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Performance evaluation of actively managed portfolios

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Past performance is not a guide to future performance.

Outline of the presentation

Topics

- Goal and universe of performance measurement
- Performance metrics
  - Return
  - Risk/return composite
  - Alternatives
- Factor performance attribution
- Luck versus skill
- Alpha vs Beta in practice
- Trading factors
- The factor zoo and „taming”

What is the goal of performance evaluation

How well the portfolio (manager) performed?

How well the portfolio (manager) will perform in the future?

- Why?
- What skills?
- Luck vs
  skill vs
  other contribution?

- Evaluate a manager how well they did their job
- Does the performance justify fees?
- Comparison of funds
- Fund performance vs other investment alternatives
- Fund performance vs benchmark
- Fund performance vs factors
- Fund performance vs a randomly trading manager (with some luck)

What is the goal of performance evaluation

Investment universe

Fund manager selecting from:
- Stocks
- Bonds
- Cash

- Other: alternatives
  (Private Equity, Real Estate, Infrastructure, Commodities, etc)

Active
- Dynamic allocation
- Stock picking
- High turnover (trading)
- Higher cost
- „View” / differentiating

Passive
- Index:
- Index following ETF / index funds
- Benchmark
- Low/zero turnover
- Rule-based (systhematic)
- Low cost

Investment universe

- Benchmark: any asset/portfolio to compare your fund
  Can be an index, a mix of indices, cash, etc…
- Index: hypothetical portfolio of securities representing a particular market or a segment of it.
- Tradeable index:
  Index Fund following and index (mutual fund, ETF)

Investment universe

Index:

- Cap weighted market index
- Other weights:
  Equal weighted (dollar weighted)
  Simple average (Dow Jones Index)

- Geographical /size based segregation
  Global , US, UK, EM, APAC,…
  Large Cap, Mid Cap, Small Cap

- Sector Index
  IT, Health Care, Auto, Financials, etc…

- Style index: MSCI _Value Index

(factor replication/ tradable portfolios: details later)

General performance attribution

How do we measure performance of an portfolio?

Performance metrics:

- Return based metrics
- Composite metrics
- Alternative metrics to measure allocation effect
- +considering factors

Return based metrics

Definition of return:

$$P_{t+1} = P_t(1 + R)$$

$$R = \frac{P_{t+1} - P_t}{P_t} - 1 \ , P_{t+1} = P_t(1 + R)$$

Compounding returns

$$P_{t+T} = P_t(1 + \mathrm{r})^T$$

T is measure in years (annualized return)

Return: some details

Which kind of return ?

- Absolute / excess return
- Real/Nominal (adjusting for inflation)
- Total return (dividends are re-invested)
- Annualized return : geometric / arithmetic average
- Local currency / investor currency/ USD (+hedged share class)
- Gross return/net return (adjusting for cost)

- Mathematical variations: log return

- Generalized to more general cash-flow: IRR

Absolute vs Relative return

Absolute return = Benchmark return + Excess return
total passive active

Relative return of active strategies

Zero sum game:
The weighted sum of active strategies, is zero above market before cost if measured properly.

Sharpe, The Financial Analysts' Journal Vol. 47, No. 1, January/February 1991. pp. 7-9

How can one get different result?
Issues about measuring average return of active funds

- Dollar weighting vs simple average
- Cash holding funds
- Survivorship bias

Relative return of active strategies

Log-return

Commonly used in econometrics, financial mathematics, regressions and factor models:

$$(1 + r) = e^{\tilde{r}}$$

SIMPLE RETURN

$$P_{t+1} = P_t(1 + \mathrm{r})$$

$$P_{t+T} = P_t(1 + \mathrm{r})^T$$

$$P_{t+N} = P_t(1 + r_1)(1 + r_2) \dots (1 + r_N)$$

LOGRETURN

$$P_{t+1} = P_t e^{\tilde{r}}$$

$$P_{t+T} = P_t e^{\widetilde{rT}}$$

$$P_{t+N} = P_t \, e^{(\widetilde{r_1} + \widetilde{r_2} + \dots + \widetilde{r_N})T}$$

$$r = e^{\tilde{r}} - 1$$

$$\tilde{r} = \ln(1 + r)$$

$$AVG(r) = \sqrt[N]{(1 + r_1)(1 + r_2) \dots (1 + r_N)}$$

$$AVG(r) = \frac{(\widetilde{r_1} + \widetilde{r_2} + \dots + \widetilde{r_N})}{N}$$

Log-return

Commonly used in econometrics, financial mathematics, regressions and factor models:

$$(1 + r) = e^{\tilde{r}}$$

SIMPLE RETURN

+10% + -10% = -1%

- Compounding
- Consistent with normal distribution, floored by -100%
- Not symmetric

- Equal with dollar earned investing 100$

LOGRETURN

+10% + -10% = **0%**

- Addition
- Consistent with log-normal distribution
- Symmetric
- Central limit theorem, t-stat,

- Need to be transformed back, to get real money terms

Return convention :

In the following considerations, we will use

- Annualized (geometrical average)
- Absolute return + relative return with explicitly mentioned
- Nominal return

Risk adjusted metrics: dimensionless ratios

Sharpe ratio $$Sh = \frac{Ri - RFR}{\sigma_i}$$

Treynor index $$T = \frac{Ri - R_B}{\beta_i}$$

Information ratio $$IR = \frac{Ri - R_B}{\sigma_{(R_i - R_B)}}$$

Sortino ratio $$ST = \frac{Ri - RFR}{DR_i}$$ $$DR_i = \left[\int_{\infty}^{\tau} (\tau - R_i)^2 f(R_i) dR_i\right]^{0.5}$$

Calmar ratio $$C = \frac{Ri - RFR}{MDD_i}$$

Risk adjusted metrics II.:

Modigliani risk-adjusted performance

$$M_{2\mathrm{a}} = (R_E - R_B)\frac{\sigma_B}{\sigma_E}$$

Jensen alpha

$$R_i = \alpha + \beta(R_M - RFR) + RFR$$

$$R_i = \alpha + \sum_k \beta^{(k)}\left(R_{(k)-factor} - RFR\right) + RFR$$

Sharpe ratio

Sharpe ratio

$$S_i = \frac{\bar{R_i} - R\bar{F}R}{\sigma_i}$$

- Normal return (CAPM) assumption
- Leverage / deleverage to a given volatility
- Risk aversion

Sharpe Ratio vs t-stat

- Sharpe ratio is proportional to t-statistics:
  (in case of iid. returns)

$$SR = \frac{\hat{\mu}}{\hat{\sigma}} \qquad t = \frac{\hat{\mu}}{\hat{\sigma}/\sqrt{T}} \qquad t = SR * \sqrt{T}$$

- Considering annualization (A is the annualization factor, in case of monthly return A=12)

$$SR = \frac{\hat{\mu} * A}{\hat{\sigma} * \sqrt{A}} \qquad t = SR * \sqrt{T/A}$$

Rule of thumbs:

$$t\text{-}stat = Sharpe * \sqrt{T}_{\text{in years}}$$

Sharpe Ratio: pitfalls

- Normal distribution of return (CAPM) assumption
- Penalize up and down movement equally
  (not a problem if distribution is symmetric)
- Risk considered only to the 2nd order (skew, kurtosis disregarded)
- Systematic risk is not considered:
  leverage the low vol portfolio can even enlarge systematic down-turn
- Prone to manipulations
- Hard to interpret negative values (e.g. larger risk mean less negative Sharpe)

Sharpe Ratio: pitfalls

Sharpe manipulations:

- after periods of high returns, the fund manager has the incentive to lower the risk
- while after periods of low returns, the manager has the incentive to increase the risk

- Writing put-options, or similar payoffs (selling insurance)

Sharpe Ratio: examples

INDEX RISK AND RETURN CHARACTERISTICS (SEP 30, 2019)

	Turnover (%) [1]	ANNUALIZED STD DEV (%) [2]			SHARPE RATIO [2,3]				MAXIMUM DRAWDOWN	
		3 Yr	5 Yr	10 Yr	3 Yr	5 Yr	10 Yr	Since Dec 31, 1987	(%)	Period YYYY-MM-DD
MSCI World	2.37	11.30	11.63	13.02	0.82	0.61	0.72	0.36	57.46	2007-10-31—2009-03-09
MSCI Emerging Markets	8.99	14.04	15.55	17.04	0.39	0.18	0.26	0.40	65.14	2007-10-29—2008-10-27
MSCI ACWI	2.96	11.32	11.71	13.20	0.78	0.56	0.66	0.35	58.06	2007-10-31—2009-03-09

[1] Last 12 months [2] Based on monthly gross returns data [3] Based on ICE LIBOR 1M

Sharpe Ratio: examples

Warren Buffet

Sharpe Ratio for 1976 - 2011 is 0.76:
Berkshire average excess annual return is 19% over T-bills;

Realized volatility is 24.9% (vs. the market's 15.8%);

Sharpe ratio is 19/24.9 = 0.76 (vs. the market’s 0.39).

Sharpe Ratio: sampling error vs observation time

Sharpe Ratio is a statistical estimator. It has a standard error!

- Andrew W Lo : The Statistics of Sharpe Ratios
- Article in Financial Analysts Journal · February 2003

$$\frac{\mathrm{SE}(\widehat{\mathrm{SR}})}{\mathrm{SR}} = \sqrt{\frac{1+(1/2)\,\mathrm{SR}^2}{T\,\mathrm{SR}^2}} \rightarrow \sqrt{\frac{1}{2T}}$$

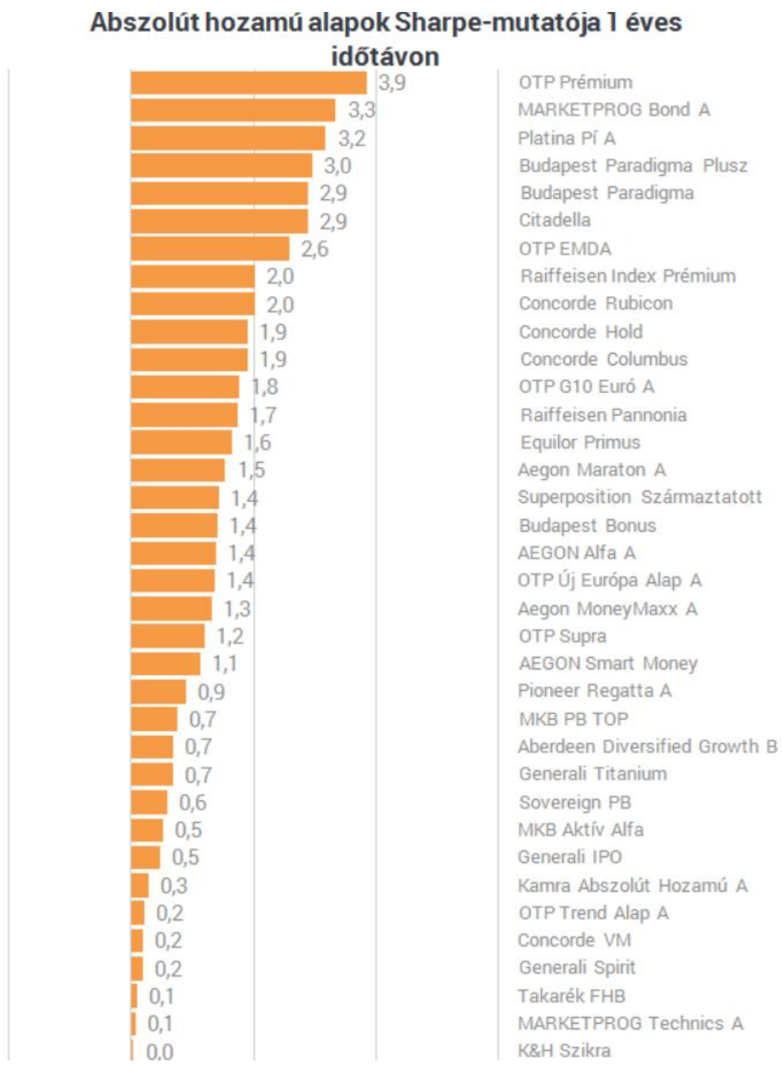
Sharpe Ratio: sampling error vs observation time

Table 1. Asymptotic Standard Errors of Sharpe Ratio Estimators for Combinations of Sharpe Ratio and Sample Size

	Sample Size, T							
SR	12	24	36	48	60	125	250	500
0.50	0.306	0.217	0.177	0.153	0.137	0.095	0.067	0.047
0.75	0.327	0.231	0.189	0.163	0.146	0.101	0.072	0.051
1.00	0.354	0.250	0.204	0.177	0.158	0.110	0.077	0.055
1.25	0.385	0.272	0.222	0.193	0.172	0.119	0.084	0.060
1.50	0.421	0.298	0.243	0.210	0.188	0.130	0.092	0.065
1.75	0.459	0.325	0.265	0.230	0.205	0.142	0.101	0.071
2.00	0.500	0.354	0.289	0.250	0.224	0.155	0.110	0.077
2.25	0.542	0.384	0.313	0.271	0.243	0.168	0.119	0.084
2.50	0.586	0.415	0.339	0.293	0.262	0.182	0.128	0.091
2.75	0.631	0.446	0.364	0.316	0.282	0.196	0.138	0.098
3.00	0.677	0.479	0.391	0.339	0.303	0.210	0.148	0.105

Note: Returns are assumed to be IID, which implies $V_{IID} = 1 + 1/2\mathrm{SR}^2$.

Sharpe Ratio: examples



The fundamental Law of Active Management

- Fundamental Law of Active Management (Grinold,Richard C. 1989.)

$$IR = IC \ * \sqrt{N}$$

- Information Ratio

- Information Coefficient
- Correlation of predicted return and realized return

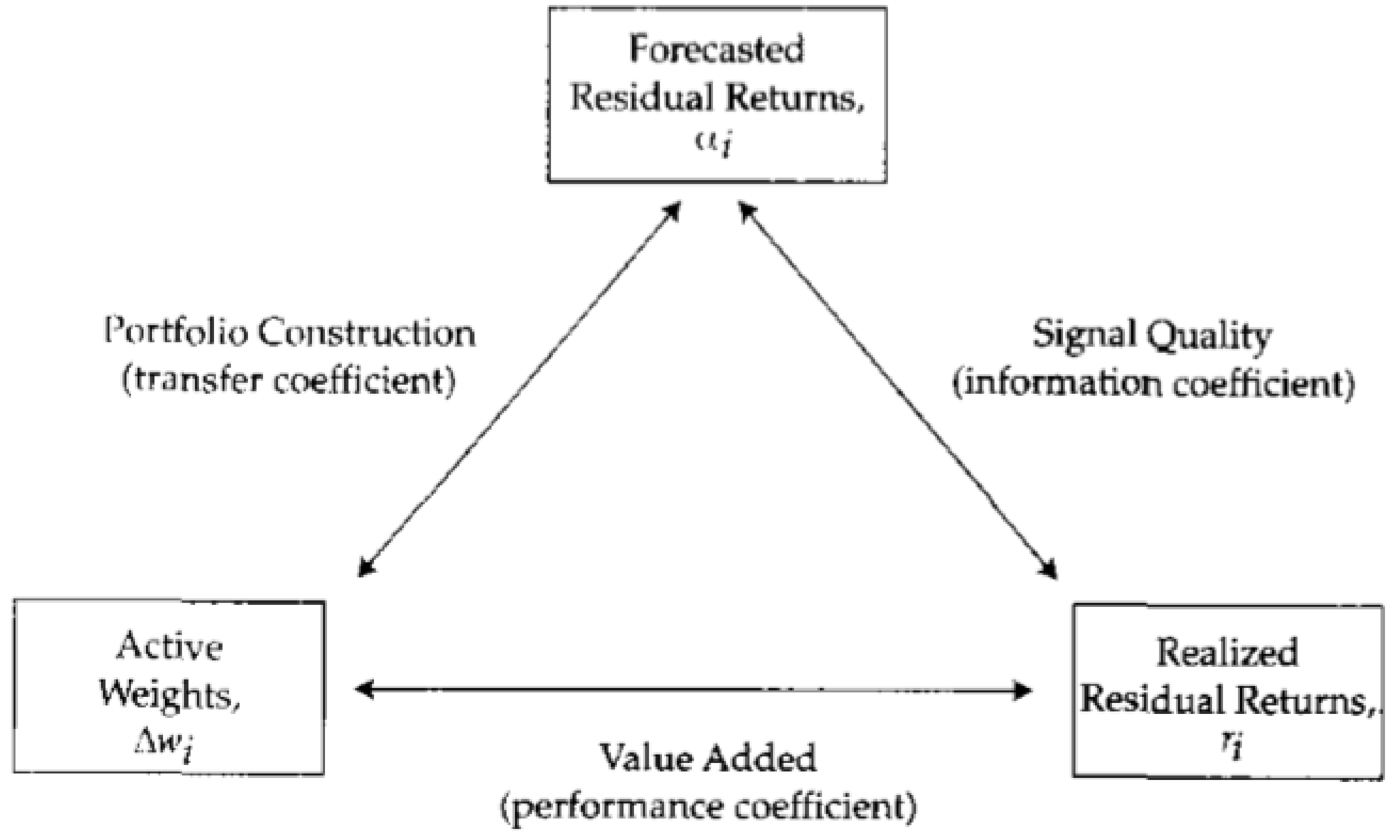
- Breadth: number of independent bets

- Transfer coefficient:

$$IR = IC \ * \sqrt{N} * TC$$

The fundamental Law of Active Management

Figure 1. The Correlation Triangle



Performance metrics: Jensen alpha

Measure if the performance can be explained by factors.

$$R_i = \alpha + \beta(R_M - RFR) + RFR$$

$$R_i = \alpha + \sum_k \beta^{(k)}\left(f_{(k)} - RFR\right) + RFR$$

Attribution analysis

What are the sources of over performances?

- Attribution among asset classes
- Stock picking ability
- Timing

Attribution analysis

Grinblatt and Titman (GT) metric:
Measures the contribution of a manager in terms of the adjustments they make to portfolio weights

$$
\begin{aligned}
GT &= \sum_j (w_{jt} - w_{j,t-1}) R_{jt} \\
\bar{GT} &= \frac{1}{T} \sum_t GT_t
\end{aligned}
$$

Attribution analysis

Attribution Effect

$$AE = \sum_i [(w_{ai} - w_{pi})(R_{pi} - R_p)]$$

Selection Effect

$$SE = \sum_i [w_{ai}(R_{ai} - R_{pi})]$$

- w_{ai}, w_{pi} : the investment proportions in the i – th market segment in the manager's actual portfolio and the benchmark portfolio respectively.
- R_{ai}, R_{pi} :the investment returns to the i – th market segment in the manager's actual portfolio and the benchmark portfolio respectively.
- R_p is the total benchmark return

Measuring timing ability

Perfect timing: manager can decide in each timestep between

- Hold only the Stock
- Hold only the Bond
- Hold cash

Optimal timing is the ability to choose the one with maximum return (beforehand):

$$R_{pt} = RFR_t + max[(R_{st} - RFR_t), (R_{bt} - RFR_t), 0]$$

Let's attribute our profit to perfect timing performance vs static bond/stock holdings:

$$\begin{aligned} [R_{pt} - RFR_t] &= \hat{\alpha} + \hat{\beta}_s(R_{st} - RFR_t) + \hat{\beta}_b(R_{bt} - RFR_t) \\ &+ \hat{\gamma}[max[(R_{st} - RFR_t), (R_{bt} - RFR_t), 0]] \\ &+ \hat{e}_t \qquad (10) \end{aligned}$$

Factor models

- Similar returns can be explained by similarities e.g. factors between assets (stocks)
- The returns in a cross section is driven by factors represents these similarities
- Factors:
- Market
- Sector/group: industry, country, …
- Return based: momentum, reversal, volatility,
- Fundamentals and other features: value, growth, carry , dividend, quality, etc

Factor models

return exposure factor specific error

$$\underset{n\times 1}{\boxed{r}} = \underset{n\times k}{\boxed{X}}\;\underset{k\times 1}{\boxed{f}} + \underset{n\times 1}{\boxed{\varepsilon}}\,, \qquad \varepsilon \sim N(0, \Sigma_\varepsilon)$$

$$\boldsymbol{r_t^i} = \boldsymbol{X_t^{(1)i} F_t} + \boldsymbol{X_t^{(2)i} F_t} + \boldsymbol{X_t^{(3)i} F_t} + \boldsymbol{\varepsilon_t} + \boldsymbol{\alpha}$$

Application for factors

- Return can be attributed to factor + residual, and the measures can be applied to this components
- Jensen alpha
- Risk management, volatility estimation
- Factor allocation / factor rotation
- Factor timing
- Understanding effect (ESG factor, etc)
- …

Alpha or Beta?

Active strategies can be (at least partially) replicated by a factor index strategy.

E.g. the skill of a value trader manager can be replaced by a Value factor index.

Alpha -> “Smart beta”

Smart beta : capturing investment factors or market inefficiencies in a rules-based and transparent way.
E.g.: factor following tradable indices.

Paradigm shifts, a stylized story…

- 19th sc. Fund manager is paid for their return (+ diversification), it is the absolute return what matters
- Lets benchmark them: creating broad market index (1969 Capital International)
- Buy the index? Build tradeable index ETFs: 1993 State Street, Spider (SP 500)

- Fund manager is paid for excess return: absolute – benchmark
- Is the return really compelling? Skill or just replicating factors?
- Lets attribute for factors
- Build tradeable ETF for style factors

- Fund manager is paid for Alpha (Jensen-alpha) residual after adjusting market and factors
- New factor is introduced..
- …

Trading factors

How to make factors tradable ?
Creating a portfolio which proxies a given factor

Long-short: rank stocks (assets)
long top quantile / short bottom quantile

More general: weight assets by their loadings in the factor model (X)

Over-weigh/under-weigh assets in the index according their loading (score)

Trading factors

Possible way to create profitable quantitive strategies by using factors:

- Finding new factors. Not easy.
  Any trading signal can be handled as a factor
  New factors are arbitraged away quickly.
- Creating custom (proprietary) factor versions , by optimization of parameters (back-testing)
- Factors with shorter lifespan: „arm-race”
- Timing factors
- Playing factor momentum or reversals
- Combining factors

Taming the factor zoo

ID	Description	Year.pub	Year.end	Avg.Ret.	Annual S.R.	Reference
1	Excess Market Return	1972	1965	0.64%	50.6%	Jensen et al. (1972)
2	Market Beta	1973	1968	-0.08%	-5.4%	Fama and MacBeth (1973)
3	Earnings to price	1977	1971	0.28%	29.7%	Basu (1977)
4	Dividend to price	1979	1977	0.01%	0.6%	Litzenberger and Ramaswamy (1979)
5	Unexpected quarterly earnings	1982	1980	0.12%	26.3%	Rendleman et al. (1982)
6	Share price	1982	1978	0.02%	2.2%	Miller and Scholes (1982)
7	Long-Term Reversal	1985	1982	0.34%	36.3%	Bondt and Thaler (1985)
8	Leverage	1988	1981	0.21%	24.3%	Bhandari (1988)
9	Cash flow to debt	1989	1984	-0.09%	-17.0%	Ou and Penman (1989)
10	Current ratio	1989	1984	0.06%	7.7%	Ou and Penman (1989)
11	% change in current ratio	1989	1984	0.00%	0.5%	Ou and Penman (1989)
12	% change in quick ratio	1989	1984	-0.04%	-11.9%	Ou and Penman (1989)
13	% change sales-to-inventory	1989	1984	0.17%	46.2%	Ou and Penman (1989)
14	Quick ratio	1989	1984	-0.02%	-2.9%	Ou and Penman (1989)
15	Sales to cash	1989	1984	0.01%	1.5%	Ou and Penman (1989)
16	Sales to inventory	1989	1984	0.09%	16.1%	Ou and Penman (1989)
17	Sales to receivables	1989	1984	0.14%	22.8%	Ou and Penman (1989)
18	Bid-ask spread	1989	1979	-0.04%	-3.3%	Amihud and Mendelson (1989)
19	Depreciation / PP&E	1992	1988	0.11%	12.1%	Holthausen and Larcker (1992)
20	% change in depreciation	1992	1988	0.08%	23.1%	Holthausen and Larcker (1992)
21	Small Minus Big	1993	1991	0.21%	24.5%	Fama and French (1993)
22	High Minus Low	1993	1991	0.28%	34.3%	Fama and French (1993)
23	Short-Term Reversal	1993	1989	0.15%	21.7%	Jegadeesh and Titman (1993)
24	6-month momentum	1993	1989	0.21%	27.8%	Jegadeesh and Titman (1993)
25	36-month momentum	1993	1989	0.09%	13.4%	Jegadeesh and Titman (1993)
26	Sales growth	1994	1990	0.04%	5.8%	Lakonishok et al. (1994)
27	Cash flow-to-price	1994	1990	0.31%	32.5%	Lakonishok et al. (1994)
28	New equity issue	1995	1990	0.10%	8.7%	Loughran and Ritter (1995)
29	Dividend initiation	1995	1988	-0.03%	-3.4%	Michaely et al. (1995)
30	Dividend omission	1995	1988	-0.18%	-18.0%	Michaely et al. (1995)

Momentum factor

Jegadeesh and Titman (1993)

Market + Small Minus Big + High minus Low+ Winner minus Looser

4th factor: the return difference of winner and loser stocks of the past twelve months

Summary

- Performance measurement is important, to understand strategies, access manager skills, compare funds to each other, or tradable alternatives
- Returns, risk adjusted complex measures, and attribution measures has been introduced
- Measures are estimators. Let be aware of pitfalls, limitations, hidden assumptions, statistics behind them.
- Factor models can help to understand the strategy, and what skills the manager is paid for.
- Factor attribution can attribute performance and risk to certain factors
- Factor zoo is huge (150+ funds), can be sliced to much less number of relevant and irredundant factors

Thank you for your attention

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