

Skewness Preference and Price Momentum

By

K.C. Chen

California State University, Fresno

Sangphil Kim

University of Massachusetts at Lowell

Peter Xu

Prudential Investments

Skewness Preference and Price Momentum

Abstract: This paper presents a rational explanation for the price momentum anomaly documented in recent research. Unlike the behavioral hypothesis, which assumes that investors irrationally under-react to new information, we assume that investors are rational but have preference for skewness. We hypothesize that investors demand higher expected returns on winner stocks because the future returns on these stocks are negatively skewed. On the other hand, investors demand lower expected returns on loser stocks because their future returns are positively skewed. We present empirical results that are consistent with our hypothesis.

Skewness Preference and Price Momentum

I. Introduction

Short-term price momentum documented by DeBondt and Thaler (1985) stands as one of the most puzzling anomalies for finance researchers. Unlike long-term reversals and other market anomalies of contrarian nature, the momentum effect does not have an inherent risk-based explanation. The long-term reversals, price-to-earnings, price-to-book, and size effects are consistent with the notion that everything else the same as a stock becomes riskier its price will trend lower to reflect increased level of risk (Berk 1995). This is true even though the true measure of risk is unknown. However, for the momentum effect to be a risk phenomenon, it would be necessary that risk increases just because price has gone up, something inconceivable in our conception about risk. Fama and French (1996) show that a three-factor model can explain long-term stock return reversals along with other contrarian stock market anomalies, but the same three-factor model fails to explain the momentum effect.

Some researchers have offered explanations for the price momentum effect that are based on irrational investor behavior. Chan, Jegadeesh, and Lakonishok (1996) relate stock price momentum to the evidence of market under-reaction to earnings-related information found in other studies (e.g., Latane and Jones (1979), and Bernard and Thomas (1989)). They conclude that price momentum is due to investor under-reaction to new information about stocks' true economic earnings, which are only measured imperfectly by accounting earnings. Daniel, Hirshleifer, and Subrahmanyam (1998) provide a theoretical model of investor psychology that predicts short-term price momentum. The main argument of a psychology-based explanation of the momentum effect is that investors are overconfident, and they discount new information that conflicts with their prior beliefs. More recently, Jegadeesh and Titman (2001) evaluate various explanations for the profitability of momentum strategies documented in their early work (Jegadeesh and Titman (1993)). Their evidence provides support for the behavioral models.

In this paper, we present an alternative explanation for the momentum effect that does not assume irrational behavior by investors. We show that the momentum effect is

consistent with investors' preference for skewness. We argue and also present evidence that subsequent returns on portfolios of high momentum or winner stocks are negatively skewed, while subsequent returns on portfolios of low momentum or loser stocks are positively skewed. As a result, investors demand a higher expected return on the winner stocks and a lower expected return on the loser stocks.

The skewness of returns on momentum portfolios is not surprising. For example, Wall Street dubs a high momentum stock that suddenly collapses as "torpedo". A torpedoed stock is a stock hit by new negative information after a long period of positive news (Berntein 1993). It is plausible that for a stock that has had continuous increases in earnings in the past, investors may expect that the company's business conditions and hence the upward trend in earnings will more likely continue than reverse. There is a small but non-zero probability that the trend of increasing earnings may suddenly reverse, and when this occurs, the negative effect on the stock's earnings may be severe. A good example will be stocks in the technology sector where new innovations may make existing technologies obsolete, and cause fast-growing companies that depend on existing technologies to suddenly stop growing.

Using stock return data from January 1970 through December 1998, we find that returns on portfolios of stocks that have done well in the recent past are negatively skewed while returns on portfolios of stocks that have done poorly in the recent past tend to be positively skewed. Furthermore, portfolios of winner stocks have downside betas significantly higher than their upside betas. These results are robust to whether the portfolios are constructed using all stocks or just large-capitalization stocks, and also robust to different definitions of up and down markets utilized in previous literature. We also find that our measure of downside risk is significantly correlated with cross-sectional portfolio returns.

The relationship between momentum and downside risk provides a possible alternative to the behavioral hypothesis that momentum is due to investors' under-reaction to new information. But the two are not mutually exclusive. The difference in future returns between winner and loser stocks may still be larger than warranted by their difference in downside risk. Whether downside risk explains all the momentum effect requires an equilibrium model of expected returns (see Harvey and Siddique (2000)). In

this paper, we are mainly interested in the relationship between momentum and downside risk, and showing a possibility of a risk-based explanation of the momentum effect. We are less concerned about whether downside risk is the only relevant risk or whether downside beta is the right measure of downside risk. Our own view is that downside beta is important and may probably affect equilibrium expected returns, but investors' tendency to discount new information that disagrees with their prior mindset is also an important bias deeply rooted in psychology, and everywhere present in human behavior.

The remaining of this paper is organized as follows. Section II discusses our data and the methodology used in our study. Section III contains the results of our empirical tests. Section IV presents our conclusions.

II. Data and Methodology

At the beginning of each month from January 1970 through December 1998, we take all stocks that have recorded return data in each of the previous twelve months on COMPUSTAT. Since stocks with very low prices may skew the results, we exclude all stocks with market capitalization less than \$10 million at the beginning of the month. This screening process results in an average sample size of 3,096 stocks each month, ranging from 1,662 to 4,556.

Stocks are then ranked on the basis of their total returns in the past twelve months, and separated into deciles each containing approximately equal number of stocks. Previous studies on price momentum have used different ranking periods from prior three months to twelve months, with the results stronger for ranking periods from prior six months to twelve months. In this paper, we arbitrarily choose a twelve-month interval as the ranking period. The holding period is one month following portfolio formation. After portfolios are formed at the beginning of the month, their returns in this month are recorded. The return on each portfolio in each month is a simple equally weighted average of returns on all the stocks in the portfolio. If the holding period return for a stock is missing, then it is not included in the calculation of the portfolio return. This is effectively assuming that the investment in this stock earned the same rate of return as the average stock in its portfolio. This process repeats 348 times, resulting in a series of 348 monthly returns on each of the ten portfolios. These monthly returns are then used for analyzing the downside risk of each portfolio.

To estimate the downside risk of a portfolio, we estimate the following time-series regression:

$$R_{it} = \text{INTCP}_i + \text{UPBETA}_i * \text{MKT}_t + \text{XDNBETA}_i * \text{DNMKT}_t + e_{it} \quad (1)$$

for $i=1$ to 10, where i stands for the i^{th} portfolio; t stands for the holding period; R_{it} is return on the i^{th} portfolio in month t ; and MKT_t is market return in month t computed as the value-weighted returns of all stocks in the sample. DNMKT_t is equal to the market return when the market return is negative, and 0 otherwise. The UPBETA_i coefficient measures i^{th} portfolio's sensitivity to the market when the market is an up market, and XDNBETA_i captures the additional sensitivity to the market (i.e., change in beta) when the market is a down market. A down market is a month in which the market return is negative, and an up market is a month in which the market return is non-negative¹. The advantage of regression specification in equation (1) is that it not only shows how different the beta of a portfolio is in up versus down markets, it also enables us to test whether the difference is statistically significant.

A slightly different form of regression from equation (1) is the following:

$$R_{it} = \text{INTCP}_i + \text{UPBETA}_i * \text{UPMKT}_t + \text{DNBETA}_i * \text{DNMKT}_t + e_{it} \quad (2)$$

where UPMKT_t is equal to the market return when the market return is non-negative; and 0 otherwise. DNMKT_t is defined the same as before. The coefficients UPBETA_i and DNBETA_i are the sensitivities of the i^{th} portfolio to the market when the market returns are non-negative and negative, respectively. Equation (2) is essentially the same as equation (1) except that DNBETA_i is the sum of UPBETA_i and XDNBETA_i .

To test whether a portfolio's risk profile as defined in equations (1) and (2) explains the performance of the portfolio, we use the risk estimates in equation (1) and

¹ We also reestimated all regressions using a different definition of up and down markets where a down market is a month in which the market return is less than the return on the 30-day Treasury Bills, and an up market is a month in which the market return is equal to or greater than the return on the 30-day Treasury Bills. All the results under this alternative definition of up and down markets are virtually identical to the results reported here.

(2), respectively, as explanatory variables in pooled cross-sectional regressions of monthly portfolio returns. Specifically, we estimate the following two regressions:

$$R_{it} = \text{INTCP} + \text{RPUP} * \text{UPBETA}_i + \text{RPXDN} * \text{XDNBETA}_i + e_{it} \quad (3)$$

and

$$R_{it} = \text{INTCP} + \text{RPUP} * \text{UPBETA}_i + \text{RPDN} * \text{DNBETA}_i + e_{it} \quad (4)$$

where R_{it} is return on the i^{th} portfolio in month t ; UPBETA_i , XDNBETA_i and DNBETA_i are estimates from time-series regressions of (1) and (2); and RPUP , RPXDN , and RPDN are risk premiums of the three explanatory variables.

To examine whether our results are robust to large-capitalization stocks, we repeat all analyses for the subset of larger stocks. This is done by ranking all stocks in the sample each month based on market capitalization, and using only stocks with above-average market capitalization in building portfolios. But for the results to be comparable, the momentum ranks and market returns are still computed based on all stocks. For example, suppose there are 3,000 stocks in the sample in a particular month, the number of stocks in each momentum decile is still 300. But the portfolio that tracks the performance of stocks in the top momentum decile may only consist of, say, 160 stocks that have above-average market capitalization, while the portfolio that tracks the stocks in the bottom decile may consist of, say, 140 large-capitalization stocks.

III. Empirical Results

Table 1 Panel A reports the distribution characteristics of monthly returns on the ten momentum portfolios. The results for portfolios of larger stocks only are reported separately in Panel B. Table 1 clearly shows that stocks that have done well in the recent past continue to outperform, while stocks that have done poorly in the recent past tend to continue to underperform. In Panel A, for example, stocks in the top momentum decile have an average return of 1.50 percent in the following month, while stocks in the bottom momentum decile have an average return of only 0.29 percent. This represents an annualized spread of 14.5 percent between the top and bottom deciles. The results in Panel B are similar.

Table 1 also shows that the returns on stocks in higher momentum deciles are negatively skewed, whereas the returns on stocks in lower momentum deciles tend to be positively skewed. In Panel A, the median of returns on the highest momentum portfolio is 1.99 percent, or 0.49 percent higher than the mean, while the median of returns on the lowest momentum portfolio is -0.11 percent, or 0.40 percent less than the mean. The skewness of returns on the top momentum portfolio is -0.92 and the skewness of returns on the bottom momentum portfolio is 0.45. Although the statistical significance of the difference in skewness between winner and loser stocks is untested here, the pattern is consistent with our hypothesis. Our hypothesis predicts that as the price of a stock goes up, investors' expectation about the stock's future earnings also increases. Even though these stocks on average continue to outperform, there are always some of them for which the high expectations built up earlier may turn out to be unfounded, and whose prices will crater when disappointing news arrives.

We think the exposure to a sudden change in the direction of news may have a systematic component. Modern portfolio theory tells us that only systematic risk that cannot be diversified away affects expected returns. We use the asymmetric beta concept previously utilized in the finance literature to analyze the skewness in the systematic risk of momentum portfolios. Specifically, monthly returns on each portfolio are regressed in a time-series regression against monthly market returns. In each month we use the value-weighted returns of all stocks in our sample as the market return in that month.

The regression results of equation (1) are reported in Table 2. The three parameter estimates are placed in a column and each column represents one of the ten momentum portfolios, with the highest momentum at right and lowest momentum at left. INTCP is the estimate for the intercept of the regression equation, UPBETA is the systematic risk or beta of the portfolio in an up market, and XDNBETA is the additional systematic risk of the portfolio in a down market. The numbers in parentheses are t-statistics of the estimates.

Table 2 reveals an interesting pattern of differing skewnesses in systematic risk from low to high momentum portfolios. The lower momentum portfolios have fairly symmetric betas in up and down markets, but the higher momentum portfolios exhibit downside betas that are significantly higher than their upside counterparts. The highest

momentum portfolio shown in Panel A, for example, has a beta of 0.96 when the market return is positive, but its beta is 1.49 when the market return is negative. The difference between downside and upside betas of this top momentum portfolio is 0.53 with a t-statistic of 4.05. More importantly, the difference in the two betas decreases fairly monotonically from high to low momentum ranks, with the top five momentum portfolios showing some statistical significance. In addition, the upside betas seem to be U-shaped from low to high momentum portfolios, with the lowest momentum portfolio having a particularly high upside beta of 1.32. When portfolios are constructed using only stocks with above-average market capitalization, the results reported in Panel B are very similar to those shown in Panel A.

The significant asymmetry in systematic risk reported in Table 2 contrasts with the results of some earlier studies. Fabozzi and Francis (1977), Kim and Zumwalt (1979), and Chen (1982) find that most of the securities exhibit betas that are not statistically different in up and down markets. In a more recent study, Clinebell, Squires, and Stevens (1993) replicate the Fabozzi and Francis procedures over more current time periods and find that the probability of stocks exhibiting statistically different betas in up and down markets is significantly greater than that caused by random chance. There is also an important procedural difference between our approach and the approach adopted in previous studies. Those studies all follow a stock over a long interval ranging from six to fifteen years and estimate the stock's upside and downside betas over the entire period. If upside and downside betas vary significantly over time as they would if they are functions of past performance, then the use of a long estimation interval may lead to rejection of the alternative hypothesis too often. The dynamic portfolio approach employed in our study can avoid this problem.

In addition, the intercept term reported in Table 2 represents a drift in the portfolio return when the market return is zero. For the top momentum portfolio in Panel A, this intercept is 1.43, which means that if the market return is zero, this portfolio would return roughly 1.43 percent. On the contrary, the bottom momentum portfolio has a drift of -0.79 percent per month. Notice that the drift for the top momentum portfolio is lower than, but fairly close to, the portfolio's average monthly return. But for the bottom momentum portfolio, the drift is a lot lower than the average monthly return on the

portfolio. The relatively favorable systematic risk of the bottom momentum portfolio partially offsets its big negative drift.

To further examine the risk exposure of momentum strategies in more detail, we look at the systematic risks of returns on a long-short portfolio. The long-short portfolio assumes investing equally in all stocks in the top momentum decile and shorting same total amount equally in all stocks in the bottom momentum decile. In each month, the return on the long-short portfolio is the spread in returns between the top and bottom momentum portfolios. The time series of monthly returns on this long-short portfolio are first regressed against market returns in the same manner as described in Table 2. For the long-short portfolio we are interested in its betas in up and down markets but less interested in whether its two betas are significantly different, so we also estimate the regression as specified in equation (2).

The results are shown in Table 3. The intercept in Panel A shows that the long-short strategy would earn 2.21 percent per month if the market return is zero. This “drift” is statistically significant with a t-statistic of 5.33. But the portfolio has a negative beta of -0.36 in up markets and a positive downside beta of 0.18 . This systematic risk exposure suggests that any co-movement of the long-short portfolio with the market index reduce its profitability. This long-short strategy is most profitable when the market is flat (i.e., market return equals zero). Comparing both betas with the drift term indicates that if the market goes up by more than 6.14 percent or goes down by more than 12.28 percent in a month, then this long-short strategy will lose money.

Again, we repeat the above analysis of a hypothetical long-short strategy assuming that we can only buy or short stocks that have above-average market capitalization. The results are reported in Panel B, and they are very similar to those reported in Panel A.

Since high momentum portfolios on average have positive excess returns but have unfavorable systematic risk exposures, a natural question is whether the two are related. To investigate this issue, we use the beta estimates reported in Table 2 as the unconditional risk measures to explain portfolio returns. For example, as shown in Panel A of Table 2, the top momentum portfolio has an upside beta of 0.96 and a downside beta of 1.49 which is 0.53 higher than the upside beta. These risk estimates are then assigned

to all the 348 monthly returns of the top momentum portfolio. This process is repeated for all ten portfolios, resulting in 3,480 observations for the pooled regressions. Two regressions are estimated, one using the upside beta and the difference between downside and upside betas as explanatory variables, and the other using both upside and downside betas as explanatory variables.

The results are presented in Table 4 Panel A. When portfolio returns are regressed against both upside and downside betas, the coefficient for the downside beta is 1.53 percent per month with a t-statistic of 2.09, whereas the coefficient for the upside beta is -1.95 percent per month with a t-statistic of -2.86 . These results suggest that while investors receive compensation for an asset's systematic risk in a down market, they actually pay for the asset's potential in an up market. This provides an alternative view on the results of some previous empirical tests that find beta lack of explanatory power for cross-sectional stock returns (see Fama and French (1992)). Our results suggest that assets may have asymmetric systematic risks in both up and down markets that are priced separately.

The intercept term of the regressions in Table 4 Panel A is 1.02 percent per month with a t-statistic of 0.92. This intercept is the return on a portfolio that does not correlate with the market. If the market factor is the only risk factor, then this return should be equal to the risk-free interest rate.

Panel B of Table 4 reports similar regression results for larger companies. These results are qualitatively the same, but the magnitude of the risk premium estimates is smaller than that for all stocks. For example, when portfolio returns are regressed against both upside and downside betas, the coefficients for upside and downside betas are -1.44 and 1.20, respectively, which are smaller in magnitude than their Panel A counterparts of -1.95 and 1.53.

IV. Conclusions

In this paper, we explore the risk characteristics of portfolios based on past price momentum. We find that returns on stocks that have done well in the recent past are negatively skewed while returns on portfolios of stocks that have done poorly in the recent past tend to be positively skewed. Furthermore, stocks that outperformed in the recent past have downside betas significantly higher than their upside counterparts. We

also find that this asymmetric downside risk is significantly correlated with cross-sectional portfolio returns.

The relationship between momentum and downside risk provides a possible alternative to the behavioral hypothesis that the momentum effect is due to investors' under-reaction to new information. But the two are not mutually exclusive. Our results show that high-momentum stocks will underperform low-momentum stocks when the market return is either very positive or very negative. But whether the probabilities of having very positive or very negative market returns warrant the difference in average returns between high and low momentum stocks requires knowledge of investors' risk preference and an equilibrium model of expected returns that allows for more complex measures of risk.

Our results are particularly important for investors who use momentum in a long-short or market neutral strategy. A long-short strategy that buys stocks with good recent performance and sells short stocks with poor recent performance exhibits a negative correlation with the market when the market goes up and a positive correlation when the market goes down. So, a market "neutral" fund may have a zero overall market beta, but its market exposure is not necessarily neutralized. Our results suggest that a truly market neutral strategy, especially one that uses momentum in selecting stocks, should have zero betas in both up and down markets. So long as the momentum effect is partially due to investors' behavioral bias of under-reacting to news, a truly market neutral momentum strategy should still have positive risk-adjusted returns.

References

- Berk, J.B., "A Critique of Size-related Anomalies," *Review of Financial Studies*, 8 (1995): 275-286.
- Bernard, V.L. and J. K. Thomas, "Post-Earnings-Announcement Drift: Delayed Price Response or Risk Premium?" *Journal of Accounting Research (Supplement)*, 27 (1989): 1-36.
- Bernstein, R., "The Earnings Expectations Life Cycle," *Financial Analyst Journal* (1993): 90-93.
- Campbell, R. H. and A. Siddique, "Conditional Skewness in Asset Pricing Tests," *Journal of Finance*, 55 (2000): 1263-1295.
- Chan, L., N. Jegadeesh, and J. Lakonishok, "Momentum Strategies," *Journal of Finance*, 51 (1996): 1681-1713.
- Chen, S.N., "An Examination of Risk-Return Relationship in Bull and Bear Markets Using Time-Varying Betas," *Journal of Financial and Quantitative Analysis*, 17 (1982): 265-285.
- Clinebell, J.M., J. R. Squires, and J. L. Stevens, "Investment Performance over Bull and Bear Markets: Fabozzi and Francis Revisited," *Quarterly Journal of Business and Economics*, 32 (1993): 14-25.
- Daniel, K., D. Hirshleifer, and A. Subrahmanyam, "Investor Psychology and Security Market Under- and Overreactions," *Journal of Finance*, 53 (1998): 1839-1885.
- DeBondt, W. and R. Thaler, "Does the Stock Market Overreact?" *Journal of Finance*, 40 (1985): 793-805.
- Fabozzi, F. and J. Francis, "Stability Tests for Betas over Bull and Bear Market Conditions," *Journal of Finance*, 32 (1977): 1093-1099.
- Fama, E.F. and K. R. French, "The Cross-section of Expected Stock Returns," *Journal of Finance*, 47 (1992): 427-465.
- Fama, E.F. and K. R. French, "Multifactor Explanations of Asset Pricing Anomalies," *Journal of Finance*, 51 (1996): 55-84.
- Grundy, B.D. and J. S. Martin, "Understanding the Nature of the Risks and the Source of the Rewards to Momentum Investing," *The Review of Financial Studies*, 14 (2001): 29-78.

- Jegadeesh, N. and S. Titman, "Returns to Buying Winners and Selling Losers: Implications for Stock Market Efficiency," *Journal of Finance*, 48 (1993): 65-91.
- Jegadeesh, N. and S. Titman, "Profitability of Momentum Strategies: An Evaluation of Alternative Explanations," *Journal of Finance*, 56 (2001): 699-720.
- Kim, M. K. and J. K. Zumwalt, "An Analysis of Risk in Bull and Bear Markets," *Journal of Financial and Quantitative Analysis*, 14 (1979): 1015-1025.
- Kraus, A. and R. Litzenberger, "Skewness Preference and the Valuation of Risky Assets," *Journal of Finance*, 31 (1976): 1085-1100.
- Latane, H.A. and C. P. Jones, "Standardized Unexpected Earnings," *Journal of Finance*, 34 (1979): 717-724.
- Scott, J., M. Stumpp, and P. Xu, "Behavioral Bias, Valuation, and Active Management," *Financial Analyst Journal*, Vol. 55, No. 4 (July/August 1999): 49-57.
- Sears, R.S. and K. C. Wei, "Asset Pricing, Higher Momentum, and the Market Risk Premium: A Note," *Journal of Finance*, Vol. 40, No. 4: 1251-1253.

Table 1. Distribution Characteristics of Monthly Returns on Momentum Portfolios

At the beginning of each month from January 1970 through December 1998, all stocks in the sample are separated into ten portfolios of equal number of stocks based on the total return in the previous 12 months. Returns on these portfolios in the next month are computed as an equally weighted average of returns on all stocks in each portfolio. This results in a time series of 348 monthly returns on each of the 10 portfolios. The distribution characteristics of these returns are reported in Panel A. Same statistics are reported in Panel B for portfolios comprised of stocks that rank above average on market capitalization at the beginning of each month. The sample includes all stocks recorded on COMPUSTAT with returns in all of the previous 12 months and with market capitalization exceeding \$10 million. All figures are in percent.

Panel A. All Stocks

	Portfolio									
	1	2	3	4	5	6	7	8	9	10
	(Loser)					(Winner)				
Mean	0.29	0.51	0.67	0.76	0.79	0.88	1.02	1.17	1.33	1.50
Median	-0.11	0.38	0.58	0.85	1.08	1.37	1.39	1.69	1.86	1.99
Std Dev	7.78	6.26	5.59	5.26	4.92	4.92	4.95	5.11	5.57	6.56
Skewness	0.45	0.20	0.03	-0.19	-0.44	-0.54	-0.87	-1.16	-1.02	-0.92

Panel B. Largest 50% Stocks

	Portfolio									
	1	2	3	4	5	6	7	8	9	10
	(Loser)					(Winner)				
Mean	0.30	0.52	0.66	0.72	0.74	0.77	0.93	1.05	1.25	1.43
Median	-0.06	0.41	0.54	0.86	0.88	1.18	1.35	1.66	1.74	2.09
Std Dev	7.64	6.28	5.53	5.17	4.79	4.75	4.73	4.96	5.40	6.47
Skewness	0.18	0.09	0.08	0.00	-0.47	-0.72	-0.92	-1.11	-0.88	-0.94

Table 2. Time-Series Regressions of Monthly Portfolio Returns and Asymmetry in Market Beta

At the beginning of each month from January 1970 through December 1998, all stocks in the sample are separated into ten portfolios of equal number of stocks based on the total return in the previous 12 months. Returns on these portfolios in the next month are computed as an equally weighted average of returns on all stocks in each portfolio. This results in a time series of 348 monthly returns on each of the 10 portfolios. These monthly returns are then used to estimate the following regression:

$$R_{it} = \text{INTCP}_i + \text{UPBETA}_i * \text{MKT}_t + \text{XDNBETA}_i * \text{DNMKT}_t + e_{it} \text{ for } i=1 \text{ to } 10,$$

where i stands for the i^{th} portfolio; t stands for the time period; R_{it} is return on the i^{th} portfolio in month t ; and MKT_t is market return in month t computed as the monthly value-weighted returns of all stocks in the sample. DNMKT_t is equal to the market return when the market return is negative; and 0 otherwise. The UPBETA_i coefficient captures i^{th} portfolio's sensitivity to the market when the market return is non-negative, and XDNBETA_i captures the additional sensitivity to the market (i.e., change in beta) when market return is negative. Numbers in parentheses are t-statistics.

Panel A. All Stocks

	1 (Loser)	2	3	4	5	6	7	8	9	10 (Winner)
INTCP	-0.79 (-1.86)	-0.51 (-1.76)	-0.20 (-0.86)	0.05 (0.23)	0.25 (1.40)	0.40 (2.35)	0.67 (3.96)	1.00 (5.80)	1.16 (5.68)	1.43 (4.81)
UPBETA	1.32 (12.1)	1.19 (15.7)	1.08 (17.8)	1.01 (18.9)	0.92 (19.8)	0.91 (20.4)	0.88 (20.2)	0.85 (18.9)	0.91 (17.1)	0.96 (12.5)
XDNBETA	-0.02 (-0.08)	-0.06 (-0.44)	-0.01 (-0.05)	0.07 (0.79)	0.15 (1.90)	0.19 (2.49)	0.27 (3.63)	0.39 (5.10)	0.42 (4.68)	0.53 (4.05)

Panel B. Largest 50% Stocks

	1 (Loser)	2	3	4	5	6	7	8	9	10 (Winner)
INTCP	-1.02 (-2.70)	-0.83 (-1.76)	-0.56 (-2.67)	-0.35 (-2.09)	0.02 (0.13)	0.16 (1.32)	0.38 (3.20)	0.64 (4.80)	0.82 (4.83)	1.21 (4.43)
UPBETA	1.43 (14.6)	1.34 (20.2)	1.20 (22.2)	1.13 (25.5)	0.98 (26.6)	0.95 (29.6)	0.94 (30.4)	0.92 (26.6)	0.99 (22.4)	1.02 (14.3)
XDNBETA	-0.13 (-0.80)	-0.22 (-1.99)	-0.20 (-2.16)	-0.13 (-1.79)	0.05 (0.76)	0.12 (2.14)	0.15 (2.88)	0.26 (4.35)	0.27 (3.61)	0.45 (3.74)

Table 3. Time-Series Regressions of Monthly Returns on a Long-Short Portfolio Based on Momentum

At the beginning of each month from January 1970 through December 1998, all stocks in the sample are separated into ten portfolios of equal number of stocks based on the total return in the previous 12 months. A Long-Short portfolio is constructed which holds equal long positions in all stocks in the highest momentum portfolio and shorts same total dollar amount equally among stocks in the lowest momentum portfolio. This results in a time series of 348 monthly returns on this long-short strategy. These monthly returns are then used to estimate the following two regressions:

$$1. \quad R_t = \text{INTCP} + \text{UPBETA} * \text{MKT}_t + \text{XDNBETA} * \text{DNMKT}_t + e_t$$

and

$$2. \quad R_t = \text{INTCP} + \text{UPBETA} * \text{UPMKT}_t + \text{DNBETA} * \text{DNMKT}_t + e_t$$

where R_t stands for return on the long-short portfolio in month t , and MKT_t is market return computed as the monthly value-weighted returns of all stocks in the sample. UPMKT_t and DNMKT_t are market returns when market returns are non-negative and negative, respectively. The coefficients UPBETA and DNBETA capture the portfolio's sensitivity to the market when the market return is non-negative and negative, respectively. XDNBETA is the difference between DNBETA and UPBETA . Numbers in parentheses are t-statistics.

Panel A. Using all stocks in both bottom and top deciles

	INTCP	UPBETA	XDNBETA	DNBETA
1.	2.21 (5.33)	-0.36 (-3.35)	0.55 (2.98)	
2.	2.21 (5.33)	-0.36 (-3.35)		0.18 (1.64)

Panel B. Using only stocks with above-average market capitalization in both bottom and top deciles

	INTCP	UPBETA	XDNBETA	DNBETA
1.	2.23 (4.82)	-0.42 (-3.47)	0.59 (2.86)	
2.	2.23 (4.82)	-0.42 (-3.47)		0.17 (1.34)

Table 4. Cross-Sectional Regressions of Monthly Portfolio Returns on Betas

For each of the 10 momentum portfolios we first estimate the unconditional beta coefficients through time series regressions as described in Table 2. A portfolio's beta in down markets is simply the sum of UPBETA and XDNBETA as reported in Table 2. These beta estimates are used as explanatory variables in the following cross-sectional regressions of monthly portfolio returns:

$$\begin{aligned} & 1. \quad R_{it} = \text{INTCP} + \text{RPUP} * \text{UPBETA}_i + \text{RPXDN} * \text{XDNBETA}_i + e_{it} \\ \text{and} \quad & 2. \quad R_{it} = \text{INTCP} + \text{RPUP} * \text{UPBETA}_i + \text{RPDN} * \text{DNBETA}_i + e_{it} \end{aligned}$$

where $i=1$ to 10, and $t=1$ to 348. RPUP, RPXDN, and RPDN are risk premiums of the three explanatory variables. The t-statistics for these risk premium estimates are reported in parentheses.

Panel A. All Stocks

	INTCP	RPUP	RPXDN	RPUP	RPDN
1.	1.02 (0.92)	-0.42 (-0.42)	1.53 (2.09)		
2.	1.02 (0.92)			-1.95 (-2.86)	1.53 (2.09)

Panel B. Largest 50% Stocks

	INTCP	RPUP	RPXDN	RPUP	RPDN
1.	1.03 (1.08)	-0.25 (-0.29)	1.20 (1.80)		
2.	1.03 (1.08)			-1.44 (-2.57)	1.20 (1.80)