



COLUMBINE NEWSLETTER

A P O R T F O L I O M A N A G E R ' S R E S O U R C E

SPECIAL EDITION—AUGUST 2001

From
John Brush

Price Momentum
a Twenty Year
Research Effort

Summary and Overview

Even the most casual market watchers have observed anecdotal evidence of trend following in stock prices. Borrowing from the world of physics, early analysts characterized this behavior as stock *price momentum*. Over the years, researchers and practitioners have developed increasingly more sophisticated mathematical descriptions (models) of equity price momentum effects. Basically, all price momentum models analyze the time series of a stock's past prices in an attempt to forecast its future performance.

This study explores the development and characteristics of price momentum models, and in particular, of *Columbine Alpha*, a propri-

etary price momentum model created by Columbine Capital Services, Inc. The Columbine Alpha price momentum model has been in wide use by institutions for more than twenty years, both as an overlay with fundamental measures, and as a standalone idea-generating screen. The evidence presented here suggests that price momentum is not a generic ingredient.

The Columbine Alpha approach is almost twice as powerful as the best simple alternative and warrants attention by any investment manager who cares about active return.

Even simple price momentum models (sometimes called *relative strength* models) offer returns competitive with fundamental factors. Compared with the best of these simple models, Columbine Alpha has achieved a long-only return superiority of 200 to 400 basis points, and a 1st-10th decile spread advantage approaching 1000 basis

points at institutionally relevant holding periods. Columbine Alpha's dominance comes from its exploitation of some of the many complexities of price momentum. Recent non-linear improvements to Columbine Alpha incorporating adjustments for extreme absolute price changes and considerations of trading volume appear likely to add another 100 basis points to the model's 1st decile active return.

You will see in this paper that constructing a price momentum model involves compromises or tradeoffs driven by the fact that different past measurement periods produce different future return patterns. For every specific holding period there is a different optimal model. There are many peculiarities or complexities affecting price momentum not seen in traditional factors like earnings/price. Like the fable of the blind men and the elephant, price momentum can seem very different depending

how it is measured and how it is used.

Part I
Basic Price
Momentum Facts

Short-Term Price Changes

Setting aside high frequency, intra-day price changes, and defining short-term as a few days to one month, most published research (and our own proprietary work) suggests that the facts are:

- Extreme price changes over the past three to five days reverse over the next several days, partially restoring the observed change. Easily discovered, this seems to be genetically imprinted into successful traders.
- Past one-month price changes behave the same way. This fact is quite reliable, but very short lived, playing out in a few months.
- We have confirmed that one-month reversal occurs in several dozen other countries as well as the United States. We can find no country where it is not true. This too is easily discovered.

Intermediate-Term Price Changes

Considering intermediate-term to be longer than one month, but less than two years, the facts are:

- Extreme price changes persist one to twenty-four months into the future.
- The degree of persistence varies considerably based on how the past price changes are measured.
- The effect is mildly non-linear with most predictive power at the extremes.
- Immediate-term price momentum generally is more effective in smaller rather than larger capitalization stocks as are most return factors.
- The best intermediate price change measures produce future active returns competitive with measures of estimate revision and generally better than typical value factor performance.
- Intermediate-term price persistence is of use outside the United States; most country markets exhibit the effect. It is not, however, universal. In Japan and Scandinavian countries intermediate-term *reversal* is the rule.

Long-Term Price Changes

Considering long-term to be three to five years, the facts are:

- Extreme past price changes reverse over the next three years.
- The effect is most apparent in small cap stocks with past declines.
- Long-term price change's reversal effect also has been observed in the U.K. market.

January Effects

The period around year-end seems to present a special case for the use of almost all price momentum measures. In the United States this phenomenon probably is due to the tax code's distortions on the timing of loss and gain recognition. We have not observed this so-called *January effect* outside the United States.

- In two out of three Januarys, intermediate-term price change effects switch directions: *persistence* becomes *reversal*. This means that stocks that have outperformed over the past several months tend to underperform during January.

- Once the month of January is over, intermediate-term persistence resumes its course, moderating the effect of the January reversal after three months and eliminating it after twelve months.

- Short-term price change is the only price momentum effect largely unaffected by Januarys. This is not surprising since reversal over the following month is the norm for short-term price changes.

- The long-term price change reversal occurs mostly in the following Januarys. Outside the month of January, long-term price change has almost no price momentum effect.

Part II

Widely Used Price Momentum Formulations

At this point many managers might declare price momentum a confusing mess and rationalize getting along without it. Yet the return potential of carefully exploiting price momentum is compelling. Even simple, common-knowledge price momentum approaches offer returns competitive with fundamentals.

For the real world of money management we can simplify the price momentum "mess" a bit by throwing out long-term price change as impractical. The phenomenon is real enough, but with almost all of its return generated in small stocks during the month of January, long-term price change really is not a usable price momentum approach. This leaves us with intermediate- and short-term price change effects. These two approaches are present throughout most of the calendar year, and they appear in large and small cap stocks.

Simple Models

Typically, simple price momentum models are just calculations of spot-to-spot change in a stock's price over a particular time period. Although these sometimes are referred to as relative strength models, none of the formulations set out here measure a stock's price change relative to the market. There are, in fact, *relative strength* approaches that seemingly differ from straight percentage change in price. Charts often display ratios of a stock's price to the market; when the stock is outperforming the market its ratio line rises. A little algebra shows that the ratio-change approach can be

alternatively expressed as the difference between percentage change in price of the stock and the market. When rank ordering stocks the market percentage change does not affect the order, so relative strength expressed as a ratio is directly equivalent to weighted past percentage changes. Likewise, ratios of moving averages also can be approximated as weighted percentage changes. We hold the results based on the models in this study as applicable to both ratio and moving average relative strength approaches.

The seven simple formulations examined here have either been published in the open literature or are the basis of commercially available services. Many others are possible, but these seven seem to cover the most common variations and illustrate the critical concepts.

- **Model 1** - Ranks stocks based on their percentage change over the past month.

- **Model 3** - Ranks stocks based on their percentage change over the past three months.

- **Model 6** - Ranks stocks based on their percentage change over the past six months.

- **Model 6-1** - Ranks stocks based on their percentage change over the past six months, minus their percentage change in the past month.

- **Model T** - Ranks stocks based on their percentage change over the past twelve months.

- **Model T-3** - Ranks stocks based on their percentage change over the past twelve months, plus their percentage change over the past three months. This approximates O'Neil's relative strength model, as we understand it.

- **Model T-1** - Ranks stocks based on their percentage change over the eleven months ending one month ago. In effect, this is a twelve-month model that ignores the most recent month's change.

More Complex Models

The seven models listed above pretty well cover the possibilities of what can be done with one or two spot-to-spot price changes. To take price momentum to the next level of performance more complex approaches are required, but even these more elaborate models still utilize the same basic concepts of short-

and intermediate-term price change as the simple models.

The key to improving the performance of the simple price momentum models is to reject some stocks that have exhibited large price changes, but nevertheless are not being driven by persistent price momentum at all. Other influences can produce price behavior that will be misidentified as price momentum by models without the necessary sophistication to reject such false *momentum*. Refining the analysis to ignore false momentum is simply a prudent elimination of risky stocks that contaminate simple price momentum models. The three complex models discussed below represent a progression of steps to reduce various forms of false momentum.

- **Model W** - Ranks stocks based on the sum of their monthly percentage changes over the past year after a proprietary weighting structure has been applied to the monthly changes. By using every month's weighted price change, Model W excludes stocks with irrelevant high month-to-month volatility in price that may otherwise masquerade as price momentum. In Model W less weight is applied

to recent months, exploiting the short-term reversal phenomenon. The Model W weighting structure is the same as that used in the Columbine Alpha model since 1986.¹

- **Model B** - Ranks stocks based on the alpha obtained from a generalized least squares weighted regression applied to the past year's monthly percentage changes in each stock's price and the market. The S & P 500 Index is used as the market proxy. The weighting structure applied to the monthly changes is the same as used in Model W. This approach differs from the conventional relative strength model in that it "corrects" past stock price changes for the market's distorting effects using a current beta. The idea of correcting past price changes for beta is simple. A beta 2.0 stock in a market up 10% ought to be up 20%. If it is only up 15% it is underperforming. In practice the way beta is computed is critical. Traditional three- and five-year betas are not as helpful as a twelve-month GLSQ weighted beta.² Model B is the Columbine Alpha model in use from 1986 up until mid-2001.

- **Model CA** - Same formulation as Model B, with the addition of

two new (2001) improvements:
1) Adjustment for extreme price changes in the most recent month; 2) Adjustment for a particular pattern of change in trading volume. This is the current Columbine Alpha model.

Extreme Price Changes

Over the years, several of our clients have asked if there is a point at which recent strength in a stock should be considered as having gone too far. Perhaps issues that have experienced extreme absolute changes in price over a short time should not be treated the same as other stocks ranked in the 1st decile of the Columbine Alpha model.

The wild price behavior of technology stocks at the end of the 1990s provided us with a perfect laboratory to experiment with this concept. We found that, despite the Columbine Alpha model's reduced weighting of the last month's price change, stocks ranked in the model's 1st decile still can suffer from the one-month reversal effect if that recent price change is big enough. For example, when 1st decile Columbine Alpha stocks rise a substantial amount, say more than 20%, over a short period, they tend to underper-

form the other 1st decile stocks for a few months and then come roaring back with good performance. This is classic one-month reversal and cannot easily be exploited. Our solution is to adjust the ranking of these stocks, excluding them from the 1st decile until the effect of the extreme price change has passed.

This extreme price change adjustment is highly dependent on the percentage change threshold chosen, and is non-linear as well. If we set the price change threshold too high, say a rise of 200% in one month, it hardly ever occurs, but when it does these stocks typically do not recover. Set too low it excludes too many issues with good longer-term prospects.

We used the data from 1999 and 2000 to identify the optimal percentage change threshold, and then tested that level over the entire thirty years of our research database. The threshold we selected worked over the preceding years too, it just was not triggered very often prior to the 90s (typically, only half a dozen hits a year). In one-third of the years no stocks crossed the threshold. Nonetheless, in the other twenty years the imposition of the short-term price rise

exclusion improved 1st decile results 80% of the time.

We did not find a reciprocal benefit in excluding stocks from the 10th decile that have declined a lot. Issues with large absolute price drops over a short period often do bounce back, but the phenomenon is more erratic and unreliable than with positive changes. This may have to do with the fact that, unlike positive price changes, negative changes are bounded. Once a stock's price hits zero you cannot expect a "rebound."

Volume Changes

The last complexity exploited in 2001 is change in trading volume. The notion that price and volume are interrelated is longstanding financial folklore, but we never found that volume, or volume change had any persuasive return predictive power by itself. We last studied this idea in 1992, and concluded that, while change in volume did have some ability to improve price momentum, the effect was small and did not last long.

Recently, we learned from the work of Lee and Swamianthan (1999) of the potential of *long-term* volume change when used

as an overlay to simple relative strength. This led us to re-examine our previous work (which was primarily focused on short-term changes). This time we explored several ways to measure trading volume and volume change over short-, medium- and long-term periods. The two most promising approaches are short-term (three months) and long-term (multiple year) percentage changes in trading volume.

In confirmation of our 1992 findings, this latest study found that short-term change in trading volume is moderately successful by itself, but the improvement to price momentum is short-lived. Among stocks ranked in the 1st decile of the Columbine Alpha Model, short-term increases in trading volume improve short-term performance. This is some support to the old notion that rising prices on rising volume is auspicious. Unfortunately, after three months the gain deteriorates to nothing. Remarkably, longer-term change in volume works in the opposite direction from short-term change, and the benefit is much more enduring. Top decile Columbine Alpha stocks with very high long-term volume changes underperform consistently from one- to thirty-six-

month holding periods. Symmetric results are seen in 10th decile Columbine Alpha stocks, but the results are weaker and more erratic.

To implement this in the Columbine Alpha Model we identify stocks with high percentage changes in volume from the past year compared to several previous years. Excluding these stocks from the ranks of Columbine Alpha's 1st and 2nd deciles causes return to go up with little cost in added volatility. Even better, the adjustment improves return in roughly 80% of all years. The volume-change adjustment is effective at every capitalization level.

The only drawback is that volume-change adjustment typically reduces the number of stocks ranked in the 1st decile by 10%, and reduces the 2nd decile by 5%. Attempts to include volume change as a linearly weighted factor and keep a full 1st decile were not effective.

Part III

Comparison of Model Performance

Methodology

We compare these formulations

in a monthly database over the years 1971 through 2000. Rather than test in all stocks, we utilize a more institutionally relevant set of 1500 large common stocks selected on joint capitalization and liquidity criteria. The 1500-stock universe is redefined yearly to recreate the issues actually available for institutional investment in each year.

For every month in the database we compute a raw score for every stock based on each model's formulation. We then sort the stocks on each model's raw scores and assign decile rankings. In our system the 1st decile contains the issues that should be the most attractive, and the 10th decile those that are the least attractive. Each decile contains approximately 150 equally-weighted stocks. Every stock receives a decile ranking from each model in every month. We make no attempt to control for sector or group concentration in creating the deciles. This seems the best way to assess price momentum's overall ability to identify a subset of stocks to overweight for increased return, exclusive of benchmark or portfolio risk control issues. Long experience informs us that the Columbine Alpha Model works in every sec-

tor and group, and the literature reports similar success by simple measures. Positive performance may be a mix of group identification and individual stock selection.

To measure performance of each model we take eleven monthly decile rankings (no Januarys)³ for each of the past thirty years, and compute the average active return (excess over the equal-weighted universe's total return) at holding periods of one, six, and twelve months. The average of all the rankings made in each calendar year generates that year's average return. Standard deviations are based on the standard deviation of each year's average. We also compute ICs (information coefficients or equivalently, correla-

tion coefficients) between the decile rankings and the subsequent active return over the same holding periods.

To compare the various models we report their respective ICs, along with annualized active returns and standard deviations of active returns for the 1st deciles, addressing the long-only focus of most institutional managers. Compound multi-year returns are inherently risk adjusted, so we also compare competitive alternatives on the basis of 1st - 10th decile annual compound spreads to assess multi-year returns and illustrate the time pattern of extreme decile discrimination.

Results

The tables and figures below illustrate our findings. We report results at holding periods of one, six, and twelve months, recognizing that one-month evaluations are common, but real world investors are forced by transactions costs to restrict portfolio turnover and so are concerned with longer than one-month holding.

Information Coefficients

Table 1 sets out the information coefficients (ICs) for the seven simple price momentum models and the three complex models, including the current improved version of the Columbine Alpha Model.

Table 1. Information Coefficients

Price Momentum Formulation	Holding period (months)		
	1	6	12
Model CA (improved Columbine Alpha)	0.055	0.091	0.066
Model B (W , beta-adjusted)	0.054	0.089	0.064
Model W (weighted monthly % changes)	0.051	0.089	0.060
Model T-3 (T , plus 3-month % change)	0.026	0.049	0.044
Model T-1 (T , excluding latest month)	0.053	0.073	0.045
Model T (12-month % change)	0.041	0.067	0.046
Model 6-1 (6 , less 1-month % change)	0.026	0.053	0.058
Model 6 (6-month % change)	0.012	0.045	0.057
Model 3 (3-month % change)	-0.006	0.013	0.041
Model 1 (1-month % change)	-0.030	-0.006	0.014

Figure 1. Comparison of ICs

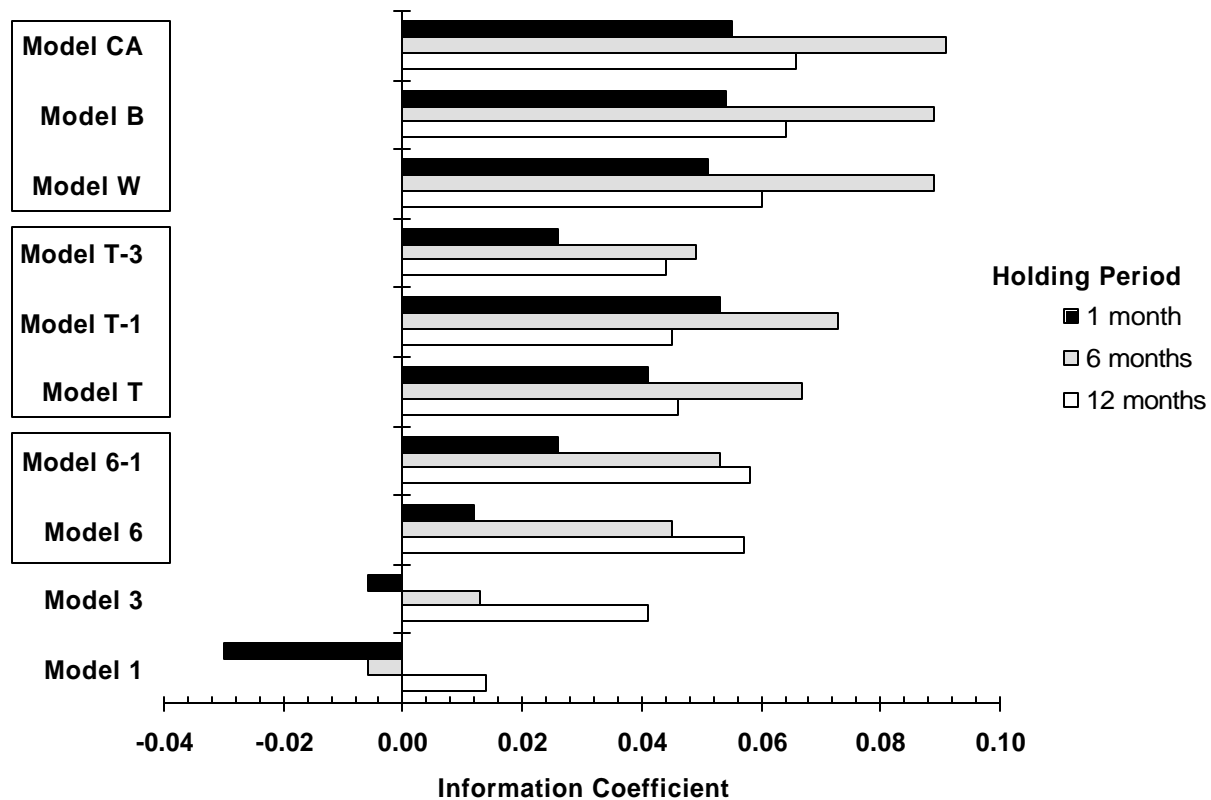


Figure 1 displays the same information in graphical form. Recall that information coefficients measure the linearity of ranking and subsequent return with weight given to all rankings. Success at extreme rankings increases a model's IC, but so does linearity. Generally, price momentum is good at extremes, but not linear, so differences in ICs may not accurately reflect extreme return potential.⁴

Ideally, one would like a model that shows reliable predictive power reflected in high ICs at all

holding periods. Among the simple models, only Models T and T-1 seem to meet these criteria.

Model 1 has a negative IC at one-month holding periods because short-term price change is a reversal effect, but Model 1's IC is essentially zero at six and twelve months. This suggests a sharp fall off in return potential of the one-month reversal at longer holding periods. The results for Model 3 demonstrate that it lies on the cusp between the short-term and intermediate-term changes, without really being helpful at either. Its one-

month holding IC is the worst of all the alternatives, and the only model it can beat at the two longer holding periods is Model 1. Model 6 starts poorly, but shows an increasing IC as holding periods lengthen, dominating all the simple models at twelve months. Enhancing Model 6 by subtracting the one-month percentage change (Model 6-1) improves correlations at one-month and six-month holding periods, and adds a little to twelve-months.

The twelve-month percentage change model (Model T) domi-

Table 2. Return and risk by holding period

Price Momentum Formulation	One month		Six months		Twelve months	
	Return	Std Dev	Return	Std Dev	Return	Std Dev
Model CA (current Columbine Alpha)	12.10	9.84	11.05	13.49	8.04	9.89
Model B (W , beta-adjusted)	11.34	9.50	10.21	13.96	7.39	9.74
Model W (weighted monthly % changes)	11.15	10.73	9.89	16.42	7.19	11.99
Model T-3 (T , plus 3-month % change)	7.77	13.21	7.59	18.21	7.28	14.91
Model T-1 (T , excluding latest month)	11.28	12.30	8.84	17.70	6.66	13.25
Model T (12-month % change)	9.51	13.12	8.76	18.36	7.21	13.86
Model 6-1 (6 , less 1-month % change)	6.04	11.57	6.85	15.02	7.07	13.92
Model 6 (6-month % change)	5.15	11.04	6.84	15.82	7.53	14.28
Model 3 (3-month % change)	1.37	10.63	2.57	12.69	5.02	11.56
Model 1 (1-month % change)	-6.46	8.34	0.02	9.24	2.66	8.01

nates shorter-term simple models at one- and six-month holding periods. Augmenting Model T by adding three-month percentage change (Model T-3) produces a lower IC than Model T at every holding period. Skipping the most recent month, thereby

avoiding one-month return reversal (Model T-1) enhances one- and six-month holding correlations as would be expected from the more aggressive approach of Model 6-1. Unfortunately Model T-1 shows a slightly lower IC than the sim-

pler Model T at the longer twelve-month holding period. Turning to the more complex models, the progression is from Model W, to Model B, to Model CA (the latest Columbine Alpha formulation), with ICs improv-

Figure 2. One-month holding results

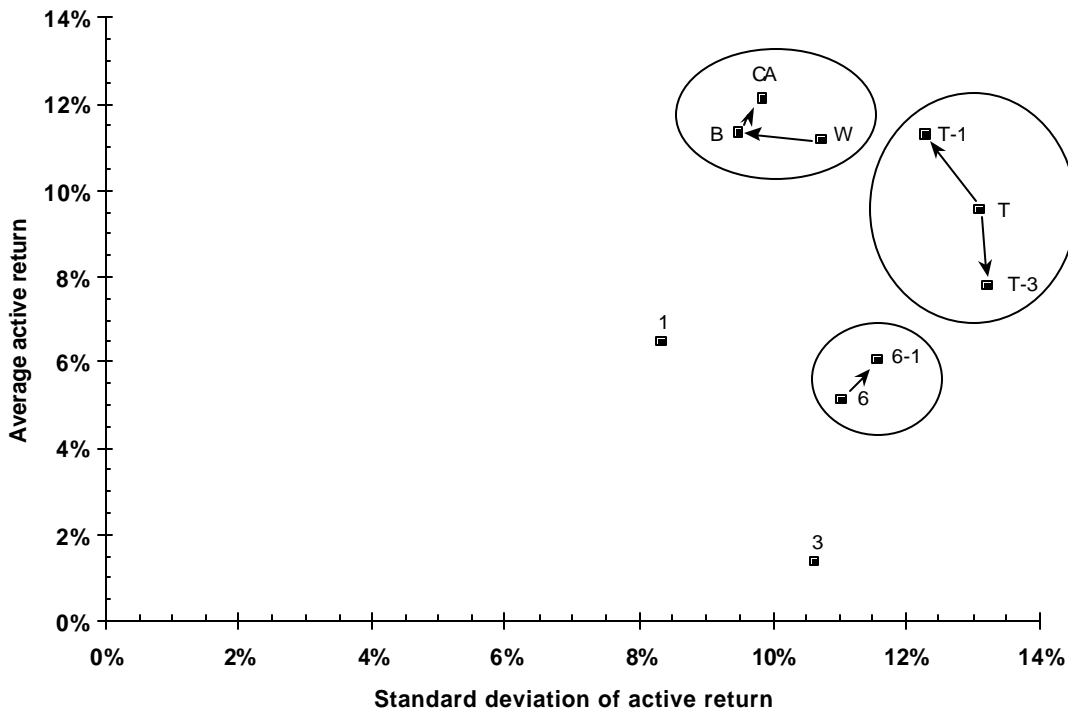
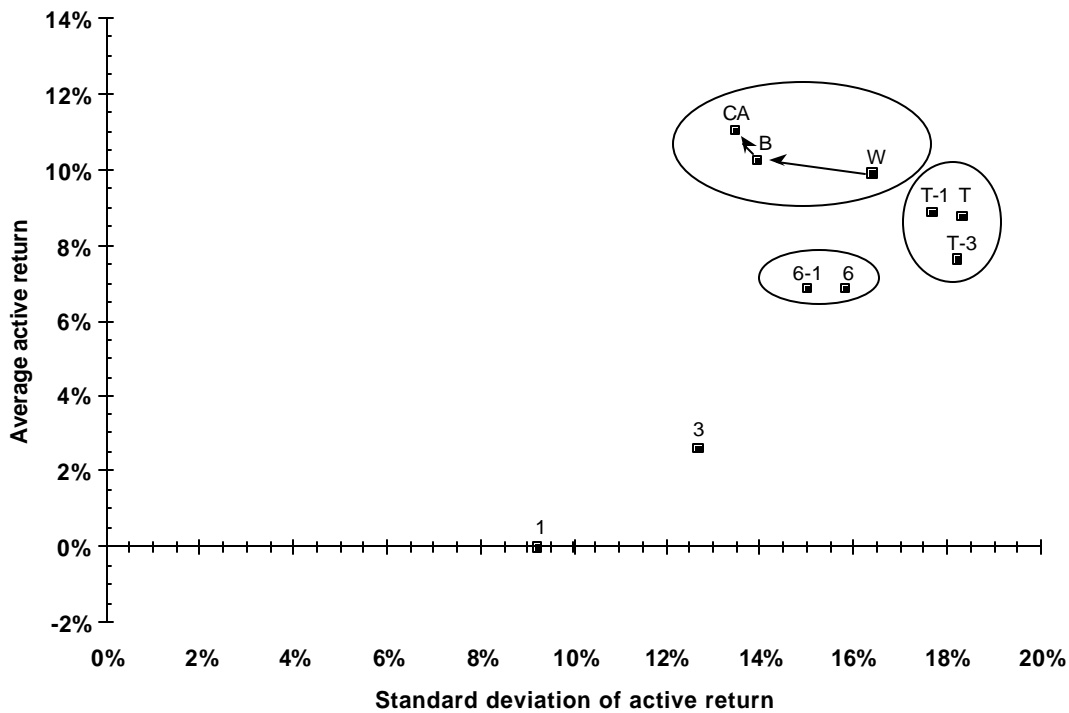


Figure 3. Six-month holding results



ing at each step. Columbine Alpha (Model CA) enjoys generally higher ICs than any simple model. If you get paid for high ICs, then Columbine Alpha beats simple models. But ICs are only part of the story. Much more critical for stock selection is positive active return of top deciles and low volatility of active returns.

Likewise return spread is of interest in overlaying or vetoing purchases and sales and for long-short portfolios.

First Decile Return and Risk

Table 2 reports each model's thirty-year average 1st decile

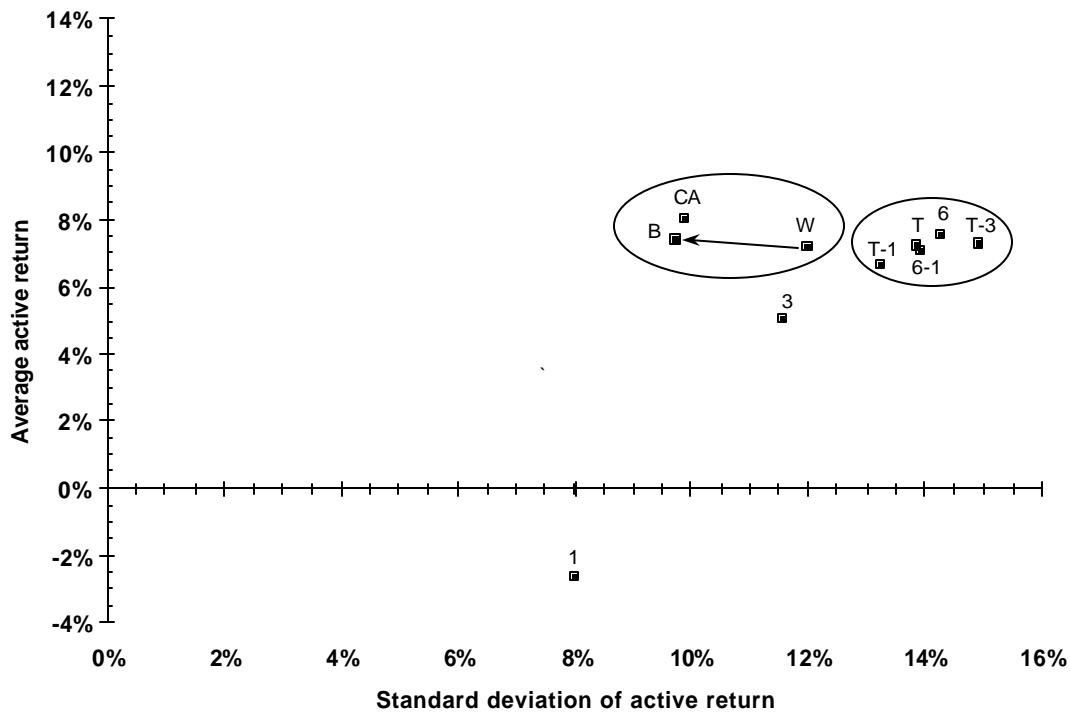
active return at one-, six-, and twelve-month holding periods. It also sets out the standard deviation of the active return.

Figures 2, 3, and 4 display the 1st deciles of each model in conventional return and risk space. The vertical axis represents annualized average active return (excess over the equal-weighted universe return), with standard deviation of annualized average active return plotted on the horizontal axis. (For clarity we have circled the data points for the variants of models 6 and T, and of the three complex models to indicate their inter-relationship.) As is usual in this presentation format, the most attractive and

useful models are highest and farthest to the left. If we were to draw a line from the lower left corner (origin) of each graph to a particular model's data point, the slope of the line would represent that model's information ratio, or active return per unit of active risk. As the slope of the line increases, so does that model's utility for stock selection.

In general, the performance of the most attractive (top) deciles of each model confirms the order of effectiveness suggested by the IC analysis. Reflecting non-linear performance, the differences among models when considering only their extreme

Figure 4. Twelve-month holding results



rankings are much larger than might be inferred from the differences in ICs.

At the one-month holding periods displayed in **Figure 2** Model 1 generates a respectable 6.8% annualized return with the lowest standard deviation of all the models. (Since Model 1 is a pure reversal model, we invert its rankings to identify attractive stocks.) Model 3's active return is inferior to all other models for this holding period, and does not improve much at the longer periods. We need not consider it further.

We can exploit Model 1's short-term predictive power in the

longer-term models. Model 6-1 makes full use of it by subtracting the most recent month's change, while Model T-1 is only a partial application (ignoring the most recent month's change). Using the short-term reversal improves return—Model 6-1 is better than Model 6, and Model T-1 is better than Model T—but volatility increases for Model 6-1 while it decreases for Model T-1.

All three of the complex models (W, B, and CA) dominate the best simple models (T or T-1) at **Figure 1's** one-month holding period. Weighting the monthly price changes individually (Model W) reduces volatility, and

the risk (beta) adjustment of Model B drops it even further. Model CA's corrections for trading volume and extreme price changes push its active return up by 76 bps over Model B with little change in risk.

Turning to **Figures 3** and **4** where the six- and twelve-month holding results of all models are displayed, the failure of Model 1 appears, and the futility of the Model 6-1 and T-1 modifications is revealed. At twelve-month holding, all versions of Model 6 and Model T models cluster together around an annual active return of 7%, and a standard deviation of active return of 14%. These are not bad results,

Figure 5. Spread comparison

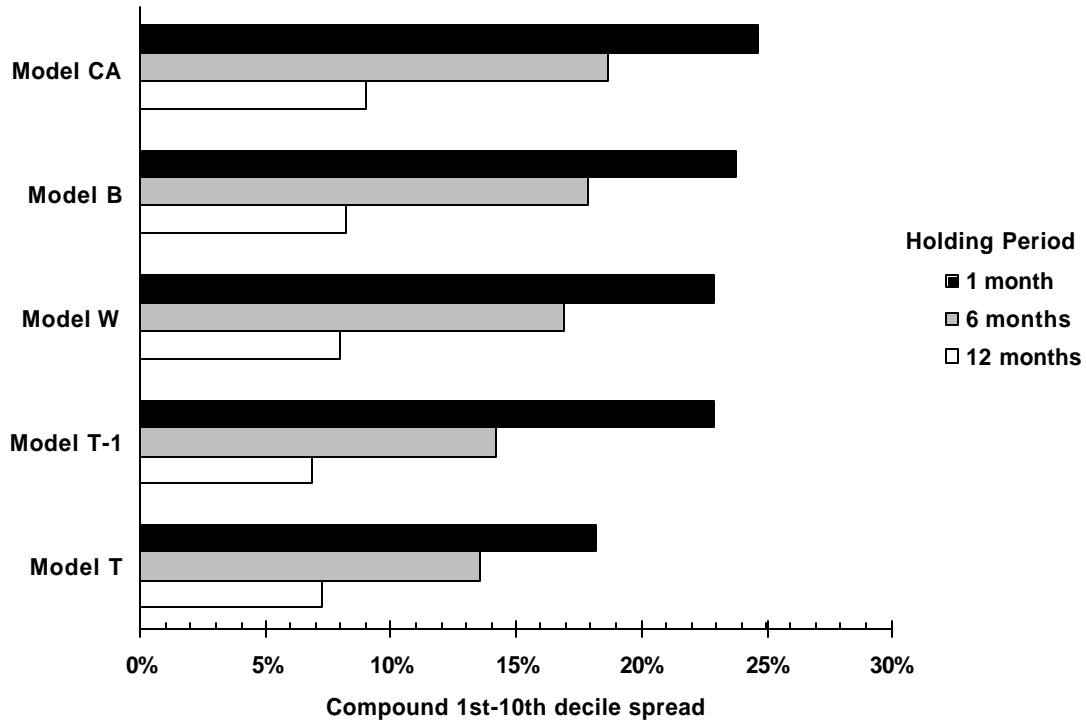
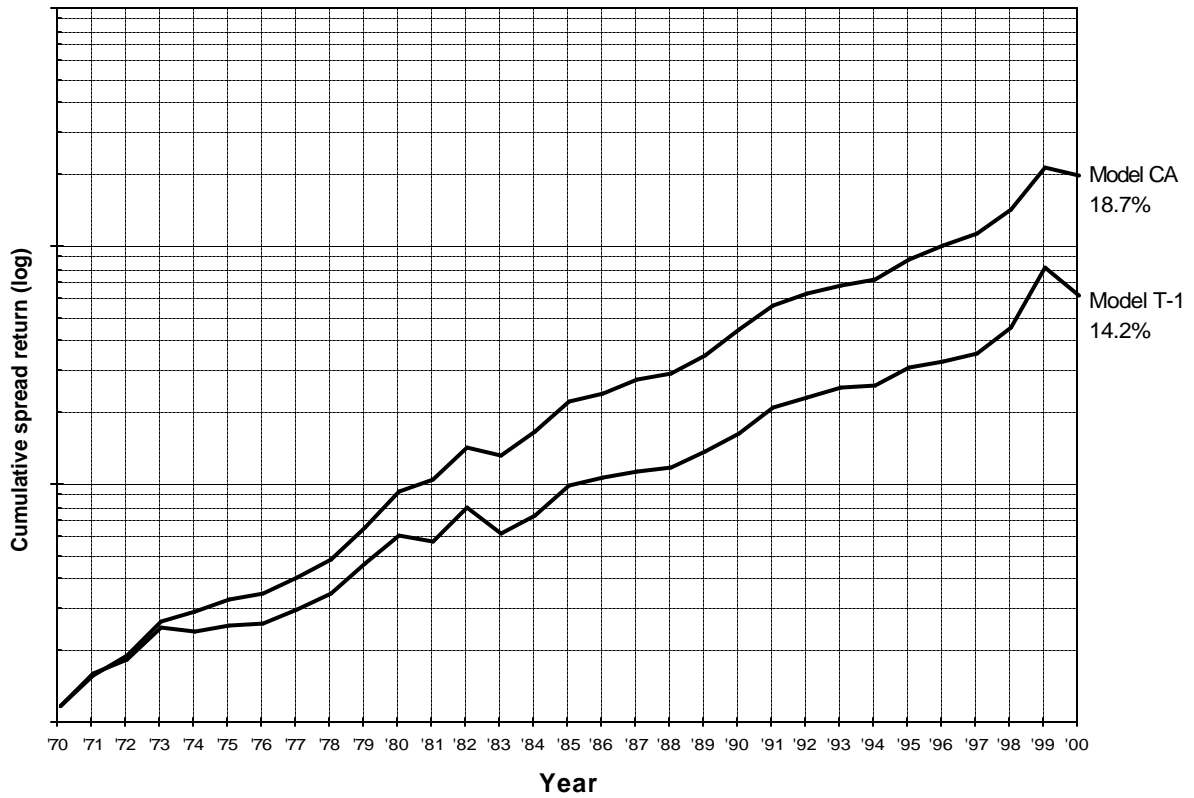


Figure 6. Compound returns



but the three complex models, and especially the improved Columbine Alpha (Model CA), are much better. Not only is the annual active return 8%, but the standard deviation of return is dramatically lower: 10% per year.⁵

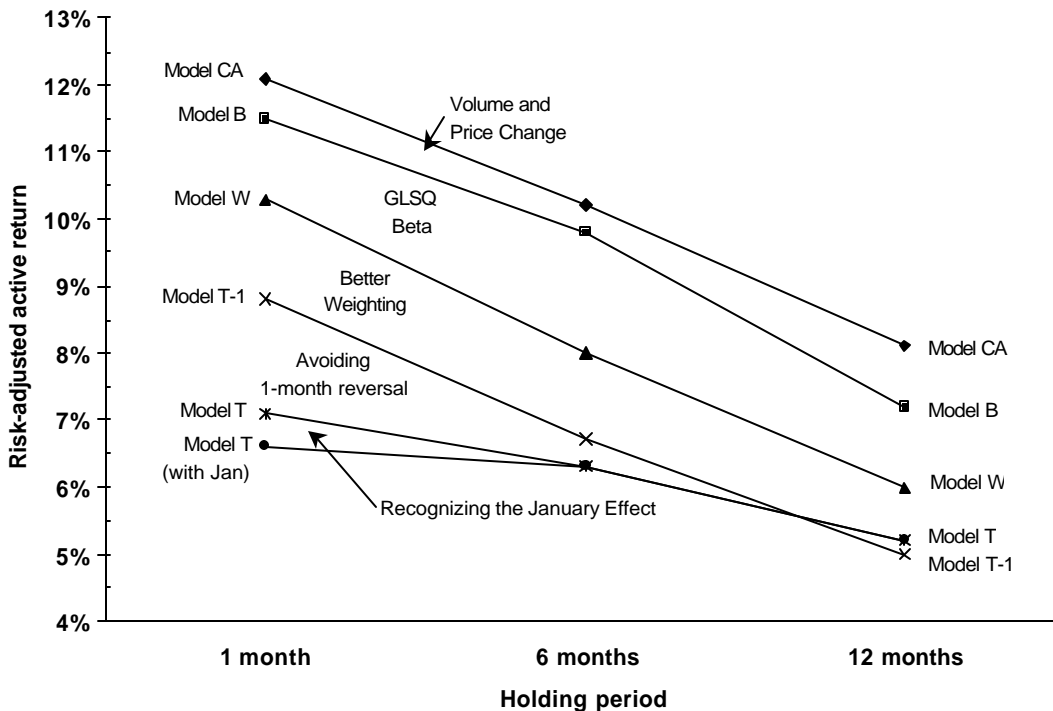
Compounded Results

Although the return-risk analysis just completed is traditional and helpful in comparing alternatives with differing return risk prospects, it hides time patterns of return and does not reflect the natural risk adjustment of multi-period compounding.

Figure 5 displays the compound annual spreads between 1st and 10th deciles at one-, six-, and twelve-month holding periods for Columbine Alpha and its variants, and for the competitive simple alternatives, Models T and T-1. This produces a picture similar to that seen in the IC comparison of Figure 1, with the more complex W, B, and CA models producing higher spread return, and Model T-1 beating Model T at one- and six-month holding. As expected from their ICs, Model T has a higher compound spread than in Model T-1 at twelve-month holding.

To assess time patterns of return, **Figure 6** displays for six-month holding periods yearly cumulative compound returns of Model CA and Model T-1 as growth of \$1 on a semi-log scale. Several points are notable: First, the difference in compound annual return (18.7% versus 14.2%) is the result of cumulative, consistent return superiority evident after only a few years. Second, the two models are highly correlated. They generally succeed or fail at the same time. Third, Model T-1 has four failure years, two of which exceed -20% return spreads. In contrast, Model CA has only two failure years of about -7%.

Figure 7. Risk-adjusted active return analysis



The last ten years reveal some interesting characteristics of simple, non-beta corrected models like T-1. Note that Model T-1 performed wonderfully well in 1999. The spread was +79.4% followed by a -24.5% in 2000. In contrast Model CA had a spread of +50.2% and -6.6% in the same years. This is exactly what you would expect in a trending market. Beta corrections were not helpful in 1999 because misidentifying high and low beta stocks as relative strength and weakness worked out well while the market continued to trend upward. When it reversed direction in 2000 the consequences of this price momentum error were revealed. The net differences favored Model CA by 6% over two years.

Part IV
Improvement
Contributions
Identified

On all three of the risk-return graphs you can compare risk-adjusted returns by noting the vertical distance from a given model's data point to straight lines projected from the origin to each of the other models. In Figure 7 we do the measuring for you for all three holding periods. The graph displays a risk-adjust-

ed return comparison between the dominant Model CA (Columbine Alpha) and each of the other formulations based on the data from **Figures 2, 3, and 4.**

The lowest return boundary is the simple Model T, including rankings for Januarys where all intermediate term models show perverse results on average. The highest return boundary is the current Columbine Alpha Model (CA). The risk-adjusted return differences are large, ranging from more than 500 basis points at one-month holding to 300 basis points at twelve-month holding. It is important to note that Model T and its variants and Model CA and its variants are highly correlated in yearly performance, so improvements seen in the simple Model T by omitting January rankings can be confidently expected to be reflected in a similar adjustment made to Model CA. Our data confirms this. This allows us to attribute performance differences among the models to their structural differences in an additive fashion. Omitting Januarys improves the one-month performance of the Model T with little effect at six- and twelve-month holding. We have labeled the improvement in risk-adjusted return

from the Model T with Januarys as the gain seen by, "Recognizing the January Effect."

Moving from Model T, ex-January, to Model T-1 produces a nearly 200 basis point improvement in return at one-month holding, which drops to less than 50 basis points at six months and actually hurts return at twelve months. This improvement is labeled, "Avoiding 1 Month Reversal." Think of it as a first step towards a better weighting of past monthly percentage changes.

The next step is a big one. Use of a better weighting approach (Model W) appears to be worth 150 basis points at all holding periods over Model T-1, and is statistically significant at three sigma. It is labeled "Better Weighting."

Including short-term beta in a two-parameter GLSQ regression approach (Model B) gives a similar boost to risk-adjusted return. The improvement is labeled "GLSQ Beta."

The move from Model B to Model CA adds in the volume change and extreme price change adjustments. This adds up to a further 100 basis points and is

labeled "Volume and Price Change." Taken together, adding the two new adjustments improves 1st decile Columbine Alpha return in 90% of the past 30 years. The cumulative gain from Model T to Model CA, omitting Januarys, is 71% (500 basis points) at one month, 80% (500 basis points) at six months and 55% (300 basis points) at twelve months. These improvements are significant at more than five sigma.⁶

Applying a risk-adjusted return analysis to 1st - 10th decile spreads of alternative models gives very similar results. As models are improved from Model T to CA there is a similar and about double improvement in risk-adjusted spread.

It is apparent that although Model CA, like Model T, uses twelve months of data, it improves over simple Model T by exploiting a number of complexities unique to price momentum. Model CA is a purified version of Model T that avoids the tendency of simple percentage change price momentum to falsely identify stocks that are simply volatile or showing strength and weakness for spurious, yet identifiable reasons.

CONCLUSION

Price momentum has been a successful part of the investment world for a long time. Its proven utility even allowed it to overcome the academic community's premature announcement of its demise. The phenomenon is multifaceted, with predictive power highly dependent on the specific treatment of past price changes, the holding period chosen, January reversals and other complexities. Even so, the best simple models produce good active returns, comparable with widely used fundamental factors at institutional holding periods.

To improve on the forecasting ability of simple price momentum the crucial concept is the rejection of false momentum—eliminating stocks with attractive price changes, but otherwise flawed characters. The Columbine Alpha Model, through its various manifestations, has focused on this notion since its introduction in 1979. The model is the result of twenty-plus years of ongoing research and development effort by Columbine Capital Services to refine and deliver the very best price momentum product available to money managers. The 2001 version of Columbine

Alpha is newly enhanced with non-linear volume and price-change adjustments that produce sharply better results than the best simple models or even Model CA's own predecessors. For investors the obvious implication is the real potential for significant positive bottom-line impact on institutional portfolios.

Notes

¹ For a discussion of weighting each period differently, see Brush, J.S. 1986. "Eight Relative Strength Models Compared." *Journal of Portfolio Management*, vol. 13, no. 1 (Fall):21-28.

² We believe the use of beta as an adjustment to price momentum was pioneered by Columbine. See Brush, J.S. and K.E. Boles. 1983. "The Predictive Power of Relative Strength & CAPM." *Journal of Portfolio Management*, vol. 9, no. 4 (Summer):20-23.

³ We exclude January rankings from the overall average because of the January effect discussed in Part I. Holding periods of one month have no overlap and do not extend into Januarys. Longer holding periods are overlapped and do extend over Januarys.

This produces averages based on every possible ranking made during the usable months of the year. Because all formulations except Model 1 are subject to adverse performance in January, all of the comparisons in **Figures 1, 2, 3, and 4** omit Januarys. **Figure 7** adds Januarys back to illustrate the benefit of dodging the effect.

⁴ Virtually all ICs reported here are highly statistically significant. We estimate the standard error associated with the thirty year ICs reported in Figure 1 to be 0.003, 0.010 and 0.013 for one-, six-, and twelve-month holding periods, respectively. Standard deviations of difference between models are estimated to be around one-third of these figures due to their high correlation with each other.

⁵ The significance of differences between model returns is estimated by taking the standard deviation of thirty yearly differences. It turns out that Models CA and T and their variants enjoy a one sigma sampling error of differences at 0.5% of all their holding periods. The sampling error is 0.8% for differences between CA and Model 6. Using these as guides, we conclude that the one month

enhancements to the Model T are two sigma significant at one month holding, but not significant at twelve month holding. At twelve month holding all simple six-month and twelve-month models and their enhancements are statistically identical.

⁶ Conventional standard deviation of mean returns based on a sample of thirty years suggests that, for six-month holding periods, the average active return for the Columbine Alpha Model (CA) is greater than zero at better than five sigma. Model T is only slightly less impressive with returns significant at better than three sigma. Taken one at a time, most enhancements from Model T to Model CA are statistically significant at 1.5 to 3.0 sigma. Avoiding the one-month reversal is two sigma significant at one month but not at six and twelve, and the overall difference between Model CA and the Model T is statistically significant at greater than five sigma at every holding period.

Risk-adjusted return comparisons made over different sub-periods of the past thirty years will give different results with higher sampling standard deviations clouding comparisons. We have examined the past ten years

and found a completely similar pattern to **Figure 7**. The main differences are that six- and twelve-month returns for all models were higher than in the previous twenty years, so the curves are flatter. Remarkably, the risk-adjusted spreads, between CA and the Model T remain the same, but the statistical significance of the CA advantage over Model T drops to about 1.5 sigma due to the reduction in sample size and increases in volatility of differences.

Appendix
Price Momentum's
History

Speculation on the time patterns of prices is probably as old as commerce and trade. Some recent studies give the impression that price momentum research has only occurred in the last decade, ignoring the debt we all owe to many contributors across more than a century of investigation.

The current situation is best characterized by wide availability of inexpensive historic databases and low cost computing power, combined with an increase in the number of practitioners with good statistical training. Many proprietary homegrown relative strength measures are doubtless in use by managers who read the literature, but do not publish their work. Columbine has tracked the literature over the past twenty years and kept the Columbine Alpha Model current by testing published ideas and by exploring ideas suggested by its money management clients.

The Literature

An important but often overlooked summary is Cootner's *Random Character of Stock Prices*

(1964), a collection of studies of price persistence beginning with the very first formal statistical study of stock prices, Bachelier's 1900 analysis of French stock options. Cootner's collection is a rich tapestry of research from spot cotton prices on the Mississippi levees to statistical analyses of stock price distributions and filters.

Edwards and Magee, *Technical Analysis of Common Stocks* (1953), is the bible of chart reading and the idea source for some of the first computer analysis of stock patterns done by students at MIT in the stone age of digital computing - the early 1960s. Andrew Lo (2001) revisited this question forty years later with dramatically more computer power and data, but still motivated by, and properly citing, Edwards and Magee's patterns.

With the advent of modern portfolio theory many professors of finance turned their backs on price momentum, rejecting it as inconsistent with the efficient market hypothesis. Eventually, a few academicians "discovered" price momentum (often describing phenomena previously reported by practitioners). Important academic contributors include Rosenberg

and Lanstein (1981) who reported the one-month reversal phenomena. DeBondt and Thaler (1985) described long-term price reversal, and Jagadeesh and Titman (1993) gave an account of the performance potential of modified twelve-month models. Fama and French (1996) examined variants of a twelve-month percentage change price momentum measure, and Chan, Jagadeesh and Lakonishok (1996) demonstrated that six-month price momentum works and adds value to earnings surprise.

Practitioner studies of price momentum have appeared for three decades, including Arnott (1979), who identified short-term price momentum reversal before Barr Rosenberg, and Brush and Boles (1983) who may be the first to point out that correcting relative strength for beta holds promise. Practitioner William O'Neil has published a commercial relative strength measure for more than twenty years.

Theory

Price momentum theory is almost a blank page. While practitioners are not much troubled by this, academics bemoan the

lack of an underlying concept. Yet weak theory is common in finance. For example, consider low P/E "value" investing. The theories most often posited have prices moving to correct temporarily "incorrect" valuations. But price movement is price momentum. If you ask why not just look for the price change in the first place you seem to cross a line from science to alchemy.

Some researchers have suggested that price momentum is a reflection of something else, yet to be discovered, or that all return factors or anomalies are associated with some kind of increase in risk and so are not inconsistent with the efficient market hypothesis. Recent work in behavioral finance rejecting the use of utility functions and complicating the whole concept of risk may yet succeed in setting price momentum into some sort of theoretical niche. A promising approach may be the work of Jonathan Berk (1999) who created from first principles a dynamic process of firm evolution leading to what might be called a prediction of price momentum effectiveness.

Our own cruel summary of the state of price momentum theory is that theoreticians have the

unpleasant choice of twisting and bending the existing framework of efficient markets and rational investor behavior to accommodate the growing empirical evidence for price momentum's effectiveness, or of abandoning existing theory and constructing a replacement. For the moment, price momentum theory is definitely still a work in progress.

References

Arnott, R.D. 1979. "Relative Strength Revisited." *Journal of Portfolio Management*, (Spring 1979):19-23.

Berk, J., R. Green and V. Naik. 1999. "Optimal Investment, Growth Options, and Security Returns." *Journal of Finance*, vol. 54:1553-1607.

Brush, J.S., and K.E. Boles. 1983. "The Predictive Power in Relative Strength and CAPM." *Journal of Portfolio Management*, (Summer 1983):20-23.

Chan, L.K.C., N. Jegadeesh and J. Lakonishak. 1996. "Momentum Strategies." *Journal of Finance*, vol 51, no. 5:1681-1713.

Cootner, P.H. 1964. "The

Random Character of Stock Market Prices." Cambridge: M.I.T. Press.

DeBondt, W. and R. Thaler. 1985. "Does the Stock Market Overreact?" *Journal of Finance*, vol 40:557-581.

Edwards, R. and J. Magee. 1966. "Technical Analysis of Stock Trends." Boston, MA: John Magee Inc. 5th Edition.

Fama, E. F. and K.R. French. 1996. "Multifactor Explanations of Asset Pricing Anomalies." *Journal of Finance*, vol. 51, (March):55-84.

Jegadeesh, N. and S. Titman. 1993. "Returns to Buying Winners and Selling Losers: Implications for Stock Market Efficiency." *Journal of Finance*, vol. 48:65-91.

Lee, M.C. and B. Swaminathan. 2000. "Price Momentum and Trading Volume." *Journal of Finance*, vol. 55, (October).

Lo, A.W., H. Mamaysky and J. Wang. 2000. "Foundations of Technical analysis: Computational Algorithms, Statistical Inference, and Empirical Implementation." *National Bureau of Economic Research*. Working Paper

7613, (March 2000).

Rosenberg, B., K. Reid and R.
Lanstein. 1985. "Persuasive
Evidence of Market
Inefficiency." *Journal of Portfolio
Management*,. (Spring 1985):9-16.

For further information about any of our services, please
contact:

David Ament
Columbine Capital Services, Inc.
Two North Cascade Avenue,
Suite 450
Colorado Springs, CO 80903
Phone: (800) 835-0751
FAX: (719) 634-5867
email: info@columbinecap.com