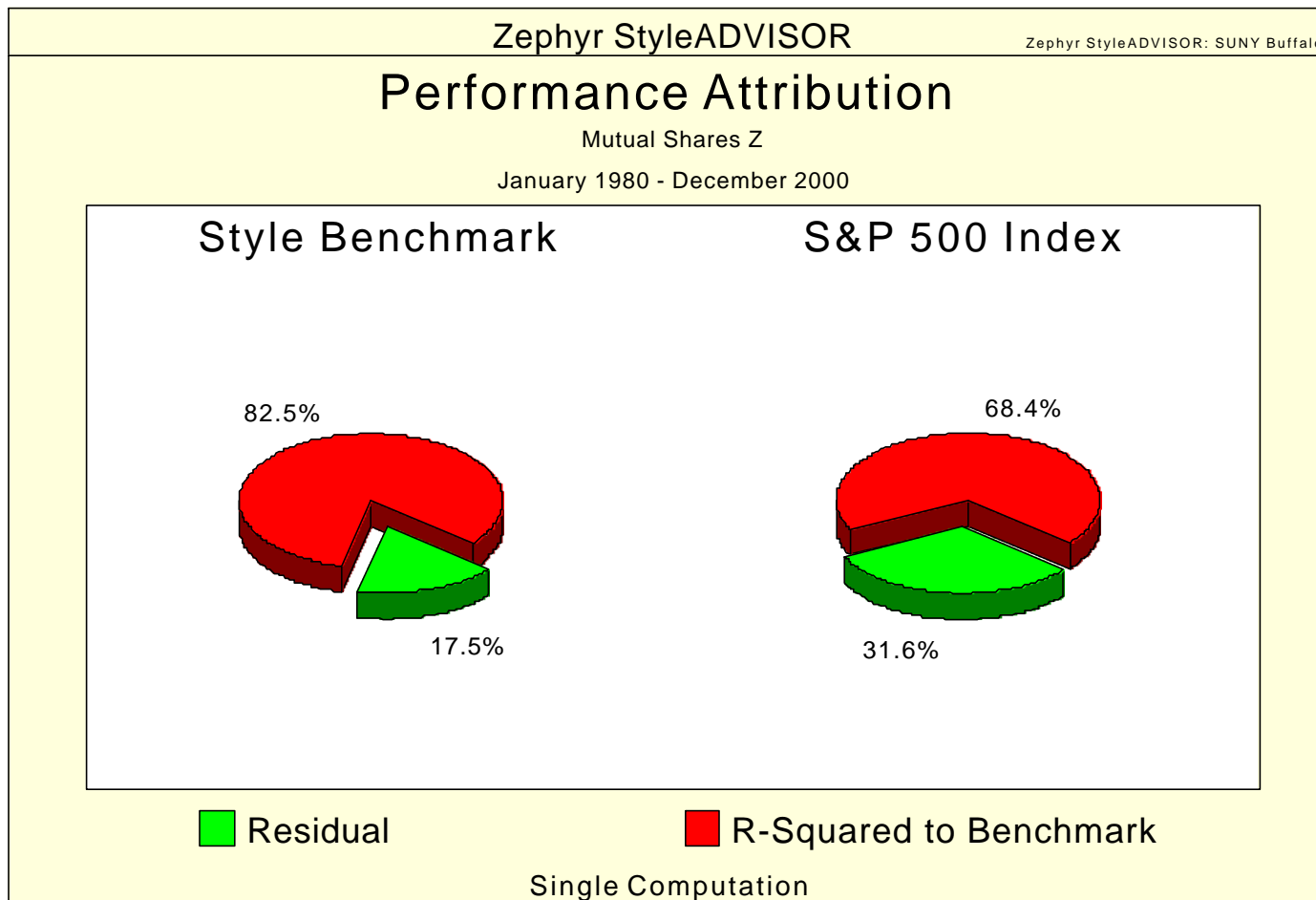


**Cumulative Excess Return of Mutual Fund Shares Relative to “Style Benchmark”**  
*idea:* you can get the “style benchmark” return by simply putting a % of the assets into the indices in the same % as the weights from the style model. The manager should be able to beat this passive strategy



Dividing the Out of Sample Performance of the Fund between:

1. The Estimated “Style” Model and the Manager
2. The Estimated Market Model and the Manager



# Refinements

- What sample period best represents what the manager *will* do?
- What changes has the active manager made over the history of the portfolio?
- How well does the passive strategy do *out of sample*?
  - If it is really *investible* then we must hold it out of sample, how well would we have done?
- Other twists:
  - What happens if I can short the indices?
  - Does the optimization routine make a difference?

# Summary

- Risk Models are widely used for performance measurement, style analysis (communication and risk control), and estimation of expected returns
- statistical models have strengths
  - objective, clear, inexpensive,and limitations
  - statistical assumptions are never quite true
  - model cannot capture qualitative information
- the importance of the strengths and limitations depend on how the models are used