Axioma AXWW4 Model Supplement

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This document provides a detailed overview of Axioma's World Wide model (AXWW4) style factors. Asset-level exposures to these factors are calculated using total local returns, according to the given definitions. Prior to being used in the regression, all style factor exposures are standardized: raw exposures are centered around their cap-weighted mean and scaled by their equal-weighted standard deviation. Centering around a weighted mean ensures that a market benchmark using the same weighting scheme will be style-neutral; i.e., it will have an exposure of approximately zero to all of the style factors. Scaling ensures that all exposures are of similar magnitude in the regression and that the factor returns will have a corresponding similar magnitude to the asset returns.

The returns to these factors are estimated via cross-sectional regressions: the global market factor return, country returns, industry returns and style factor returns are estimated from a single-stage regression of the daily excess local returns. Since we have a perfect collinearity between the market and the sum of all industries and sum of all the countries, we run a constrained regression so the weighted sum of the industries and countries equal zero. This ensures that the market factor return is roughly equal to the cap-weighted estimation universe return.

Both style factor exposures and style factor returns are updated on a daily basis.

1 Market-Based Style Factors

1.1 Exchange-Rate Sensitivity

This is a measure of an asset's response to fluctuations in the foreign exchange market. For the medium horizon (MH) variant of AXWW4, it is calculated by regressing two years of weekly asset returns against the returns of the Special Drawing Rights currency basket c_t, the market return $r_{M,t}$, and an intercept term:

$$r_{i,t} = \alpha_i + \beta_{i,0} r_{M,t} + \beta_{i,1} c_t + \epsilon_{i,t}$$

c_t represents the return of the stock's local currency using the currency basket as numeraire, and $r_{M,t}$ is the return of the market to which the stock belongs. $\beta_{i,1}$ is taken as the raw exposure value. The currency basket contains four currencies - USD, EUR, GBP, JPY and CNY. For the short horizon (SH) variant of the model, one year of weekly asset returns are used to calculate the exposures.

To improve the stability of exposures, the return histories used to calculate the exposures are weighted by a new trapezoidal weighting scheme instead of equal weighting. The returns at the beginning and end of the series are down weighted while the central portion of the series is equally weighted to form a trapezoid. Down-weighting is done in a linear fashion, with the first and last return in the series having the smallest weight, the second and penultimate return having the next smallest weight, and so on, until the central portion of the series is reached. For both MH and SH variant of the model, at every period the first and last four return observations are down weighted.

1.2 Market Sensitivity

This is a measure of an asset's performance relative to that of the overall market, based on historical data. It is calculated by regressing the historical time-series of an asset's return against the global market return and an intercept term. Thus,

$$r_{i,t} = \alpha_i + \beta_i r_{M,t} + \epsilon_{i,t},$$

where

$$r_{M,t} = r_t^T h_{M,t-1}$$

and h_M are the weights of the "market" portfolio at time $t-1$. The composition of the market portfolio is typically a proxy for the global benchmark index. The regression coefficient β_i is simply the stock's *historical beta*, estimated using the Market Model. This historical beta is used as the raw input for the Market Sensitivity exposure.

For the MH variant of AXWW4, two years of weekly returns are used for the regression. For the SH variant of the model, one year of weekly returns are used. For both models the beta is corrected for serial correlation and asynchronous trading via the Scholes-Williams formula with a lead/lag value of 1.

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1.3 Liquidity

The liquidity factor provides a measure of a stock's trading activity, or lack thereof. The liquidity factor is calculated as the equal weighted average of Volume/Market Cap, inverse of Amihud illiquidity ratio and percent of returns traded. All the three descriptors are standardized prior to summation.

$$LIQ_i = \frac{1}{3}(VOL/MCAP_i + 1/AMIHUD_i + PercentOfReturns_i)$$

In AXWW4, MH Volume/Market Cap is defined as the natural logarithm of the 60-day average daily volume (expressed in units currency, not shares traded), divided by the average 1-month market capitalization:

$$VOL/MCAP_i^{MH} = ln\left(\frac{\frac{1}{60}\sum_{j=1}^{60} tdv_{i,t-j}}{\frac{1}{20}\sum_{j=1}^{20} mc_{i,t-j}}\right)$$

where $tdv_{i,j}$ is the total volume traded at time j.

In the AXWW4 SH variant of the model, Volume/Market Cap is defined as the natural logarithm of the 21-day average daily volume divided by the average 20-day market capitalization.

To calculate the Amihud illiquidity factor, we first take ratio of absolute returns to (volume/market cap) at the asset level. We then take average of this ratio over 6 months (for the MH variant of the model). For SH variant of the model, we calculate the average of this ratio over 3 months.

$$AMIHUD_i^{MH} = \left(\frac{1}{180}\sum_{j=1}^{180} \frac{|r_{i,t-j}|}{tdv_{i,t-j}/mc_{i,t-j}}\right)$$

Percent of returns traded is defined as the proportion of days an asset traded over the last calendar year. This is applicable for both the MH and SH variants of the model.

$$PercentOfReturns_i = \left(\frac{\sum_{j=1}^{250} daystraded_{i,t-j}}{250} \right)$$

1.4 Medium-Term Momentum

Medium-Term Momentum gives a measure of a stock's past performance over the medium-term. It is defined as an asset's cumulative return over the last 250 trading days, with the last 20 trading days progressively down-weighted (approximately the past year excluding the past month):

$$MTM_i = \prod_{j=21}^{250} [1 + r_{i,t-j}] - 1$$

To improve the stability of exposures, the return histories used to calculate the exposures are weighted by a new trapezoidal weighting scheme instead of an equal weighting scheme. For both the MH and SH variants of the model, at every period the first 10 and last 20 return observations are down weighted.

1.5 Short-Term Momentum

The Short-Term Momentum factor is only present in the SH variant of AXWW4. It gives a measure of a stock's recent performance, and it is defined as an asset's cumulative return over the last 20 trading days (approximately one month):

$$STM_i = \prod_{j=1}^{20} [1 + r_{i,t-j}] - 1$$

1.6 Size

This differentiates large and small stocks and is defined as the natural logarithm of the total issuer market capitalization, averaged over the last month. Denoted by $mc_{i,t}$ the total issuer market capitalization of asset i at time t:

$$SIZ_i = ln \left(\frac{1}{20} \sum_{j=1}^{20} mc_{i,t-j} \right)$$

Issuer market capitalization is computed as the product of the total shares outstanding and closing price, summed over all issues common to the issuer.

1.7 Volatility

Volatility gives a measure of an asset's relative volatility over time according to its historical behavior. In the MH variant of AXWW4, it is calculated as the square-root of the 125-day average of the asset's absolute return divided by the cross-sectional volatility of the market. In the SH variant of the model, it is calculated using the square-root of the 60-day average of the asset's absolute-return divided by the cross-sectional volatility of the market. For both models, the Volatility factor is fully orthogonalized to the Market Sensitivity factor.

$$VOL_i^{MH} = \sqrt{\frac{1}{125}\sum_{j=1}^{125}\left(\frac{|r_{i,t-j}|}{csv_{t-j}}\right)}, \qquad VOL_i^{SH} = \sqrt{\frac{1}{60}\sum_{j=1}^{60}\left(\frac{|r_{i,t-j}|}{csv_{t-j}}\right)}$$

where

$$csv_t = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(r_{i,t} - \overline{r}_t)^2}$$

is the cross-sectional standard deviation of returns at time t, measured across the different markets in the model estimation universe.

To improve the stability of exposures, the return histories used to calculate the exposures are weighted by a new trapezoidal weighting scheme instead of equal weighting. For the MH variant of the model, the first and last 10 return observations are down weighted, and for SH variant the first and last 5 return observations are down weighted every period.

2 Fundamental Style Factors

2.1 Value

Value gives a measure of how fairly a stock is priced within the market. It is calculated as Book-to-price.

Book-to-price is calculated as the ratio of common equity to average 30-calendar-day total issuer market capitalization. The calculation uses the most recently reported annual common equity value:

$$BTP_i = \frac{ce_i}{\frac{1}{30}\sum_{j=1}^{30} mc_{i,t-j}}$$

2.2 Earnings Yield

Earnings Yield is calculated as a combination of three parts realized to one part forecasted earnings-to-price.

Realized earnings to price is calculated as the most recently reported annual net income value, divided by the average total issuer market capitalization computed over the last 30 calendar days.

$$ETP_i = \frac{net\_income_i}{\frac{1}{30}\sum_{j=1}^{30} mc_{i,t-j}}$$

Forecasted earnings-to-price is calculated as forward-looking earnings estimate, divided by the average total issuer market capitalization computed over the last 30 calendar days.

$$FETP_i = \frac{forward\_earnings\_estimate_i}{\frac{1}{30}\sum_{j=1}^{30} mc_{i,t-j}}$$

2.3 Leverage

Leverage provides a measure of a company's exposure to debt levels. It is calculated as the equal-weighted average of the descriptors Debt-to-assets and Debt-to-equity. Both descriptors are standardized prior to summation:

$$LEV_i = \frac{1}{2}(DTA_i + DTE_i)$$

Debt-to-assets is calculated as the ratio of long-term and short-term debt to total assets, where total assets is computed as the most recently reported value from annual reports.

$$DTA_i = \frac{debt_{LT} + debt_{ST}}{total\_assets}$$

Debt-to-equity is calculated as the ratio of long-term and short-term debt to common equity, where common equity is computed as the average of the four most recently reported values from annual reports.

$$DTE_i = \frac{debt_{LT} + debt_{ST}}{common\_equity}$$

2.4 Growth

Growth gives an indication of a company's rate of growth. The growth factor is calculated as the equal-weighted average of the earnings growth rate and the sales growth rate. Both descriptors are standardized prior to summation:

$$GRO_i = \frac{1}{2}(EAR\_GRO_i + SAL\_GRO_i)$$

To control for seasonal patterns, growth rates are computed from annual earnings (sales) data.

In AXWW4, the earnings growth rate is calculated by regressing five years of historical earnings and up to one year of forecast earnings against time plus an intercept term:

$$earnings_{i,t} = \alpha_i + \beta_i t + \epsilon_{i,t}$$

The regression slope coefficient, β_i, is then divided by the average absolute earnings to yield the final figure:

$$EAR\_GRO_i = \frac{\beta_i}{\frac{1}{T}\sum_{t=1}^{T} |earnings_{i,t}|}$$

The sales growth rate in AXWW4 is calculated by regressing five years of historical sales and up to one year of forecast sales against time plus an intercept term:

$$sales_{i,t} = \alpha_i + \beta_i t + \epsilon_{i,t}$$

The regression slope coefficient, β_i, is then divided by the average absolute sales to yield the final figure:

$$SAL\_GRO_i = \frac{\beta_i}{\frac{1}{T}\sum_{t=1}^{T} |sales_{i,t}|}$$

2.5 Profitability

Profitability factor of a company is a measure of the company's profitability and it is often associated with the quality of the company. Profitability is constructed as a linear combination of the return-on-equity, return-on-assets, cash-flow-to-assets, cash-flow-to-income, gross margin, and sales-to-assets descriptors.

Return-on-equity, ROE_i, is calculated as the most recently reported annual earnings values, divided by the average of the two most recently reported annual common equity values.

$$ROE_i = \frac{annual\_earnings_i}{\frac{1}{2}\sum_{j=1}^{2} ce_{i,t-j}}$$

Return-on-assets, ROA_i, is calculated as the most recently reported annual earnings values, divided by the average of the two most recently reported annual total assets values.

$$ROA_i = \frac{annual\_earnings_i}{\frac{1}{2}\sum_{j=1}^{2} ta_{i,t-j}}$$

Cash-flow-to-assets, $CFTA_i$, is calculated as the most recently reported annual operating cash flow divided by the average of the two most recently reported annual total assets values.

$$CFTA_i = \frac{annual\_operating\_cf_i}{\frac{1}{2}\sum_{j=1}^{2} ta_{i,t-j}}$$

Cash-flow-to-income, $CFTI_i$, is calculated as the average of the two most recently reported annual operating cash flows divided by the average of the two most recently reported annual income values.

$$CFTI_i = \frac{\frac{1}{2}\sum_{j=1}^{2} annual\_operating\_cf_{i,t-j}}{\frac{1}{2}\sum_{j=1}^{2} annual\_income_{i,t-j}}$$

Gross margin, GM_i is calculated as net sales (sales minus the cost of goods sold), divided by sales. Both the numerator and the denominator values are computed as the most recently reported annual values.

$$GM_i = \frac{net\_sales_i}{annual\_sales_i}$$

Sales-to-assets, STA_i, is calculated as the most recently reported annual sales values, divided by the most recently reported total assets values.

$$STA_i = \frac{net\_sales_i}{\frac{1}{2}\sum_{j=1}^{2} ta_{i,t-j}}$$

2.6 Dividend Yield

Dividend yield is calculated as the sum of the dividends paid (excluding non-recurring, special dividends) over the most recent year, divided by the average total issuer market capitalization computed over the last 30 calendar days:

$$DIV\_YLD_i = \frac{ann\_dividends_i}{\frac{1}{30}\sum_{j=1}^{30} mc_{i,t-j}}.$$

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