Time Series Properties of Valuation Models

Introduction

Since 1991, Northfield has published a series stock selection rankings derived from five models of US equity behavior. In this paper, we review the development and design of these five models. We also show various measures of the performance of such models as predictive indicators by which investors might choose to select stocks. Finally, we explore the time series properties of the performance histories of the models and show how these properties can be used to further enhance the predictive abilities of these models.

Northfield has calculated and published the rankings that are derived from the five models since April of 1991. Throughout this period, the five models were applied to the entire universe covered by Northfield, which includes all stocks on the NYSE, AMEX, and NASDAQ, less some ADRs and REITs. More complete coverage of REITs began in late 1995. All ranking data and performance results were calculated and saved as they occurred in time, eliminating the potential for survivorship bias, which is prevalent in studies dependent on "backtesting". The methods underlying each model have been unchanged during the entire period.

The Models

In 1989, Northfield conducted a survey of US equity management firms. Each manager was asked to characterize his investment style and to provide a short mathematical expression which summarized his stock selection approach. Based on cluster analysis of the results, seven widely-used styles of equity management were identified. Five of the seven approaches were modeled. The sixth identified style, "top down economic forecasts," and the seventh, "market timers," were not modeled.

The five styles that were modeled were:

Value
Growth
Price Momentum
Sector Rotation (also referred to as Timeliness)
Safety

At each month-end since April of 1991, each stock in the Northfield universe was given a score of 0 to 100 for each of the five listed models. The scores are normalized percentile ranks. Each of the five models is a composite of two to eight sub-models. Each model ranking is an equal-weighted combination of the rankings of the sub-models included within that model.

It should be noted that the process of surveying managers and tabulating those surveys was done without any regard to the past performance or business success of the managers. As such, there is no *a priori* reason to believe that these models would lead to a ranking system that would produce superior investment results. Rather, the rankings portray the level of probable attractiveness that a given stock would have for each type of manager at a particular moment.

The "Value" model has five components (sub-models). These are:

1. Dividend Discount Model
2. Graham-Dodd Formula

3. Relative Value to Universe (cross-sectional regression of P/E, P/B, and Yield)
4. Relative Value Within Industry (cross-sectional regression of P/E, P/B and Yield)
5. Time Series of Price/Value Ratio, with Value defined as 12 month EPS capitalized at the T-Bill rate

The "Growth" model has eight sub-models. These are:

1. True Growth Rate as defined by EUPS (an elaborate model of corporate growth and reinvestment)
2. True Growth Consistency as defined by EUPS
3. Earnings Momentum (2nd derivative with respect to time of a curve fit to the EPS time series)
4. Earnings Surprises (as reported by I/B/E/S)
5. Estimate Revision 1 Month ((no. of up revisions - number of down revisions) / (no. of analysts))
6. 5-Year Trend of Sales and 5-Year Trend of Margins
7. 5-Year Growth of Dividends
8. "Torpedo Effect" (assumes stocks with highest earnings-growth expectations will disappoint)

The "Price Momentum" model has four sub models. These are:

1. 13-Week Jensen's Alpha
2. 52-Week Relative Strength
3. Consistency of 5-year price increases (looking for higher annual highs and higher annual lows)
4. Regression beta measured in up markets minus regression beta measured in down markets

The "Sector Rotation" (Timeliness) model has two sub-models: These are:

1. Expected Jensen's alpha based on Factor Exposure
2. Expected Jensen's alpha based on Industry Participation

Details of the construction of the Timeliness model and its two sub-components can be found in *Trend Extrapolation Strategies* by Adam J. Apt, Ph.D. and Eugene A. Godfredsen, Ph.D., Northfield Conference Proceedings, 1993. The model starts with standard CAPM assumptions. Each month a cross-sectional regression analysis is performed, which yields the statistical relationship between observed Jensen's alpha (at the individual security level) and sixty-six fundamental characteristics of stocks (11 continuous variables such as P/E, Yield, Size, etc. and 55 "dummies" for industry groups). As this process is repeated each month, a time series is created for each of the sixty-six factors. Using the time series methods of Box and Jenkins, an ARIMA (1,0,1) model is used to forecast the expected next value in each of the sixty-six series. Given these forecasts of factor alpha, a forecast of alpha for each stock is calculated as the vector product of the observed factor exposures times the expected factor alphas.

The "Safety" model has two components. These are:

1. Forecast Beta. Historical regression beta adjusted to reflect changes in company fundamentals
2. Price Volatility, calculated as (52-week high - 52-week low) / (52-week high + 52-week low)

Performance Measurement Methodology

The metric was to break the stocks under study into quintiles and track the performance of quintile portfolios, with stocks both equally weighted and weighted by market capitalization. Transaction costs of zero are assumed.

For the purposes of this paper, the sample universe was limited to the constituents of the Standard & Poor's 500 index. As the most widely followed group of equities in the domestic market, the S&P 500 is assumed to be the most efficient subset of the entire equity market. As such, the likelihood that a predictive scheme applied to them would be effective is reduced. Coupled with the construction of the models without regard to the historical performance of managers who followed them (as previously discussed), this may increase the likelihood that the models would show no statistically significant predictive ability.

Performance Results

Table 1 of the appendix shows the performance of the "best" quintile portfolios over the five-year period from May 1991 through April 1996. Comparative values for the S&P 500 index, the S&P/BARRA Growth Index, and the S&P/BARRA Value Index are presented. The S&P/BARRA indices are mutually exclusive and jointly exhaustive subsets of the S&P 500. The separation into a Growth subset and a Value subset is based solely on the ratio of a stock's price to its book value per share.

Timeliness Rank portfolios substantially outperformed both the S&P indices and the other Northfield models. Surprisingly, the superior returns of the Timeliness portfolios (consisting of 100 of the 500 stocks) were accompanied by volatility values which were substantially less than the S&P 500 itself! Despite being smaller in size, the Timeliness portfolio offered **higher returns and less risk.** Another way to look at this result would be a scenario where the Timeliness portfolio is purchased in a margin account using such leverage as would make the observed volatility level equal to that of the observed volatility of the S&P 500. Assuming a margin loan rate equal to 90-day Treasury bills plus one percent, such a leveraged Timeliness portfolio would have produced a return of over 25% per annum, as compared to just under 15% for the S&P 500.

The Value Rank and Growth Rank portfolios weighted by market capitalization both outperformed the respective S&P/BARRA indices by small margins. The Value Rank and Growth Rank portfolios also showed lower volatility than the respective S&P/BARRA indices. Again, these lower observed volatilities are surprising given that the Northfield model portfolios have 100 stocks each, while the S&P/BARRA indices average 250 constituent stocks each. We speculate that the richer (multiple sub-model) definitions of "growth" and "value" of the Northfield models allow for more stable performance. In addition, the Northfield definitions of "growth" and "value" are not mutually exclusive. As measured by both the Northfield models and the S&P/BARRA indices, Value strategies outperformed Growth strategies during the sample period.

Of the five Northfield models, the Price Momentum model has the largest spread between equal-weighted and capitalization-weighted quintile performance, with a spread of nearly one and a half percent return per annum. This suggests that price momentum strategies may be more effective with smaller rather than larger companies. The smallest difference between equal- and capitalization-weighted results was in the Timeliness model, with a difference of just over one tenth of one percent annually.

Table 2 shows the distribution of monthly return differences between the "best" and "worst" quintiles for each model. The Timeliness Rank model is as highly statistically significant for both weighting schemes. No other model shows monthly returns differences that were consistent enough to be considered significantly different from zero.

Tables 3 and 4 show further detail of the monthly "best minus worst" return distributions. Table 3 shows the equal-weighted portfolios with the capitalization-weighted portfolios below in table 4. Both of these tables show numbers in decimal form rather than the percentage form used on the preceding page.

Table 5 is a correlation matrix of the results of the "best minus worst" return series. What is most notable is that the results of the Timeliness model have relatively little correlation with the results of other models. The Timeliness model could therefore be efficiently combined with other models in order to produce a composite prediction of greater power. Another interesting item is the correlation of the Value and Growth models. While the correlation is negative and large, it is not close to the negative one value that one would expect if Value and Growth were mirror images of one another, as implied by mutually exclusive index construction.

Our last test of relative performance of the models is the Sign Test. This test measures the number of months that each model has outperformed each of the other models. None of these results (presented in table 6) was statistically significant.

Time Series Properties of the Models

Our first test of the time series properties of the models was to perform a Wald-Wolfowitz Runs Test on the "best minus worst" return time series. In this test, we measure the number of sign changes from the return value for one month to the next for a model. We would expect a sign change half the time (a plus can stay plus or change to minus, a minus can change to plus or stay minus). Based on this test, the performance of the Value model appeared to mean revert (more than the expected number of sign changes), while the Growth model and Price Momentum model seemed to trend (fewer than the expected number of sign changes). The level of time series behavior for all three of these models bordered statistical significance at the 90% level. As the results are nearly identical for both equal-weighted and capitalization-weighted portfolios, we present only the tabular results for the equal-weighted portfolios in table 7.

The final ten tables (tables 8 through 17) of the appendix are autocorrelation plots for the "best minus worst" return time series for each model. The upper plot is for the model return series itself, while the lower plot is for "first differences" (the difference between each value in the series and its predecessor). The curved bands represent a two standard error level of statistical significance.

While statistically significant relationships appear for each of the models at various lags, one should keep in mind that in estimating so many coefficients (145 in all), we would expect to get randomly about seven relationships that appear significant at the 95% level, or fifteen at the 90% level. More than twenty such relationships at various lags are calculated. While it is impossible to say without further study which of these observed relationships are real and which are spurious, there is strong evidence of predictable time properties in the effectiveness of the models.

Conclusion

Our tests indicate that the Sector Rotation (Timeliness) model has statistically significant ability to predict subsequent month returns. Due to low correlation with other models and comparable performance both equal-weighted and capitalization weighted, the Timeliness model appears compatible with a wide variety of other stock selection and portfolio construction techniques. The sample period was one where Value-oriented styles outperformed Growth-oriented styles. However, neither the frequency nor the magnitude of such outperformance was sufficiently consistent on a monthly basis to be statistically significant. Strong evidence exists for serial correlation in the performance of each of the five models. While some of the estimated relationships are likely to be spurious, such serial correlations may be useful in making predictions of the likely effectiveness of each model in the next period.

APPENDIX

Table 1. Best Quintile Performance Statistics

Factor	Equal-Weighted			Capitalization-Weighted		
	Cumulative Value	Annualized Return	Annualized St. Dev.	Cumulative Value	Annualized Return	Annualize Dev.
VALUE	215.21	16.57	6.97	209.44	15.93	8.16
GROWTH	188.83	13.56	9.00	179.75	12.44	10.10
MOMENTUM	223.44	17.44	7.82	210.10	16.01	9.55
TIMELINESS	246.61	19.78	6.36	245.12	19.64	6.93
SAFETY	202.68	15.18	11.55	192.46	13.99	10.68
S&P 500	-	-	-	200.53	14.93	9.57
S&P/BARRA Growth	-	-	-	192.68	14.02	10.84
S&P/BARRA Value	-	-	-	207.18	15.68	9.58

Table 2. Best Quintile Returns Minus Worst Quintile Returns

Factor	Equal-Weighted			Capitalization-Weighted		
	Mean	Standard Deviation	T-statistic	Mean	Standard Deviation	T-statist
VALUE	0.21	2.01	0.79	0.22	2.36	0.72
GROWTH	-0.19	2.60	-0.56	-0.07	2.92	-0.18
MOMENTUM	0.02	2.26	0.06	0.02	2.76	0.05
TIMELINESS	0.46	1.84	1.95	0.52	2.00	2.02
SAFETY	-0.35	3.33	-0.82	-0.30	3.08	-0.76

*All Data is for 60 months ending April 30, 1996.

Table 3. Best Minus Worst Return Statistics: Equal-Weighted

	VALUE	GROWTH	MOMENTUM	TIMELINESS	SAFETY
MINIMUM	0.05	-0.1	-0.072	-0.028	-0.091
MAXIMUM	0.086	0.061	0.042	0.042	0.06
MEAN	0.002	-0.002	0	0.005	-0.004
STANDARD DEV	0.02	0.026	0.023	0.018	0.033
SKEWNESS(G1)	1.002	-0.824	-0.602	0.188	-0.499
MEDIAN	0	0.004	0.004	0.003	-0.001

*All Data is for 60 months ending April 30, 1996.

Table 4. Best Minus Worst Return Statistics: Cap-Weighted

	VALUE	GROWTH	MOMENTUM	TIMELINESS	SAFETY
MINIMUM	0.05	-0.099	-0.066	-0.03	-0.074
MAXIMUM	0.09	0.072	0.066	0.05	0.056
MEAN	0.002	-0.001	0	0.005	-0.003
STANDARD DEV	0.024	0.029	0.028	0.02	0.031
SKEWNESS(G1)	0.94	-0.527	-0.09	0.276	-0.108
MEDIAN	0	0.003	0.002	0.001	-0.001

Table 5. The Pearson Correlation Matrix

	VALUE	GROWTH	MOMENTUM	TIMELINESS	SAFETY
VALUE	1				
GROWTH	-0.628	1			
MOMENTUM	-0.638	0.754	1		
TIMELINESS	-0.027	-0.036	0.113	1	
SAFETY	-0.35	0.154	0.21	0.341	1

Table 6. Sign Test Results

	VALUE	GROWTH	MOMENTUM	TIMELINESS	SAFETY
VALUE	0	30	27	28	32
GROWTH	30	0	29	27	30
MOMENTUM	33	31	0	28	33
TIMELINESS	32	33	32	0	31
SAFETY	28	30	26	29	0

*Calculated for equal-weighted portfolios

**Counts of differences (row variable greater than column)

Table 7. Wald-Wolfowitz Runs Test Results

	<= CUT CASES	> CUT CASES	RUNS	Z	(2-TAIL) PROBABILITY
VALUE	28	32	37	1.604	0.109
GROWTH	28	32	25	-1.535	0.125
MOMENTUM	25	35	24	-1.653	0.098
TIMELINESS	28	32	34	0.82	0.412
SAFETY	32	28	30	-0.227	0.821

*Calculated for equal-weighted portfolios

**Test performed using cutpoint=.000

Table 8. Plot of autocorrelations of VALUE EQ

NUMBER OF CASES = 60
MEAN OF SERIES = 0.002
STANDARD DEVIATION OF SERIES = 0.020

```
 LAG    CORR     SE   -1.0  -.8  -.6  -.4  -.2   .0   .2   .4   .6   .8  1.0
                        +----+----+----+----+----+----+----+----+----+----+
   1    .101   .129                        (     |XX   )
   2   -.190   .130                        ( XXXX|     )
   3   -.066   .135                        (    X|     )
   4   -.132   .136                        (  XXX|     )
   5    .037   .138                        (     |     )
   6   -.129   .138                        (  XXX|     )
   7   -.161   .140                        ( XXXX|     )
   8   -.118   .143                       (    XX|      )
   9   -.008   .144                       (      |      )
  10    .189   .144                       (      |XXXX  )
  11    .216   .149                       (      |XXXXX )
  12    .091   .154                       (      |XX    )
  13   -.112   .155                       (    XX|      )
  14   -.218   .156                       ( XXXXX|      )
  15    .173   .161                      (       |XXXX    )
```

Table 9. Plot of autocorrelations of first differences of VALUE EQ

NUMBER OF CASES = 59
MEAN OF SERIES = -0.000
STANDARD DEVIATION OF SERIES = 0.027

```
 LAG    CORR     SE   -1.0  -.8  -.6  -.4  -.2   .0   .2   .4   .6   .8  1.0
                        +----+----+----+----+----+----+----+----+----+----+
   1   -.318   .130                       X(XXXXX|     )
   2   -.245   .143                       (XXXXXX|      )
   3    .103   .150                       (      |XX    )
   4   -.142   .151                       (   XXX|      )
   5    .192   .153                       (      |XXXX  )
   6   -.069   .157                       (     X|      )
   7   -.044   .158                       (     X|      )
   8   -.030   .158                       (      |      )
   9   -.060   .158                       (     X|      )
  10    .102   .158                       (      |XX    )
  11    .082   .159                       (      |XX    )
  12    .051   .160                      (       |X      )
  13   -.052   .160                      (      X|       )
  14   -.296   .161                      (XXXXXXX|       )
  15    .304   .170                      (       |XXXXXXX)
```

Table 10. Plot of autocorrelations of GROWTH EQ

NUMBER OF CASES = 60
MEAN OF SERIES = -0.002
STANDARD DEVIATION OF SERIES = 0.026

```
LAG   CORR      SE -1.0  -.8  -.6  -.4  -.2   .0   .2   .4   .6   .8  1.0
                    +----+--- +----+----+----+----+----+----+----+----+
  1   .215    .129                     (    |XXXXX)
  2  -.136    .135                     (  XXX|    )
  3   .071    .137                     (    |X    )
  4  -.135    .138                     (  XXX|    )
  5  -.323    .140                   XX(XXXXX|    )
  6  -.216    .152                    ( XXXXX|     )
  7  -.079    .157                    (     X|     )
  8   .007    .158                    (     |     )
  9   .043    .158                    (     |X    )
 10   .111    .158                    (     |XX   )
 11   .174    .159                    (     |XXXX )
 12   .144    .162                   (      |XXX   )
 13   .003    .164                   (      |      )
 14  -.110    .164                   (    XX|      )
 15   .010    .166                   (      |      )
```

Table 11. Plot of autocorrelations of first differences of GROWTH EQ

NUMBER OF CASES = 59
MEAN OF SERIES = 0.000
STANDARD DEVIATION OF SERIES = 0.032

```
LAG   CORR      SE -1.0  -.8  -.6  -.4  -.2   .0   .2   .4   .6   .8  1.0
                    +----+----+----+----+----+----+----+----+----+----+
  1  -.264    .130                     (XXXXX|    )
  2  -.364    .139                  XXX(XXXXX|    )
  3   .261    .154                    (     |XXXXXX)
  4  -.016    .162                   (      |      )
  5  -.198    .162                   (   XXXX|      )
  6  -.009    .166                   (      |      )
  7   .054    .166                   (      |X     )
  8   .024    .166                   (      |      )
  9  -.025    .166                   (      |      )
 10   .002    .166                   (      |      )
 11   .060    .166                   (      |X     )
 12   .065    .167                   (      |X     )
 13  -.012    .167                   (      |      )
 14  -.160    .167                   (   XXXX|      )
 15   .175    .170                   (      |XXXX  )
```

Table 12. Plot of autocorrelations of MOMENTUM EQ

NUMBER OF CASES = 60
MEAN OF SERIES = 0.000
STANDARD DEVIATION OF SERIES = 0.022

```
 LAG   CORR    SE -1.0  -.8  -.6  -.4  -.2   .0   .2   .4   .6   .8  1.0
                   +----+----+----+----+----+----+----+----+----+ ---+
  1    .170   .129                     (     |XXXX )
  2   -.109   .133                     (   XX|     )
  3    .199   .134                     (     |XXXX )
  4   -.127   .139                     (  XXX|     )
  5   -.076   .141                    (     X|      )
  6   -.104   .142                    (    XX|      )
  7   -.151   .143                    (   XXX|      )
  8   -.073   .146                    (     X|      )
  9   -.017   .146                    (      |      )
 10    .100   .146                    (      |XX    )
 11   -.014   .147                    (      |      )
 12    .019   .147                    (      |      )
 13   -.102   .147                    (    XX|      )
 14   -.210   .149                    ( XXXXX|      )
 15    .136   .153                    (      |XXX   )
```

Table 13. Plot of autocorrelations of first differences of MOMENTUM EQ

NUMBER OF CASES = 59
MEAN OF SERIES = -0.000
STANDARD DEVIATION OF SERIES = 0.029

```
 LAG   CORR    SE -1.0  -.8  -.6  -.4  -.2   .0   .2   .4   .6   .8  1.0
                   +----+----+----+----+----+----+----+----+----+----+
  1   -.338   .130                   XX(XXXXX|      )
  2   -.351   .144                   X(XXXXXX|       )
  3    .382   .158                    (      |XXXXXX)XX
  4   -.222   .173                   (  XXXXX|       )
  5    .039   .178                   (       |       )
  6    .008   .178                   (       |       )
  7   -.050   .178                   (      X|       )
  8    .008   .178                   (       |       )
  9   -.046   .178                   (      X|       )
 10    .143   .178                   (       |XXX    )
 11   -.093   .180                  (      XX|        )
 12    .091   .181                  (        |XX      )
 13   -.008   .182                  (        |        )
 14   -.276   .182                  (  XXXXXX|        )
 15    .341   .189                  (        |XXXXXXXX)
```

Table 14. Plot of autocorrelations of TIMELINESS EQ

NUMBER OF CASES = 60
MEAN OF SERIES = 0.005
STANDARD DEVIATION OF SERIES = 0.018

```
LAG    CORR       SE -1.0 -.8  -.6  -.4  -.2   .0   .2   .4   .6   .8  1.0
                      +----+----+----+----+----+----+----+----+----+----+
  1    .003   .129                       (     |     )
  2   -.117   .129                       (   XX|     )
  3   -.111   .131                       (   XX|     )
  4   -.082   .132                       (   XX|     )
  5   -.137   .133                       (  XXX|     )
  6   -.232   .136                       (XXXXX|     )
  7    .060   .142                      (      |X     )
  8    .188   .142                      (      |XXXX  )
  9    .163   .147                      (      |XXXX  )
 10   -.104   .149                      (    XX|      )
 11   -.146   .151                      (   XXX|      )
 12   -.020   .153                      (      |      )
 13    .100   .153                      (      |XX    )
 14   -.080   .154                      (     X|      )
 15   -.065   .155                      (     X|      )
```

Table 15. Plot of autocorrelations of first differences of TIMELINESS EQ

NUMBER OF CASES = 59
MEAN OF SERIES = 0.000
STANDARD DEVIATION OF SERIES = 0.026

```
LAG    CORR       SE -1.0 -.8  -.6  -.4  -.2   .0   .2   .4   .6   .8  1.0
                      +----+----+----+----+----+----+----+----+----+----+
  1   -.415   .130                 XXXX (XXXXX|     )
  2   -.072   .151                      (     X|      )
  3   -.016   .152                      (      |      )
  4    .031   .152                      (      |      )
  5    .028   .152                      (      |      )
  6   -.210   .152                      ( XXXXX|      )
  7    .083   .157                      (      |XX    )
  8    .092   .157                      (      |XX    )
  9    .118   .158                      (      |XX    )
 10   -.100   .160                      (    XX|      )
 11   -.095   .161                     (     XX|       )
 12   -.003   .162                     (       |       )
 13    .141   .162                     (       |XXX    )
 14   -.081   .164                     (     XX|       )
 15   -.099   .165                     (     XX|       )
```

Table 16. Plot of autocorrelations of SAFETY EQ

NUMBER OF CASES = 60
MEAN OF SERIES = -0.004
STANDARD DEVIATION OF SERIES = 0.033

```
 LAG   CORR     SE -1.0 -.8  -.6  -.4  -.2   .0   .2   .4   .6   .8  1.0
                      +----+----+----+----+----+----+----+----+----+----+
   1    .211   .129                      (     |XXXXX)
   2   -.005   .135                      (     |     )
   3   -.126   .135                      (  XXX|     )
   4   -.278   .137                      (XXXXX|     )
   5   -.252   .146                     (XXXXXX|      )
   6   -.261   .153                     (XXXXXX|      )
   7   -.117   .160                    (     XX|       )
   8    .010   .162                    (       |       )
   9    .097   .162                    (       |XX     )
  10    .323   .163                    (       |XXXXXXX)
  11    .130   .173                    (       |XXX    )
  12    .031   .175                    (       |       )
  13   -.100   .175                    (     XX|       )
  14   -.094   .176                    (     XX|       )
  15   -.011   .176                    (       |       )
```

Table 17. Plot of autocorrelations of first differences of SAFETY EQ

NUMBER OF CASES = 59
MEAN OF SERIES = -0.001
STANDARD DEVIATION OF SERIES = 0.042

```
 LAG   CORR     SE -1.0 -.8  -.6  -.4  -.2   .0   .2   .4   .6   .8  1.0
                      +----+----+----+----+----+----+----+----+----+----+
   1   -.359   .130                    XX(XXXXX|     )
   2   -.054   .146                     (     X|      )
   3    .005   .146                     (      |      )
   4   -.105   .146                     (    XX|      )
   5    .021   .148                     (      |      )
   6   -.070   .148                     (     X|      )
   7    .014   .148                     (      |      )
   8    .013   .148                     (      |      )
   9   -.109   .148                     (    XX|      )
  10    .258   .150                     (      |XXXXXX)
  11   -.057   .157                     (     X|      )
  12    .020   .157                     (      |      )
  13   -.082   .157                     (    XX|      )
  14   -.064   .158                     (     X|      )
  15    .126   .159                     (      |XXX   )
```