Carpenter Analytical Services
Market Models & Metrics

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The Death of Momentum

January 2006

Contents & Summary

Recent years have brought structural and institutional change to securities markets. New systems, new securities, and new participants imply new price behaviors. This paper describes one aspect of market behavior change—a shift from trendy to reversionary pricing—and considers its effect on strategy.

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<tr><td>

- **Runs Analysis**

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In trendy markets, up-days cluster and down-days cluster in consecutive "runs." Analyzing runs can show trendiness changes over time. In recent years, major market indexes now *de*-cluster, having turned *un*-trendy.

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- **Momentum & Strategy**

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Many strategies include a momentum component. Momentum strategies depend on trendiness. Today's un-trendy markets are unproductive for momentum strategy.

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- **Price Reversion**

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Another measure, more robust than runs analysis, indicates the prevalence of price reversion or extension in a price series. As with runs, today's reversion behavior is unfavorable to momentum strategy.

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- **Sector Quest**

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With broad markets un-trendy and reversion-prone, analysis turns to sectors and stocks. Only three of nineteen prominent ETFs show consistent trendiness. Three trendiest tech stocks avoid reversion and favor momentum.

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- **Conclusion**

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Markets are now un-trendy on average. Strategies with momentum component should seek and test for trendiness in narrower niches and individual issues.

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Appendixes

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A) More on Runs   B) What's Going On?

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The Death of Momentum

The times they are a-changin'. --Bob Dylan

Markets are never what they used to be. Structural and technological change broadens opportunities and speeds the pace of almost every process. Liquidity is up, transaction costs are down, the range and variety of composite and derivative instruments has exploded. Hedge fund assets have grown ten-fold in a decade. Program trading, automated execution, and arbitrage strategies have penetrated every corner of the market.

With all the institutional change, we can't be surprised to discover changes in stock price behavior. Other studies have examined the higher trading volumes, narrower spreads, and reduced volatility of recent years. The present analysis identifies another notable change; new patterns and sequences of price paths.

In particular, we find substantial and significant loss of "trendiness." Across three major market indexes, and a number of differentiated ETFs, we find a virtual evaporation of the trend persistence that had been a dependable characteristic of price behavior over many years, and a key element for momentum strategy.

Runs Analysis. In a recent client study, statistical analysis found significant change in S&P 500 index behavior. The finding—based on "runs analysis"—showed daily reversals in the S&P 500 running at rates far higher than attributable to chance…and far higher rates than prior years. Runs analysis provides a formal measure of trendiness or momentum in a price series. Follow-up analysis finds the behavior change is far more pervasive than just the S&P, and coincides with a productivity loss for momentum strategy.

The *runs* analysis counts how many consecutive up-day sets and down-day sets ("up-runs" and "down-runs") occur over a given period. A set of five up-days and

This study developed from findings from a quantitative performance analysis originally undertaken for *Data 500 Advisors* of New York City.
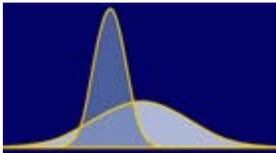
five down-days, for example, can have as few as two runs (five up days in a row, then five down), or as many as ten one-day "runs" (if up-days and down-days alternate). In practice, the count almost always falls somewhere in between.[*]

Any set of sequential returns has an *expected* number of runs, based on the total number of up-days and down-days in the set. The difference between expected and actual runs gives a measure of direction continuity or *trendiness*. In trendy markets, actual runs are fewer (and longer) than mathematically expected. In un-trendy markets, actual runs are more frequent (and shorter) than expected.

Figure 1 shows a bar chart of annual runs counts on the S&P 500 (SPX). Each pair of bars shows one year's expected and actual number of runs for the year. Actual runs are plainly fewer than expected until the early 1980s, then about equal, then finally the actual counts exceed expected in the recent years.
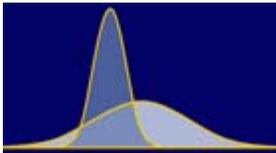
Figure 1. Expected and Actual Runs: S&P 500
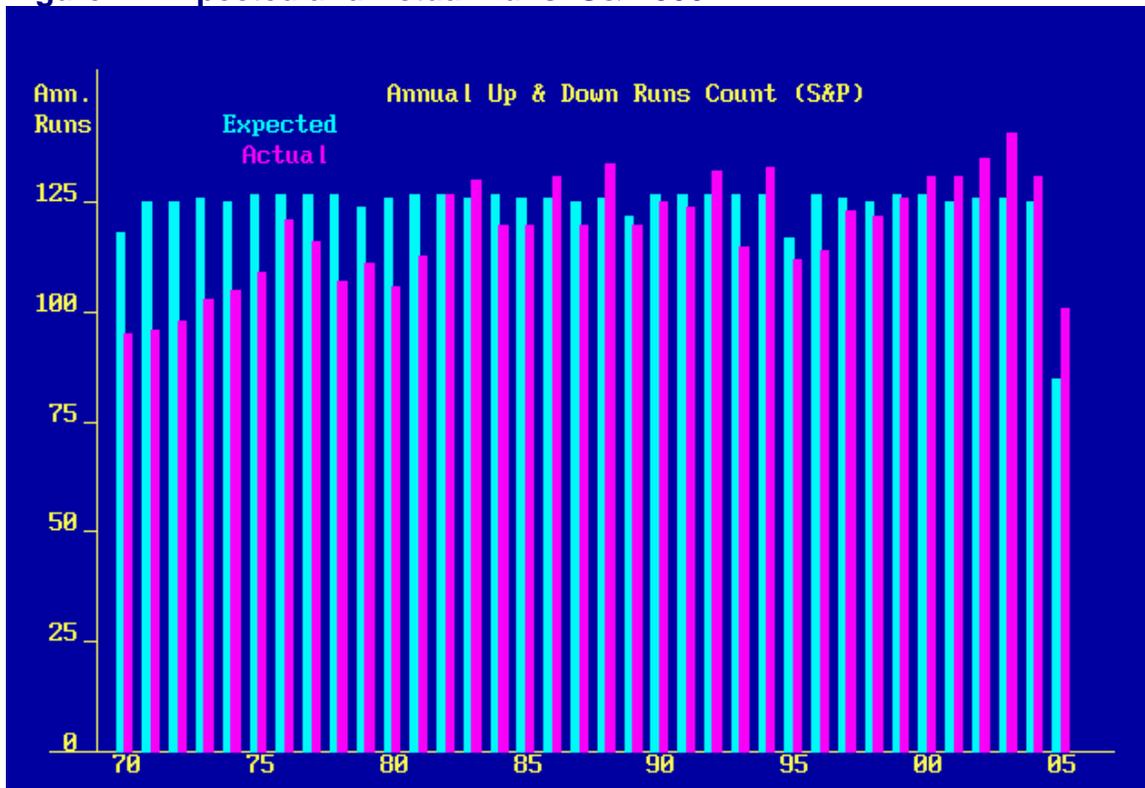
Series basis is daily S&P 500 adjusted for total return. Data for 2005 is based on 168 days (eight months).

For more explicit comparison, the difference between actual and expected runs can be normalized and expressed in standard deviations from parity. Positive

**(*) Appendix A further explains and illustrates the runs analysis.**

normalized values indicate *trendy* behavior; fewer runs of longer duration than mathematically expected. Negative normalized values indicate *un-trendy* behavior; frequent reversals of shorter duration than expected.

Figure 2 shows annual normalized values based on the expected and actual runs counts shown in Figure 1. All the values are positive (trendy) up through 1981. In fact, eight of these first twelve years are positive by more than 2 standard deviations…an outcome that is essentially impossible except by systematic trendiness in the series.

Figure 2. Normalized Runs Scores: S&P 500
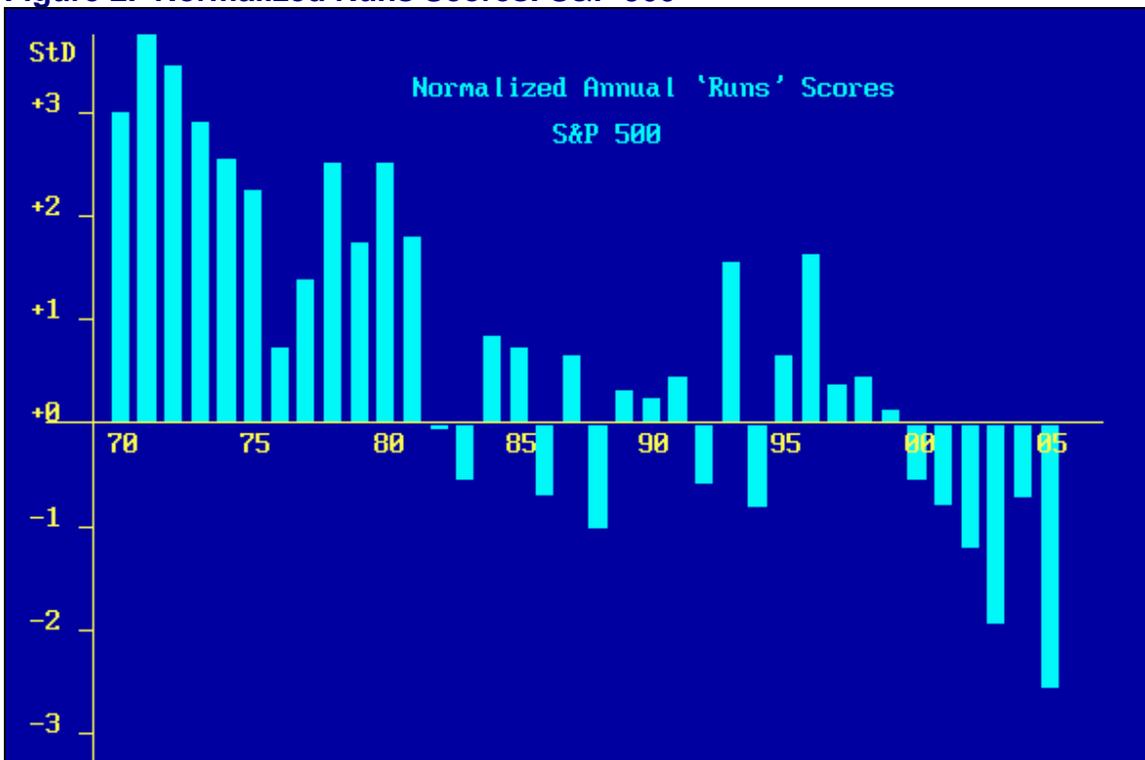
The trendy behavior ends abruptly in 1982. From 1982 through the 1990s, trendiness is about neutral on average. Then early in the 2000s, a pretty clear *un*-trendiness emerges. By 2003 the descent into un-trendiness is unmistakable. By 2005 it is statistically significant at better than .01 threshold.

The S&P's emergent un-trendiness impairs momentum strategies, as will be shown. But as the S&P 500 is not made up of typical stocks (being all-mega-cap), we look around first to examine trendiness in other market segments.
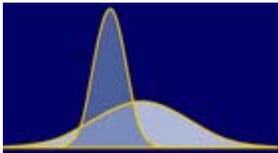
Nasdaq Behavior. The bar chart of <u>Figure 3</u> shows normalized annual runs scores for the Nasdaq 100 index, in the same framework of Figure 2. Positive values indicate trendy behavior of fewer but longer runs than mathematically expected. Negative values indicate *un*-trendy behavior of shorter runs with more frequent reversals. As above, the vertical scale is in standard deviations away from neutral (where actual would equal expected).

Figure 3. Normalized Runs Scores: Nasdaq 100
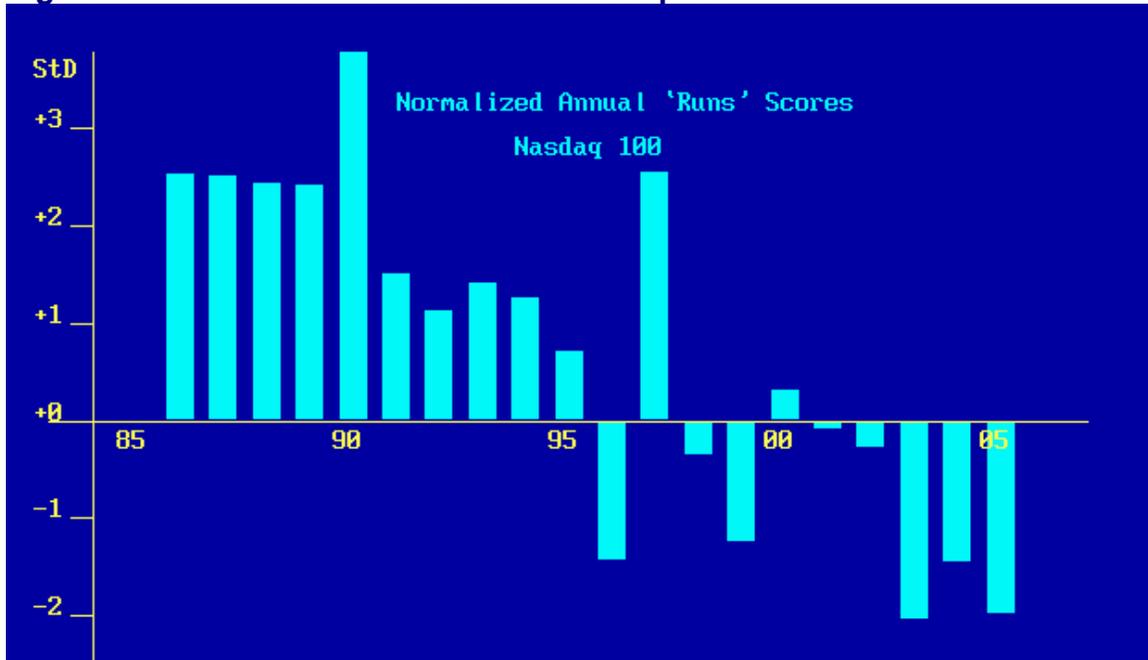
Series basis is daily Nasdaq 100 (NDX). Data for 2005 is based on 168 days (eight months).

The NDX pattern is strikingly similar to the SPX, but the down-shift occurs years later. Scores are consistently positive up to 1996. The five years up through 1990 average +2.73 sigma. The probability of such five-year string occurring under neutral conditions is less than one in a billion. The trendiness recedes a bit in the five years ending 1995, averaging +1.20 sigma. These five years are also significant; although a single-year deviation (from zero) of 1.20 sigma would be unremarkable, finding five in a row has about a 1-in-10,000 probability.

In 1996 the NDX behavior turned notably negative (un-trendy), then oscillated around zero for seven years. Then in the last three years 2003-04-05, the behavior turned more forcefully negative, apparently (so far) with persistence.

The descent from trendy to un-trendy behavior also occurs in the small-cap sector, as shown with the Russell 2000, following.
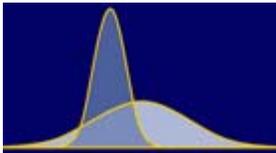
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Small-Cap Behavior. Using the Russell 2000 as a measure of small-cap behavior, we find a similar pattern playing out again. Initially persistent trendy behavior weakens over several years, and eventually gives way first to neutral vacillation, and finally shifts into plainly un-trendy behavior.

Figure 4. Normalized Runs Scores: Russell 2000
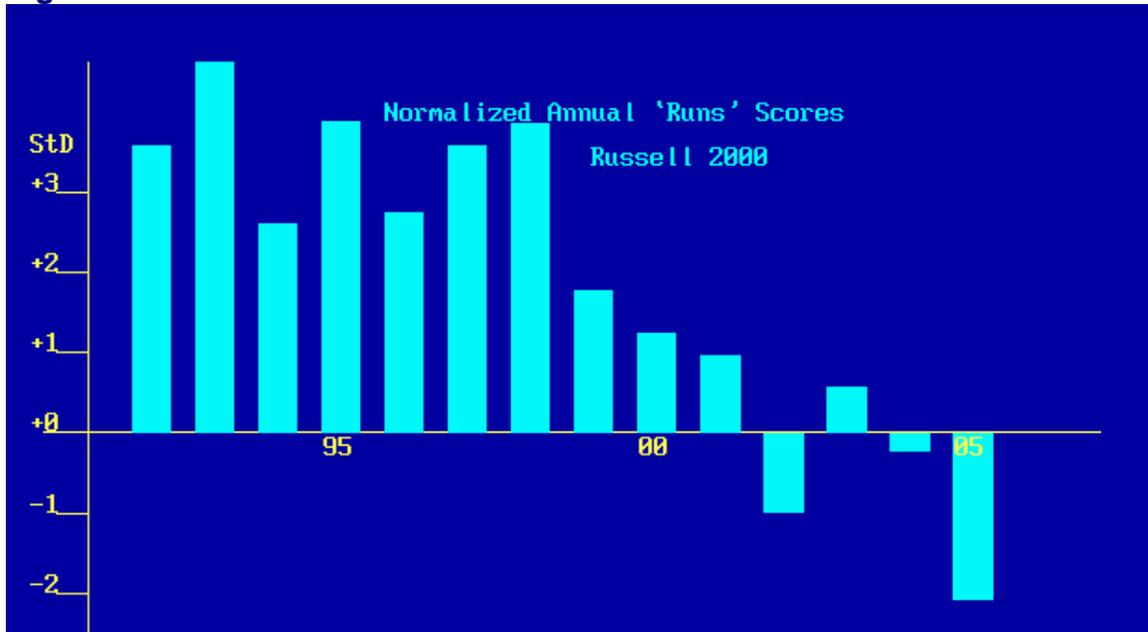

Series basis is daily Russell 2000 (RUT). Data for 2005 is based on 168 days (eight months).

The era of initial trendiness shows even stronger runs scores for the Russell than for the S&P or Nasdaq indexes. From 1992 through 1998 the scores average +3.57, which would be a highly significant finding for any *single* year and has a vanishingly small probability for seven years in succession.

Not only is the Russell history *more* trendy when it's trendy, the trendiness also survives much *later* then for the S&P or Nasdaq. The first year of negative Russell scores occurs in 2002, six years after the Nasdaq 100, and a full 20 years after the S&P 500. This sequence may reflect a progression from strictly large cap index (SPX) to less large (NDX), to actual small cap (RUT). Or it may reflect broader structural market change, which is addressed in Appendix B[*].

But first we consider what the trendiness changes mean for strategy. Market shifts from trendy to un-trendy behavior suggest momentum is less salient than before. Strategies with momentum component become suspect, unless tested and proven effective for specific securities, in specific environment, in very current time frame.

[*] **Appendix B suggests and illustrates possible connection to futures trading effects.**

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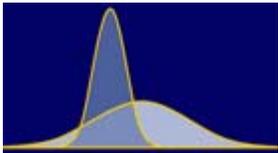
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Momentum & Strategy. Market changes call for strategy changes. Many investment strategies rely on momentum, either centrally or tangentially, implicitly or explicitly. Technical analysis generally includes important momentum components, even as is evident in terminology (e.g. "breakout," "target price" etc.) Fundamental strategy can also rely on momentum, as when earnings surprise is expected to carry prices along well after the "surprise" is out. And strategies across a range of theories involve concepts like relative strength, implicitly assuming momentum-like continuation of changes already underway.

We define a simple momentum strategy to test for performance effects of diminished trendiness: Price momentum is defined in rates-of-change in an exponential smoothing of daily returns (EMA). The strategy initiates a "buy" when both the 3-day change and 10-day change in EMA are positive, to be "sold" when the 10-day change is no longer positive. (These momentum rules are not optimized in any way. They are chosen arbitrarily, as they are used to test performance changes, not to propose a specific trading program.)

Each of the three market indexes (SPX, NDX, RUT) is partitioned into two eras based on the bar charts of Figures 2, 3, and 4. For each index, the first era lasts up through its continuously positive trendiness years; the second era runs from the first negative (un-trendy) year up through September 2005. The 3-day and 10-day momentum rule above is applied separately to each index, for each era. Then the "trading" returns are compared with the returns for the "raw" indexes themselves over the same periods.

		Era #1: Trendy	**Era #2: Un-Trendy**
S&P 500 – Raw Index		+3.8%	+904.8%
--Momentum		+6.0% (Gain)	+119.5% (Loss)
NDX	**--Raw Index**	+119.8%	+178.0%
	--Momentum	+343.8% (Gain)	+85.0% (Loss)
Russell	**--Raw Index**	+150.9%	+35.3%
	--Momentum	+172.4% (Gain)	+18.2% (Loss)

Change points from Era #1 to Era #2**:** SPX changes at EOY 1981; NDX at EOY 1996; RUT at EOY 2002

In each *Trendy Era*, the index's momentum strategy out-performed its raw index (indicated as a "gain"). In each *Un-trendy Era*, the momentum strategy under-performed its index (indicated as a "loss"). The loss of momentum is a real loss.
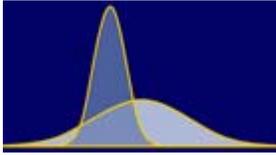
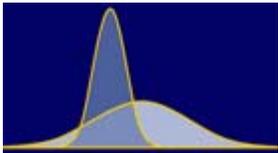**Carpenter Analytix**

Reversion/Extension. The "runs" approach is not the only way to measure trendiness. Although easy to describe, the runs approach has limitations. First, if is based strictly on the binary distinction of counting up-or-down directions. That is, runs counts ignore magnitudes in favor of direction alone. And the analysis only addresses one-day time units; longer-span relationships are ignored.

Our proprietary *VaR/X* model assesses trend and momentum from a different perspective. It measures price *reversion* or *extension* behavior, across a range of cycle spans. The model generates a reversion/extension ratio for every potential cycle span (every 2- to 21-day span here) across a designated era (1973-1981 in Figure 5), giving a robust profile of behavior. Ratio values less than unity indicate reversion; values greater than unity indicate extension. Figures 5 and 6 present *VaR/X* profiles for the S&P 500 in the trendy "Era #1" and the un-trendy "Era #2" as defined in the runs analysis.

Figure 5: *VaR/X* Profile: S&P in Runs-Trendy Era

```
                          S&P 500
                   VaR/X Reversion/Extension
                       (721231 - 811231)
   Cycle     Extension
   (Days)      Ratio    |--------Reversion-------|--------Extension-------|
     2        1.198***                           |xxxxxxxxxx
     3        1.259***                           |xxxxxxxxxxxxx
     4        1.289***                           |xxxxxxxxxxxxxx
     5        1.295***                           |xxxxxxxxxxxxxx
     6        1.292***                           |xxxxxxxxxxxxxx
     7        1.279***                           |xxxxxxxxxxxxxx
     8        1.273***                           |xxxxxxxxxxxxx
     9        1.264***                           |xxxxxxxxxxxxx
    10        1.252***                           |xxxxxxxxxxx
    11        1.240**                            |xxxxxxxxxxx
    12        1.231**                            |xxxxxxxxxx
    13        1.228**                            |xxxxxxxxxx
    14        1.226**                            |xxxxxxxxxx
    15        1.232**                            |xxxxxxxxxx
    16        1.243**                            |xxxxxxxxxxx
    17        1.254**                            |xxxxxxxxxxx
    18        1.266**                            |xxxxxxxxxxxx
    19        1.279**                            |xxxxxxxxxxxxx
    20        1.290**                            |xxxxxxxxxxxxx
    21        1.297**                            |xxxxxxxxxxxxxx

   Average    1.259
```
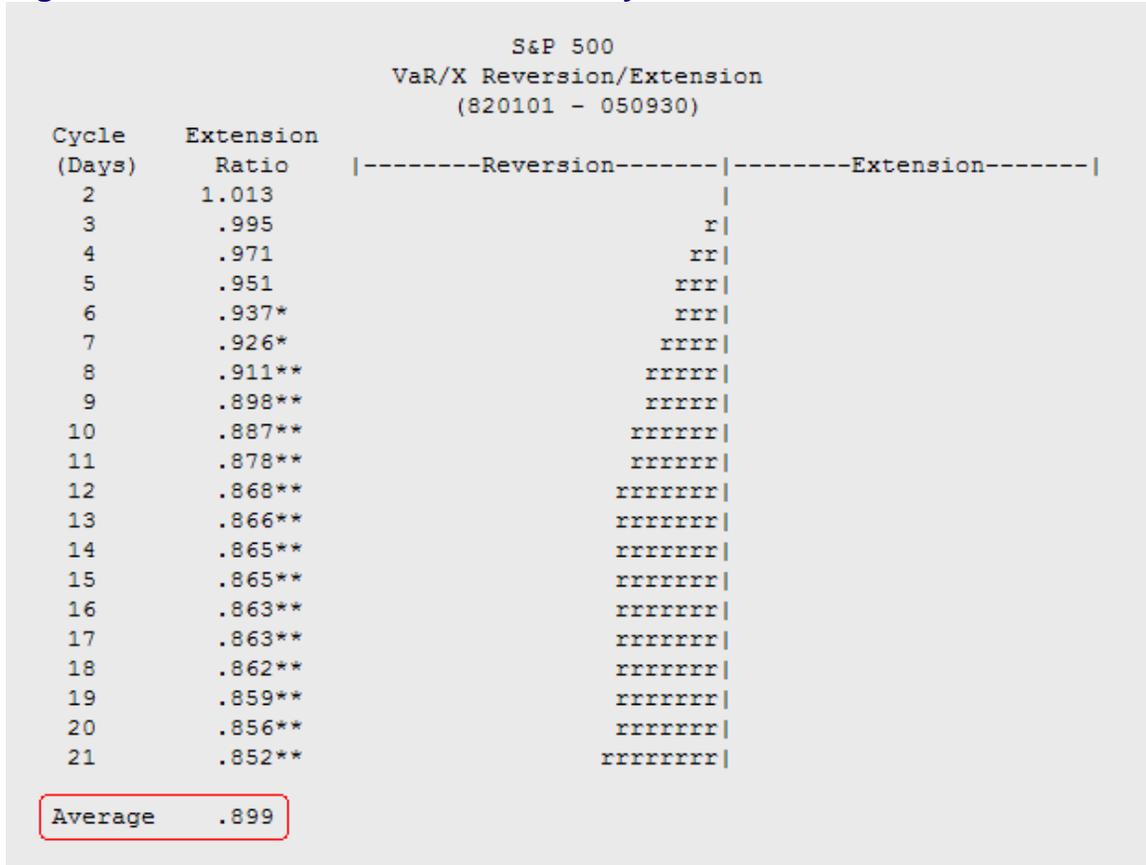
All the values in Era #1 are greater than 1.00, indicating consistent "extension" behavior (trendiness). Asterisks indicate statistical significance at .10 (*), .05 (**), and .01 (***) thresholds. The average *VaR/X* ratio prior to 1982 was 1.259.

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From 1982-on (un-trendy runs), the profile is reversed; all *VaR/X* cycle spans (except 2-day) have ratios less than 1.00, indicating consistent price reversion. Note the values plateau after about twelve days, with the implication that most reversion operates on a two-to-three week delay or longer over this period. The average *VaR/X* ratio for Era #2 is .899.

Figure 6: VaR/X Profile: S&P in Un-Trendy Era

```
                             S&P 500
                      VaR/X Reversion/Extension
                         (820101 - 050930)
    Cycle      Extension
    (Days)      Ratio     |--------Reversion-------|--------Extension-------|
      2         1.013                              |
      3          .995                             r|
      4          .971                            rr|
      5          .951                           rrr|
      6          .937*                          rrr|
      7          .926*                         rrrr|
      8          .911**                       rrrrr|
      9          .898**                       rrrrr|
     10          .887**                      rrrrrr|
     11          .878**                      rrrrrr|
     12          .868**                     rrrrrrr|
     13          .866**                     rrrrrrr|
     14          .865**                     rrrrrrr|
     15          .865**                     rrrrrrr|
     16          .863**                     rrrrrrr|
     17          .863**                     rrrrrrr|
     18          .862**                     rrrrrrr|
     19          .859**                     rrrrrrr|
     20          .856**                     rrrrrrr|
     21          .852**                    rrrrrrrr|

   Average       .899
```

Agreement between runs analysis and *VaR/X* is not limited to the S&P. All three major indexes show reversion and extension scores wholly consistent with the trendy and un-trendy eras found in the runs analysis.

Average *VaR/X* Ratios

|	Era #1: Extension	Era #2: Reversion
S&P 500	1.259	0.899
Nasdaq 100	1.036	0.813
Russell 2000	1.217	0.846
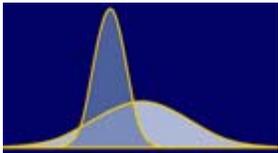
Sector Quest. With the S&P un-trendy since 1982, and Nasdaq and Russell now also un-trendy (since 1996 and 2002), momentum strategies can expect to find less opportunity for performance. Broad indexes, and securities dependent on broad indexes, will be unpromising vehicles unless or until the market reverts toward its former trendiness. Until that happens (if it does) the momentum manager will need to add a new layer of selective screening. Individual securities should now be required to show hard evidence of trendy behavior.

Styles and sectors provide one dimension for selective screening, and Exchange Traded Funds present handy vehicles for analysis. Alas, many major ETFs are also proving un-trendy in recent markets. Among nineteen of the largest and most popular ETFs, the *VaR/X* model finds only three showing average price *extension* ratios (red rectangle below) over a recent twelve month span. An additional five show net extension for at least *some* spans (blue rectangles), yet net reversion prevailing on average over the year.

VaR/X Ratios for 19 Major ETFs

```
          Reversion/Extension (2-21 Day Spans)
                  (040930 - 050930)


ETF Name            |--------VaR/X Ratios--------|
                      Min       Max       Avg


SPDR Health         .380**    .943       .669
SPDR Utilities      .453*    [1.029]      .707
SPDR Cons Staples   .608      .989       .779
Ishr R1000 V        .642      .941       .784
SPDR Financial      .641      .939       .816
SPDR Energy         .750     [1.000]      .835
SPDR Trust          .702      .951       .835
Vipers Total Stk    .806      .972       .882
Ishr R2000 V        .850      .966       .883
Ishr R1000 G        .799      .975       .884
Ishr R2000          .851      .972       .893
Ishr R2000 G        .847      .986       .898
SPDR Indust         .883      .959       .920
S&P Midcap 400      .900     [1.042]      .954
DOW Diamonds        .806     [1.050]      .956
SPDR Technol        .941     [1.025]      .975
SPDR Cons Disc.     .970     [1.068]     [1.013]
SPDR Basic Mat      .949     [1.088]     [1.020]
Nasdaq 100          .951     [1.153]     [1.042]
```

The twelve-month extension value (1.042) for the *Nasdaq 100 Trust* (QQQ) is mildly hopeful relative to the net reversionary behavior (0.932) of its underlying index (NDX). Even so, these divergent indications are far from the robust momentum behavior of earlier years.
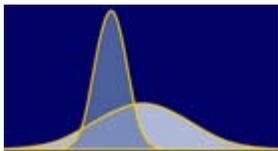
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But even sector ETFs, though more differentiated than broad indexes, represent aggregations of securities of varying characteristics. They represent combined behavior across their components. In today's era of average un-trendiness, any aggregation of the many will naturally tend toward the un-trendiness of the whole.

Yet individual components can be very trendy. Within those broad indexes and ETFs (mildly trendy and mildly un-trendy respectively), individual stocks can be great candidates for use with momentum strategies. Selecting just ten well-known Tech and Net stocks gives a sense of the reversion/extension range.

Ten Tech & Internet Favorites

```
        VaR/X Reversion/Extension (2-21 Day Spans)
                (040930 - 050930)


                    |--------VaR/X Ratios--------|
        SYMBOL         Min        Max        Avg

        CSCO          .640      1.006       .764
        MSFT          .762       .984       .864
        AAPL          .978      1.099      1.029
        AMZN          .953      1.150      1.050
        QCOM          .973      1.126      1.060
        GOOG          .931      1.167      1.061
        SUNW          .967      1.158      1.108
        EBAY          .942      1.442      1.271
        DELL         1.063      1.524      1.288
        IBM          1.077      1.735*     1.509
```

The red rectangle highlights three highly trendy stocks over twelve months. Applying the same momentum strategy described earlier, IBM shows trading results 19% better than its own "raw" return; DELL shows results 11% better than "raw"; and EBAY shows 18% better than "raw." Conversely, the same momentum strategy applied to the other seven stocks produces results ranging from –145% (worse than the stock) to +6% (better). The average momentum difference (trading strategy less raw price return) across the seven less trendy stocks was –28%.

Conclusion. Markets of longstanding trendiness have grown notably un-trendy in recent years. Un-trendy behavior is inimical to market momentum, so strategies with momentum component are compromised. Individual securities can still be notably trendy, however, even in the un-trendy environment. Investors and managers relying on momentum should measure and test for specific evidence of actual and current trendy behavior.
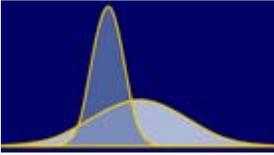
Appendix A: <u>More on Runs</u>

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The "runs analysis" counts consecutive up-days as an up-run, and consecutive down-days ads a down-run. When up-days or down-days cluster together, there are fewer but longer runs. When up-days and down-days are interspersed (alternating frequently), the runs are more numerous but shorter.

In the two following ten-day examples, the first has two runs of five days each, the second has ten runs of 1-day each.

Two Five-Day Runs (trendy)

Up	Up	Up	Up	Up	Dn	Dn	Dn	Dn	Dn
Run #1					Run #2				

Ten One-Day Runs (un-trendy)

Up	Dn	Up	Dn	Up	Dn	Up	Dn	Up	Dn
#1	#2	#3	#4	#5	#6	#7	#8	#9	#10

If the pattern of up-days and down-days are randomly distributed, the mathematically "expected" number of runs depends on the number of up-days and number of down days, according to the following formula:

$$E(Runs) = (2 * ups * dns)/(ups + dns) + 1$$

For five ups and five downs as in the illustration here, if randomly distributed the expected number of runs would be…

$$E(Runs) = (2 * 5 * 5)/(5 + 5) + 1 = 6 \text{ runs}$$

A Six-Runs Mixed Pattern of 5 Up-Days & 5 Down-Days

Up	Up	Up	Dn	Up	Dn	Dn	Dn	Up	Dn
#1			#2	#3	#4			#5	#6

As the sample sizes (number of days) increase, the number of possible sequence patterns increases even faster, and the runs count tends to converge closer and closer to the expected value. In a calendar year of 253 market days split 140 ups (55%) and 113 downs (45%), the expected number of runs would be 125. In a 50-50 mix, the expectation is 127, and in a 60-40 mix the expectation is 121. So the *expected* number varies little from year to year, as evident in the light blue bars of annual expected runs of Figure 1 in the body of the text. Most variation is in the *actual* number of runs, not the expected number.

The runs count is normalized by dividing the expected-actual difference by the standard deviation, giving the values represented by the bar charts of Figures 2, 3 and 4. The sampling distribution of expected runs is approximately normal, so interpretation of normalized values is straightforward.

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Appendix B: What's Going On?

While the shift from trendy to un-trendy behavior is unmistakable, the causes are not known. Markets have been changing in so many ways that it would take substantial further analysis to sort out specific causes.

One obvious candidate is the spread of computerized trading. With instant and comprehensive information processing, and low-cost transactions, almost any price change can invite counter-trade or arbitrage. The explosion in hedge funds, with many exploiting just such micro-deviations, would compound these effects.

Index futures trading may also play a part, both in itself and as a correlative of market automation and hedge fund growth. Figure 7 repeats the normalized runs information from Figure 2, but also shows the volume of SPX futures contracts on the Chicago Mercantile Exchange. The first year of futures trading is 1982, which is also the first year of negative runs score. Through the 1980s and '90s, futures trading volume varies from about 10 million to 38 million contracts, as trendiness fluctuates around zero.

Figure 7. Runs Scores and CME Futures Contracts
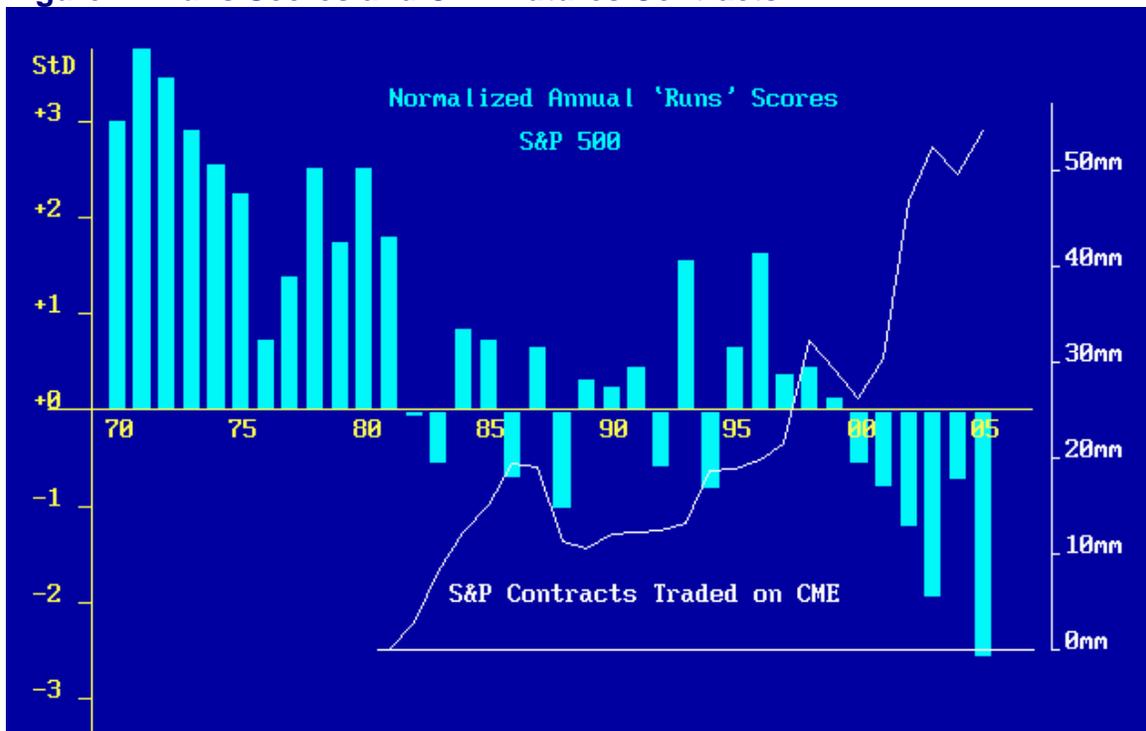
Futures contracts right scale. E-Mini contracts introduced 1997, included here at 1/5 for parity.

Then in 2002, total contract volume jumped by more than 50%. As futures volume soared (with near tripling of the E-Mini contract), trendiness hit its most negative value up to that year. In 2003-04-05, annual trendiness continued to mirror futures volumes.

Similarly with Nasdaq 100 (not shown), the first un-trendy year also occurred the same year futures trading was approved on CME and CBOE (1996). And Russell 2000 first turned un-trendy in 2001, shortly following E-Mini futures approval in August 2000. (Other Russell contract approvals range from 1992-2003.) Derivatives count.