What algorithmic strategies work?

Look for signals X that are useful in investment rules

$$a(X,Z)$$

To be used e.g. in a single period investment decision:

$$W[a(x,Z)(1+R)+(1-a(X,Z)Rf)]$$

Many prominent *unsuccessful* attempts to answer this

- On average, mutual funds underperform market
- No (?) predictability of fund risk-adjusted performance

But there is evidence there are such signals

Buffet's performance

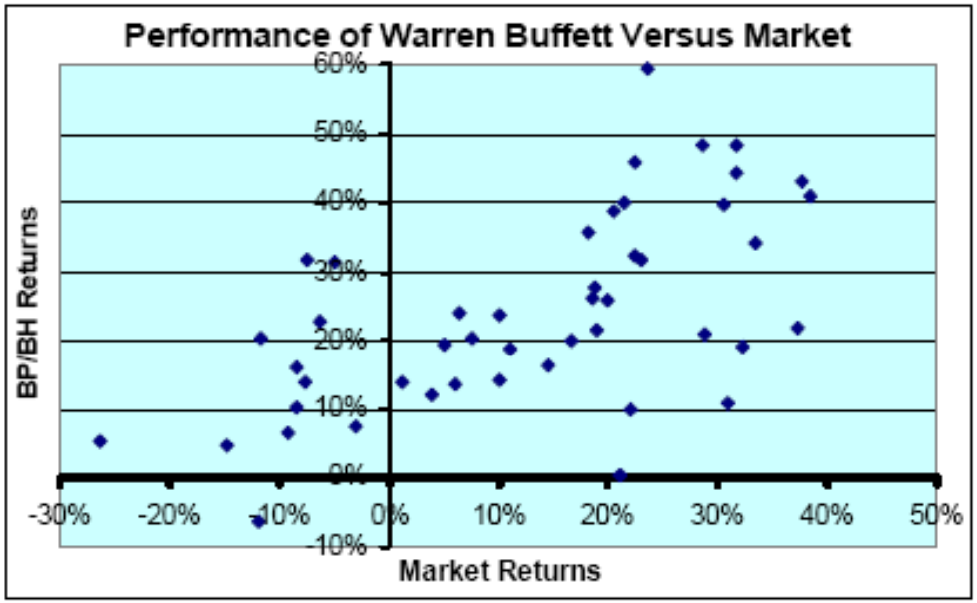


Chart 1: Performance of Warren Buffett as measured by the annual growth of the Buffett Partnerships from 1957 to 1964 and then Berkshire Hathaway from 1965 to 2003 compared to the annual growth of the market as measured by the Dow Jones Industrial Average from 1957 to 1964 and the S&P 500 with dividends reinvested after that.

Graham value investing

Table 1 • Walter J. Schloss

Year	S&P Overall Gain, Including Dividends (%)	WJS Ltd Partners Overall Gain per year (%)	WJS Partnership Overall Gain per year (%)
1956	7.5	5.1	6.8
1957	−10.5	− 4.7	− 4.7
1958	42.1	42.1	54.6
1959	12.7	17.5	23.3
1960	− 1.6	7.0	9.3
1961	26.4	21.6	28.8
1962	−10.2	8.3	11.1
1963	23.3	15.1	20.1
1964	16.5	17.1	22.8
1965	13.1	26.8	35.7
1966	−10.4	0.5	0.7
1967	26.8	25.8	34.4
1968	10.6	26.6	35.5
1969	− 7.5	−9.0	−9.0
1970	2.4	− 8.2	− 8.2
1971	14.9	25.5	28.3
1972	19.8	11.6	15.5
1973	−14.8	− 8.0	− 8.0
1974	−26.6	− 6.2	− 6.2
1975	36.9	42.7	52.2
1976	22.4	29.4	39.2
1977	− 8.6	25.8	34.4
1978	7.0	36.6	48.8
1979	17.6	29.8	39.7
1980	32.1	23.3	31.1
1981	− 6.7	18.4	24.5
1982	20.2	24.1	32.1
1983	22.8	38.4	51.2
1984 1st Qtr.	− 2.3	0.8	1.1

Standard & Poor's 28 1/4 year compounded gain	887.2%
WJS Limited Partners 28 1/4 year compounded gain	6,678.9%
WJS Partnership 28 1/4 year compounded gain	23,104.7%
Standard & Poor's 28 1/4 year annual compounded rate	8.4%
WJS Limited Partners 28 1/4 year annual compounded rate	16.1%
WJS Partnership 28 1/4 year annual compounded rate	21.3%

During the history of the Partnership it has owned over 800 issues and, at most times, has had at least 100 positions. Present assets under management approximate $45 million.

Table 2 · Tweedy, Browne Inc.

Period Ended (September 30)	Dow Jones* (%)	S & P 500* (%)	TBK Overall (%)	TBK Limited Partners (%)
1968 (9 mos.)	6.0	8.8	27.6	22.0
1969	– 9.5	– 6.2	12.7	10.0
1970	– 2.5	– 6.1	– 1.3	– 1.9
1971	20.7	20.4	20.9	16.1
1972	11.0	15.5	14.6	11.8
1973	2.9	1.0	8.3	7.5
1974	–31.8	–38.1	1.5	1.5
1975	36.9	37.8	28.8	22.0
1976	29.6	30.1	40.2	32.8
1977	– 9.9	–4.0	23.4	18.7
1978	8.3	11.9	41.0	32.1
1979	7.9	12.7	25.5	20.5
1980	13.0	21.1	21.4	17.3
1981	– 3.3	– 2.7	14.4	11.6
1982	12.5	10.1	10.2	8.2
1983	44.5	44.3	35.0	25.2
Total Return				
15 3/4 years	**191.8%**	**238.5%**	**1,661.2%**	**936.4%**
Standard & Poor's 15 3/4 year annual compounded rate				**7.0%**
TBK Limited Partners 15 3/4 year annual compounded rate				**16.0%**
TBK Overall 15 3/4 year annual compounded rate				**20.0%**

*Includes dividends paid for both Standard & Poor's 500 Composite Index and Dow Jones Industrial Average.

Table 3 · Buffett Partnership, Ltd.

Year	Overall Results From Dow (%)	Partnership Results (%)	Limited Partners' Results (%)
1957	– 8.4	10.4	9.3
1958	38.5	40.9	32.2
1959	20.0	25.9	20.9
1960	– 6.2	22.8	18.6
1961	22.4	45.9	35.9
1962	– 7.6	13.9	11.9
1963	20.6	38.7	30.5
1964	18.7	27.8	22.3
1965	14.2	47.2	36.9
1966	–15.6	20.4	16.8
1967	19.0	35.9	28.4
1968	7.7	58.8	45.6
1969	–11.6	6.8	6.6
On a cumulative or compounded basis, the results are:			
1957	– 8.4	10.4	9.3
1957–58	26.9	55.6	44.5
1957–59	52.3	95.9	74.7
1957–60	42.9	140.6	107.2
1957–61	74.9	251.0	181.6
1957–62	61.6	299.8	215.1
1957–63	94.9	454.5	311.2
1957–64	131.3	608.7	402.9
1957–65	164.1	943.2	588.5
1957–66	122.9	1156.0	704.2
1957–67	165.3	1606.9	932.6
1957–68	185.7	2610.6	1403.5
1957–69	152.6	2794.9	1502.7
Annual Compounded Rate	7.4	29.5	23.8

Table 4 • Sequoia Fund, Inc.

Year	Annual Percentage Change**	
	Sequoia Fund (%)	S&P 500 Index* (%)
1970 (from July 15)	12.1	20.6
1971	13.5	14.3
1972	3.7	18.9
1973	– 24.0	– 14.8
1974	– 15.7	– 26.4
1975	60.5	37.2
1976	72.3	23.6
1977	19.9	– 7.4
1978	23.9	6.4
1979	12.1	18.2
1980	12.6	32.3
1981	21.5	– 5.0
1982	31.2	21.4
1983	27.3	22.4
1984 (first quarter)	– 1.6	– 2.4
Entire Period	775.3%	270.0%
Compound Annual Return	17.2%	10.0%
Plus 1% Management Fee	1.0%	
Gross Investment Return	**18.2%**	**10.0%**

*Includes dividends (and capital gains distributions in the case of Sequoia Fund) treated as though reinvested.

**These figures differ slightly from the S&P figures in Table 1 because of a difference in calculation of reinvested dividends.

Table 5 · Charles Munger

Year	Mass. Inv. Trust (%)	Investors Stock (%)	Lehman (%)	Tri-Cont. (%)	Dow (%)	Over-all Partnership (%)	Limited Partners (%)
Yearly Results (1)							
1962	– 9.8	–13.4	–14.4	– 12.2	– 7.6	30.1	20.1
1963	20.0	16.5	23.8	20.3	20.6	71.7	47.8
1964	15.9	14.3	13.6	13.3	18.7	49.7	33.1
1965	10.2	9.8	19.0	10.7	14.2	8.4	6.0
1966	– 7.7	– 9.9	– 2.6	– 6.9	– 15.7	12.4	8.3
1967	20.0	22.8	28.0	25.4	19.0	56.2	37.5
1968	10.3	8.1	6.7	6.8	7.7	40.4	27.0
1969	– 4.8	– 7.9	– 1.9	0.1	– 11.6	28.3	21.3
1970	0.6	– 4.1	– 7.2	– 1.0	8.7	– 0.1	– 0.1
1971	9.0	16.8	26.6	22.4	9.8	25.4	20.6
1972	11.0	15.2	23.7	21.4	18.2	8.3	7.3
1973	–12.5	–17.6	–14.3	– 21.3	– 13.1	– 31.9	– 31.9
1974	–25.5	–25.6	–30.3	– 27.6	– 23.1	– 31.5	– 31.5
1975	32.9	33.3	30.8	35.4	44.4	73.2	73.2
Compound Results (2)							
1962	– 9.8	–13.4	– 14.4	– 12.2	– 7.6	30.1	20.1
1962–3	8.2	0.9	6.0	5.6	11.5	123.4	77.5
1962–4	25.4	15.3	20.4	19.6	32.4	234.4	136.3
1962–5	38.2	26.6	43.3	32.4	51.2	262.5	150.5
1962–6	27.5	14.1	39.5	23.2	27.5	307.5	171.3
1962–7	53.0	40.1	78.5	54.5	51.8	536.5	273.0
1962–8	68.8	51.4	90.5	65.0	63.5	793.6	373.7
1962–9	60.7	39.4	86.9	65.2	44.5	1046.5	474.6
1962–70	61.7	33.7	73.4	63.5	57.1	1045.4	474.0
1962–71	76.3	56.2	119.5	100.1	72.5	1336.3	592.2
1962–72	95.7	79.9	171.5	142.9	103.9	1455.5	642.7
1962–73	71.2	48.2	132.7	91.2	77.2	959.3	405.8
1962–74	27.5	10.3	62.2	38.4	36.3	625.6	246.5
1962–75	69.4	47.0	112.2	87.4	96.8	1156.7	500.1
Average Annual Compounded Rate	**3.8**	**2.8**	**5.5**	**4.6**	**5.0**	**19.8**	**13.7**

Table 6 · Pacific Partners, Ltd.

Year	S & P 500 Index (%)	Limited Partnership Results (%)	Overall Partnership Results (%)
1965	12.4	21.2	32.0
1966	–10.1	24.5	36.7
1967	23.9	120.1	180.1
1968	11.0	114.6	171.9
1969	– 8.4	64.7	97.1
1970	3.9	– 7.2	– 7.2
1971	14.6	10.9	16.4
1972	18.9	12.8	17.1
1973	–14.8	– 42.1	– 42.1
1974	–26.4	– 34.4	– 34.4
1975	37.2	23.4	31.2
1976	23.6	127.8	127.8
1977	– 7.4	20.3	27.1
1978	6.4	28.4	37.9
1979	18.2	36.1	48.2
1980	32.3	18.1	24.1
1981	– 5.0	6.0	8.0
1982	21.4	24.0	32.0
1983	22.4	18.6	24.8
Standard & Poor's 19 year compounded gain			**316.4%**
Ltd. Partnership 19 year compounded gain			**5,530.2%**
Overall Partnership 19 year compounded gain			**22,200.0%**
Standard & Poor's 19 year annual compounded rate			**7.8%**
Ltd. Partnership 19 year annual compounded rate			**23.6%**
Overall Partnership 19 year annual compounded rate			**32.9%**

Anomalies are published by rational researchers with greatest incentive

This table reports the mean and median values of all the possible explanatory variables in equations (24) and (25) for both the anomaly observations and for the matched observations. The differences in the mean values between the anomaly and matched samples are tested using a simple pair-wise t-test, while the differences in the median values are tested using a simple non-parametric median two-sample test. The variables reported are defined in the first column of the table.

	N		Mean				Sign		Median				Sign	
Variable	Anom.	Matched	Anom.	Matched	Dif	Sig.	Actual	Expected	Anom.	Matched	Dif.	Sig.	Actual	Expected
Previous Total Publications (PP)	68	71	7.59	7.75	-0.16		-	-	2.00	4.00	-2.00		-	-
Previous Total Publications per Year (PPY)	60	54	0.71	0.91	-0.20		-	-	0.52	0.88	-0.37	**	-	-
Previous Non-Top Publications (PNP)	68	71	3.84	4.44	-0.60		-	-	1.00	2.00	-1.00	**	-	-
Previous Non-Top Publications per Year (PNPY)	60	54	0.34	0.49	-0.15		-	-	0.20	0.35	-0.15	*	-	-
Residual Previous Total Publications (RPP)	68	71	-0.45	0.43	-0.88		-	-	-1.91	-1.55	-0.37		-	-
Residual Previous Non-Top Publications per Year (RPNPY)	60	54	-0.06	0.07	-0.13		-	-	-0.25	-0.17	-0.09		-	-
Previous Top Publications (PTP)	68	71	3.75	3.31	0.44		+	-	1.00	1.00	0.00			-
Previous Top Publications per Year (PTPY)	60	54	0.37	0.42	-0.05		-	-	0.26	0.33	-0.08		-	-
Subsequent Publications (SP)	68	71	13.09	12.58	0.51		+	-/+	4.00	7.00	-3.00		-	-/+
Subsequent Publications per Year (SPY)	68	71	0.77	0.72	0.04		+	-/+	0.50	0.50	0.00			-/+
Subsequent Non-Top Publications (SNP)	68	71	8.04	9.45	-1.41		-	-/+	2.00	4.00	-2.00	**	-	-/+
Subsequent Non-Top Publications per Year (SNPY)	68	71	0.45	0.53	-0.08		-	-/+	0.25	0.28	-0.03		-	-/+
Subsequent Top Publications (STP)	68	71	5.04	3.13	1.92	*	+	-/+	1.50	1.00	0.50		+	-/+
Subsequent Top Publications per Year (STPY)	68	71	0.32	0.20	0.12	**	+	-/+	0.11	0.09	0.02		+	-/+
Residual Subsequent Publications (RSP)	68	71	-1.51	1.45	-2.96		-	-/+	-5.47	-4.47	-1.00		-	-/+
Residual Subsequent Non-Top Publications per Year (RSNPY)	68	71	-0.07	0.07	-0.14		-	-/+	-0.26	-0.14	-0.12	*	-	-/+
Years Between Obtaining PhD and Publishing Paper (Years)	60	54	8.20	8.26	-0.06		-	-	6.00	8.00	-2.00	**	-	-
# of Authors on Paper (Auth)	68	71	2.06	2.27	-0.21		-	-/+	2.00	2.00	0.00			-/+
Not in Top 50 Authors List (NTOP50)	68	71	0.85	0.90	-0.05		-	-/+	1.00	1.00	0.00			-/+
Not in Any Top Authors List (NPAL)	68	71	0.62	0.73	-0.11		-	-/+	1.00	1.00	0.00			-/+

* Significant at 10% level
** Significant at 5% level
*** Significant at 1% level

- Some evidence of performance persistence for a few hedge fund / mutual fund / private equity managers

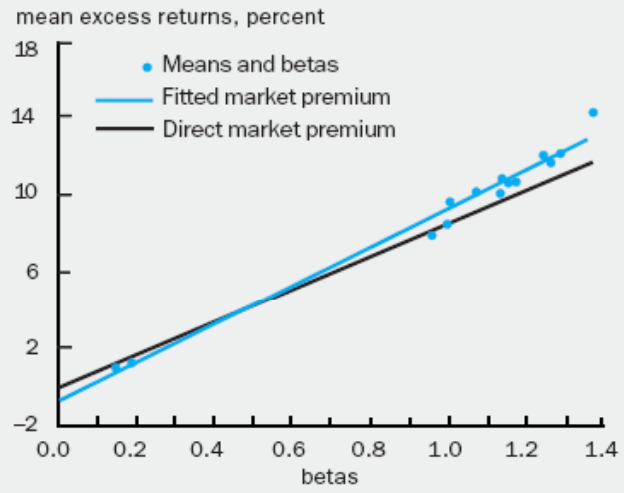
Risk

Fama-French factors

Beta

FIGURE 1

CAPM—Mean excess returns vs. beta, version 1

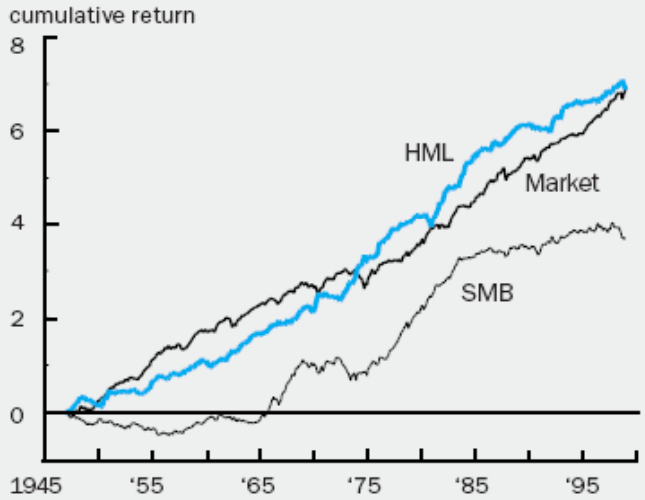


Notes: Average returns versus betas on the NYSE value-weighted portfolio for ten size-sorted stock portfolios, government bonds, and corporate bonds. Sample period 1947–96. The black line draws the CAPM prediction by fitting the market proxy and Treasury bill rates exactly (a time-series test) and the colored line draws the CAPM prediction by fitting an OLS cross-sectional regression to the displayed data points (a second-pass or cross-sectional test). The small-firm portfolios are at the top right. Moving down and to the left, one sees increasingly large-firm portfolios and the market index. The points far down and to the left are the government bond and Treasury bill returns.

Small stocks

FIGURE 6

Cumulative returns on market portfolios

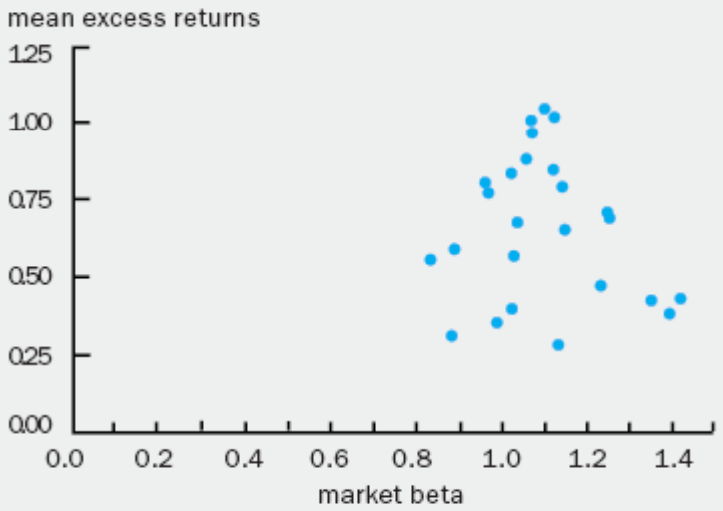


Notes: Cumulative returns on the market RMRF, SMB, and HML portfolios. The SMB return is formed by $R_t^{TB} + aSMB_t$; $a = \sigma(RMRF)/\sigma(SMB)$. In this way it is a return that can be cumulated rather than a zero-cost portfolio, and its standard deviation is equal to that of the market return. HML is adjusted similarly. The vertical axis is the log base 2 of the cumulative return or value of $1 invested at the beginning of the sample period. Thus, each time a line increases by 1 unit, the value doubles.

Value

FIGURE 3

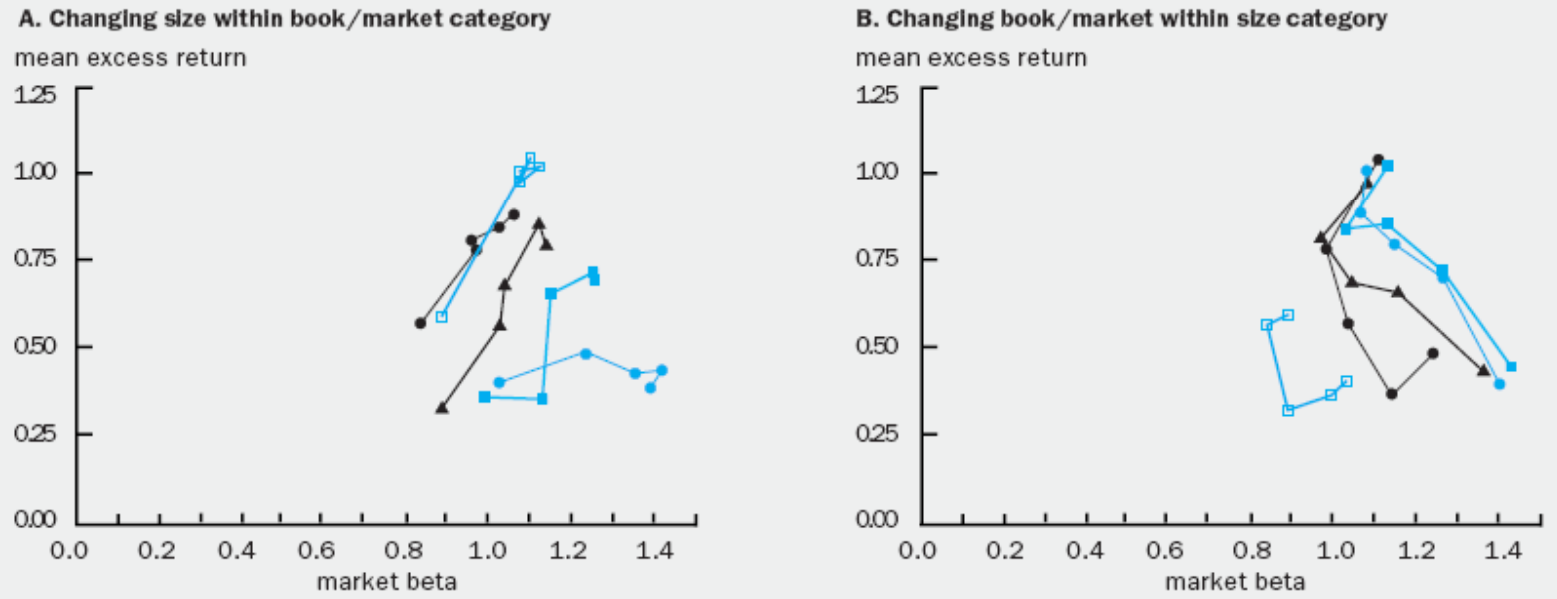
Mean excess returns vs. market beta, Fama–French portfolios



Notes: Average monthly returns versus market beta for 25 stock portfolios sorted on the basis of size and book/market ratio.

FIGURE 4

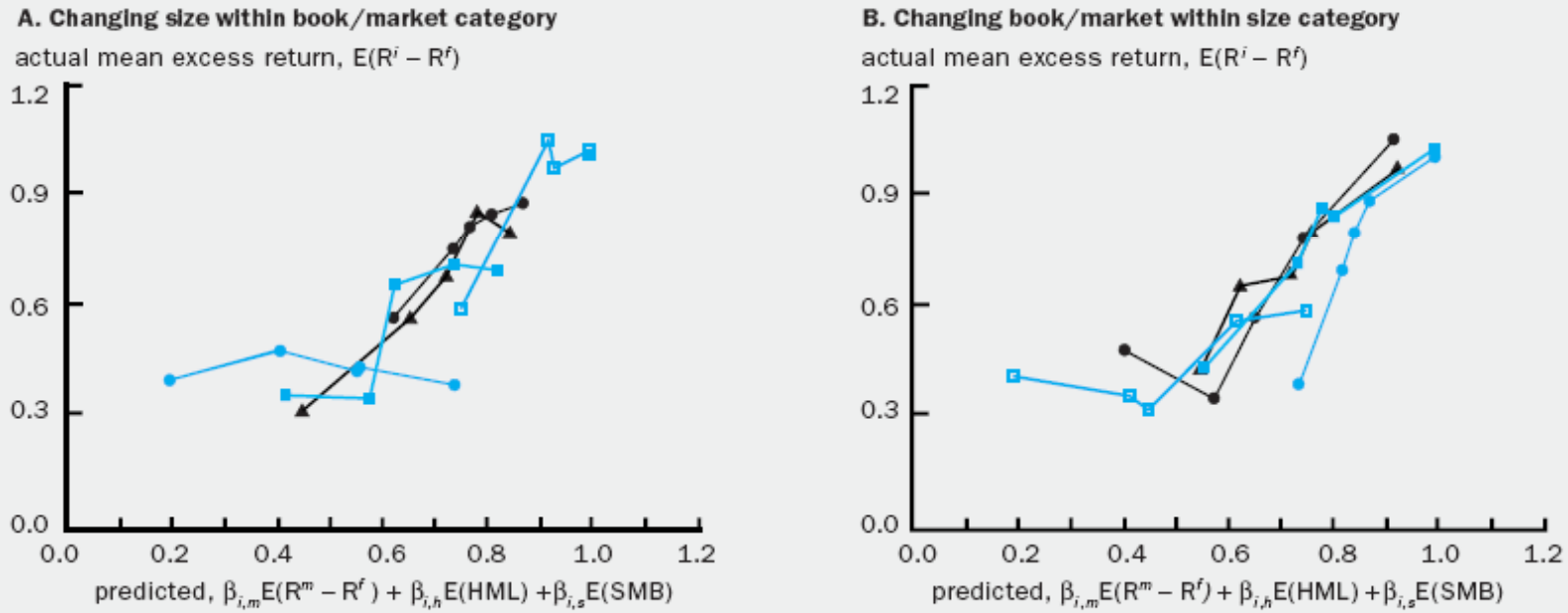
Mean excess returns vs. market beta, varying size and book/market ratio



Notes: Average returns versus market beta for 25 stock portfolios sorted on the basis of size and book/market ratio. The points are the same as figure 3. In panel A, lines connect portfolios as size varies within book/market categories; in panel B, lines connect portfolios as book/market ratio varies within size categories.

FIGURE 5

Mean excess return vs. three-factor model predictions



Notes: Average returns versus market beta for 25 stock portfolios sorted on the basis of size and book/market ratio versus predictions of Fama–French three-factor model. The predictions are derived by regressing each of the 25 portfolio returns, R^i_t, on the market portfolio, R^m_t, and the two Fama–French factor portfolios, SMB_t (small minus big) and HML_t (high minus low book/market). (See equation 4 in box 1.)

Momentum and reversal

TABLE 2

Average monthly returns, reversal and momentum strategies

Strategy	Period	Portfolio formation (months)	Average return, 10–1 (monthly%)
Reversal	July 1963–Dec. 1993	60–13	–0.74
Momentum	July 1963–Dec. 1993	12–2	+1.31
Reversal	Jan. 1931–Feb. 1963	60–13	–1.61
Momentum	Jan. 1931–Feb. 1963	12–2	+0.38

Notes: Each month, allocate all NYSE firms to 10 portfolios based on their performance during the "portfolio formation months" interval. For example, 60–13 forms portfolios based on returns from 5 years ago to 1 year, 1 month ago. Then buy the best-performing decile portfolio and short the worst-performing decile portfolio.

Source: Fama and French (1996, table 6).

Convergence

(aka relative-value, contrarian, mean reversion)

pairs trading

Figure 1
Daily normalized prices: Kennecott and Uniroyal (pair 5)
Trading period August 1963–January 1964.

- Formation period: 12 months
- Trading period: subsequent 6 months
- Stock universe: CRSP (several thousand)
- Frequency of trade decisions: daily
- Exclusion criteria: Stocks with a day with no trade
- Estimated parameters: pairs of stocks, using sum of squared deviation of (normalized) prices
- Replication frequency: monthly (requires adjustment of stats since overlapping returns imply correlations)

Trading rule

- Trading rule: open if spread is >2*std with std estimated in formation period;
- close when prices equal, stock is delisted or trading period ends
- Invest $1 each direction
- Return based on committed capital ($#pairs) and employed capital ($ # pairs traded)

Table 1
Excess returns of unrestricted pairs trading strategies

Pairs portfolio	Top 5	Top 20	101–120	All
A. Excess return distribution (no waiting)				
Average excess return (fully invested)	0.01308	0.01436	0.01081	0.01104
Standard error (Newey-West)	0.00148	0.00124	0.00094	0.00099
t-Statistic	8.84	11.56	11.54	11.16
Excess return distribution				
Median	0.01194	0.01235	0.00955	0.00728
Standard deviation	0.02280	0.01688	0.01540	0.01670
Skewness	0.62	1.39	1.34	3.42
Kurtosis	7.81	10.54	10.30	25.25
Minimum	–0.10573	–0.06629	–0.03857	–0.02721
Maximum	0.14716	0.13295	0.12684	0.17178
Observations with excess return < 0	26%	15%	21%	17%
Average excess return on committed capital	0.00784	0.00805	0.00679	0.00614
B. Excess return distribution (one day waiting)				
Average monthly return (fully invested)	0.00745	0.00895	0.00795	0.00715
Standard error (Newey-West)	0.00119	0.00096	0.00085	0.00090
t-Statistic	6.26	9.29	9.40	7.92
Excess return distribution				
Median	0.00699	0.00690	0.00694	0.00411
Standard deviation	0.02101	0.01527	0.01438	0.01577
Skewness	0.34	1.45	0.98	3.32
Kurtosis	10.64	16.13	7.78	25.66
Minimum	–0.12628	–0.08218	–0.04266	–0.02951
Maximum	0.14350	0.13490	0.10464	0.16325
Observations with excess return < 0	35%	23%	28%	32%
Average excess return on committed capital	0.00463	0.00520	0.00503	0.00396

Summary statistics of the monthly excess returns on portfolios of pairs between July 1963 and December 2002 (474 observations). We trade according to the rule that opens a position in a pair at the end of the day that prices of the stocks in the pair diverge by two historical standard deviations (Panel A). The results in Panel B correspond to a strategy that delays the opening of the pairs position by one day. All pairs are ranked according to least distance in historical price space. The "top *n*" portfolios include the *n* pairs with least distance measures, and the portfolio "101–120" studies the 20 pairs after the top 100. The average number of pairs in the all-pair portfolio is 2057. The *t*-statistics are computed using Newey-West standard errors with six-lag correction. Absolute kurtosis is reported.

Table 4
Systematic risk of pairs trading strategies

	Top 5	Top 20	20 after top 100	All	Equity premium
"Wait one day" portfolio performance					
Mean excess return	0.00745	0.00895	0.00795	0.00715	0.00410
Standard deviation	0.02101	0.01527	0.01438	0.01577	0.04509
Sharpe Ratio	0.35	0.59	0.55	0.45	0.09
Monthly serial correlation	0.14	0.24	0.19	0.12	0.05
Factor model: Fama–French, Momentum, Reversal					
Intercept	0.00545 (3.81)	0.00764 (7.08)	0.00714 (8.66)	0.00512 (5.30)	
Market	−0.06661 (–1.03)	−0.03155 (–0.64)	−0.07697 (–1.77)	−0.14520 (–3.10)	
SMB	−0.04233 (–0.71)	0.00111 (0.02)	−0.02333 (–0.50)	−0.07079 (–1.66)	
HML	0.05740 (1.37)	0.04514 (1.45)	−0.01724 (–0.59)	−0.05403 (–1.82)	
Momentum	−0.02804 (–0.94)	−0.04817 (–2.45)	−0.10312 (–5.83)	−0.18077 (–8.50)	
Reversal	0.10192 (1.50)	0.07237 (1.27)	0.09459 (2.24)	0.20077 (4.34)	
R^2	0.05	0.09	0.18	0.54	
Factor model: Ibbotson factors					
Intercept	0.00716 (6.32)	0.00857 (9.25)	0.00766 (9.39)	0.00651 (7.77)	
Market	−0.00182 (–0.07)	0.01377 (0.74)	0.01642 (0.90)	0.06466 (1.98)	
Small stock premium	0.04120 (1.32)	0.05227 (2.22)	0.03646 (1.66)	0.07608 (1.93)	
Bond default premium	0.14593 (1.11)	0.15989 (1.38)	0.16811 (1.81)	0.30571 (2.82)	
Bond horizon premium	0.07997 (1.55)	0.06818 (1.64)	0.04034 (1.04)	0.03422 (0.77)	
R^2	0.02	0.05	0.04	0.15	

Monthly risk exposures for portfolios of pairs formed and traded according to the "wait one day" rule discussed in the text, over the period between June 1963 and December 2002. The five actors are the three Fama–French factors, Carhart's Momentum factor, and the Reversal factor discussed in the text. Returns for the portfolios are in excess of the riskless rate. S&P 500 returns are calculated in excess of Treasury bill returns. The Ibbotson factors are from the Ibbotson EnCorrr analyzer: The U.S. Small stock premium is the monthly geometric difference between small-company stock total returns and large-company stock total returns. U.S. bond default premium is the monthly geometric difference between total return to long-term corporate bonds and long-term government bonds. The U.S. bond horizon premium is the monthly geometric difference between investing in long-term government bonds and U.S. Treasury bills. The *t*-statistics are in parentheses next to the coefficients and are computed using Newey-West standard errors with six lags.

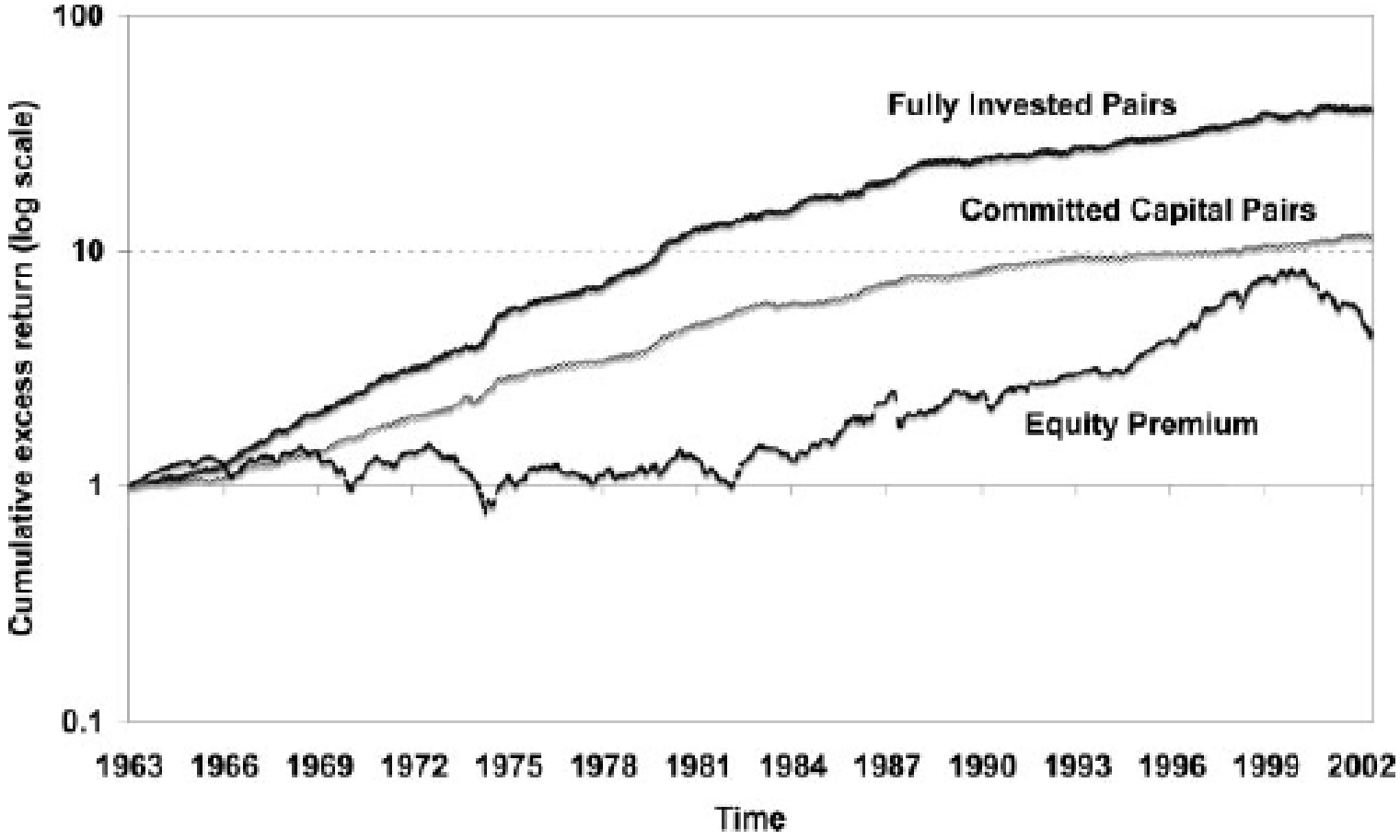


Figure 3
Cumulative excess return of top 20 pairs and S&P 500
May 1963–December 2002.

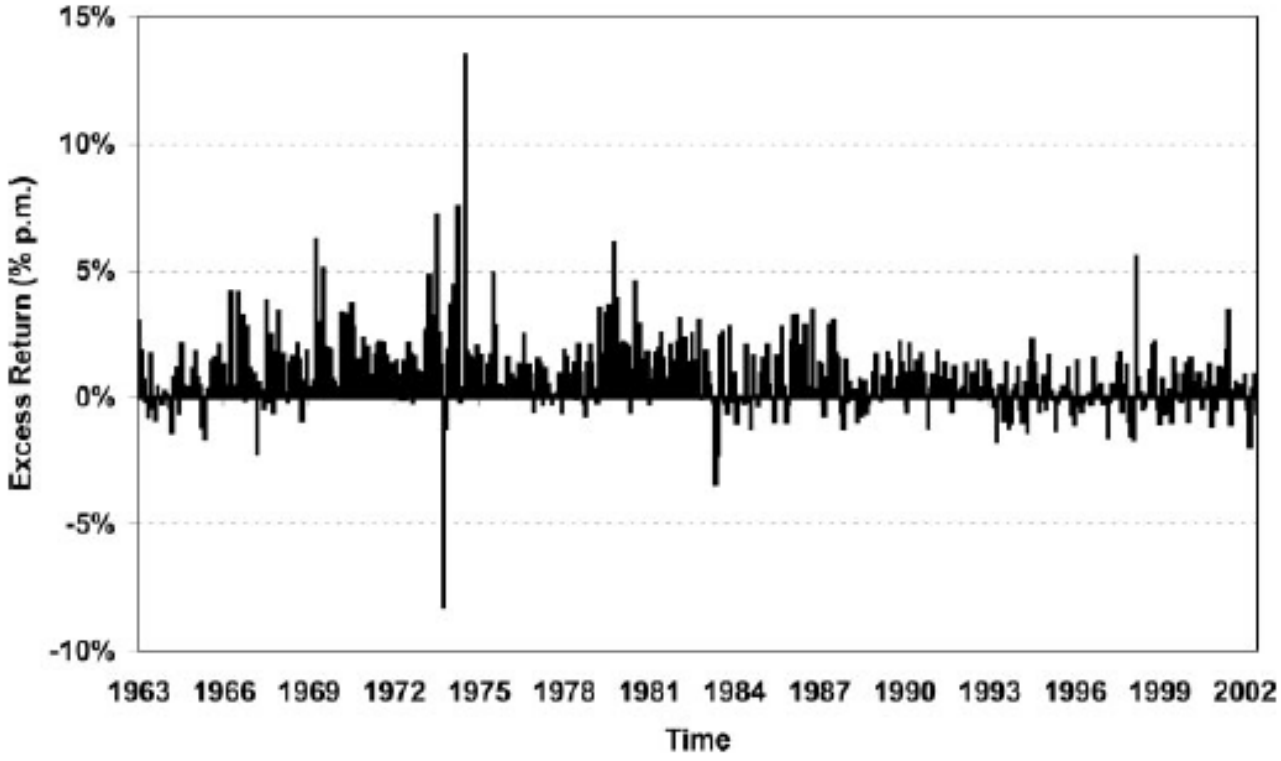


Figure 2
Monthly excess returns of top 20 pairs portfolio
May 1963–December 2002.

Convergence

(aka relative-value, contrarian, mean reversion)

multi-signal/stat-arb

$$r_{j,t} = \sum_{i=1}^{n} P_{i,t} F_{i,j,t-1} + \mu_{j,t}$$

$r_{j,t}$ = the total rate of return to stock j in month t.

$P_{i,t}$ = estimated regression coefficient (payoff) for factor i in month t.

$F_{i,j,t-1}$ = normalized value for factor i for stock j at the end of month t-1.

n = the number of factors in the expected return factor model.

$\mu_{j,t}$ = component of total monthly return for stock j in month t unexplained by set of factors.

- Residual Return is last month's residual stock return unexplained by the market.
- Cash Flow-to-Price is the 12-month trailing cash flow-per-share divided by the current price.
- Earnings-to-Price is the 12-month trailing earnings-per-share divided by the current price.
- Return On Assets is the 12-month trailing total income divided by the most recently reported total assets.
- Residual Risk is the 24-month trailing variance of residual stock return unexplained by market return.
- 12-month Return is the total return for the stock over the trailing twelve months.
- Return on Equity is the 12-month trailing earnings-per-share divided by the most recently reported book value-per-share.
- Variance is the 24-month trailing variance of total stock return.
- Book-to-Price is the most recently reported book value of equity divided by the current market price.
- Profit Margin is twelve-month trailing earnings before interest divided by 12-month trailing sales.
- 3-month Return is the total return for the stock over the trailing 3 months.
- Sales-to-Price is the 12-month trailing sales-per-share divided by the market price.

Table 2: Spreads for Decile Lines of Best Fit for Each Year

At the beginning of each month, the expected return of each stock is calculated by multiplying the normalized value for its factor exposure by the projected factor payoff for the month. The projected payoff is based on the average of trailing payoffs for the trailing twelve-month period. The factor exposure for each stock is based on information that was available at the beginning of each month. This process is repeated for each of the twelve months of each year. At the beginning of each month, stocks are ranked by their expected return and formed into deciles. The twelve monthly, realized rates of return for each decile are then linked to form a yearly return. Yearly decile returns are then regressed on decile ranking. The numbers below show the spreads between the regression lines over decile 10 (highest expected return) and decile 1 (lowest expected return).

Year	Spread	Year	Spread	Year	Spread	Year	Spread
1963	9.2%	1974	30.7%	1985	36.6%	1996	10.4%
1964	12.2%	1975	30.9%	1986	46.4%	1997	46.4%
1965	30.0%	1976	32.4%	1987	26.7%	1998	23.8%
1966	9.4%	1977	24.4%	1988	18.5%	1999	31.9%
1967	49.1%	1978	7.8%	1989	32.2%	2000	44.6%
1968	13.8%	1979	22.1%	1990	33.4%	2001	57.4%
1969	32.4%	1980	27.4%	1991	27.7%	2002	60.2%
1970	43.3%	1981	33.7%	1992	10.6%	2003	-5.5%
1971	14.7%	1982	48.6%	1993	14.0%	2004	21.1%
1972	29.7%	1983	39.1%	1994	16.8%	2005	12.8%
1973	44.4%	1984	49.7%	1995	14.2%	2006	7.5%
						2007	29.1%

lead-lag / information spillovers intranational

Table 3
Analysis of the profitability of the return-reversal strategy applied to weekly returns, for the sample of 551 CRSP NYSE-AMEX stocks with nonmissing weekly returns from July 6, 1962, to December 31, 1987 (1330 weeks)

Portfolio	Lag k	$\hat{C}_k$[1] (z-stat.)	$\hat{O}_k$[1] (z-stat.)	$\sigma^2(\hat{\mu})$[1]	$\hat{E}[\pi_t(k)]$[1] (z-stat.)	$\bar{I}_t(k)$[1] (SD[1])	%-$\hat{C}_k$	%-$\hat{O}_k$	%-$\sigma^2(\hat{\mu})$
All stocks	1	0.841	0.862	.009	1.694	151.9	49.6	50.9	−0.5
		(4.95)	(4.54)		(20.81)	(31.0)			
Smallest	1	2.048	2.493	.009	4.532	208.8	45.2	55.0	−0.2
		(6.36)	(7.12)		(18.81)	(47.3)			
Central	1	0.703	0.366	.011	1.058	138.4	66.5	34.6	−1.0
		(4.67)	(2.03)		(13.84)	(32.2)			
Largest	1	0.188	0.433	.005	0.617	117.0	30.5	70.3	−0.8
		(1.18)	(2.61)		(11.22)	(28.1)			
All stocks	2	0.253	0.298	.009	0.542	151.8	46.7	54.9	−1.6
		(1.64)	(1.67)		(10.63)	(31.0)			
Smallest	2	0.803	0.421	.009	1.216	208.8	66.1	34.7	−0.7
		(3.29)	(1.49)		(8.86)	(47.3)			
Central	2	0.184	0.308	.011	0.481	138.3	38.3	64.0	−2.3
		(1.20)	(1.64)		(7.70)	(32.2)			
Largest	2	−0.053	0.366	.005	0.308	116.9	−17.3	118.9	−1.6
		(−0.39)	(2.28)		(5.89)	(28.1)			
All stocks	3	0.223	−0.066	.009	0.149	151.7	149.9	−44.0	−5.9
		(1.60)	(−0.39)		(3.01)	(30.9)			
Smallest	3	0.552	0.038	.009	0.582	208.7	94.9	6.6	−1.5
		(2.73)	(0.14)		(3.96)	(47.3)			
Central	3	0.237	−0.192	.011	0.035	138.2	677.6	−546.7	−30.9
		(1.66)	(−1.07)		(0.50)	(32.1)			
Largest	3	0.064	−0.003	.005	0.056	116.9	114.0	−5.3	−8.8
		(0.39)	(−0.02)		(1.23)	(28.1)			
All stocks	4	0.056	0.083	.009	0.130	151.7	43.3	63.5	−6.7
		(0.43)	(0.51)		(2.40)	(30.9)			
Smallest	4	0.305	0.159	.009	0.455	208.7	67.0	34.9	−1.9
		(1.53)	(0.59)		(3.27)	(47.3)			
Central	4	0.023	−0.045	.011	−0.033	138.2	—[2]	—[2]	—[2]
		(0.18)	(−0.26)		(−0.44)	(32.0)			
Largest	4	−0.097	0.128	.005	0.026	116.8	−374.6	493.4	−18.8
		(−0.65)	(0.77)		(0.52)	(28.0)			

Expected profits are given by $E[\pi_t(k)] = C_k + O_k - \sigma^2(\mu)$, where C_k depends only on cross-autocovariances and O_k depends only on own-autocovariances. All z-statistics are asymptotically $N(0, 1)$ under the null hypothesis that the relevant population value is zero, and are robust to heteroskedasticity and autocorrelation. The average long position $\bar{I}_t(k)$ is also reported, with its sample standard deviation in parentheses underneath. The analysis is conducted for all stocks as well as for the five size-sorted quintiles; to conserve space, results for the second and fourth quintiles have been omitted.

[1] Multiplied by 10,000.

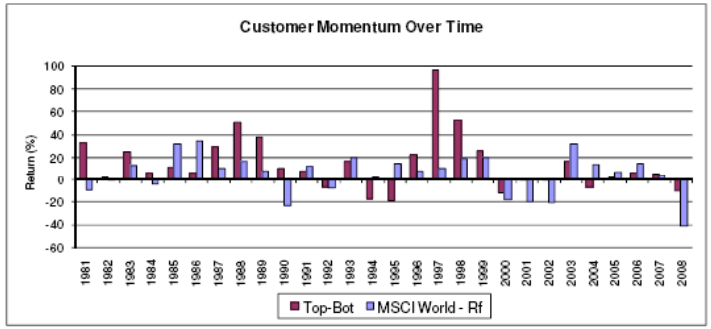
[2] Not computed when expected profits are negative.

lead-lag / information spillovers international

Figure 1: Annual Returns of Customer Momentum

At the beginning of each month from July 1981 to March 2009, sample countries (whose exports represent at least 20% of their GDP) are sorted into three groups based on the equally weighted average of the local currency returns of their major customers for the previous month. Major customers are countries that account for at least 5% of total exports. The top 30 percent of the sorted countries are assigned to the Top 30 portfolio, the bottom 30 percent are assigned to the Bot 30 portfolio, and the remainder to the Med 40 portfolio. Portfolios are equally (value) weighted and rebalanced monthly. The customer momentum portfolio is a zero-cost strategy that goes long the Top 30 portfolio and sells short the Bot 30 portfolio. This figure shows annual U.S. dollar returns on the zero-cost customer momentum portfolio, along with annual returns on the MSCI World Index in excess of the U.S. risk-free rate.

Panel A: Equal Weights



Panel B: Value Weights

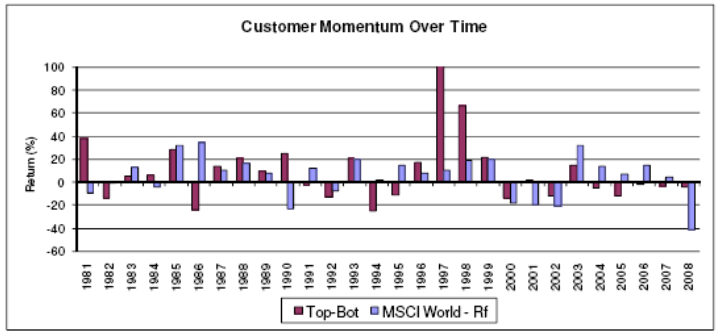
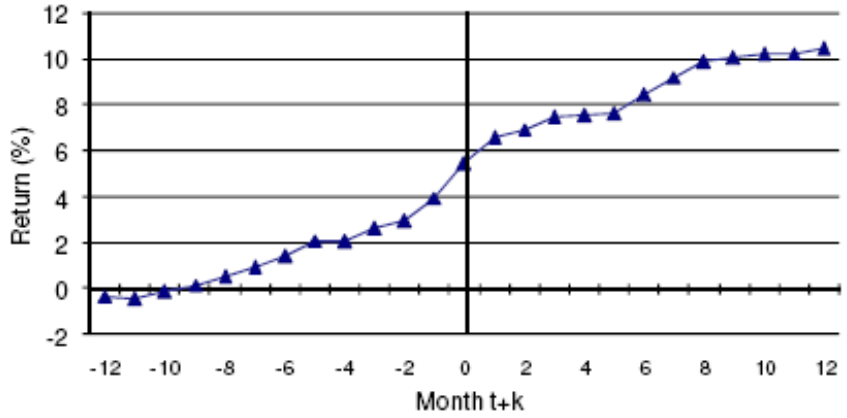


Figure 2: Customer Momentum, Event-Time Average Cumulative Returns

At the beginning of each month from July 1981 to March 2009, sample countries (whose exports represent at least 20% of their GDP) are sorted into three groups based on the equally weighted average of the local currency returns of their major customers for the previous month (t). Major customers are countries that account for at least 5% of total exports. The top 30 percent of the sorted countries are assigned to the Top 30 portfolio, the bottom 30 percent are assigned to the Bot 30 portfolio, and the remainder to the Med 40 portfolio. Portfolios are equally (value) weighted and rebalanced monthly. The customer momentum portfolio is a zero-cost strategy that goes long the Top 30 portfolio and sells short the Bot 30 portfolio. This figure shows the average cumulative U.S. dollar return on the zero-cost customer momentum portfolio in month t + k.

Panel A: Equal Weights



Panel B: Value Weights

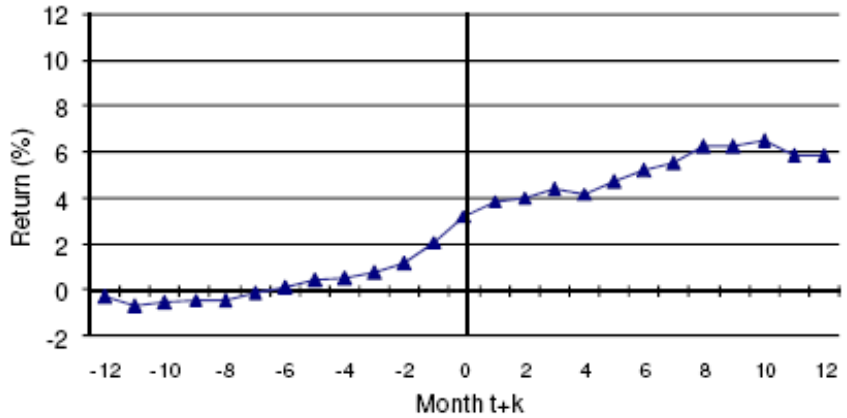


Table A1: Customer Momentum Strategy Based on Currency Returns, 7/1981-3/2009

At the beginning of each month from July 1981 to March 2009, producer countries are sorted on the lagged currency returns of their major customers. Producer countries are defined as sample countries whose exports account for at least 20% of their GDP for the year of trade. Major customers are countries that account for at least 5% of the producer's total exports. The top 30 percent of the sorted producer countries are assigned to the Top 30 portfolio, the bottom 30 percent are assigned to the Bot 30 portfolio, and the middle 40 percent to the Med 40 portfolio. Top-Bot is a zero-cost strategy that buys the currencies of the countries in the Top 30 portfolio and sells short the currencies of the countries in the Bot 30 portfolio. Portfolios are rebalanced monthly. All returns are monthly currency returns (in percent) using the U.S. dollar as the domestic currency. The currency return for month t is computed as $S_t / S_{t-1} - 1$, where S_t is the spot exchange rate at the end of month t. Exchange rates are expressed as the ratio of units of domestic currency per unit of foreign currency. Excess returns are net of the US risk-free rate. 1-factor Alpha is from a regression of excess monthly returns on a global market factor, MKT. 2-factor Alpha is from a regression of excess monthly returns on MKT and a global currency momentum factor, CMOM. T-statistics are reported below the coefficient estimates.

Panel A: Equal Weights for Customers

7/1981-3/2009 (333 months)

	Equal Weights for Producers				GDP Weights for Producers				Value Weights for Producers			
	Bot 30	Med 40	Top 30	Top-Bot	Bot 30	Med 40	Top 30	Top-Bot	Bot 30	Med 40	Top 30	Top-Bot
Excess Ret	-0.63	-0.39	-0.26	0.38	-0.69	-0.32	-0.21	0.48	-0.58	-0.23	-0.27	0.31
	[-4.89]	[-2.97]	[-1.90]	[2.74]	[-4.76]	[-2.27]	[-1.57]	[2.98]	[-4.56]	[-1.61]	[-2.10]	[2.13]
1-factor Alpha	-0.69	-0.45	-0.31	0.38	-0.74	-0.39	-0.27	0.47	-0.63	-0.29	-0.31	0.31
	[-5.52]	[-3.60]	[-2.40]	[2.72]	[-5.22]	[-2.85]	[-2.05]	[2.93]	[-5.11]	[-2.09]	[-2.54]	[2.14]
2-factor Alpha	-0.68	-0.46	-0.32	0.36	-0.73	-0.39	-0.27	0.46	-0.63	-0.29	-0.32	0.30
	[-5.39]	[-3.63]	[-2.40]	[2.61]	[-5.10]	[-2.81]	[-2.05]	[2.83]	[-5.03]	[-2.08]	[-2.58]	[2.04]

7/1981-12/1998 (210 months)

	Bot 30	Med 40	Top 30	Top-Bot	Bot 30	Med 40	Top 30	Top-Bot	Bot 30	Med 40	Top 30	Top-Bot
Excess Ret	-0.83	-0.48	-0.36	0.47	-0.92	-0.39	-0.31	0.61	-0.75	-0.31	-0.40	0.35
	[-4.79]	[-2.86]	[-2.08]	[2.60]	[-4.51]	[-2.20]	[-1.79]	[2.79]	[-4.40]	[-1.74]	[-2.46]	[1.83]
1-factor Alpha	-0.92	-0.59	-0.45	0.47	-1.02	-0.52	-0.40	0.61	-0.85	-0.42	-0.49	0.36
	[-5.37]	[-3.53]	[-2.65]	[2.55]	[-4.98]	[-2.94]	[-2.36]	[2.74]	[-4.97]	[-2.41]	[-2.99]	[1.84]
2-factor Alpha	-0.92	-0.60	-0.45	0.46	-1.01	-0.52	-0.41	0.60	-0.84	-0.42	-0.50	0.35
	[-5.27]	[-3.59]	[-2.62]	[2.49]	[-4.86]	[-2.91]	[-2.35]	[2.64]	[-4.88]	[-2.40]	[-3.03]	[1.73]

Panel B: Sales Weights for Customers

7/1981-3/2009 (333 months)

	Equal Weights for Producers				GDP Weights for Producers				Value Weights for Producers			
	Bot 30	Med 40	Top 30	Top-Bot	Bot 30	Med 40	Top 30	Top-Bot	Bot 30	Med 40	Top 30	Top-Bot
Excess Ret	-0.65	-0.34	-0.28	0.37	-0.71	-0.28	-0.25	0.46	-0.61	-0.26	-0.27	0.34
	[-4.99]	[-2.50]	[-2.11]	[2.62]	[-5.02]	[-1.86]	[-1.85]	[2.88]	[-4.65]	[-1.73]	[-2.09]	[2.27]
1-factor Alpha	-0.70	-0.41	-0.34	0.36	-0.76	-0.35	-0.31	0.46	-0.66	-0.31	-0.32	0.34
	[-5.57]	[-3.09]	[-2.66]	[2.56]	[-5.53]	[-2.34]	[-2.39]	[2.82]	[-5.15]	[-2.17]	[-2.58]	[2.24]
2-factor Alpha	-0.70	-0.41	-0.34	0.36	-0.76	-0.35	-0.31	0.45	-0.66	-0.32	-0.33	0.33
	[-5.48]	[-3.09]	[-2.63]	[2.51]	[-5.44]	[-2.32]	[-2.37]	[2.76]	[-5.11]	[-2.17]	[-2.64]	[2.16]

7/1981-12/1998 (210 months)

	Bot 30	Med 40	Top 30	Top-Bot	Bot 30	Med 40	Top 30	Top-Bot	Bot 30	Med 40	Top 30	Top-Bot
Excess Ret	-0.84	-0.43	-0.37	0.48	-0.95	-0.34	-0.34	0.61	-0.82	-0.31	-0.38	0.44
	[-4.86]	[-2.43]	[-2.20]	[2.57]	[-4.84]	[-1.72]	[-2.05]	[2.77]	[-4.61]	[-1.62]	[-2.34]	[2.17]
1-factor Alpha	-0.93	-0.54	-0.47	0.46	-1.05	-0.46	-0.45	0.60	-0.91	-0.42	-0.48	0.43
	[-5.37]	[-3.06]	[-2.88]	[2.42]	[-5.34]	[-2.33]	[-2.72]	[2.68]	[-5.10]	[-2.21]	[-2.99]	[2.08]
2-factor Alpha	-0.94	-0.54	-0.47	0.46	-1.05	-0.45	-0.46	0.59	-0.92	-0.41	-0.50	0.42
	[-5.35]	[-3.01]	[-2.86]	[2.42]	[-5.27]	[-2.23]	[-2.71]	[2.62]	[-5.10]	[-2.13]	[-3.07]	[2.01]

explanation

- Size and value are proxies for unobservable risk of financial distress (e.g. credit crunch, liquidity crunch, flight to quality to which shareholders [often owners of small businesses] are sensitive)
- Reversals explained by value effect
- Momentum explained by mild (unexploitable?) autocorrelations especially in small losing stocks

TABLE 3

First-order autocorrelation, CRSP value- and equally weighted index returns

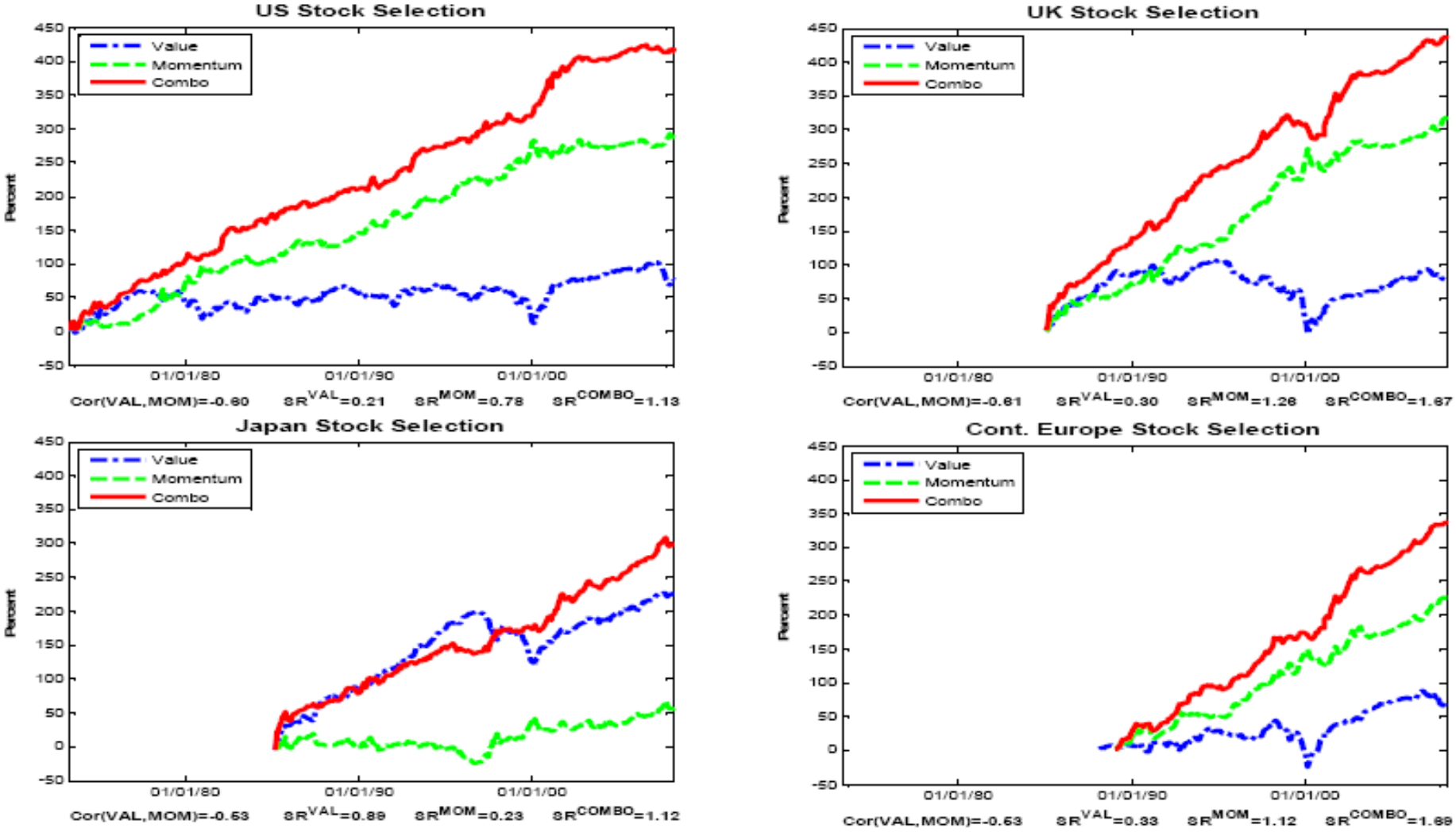
Frequency	Portfolio	Correlation ρ_1
Daily	Value-weighted	0.18
	Equally weighted	0.35
Monthly	Value-weighted	0.043
	Equally weighted	0.17

Note: Sample 1962–94.
Source: Campbell, Lo, and MacKinlay (1997).

combinations

Figure 1: Performance of value and momentum strategies for stock selection globally

Plotted are the cumulative returns to value, momentum, and a 50-50 combination of value and momentum strategies among individual stocks in four markets: US, UK, Japan, and Continental Europe. Also reported on each figure are the annualized Sharpe ratios of each strategy and the correlation between value and momentum in each market.



equity premium predictability

TABLE 1

OLS regression of excess returns on price/dividend ratio

Horizon k	b	Standard error	R^2
1 year	–1.04	0.33	0.17
2 years	–2.04	0.66	0.26
3 years	–2.84	0.88	0.38
5 years	–6.22	1.24	0.59

Notes: OLS regressions of excess returns (value-weighted NYSE–Treasury bill rate) on value-weighted price/dividend ratio.

$$R^{VW}_{t\to t+k} - R^{TB}_{t\to t+k} = a + b(P_t / D_t) + \varepsilon_{t+k}.$$

$R_{t\to t+k}$ indicates the k year return. Standard errors use GMM to correct for heteroskedasticity and serial correlation.

other ‘anomalies’

#	Anomaly	Author 1	Author 2	Author 3	Author 4	Year
1	52-week high	George	Hwang			2004
2	Changes in analyst recommendations	Jegadeesh	Kim	Krische	Lee	2004
3	Changes to analyst target prices	Brav	Lehavy			2003
4	Christmas Day Effect	Lakonishok	Smidt			1984
5	Dispersion in estimates	Diether	Malloy	Scherbina		2002
6	Dividend Yield	Campbell	Shiller			1988
7	Dividend Yield	Fama	French			1988
8	Dividends Drift	Healy	Palepu			1988
9	Ind Momentum	Moskowitz	Grinblatt			1999
10	January Effect	Rozeff	Kinney			1976
11	January Effect w/ Small Firm Effect	Keim				1983
12	January Effect w/ Small Firm Effect	Reinganum				1983
13	Momentum	Jegadeesh	Titman			1993
14	Monday Effect	Cross				1973
15	Monday Effect	French				1980
16	New Year's Day Effect	Roll				1983
17	Oct - March Seasonality	Ogden				2003
18	PE	Basu				1977
19	Post Earnings Announcement Drift	Ball	Brown			1968
20	Post IPO blues	Loughran	Ritter			1995
21	Post Listing blues	Dharan	Ikenberry			1995
22	Post Merger blues	Asquith				1983
23	Post SEO blues	Speiss	Affleck-Graves			1995
24	Pre Holiday Effect	Ariel				1990
25	Qualitative content	Asquith	Mikhail	Au		2005
26	Repurchases	Ikenberrry	Lakonishok	Vermaelen		1995
27	Reversal	DeBondt	Thaler			1985
28	S&P 500 Effect	Harris	Gurel			1986
29	S&P 500 Effect	Shleifer				1986
30	Sentiment	Baker	Wurgler			2006
31	Size Effect	Banz				1981
32	Size Effect	Reinganum				1981
33	Sunshine Effect	Hirshleifer	Shumway			2003
34	Turn of the Month Effect (first 3 days)	Lakonishok	Smidt			1988
35	Turn of the Month Effect (last day)	Ariel				1987
36	Value Line Effect	Black				1973
37	Value Line Effect	Stickel				1985
38	Value Premium	Rosenberg	Reid	Lanstein		1985
39	Value Premium	Stattman				1980
40	Stock Split	Ikenberrry	Ramnath			2002

additional ‘accounting’ anomalies

- Accruals inversely predict returns (because a reverting component of earnings [?])
- Accounting underreaction / ‘post earnings announcement drift’ (because of slow information diffusion [?])

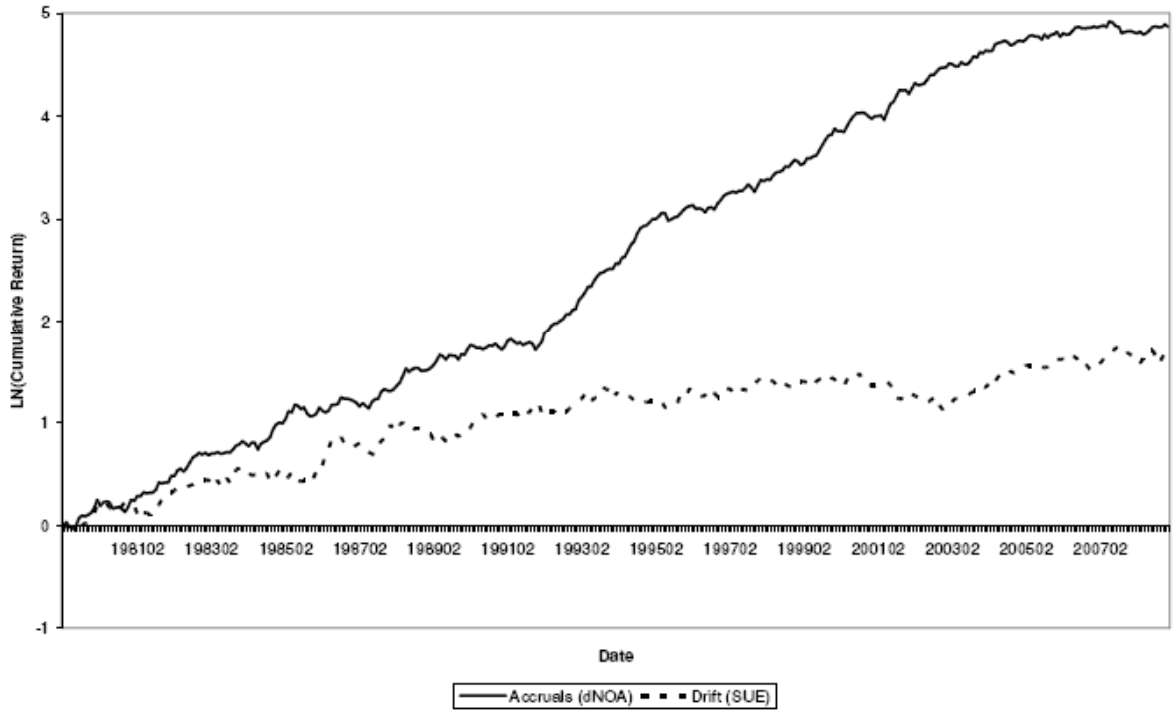


Figure 1a: Cumulative log total returns to a ΔNOA (bold line) and SUE (dashed line) characteristic portfolio for U.S. data (1979–2008). Portfolios are formed using ex ante risk and transaction cost information. Each portfolio is (i) rebalanced monthly from the largest 1,000 US securities based on market capitalization, (ii) constructed to achieve a target annualized risk level of ten percent, and (iii) subject to constraints that keep portfolio leverage less than five times, and individual security positions less than 5 percent. Returns are *before* actual transaction costs.

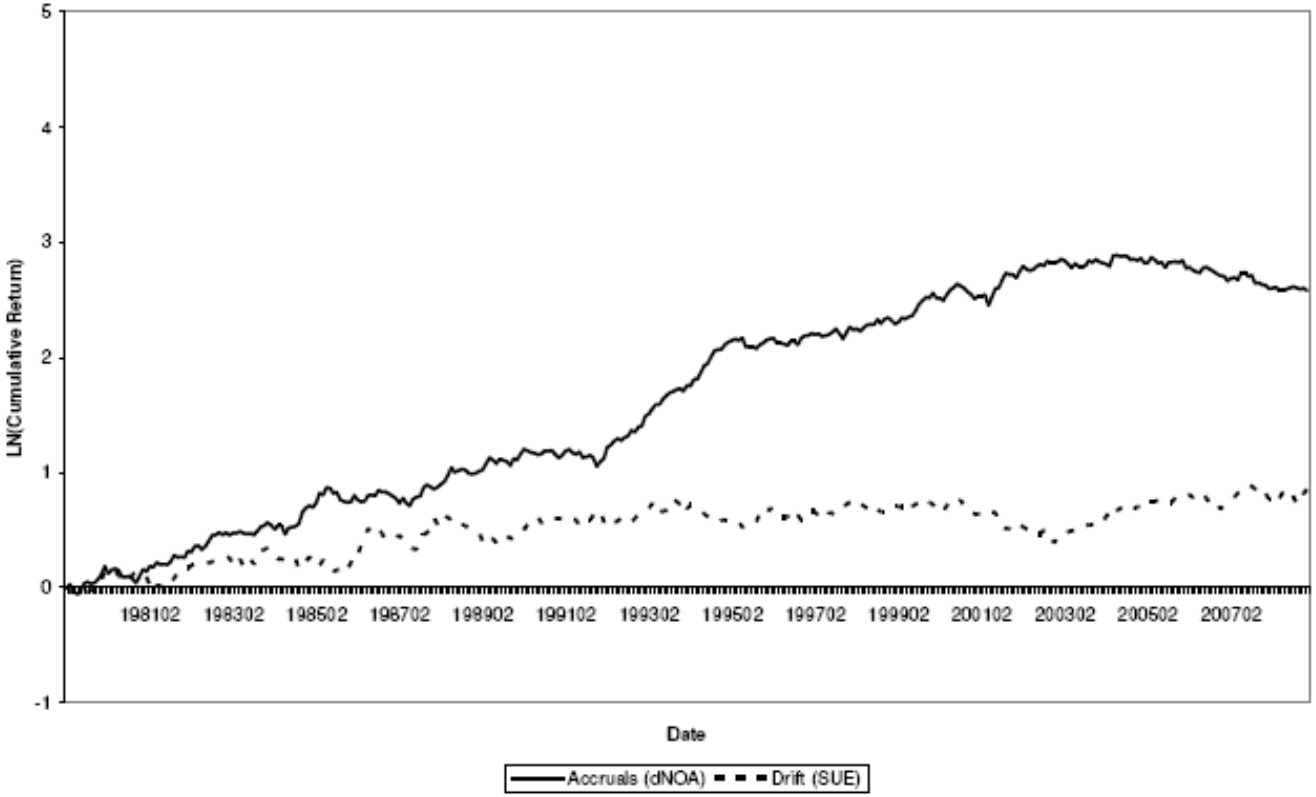
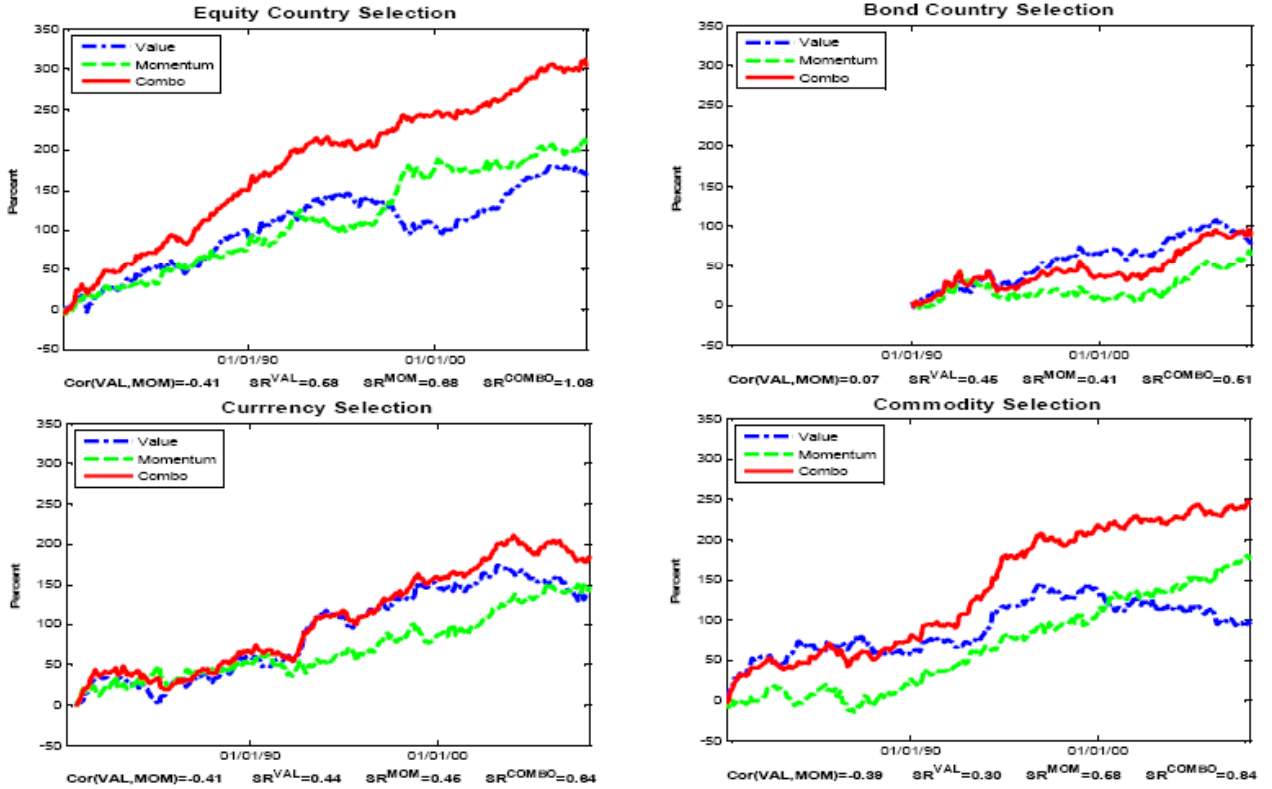


Figure 1b: Cumulative log total returns to a ΔNOA (bold line) and SUE (dashed line) characteristic portfolio for U.S. data (1979–2008). Portfolios are formed using ex ante risk and transaction cost information. Each portfolio is (i) rebalanced monthly from the largest 1,000 US securities based on market capitalization, (ii) constructed to achieve a target annualized risk level of ten percent, and (iii) subject to constraints that keep portfolio leverage less than five times, and individual security positions less than 5 percent. Returns are *after* actual transaction costs. Actual transaction costs are inferred using a simulated portfolio of $400 million at the start of 2009 and assumes that the forecasted transaction cost function reflects realized trading costs.

other assets

Figure 2: Performance of value and momentum strategies for non-stock selection

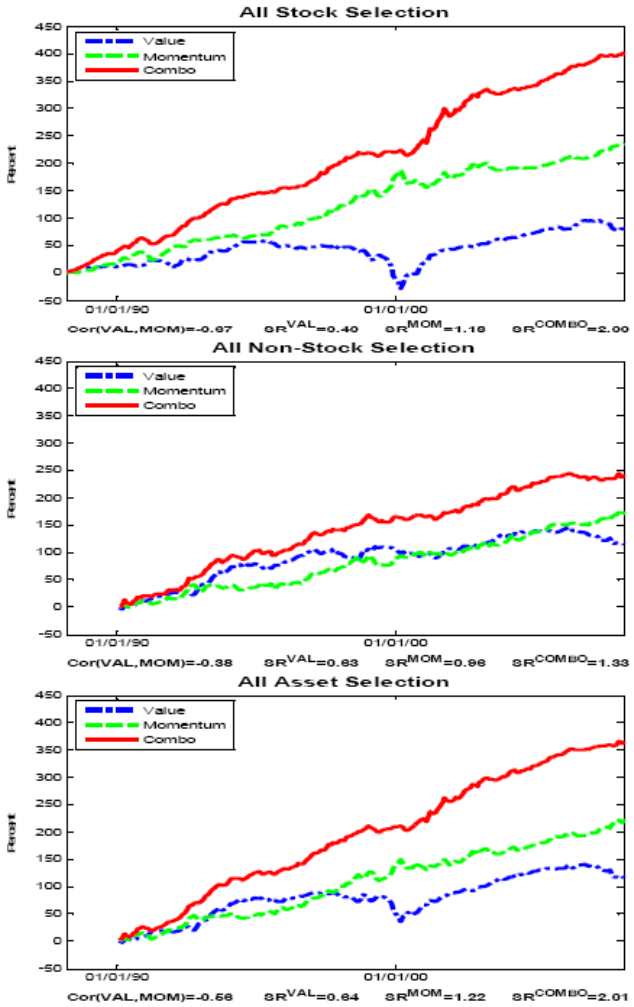
Plotted are the cumulative returns to value, momentum, and a 50-50 combination of value and momentum strategies among a cross-section of assets in four different asset classes: Country equity index futures, country bonds, currencies, and commodities. Also reported on each figure are the annualized Sharpe ratios of each strategy and the correlation between value and momentum in each asset class.



combining signals and asset classes

Figure 3: Performance of value and momentum strategies everywhere – combining markets and asset classes

Plotted are the cumulative returns to value, momentum, and a 50-50 combination of value and momentum strategies for the equal-weighted combination of all stock selection strategies, all non-stock selection strategies, and an equal-weighted combination of both. Also reported on each figure are the annualized Sharpe ratios of each strategy and the correlation between value and momentum.



value for stock indexes

TABLE 1

OLS regression of excess returns on price/dividend ratio

Horizon k	b	Standard error	R^2
1 year	−1.04	0.33	0.17
2 years	−2.04	0.66	0.26
3 years	−2.84	0.88	0.38
5 years	−6.22	1.24	0.59

Notes: OLS regressions of excess returns (value-weighted NYSE–Treasury bill rate) on value-weighted price/dividend ratio.

$$R^{VW}_{t\to t+k} - R^{TB}_{t\to t+k} = a + b(P_t / D_t) + \varepsilon_{t+k}.$$

$R_{t\to t+k}$ indicates the k year return. Standard errors use GMM to correct for heteroskedasticity and serial correlation.

Bonds

relative value based on expectations hypothesis

TABLE 5

Forecasts based on forward-spot spread

	A. Change in yields					B. Holding period returns				
N	Intercept	Standard error, intercept	Slope	Standard error, slope	Adjusted R^2	Intercept	Standard error, intercept	Slope	Standard error, slope	Adjusted R^2
1	0.10	0.3	–0.10	0.36	–0.020	–0.1	0.3	1.10	0.36	0.16
2	–0.01	0.4	0.37	0.33	0.005	–0.5	0.5	1.46	0.44	0.19
3	–0.04	0.5	0.41	0.33	0.013	–0.4	0.8	1.30	0.54	0.10
4	–0.30	0.5	0.77	0.31	0.110	–0.5	1.0	1.31	0.63	0.07

Notes: OLS regressions, 1953–97 annual data. Panel A estimates the regression $y_{t+n}^{(1)} - y_t^{(1)} = a + b\,(f_t^{(N+1)} - y_t^{(1)}) + \varepsilon_{t+N}$ and panel B estimates the regression $hpr_{t+1}^{(N)} - y_t^{(1)} = a + b\,(f_t^{(N+1)} - y_t^{(1)}) + \varepsilon_{t+1}$, where $y_t^{(N)}$ denotes the N-year bond yield at date t; $f_t^{(N)}$ denotes the N-period ahead forward rate; and $hpr_{t+1}^{(N)}$ denotes the one-year holding period return at date $t + 1$ on an N-year bond. Yields and returns in annual percentages.

Term spreads also forecasts stock returns

Currency

relative value based on forward discount puzzle

TABLE 6

Forward discount puzzle

	Deutsche-mark	Pound sterling	Yen	Swiss franc
Mean appreciation	–1.8	3.6	–5.0	–3.0
Mean interest differential	–3.9	2.1	–3.7	–5.9
b, 1975–89	–3.1	–2.0	–2.1	–2.6
R^2	.026	.033	.034	.033
b, 1976–96	–0.7	–1.8	–2.4	–1.3
b, 10-year horizon	0.8	0.6	0.5	–

Notes: The first row gives the average appreciation of the dollar against the indicated currency, in percent per year. The second row gives the average interest differential—foreign interest rate less domestic interest rate, measured as the forward premium—the 30-day forward rate less the spot exchange rate. The third through sixth rows give the coefficients and R^2 in a regression of exchange rate changes on the interest differential,

$$s_{t+1} - s_t = a + b\,(r_t^f - r_t^d) + \varepsilon_{t+1},$$

where s = log spot exchange rate, r^f = foreign interest rate, and r^d = domestic interest rate.

Source: Hodrick (2000), Engel (1996), and Meredith and Chinn (1998).

Table 2. Four benchmark carry trade strategies
Out-of-sample performance, January 2004 – December 2008

Realized Returns to an Equally-Weighted Portfolio	Carry Trade Strategy			
	Carry	**Momentum**	**Value**	**VECM**
Mean (monthly)	-0.0024	0.0027	-0.0022	0.0025
S.D.	0.018	0.018	0.015	0.018
Skewness	-2.97	1.59	-0.69	1.44
Coeff. of Variation	-7.35	6.74	-6.77	7.35
Avg. Ann. Ret (%)	2.9	3.3	-2.6	3.0
Sharpe Ratio (ann.)	-0.47	0.51	-0.51	0.47

Options

Table III

Returns of Zero-Beta Straddles

The table reports summary statistics for the returns of zero-beta straddles. The SPX sample period is January 1990 to October 1995 (305 weeks). The OEX sample period is January 1986 to October 1995 (2519 days). Bid-ask spreads are checked for significant outliers. SPX returns are recorded in weekly percentage terms. OEX returns are recorded in daily percentage terms. The straddle return is calculated according to equation (18) where β_c is the Black–Scholes beta of the call option, calculated using the CBOE's VIX index as implied volatility. $X - s$ denotes the difference between the option's strike price and the underlying price. The t-statistics test the null hypothesis that mean zero-beta straddle returns are zero.

$X - s$	−15 to −10	−10 to −5	−5 to 0	0 to 5	5 to 10
Panel A: Weekly SPX Straddle Returns					
Mean return	−4.49	−4.28	−3.15	−3.15	−2.89
t-Statistic	(−5.44)	(−4.75)	(−2.89)	(−2.72)	(−2.38)
Median	−7.17	−7.96	−7.21	−8.27	−8.17
Minimum	−29.57	−38.24	−41.46	−35.39	−44.43
Maximum	124.29	102.53	115.06	131.71	145.84
Setting β_c = 0.9 (Black–Scholes β_c)					
Mean return	−2.96	−3.23	−2.42	−2.63	−2.49
t-Statistic	(−3.48)	(−3.35)	(−2.14)	(−2.16)	(−1.98)
Setting β_c = 1.1 (Black–Scholes β_c)					
Mean return	−4.30	−4.17	−3.07	−3.10	−2.85
t-Statistic	(−5.29)	(−4.62)	(−2.82)	(−2.66)	(−2.35)
Panel B: Daily OEX Straddle Returns					
Mean return	−0.57	−0.50	−0.50	−0.48	−0.65
t-Statistic	(−3.01)	(−2.51)	(−2.76)	(−2.84)	(−3.84)
Median	−1.47	−1.37	−1.47	−1.51	−1.78
Minimum	−35.02	−31.35	−39.04	−40.44	−43.20
Maximum	253.19	279.58	233.55	206.41	152.76
Setting β_c = 0.9 (Black–Scholes β_c)					
Mean return	−0.35	−0.41	−0.44	−0.44	−0.67
t-Statistic	(−2.18)	(−2.40)	(−2.74)	(−2.76)	(−4.26)
Setting β_c = 1.1 (Black–Scholes β_c)					
Mean return	−1.38	−0.93	−0.81	−0.68	−0.83
t-Statistic	(−4.95)	(−4.16)	(−4.20)	(−3.74)	(−4.70)
Setting In-Sample Beta to Zero					
Mean return	−0.39	−0.33	−0.35	−0.32	−0.51
t-Statistic	(−2.31)	(−1.86)	(−2.12)	(−2.01)	(−3.18)
Dropping Puts and Calls more than 15 min Apart					
Mean return	−0.46	−0.44	−0.49	−0.44	−0.58
t-Statistic	(−2.05)	(−2.11)	(−2.72)	(−2.59)	(−3.44)
Subsample: 1986–1990					
Mean return	−0.33	−0.14	−0.27	−0.26	−0.56
t-Statistic	(−0.95)	(−0.36)	(−0.82)	(−0.89)	(−1.99)
Subsample: 1991–1995					
Mean return	−0.81	−0.86	−0.72	−0.69	−0.74
t-Statistic	(−4.89)	(−6.15)	(−4.81)	(−4.16)	(−3.86)

Options

Table V

Returns of Zero-Beta, Crash-Neutral Straddles

This table reports summary statistics on the returns of zero-beta, crash-neutral straddles on the OEX and SPX. The SPX sample period is January 1990 to October 1995 (305 weeks). The OEX sample period is January 1986 to October 1995 (2519 days). Both straddles are neutral to crashes of larger than 15 percent. Bid-ask spreads are checked for significant outliers. Returns are recorded in daily and weekly percentage terms. The straddle return is calculated according to equation (21) where β_c is the Black–Scholes beta of the call option, and β_{p^*} is that of the combined put position. Both are calculated using the CBOE's VIX index as implied volatility. X/s denotes the option's strike price divided by the underlying price. The t-statistics test the null hypothesis that mean zero-beta straddle returns are zero.

Panel A: Weekly SPX Straddle Returns

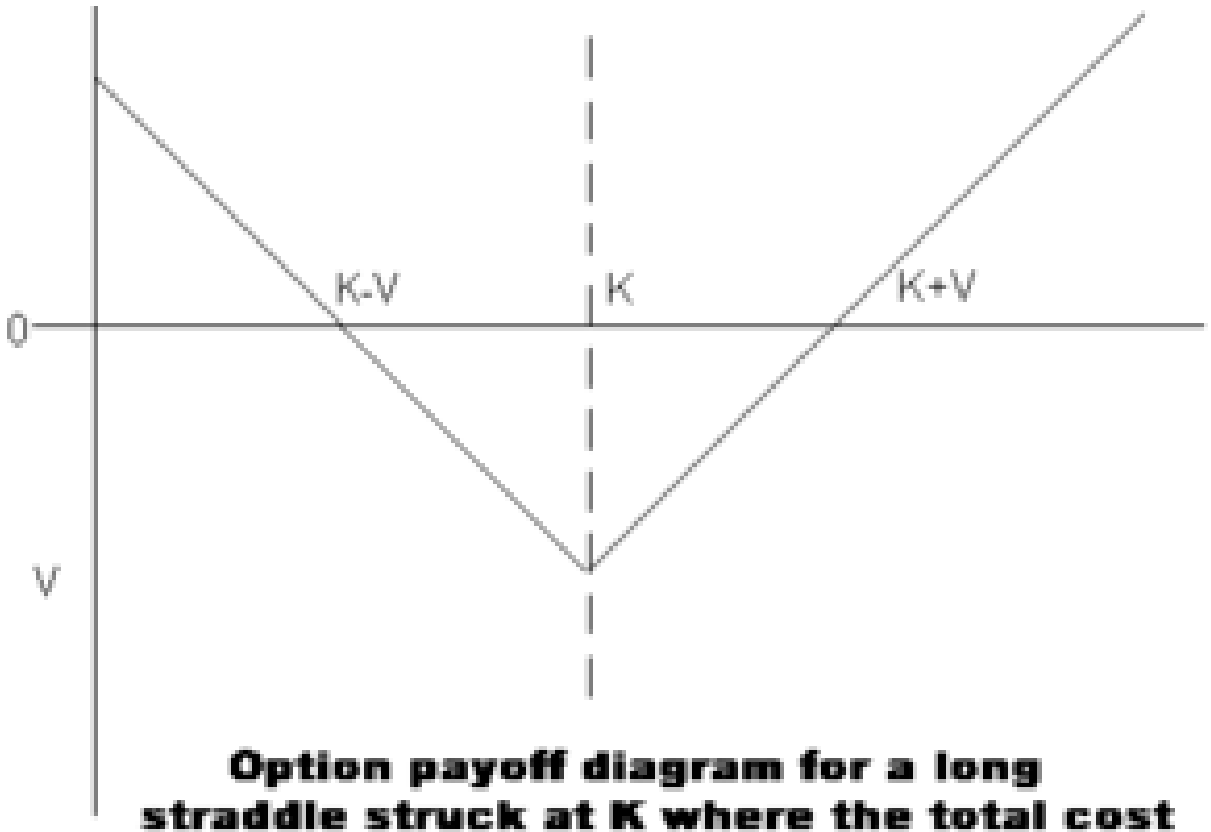
Mean return	−3.24
t-Statistic	(−2.15)
Median	−7.51
Minimum	−210.41
Maximum	149.15

Panel B: Daily OEX Straddle Returns

Mean return	−1.02
t-Statistic	(−4.09)
Median	−1.50
Minimum	−236.10
Maximum	102.79

Panel C: Out-of-the-Money Put Data Around October 19, 1987

Date	Time	Strike	X/s	Price	Return
10/16	9:04	280	0.965	3.75	780.0
10/19	9:50	255	0.931	22.00	213.6
10/20	10:53	200	0.925	80.00	−72.5
10/21	9:02	200	0.858	22.00	−36.4
10/22	9:56	220	0.867	22.00	−18.2



Option payoff diagram for a long straddle struck at K where the total cost of the two constitutent options is V

Qualifications

- Seeming signal performance may in fact be catastrophe insurance premium for tail risks
  - Writing put
  - Convergence trades on illiquid assets (e.g. LTCM sells 29.5 year bond and buys 30 year bond)
- Transaction costs
- Data mining (at profession and individual level)
- Stability of performance and *recent deterioration*

Beginner's pitfalls

- Statistical significance (standard errors, sub-period stability, outlier robustness)
- Out-sample analysis should be genuinely out-sample
- Formation periods should not overlap with trading period
- Accounting for risk factors
- Accounting for time lags in publication of information
- Accounting for transaction costs, illiquidity, bid-ask bounce and other microstructural issues
- Accounting for overlapping sample periods which bias various statistics
- Accounting for 'corporate actions': stock splits, dividend payments, etc.
- Recognizing database biases and errors, including publication dates for various items
- Overall robustness of results (vary set-up in as many ways as possible)

- Examples of similar projects at the MBA level can be found at:

http://www.duke.edu/~charvey/Classes/ba453/453index.htm