Market Factor: Not Just For Show

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The factor structure of a risk model plays an integral role in both the forecasting power of the model and the interpretation of model output. Models based upon an incomplete or misspecified factor set will necessary suffer from forecasting bias, and not surprisingly the design of a model's factor structure plays a key role in the interpretation of both factor returns and factor risk decompositions. Historically, Barra's equity models (including Barra US Equity Model (USE3) featured a set of distinct style and industry factors, customized for the specific market at hand. Daily style and industry factor returns are estimated by regressing a cross section of asset returns onto a set of asset-level style and industry exposures. The time-series of these daily estimated factor returns are ultimately used to build the factor covariance matrix which powers all Barra risk analytics.

$$r_i = X_{styles} f_{styles} + X_{industries} f_{industries} + \varepsilon \quad (1)$$

In USE3, style factor exposures are constructed such that the aggregate cap-weighted market (estimation universe) is style neutral. This implies that the return of the market is encapsulated fully by the industry factor set. Assuming that specific returns are normally distributed about 0, the weighted sum of the industry factor returns will equate to the return of the market.

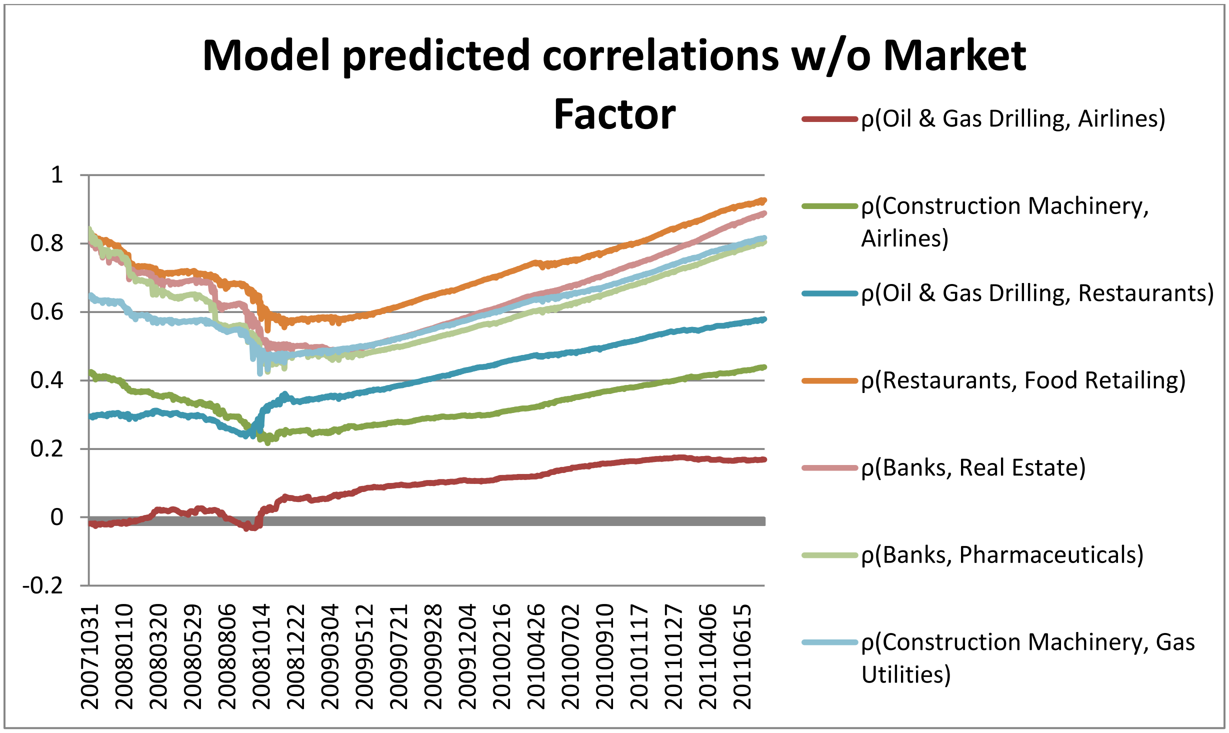
$$r_{Market} \approx X_{industry} f_{industry} \quad (2)$$

The industry returns estimated in USE3 can be interpreted as the return of a 100% net long style neutral industry portfolio. As such, these industry factor portfolios are fully invested in the market and subject to general market volatility, in addition to industry specific dynamics. From a risk attribution perspective, since the biggest driver of equity volatility tends to be general market volatility, the industry factor set exhibits substantially higher volatility than the corresponding dollar-neutral style set, and tends to exhibit an elevated degree of correlation during periods of market turmoil.

The newly launched Barra US Equity Model (USE4) model's factor structure diverges from the preceding USE3 model in one primary way. USE4 introduces a market factor and a uses a constrained regression for factor return estimation. Each asset in the estimation universe has unit exposure to the market factor and a constraint is imposed on the regression such that the cap-weighted sum of all of the industry factor returns equals zero. Adding in a dummy intercept factor (to which all assets have exposure of 1) does not alter the regression fit in any way, and by forcing the cap-weighted industry factor returns sum to zero, we are able to effectively remove the collinearity in the factor structure (sum of all industry factor exposures= market factor exposure). This results in industry factor returns which can be interpreted as additional return net of the market return. For example, an industry return of -1% in USE4 would imply that that industry underperformed the market by 100 basis points, rather than denoting an absolute return. The industry factor portfolios in USE4 are dollar-neutral portfolios which capture the return of a pure industry relative to the market and net of style effects.

At this point, it is worth noting that by adding the market factor return obtained from the constrained regression mentioned above to each of the estimated industry factor returns, we would result in industry factors returns that are analogous in spirit to the returns estimated via the unconstrained regression methodology used in the USE3 model. The introduction of the intercept does not change the fit of the model, and while disentangling market and industry specific returns can add additional insight, the real value of the USE4 factor structure lies in the ability to have greater responsiveness in the estimates of net long industry correlations. Recall that historically Barra has used a longer half-life for factor correlation estimates than for factor volatility estimates. The rationale here is that while it is desirable for the model to respond to market volatility in a timely fashion, it is essential that an adequate number of effective observations be used to estimate factor correlations to ensure that the factor covariance matrix remains well-conditioned. Using too short of a half-life for correlation estimates could lead to issues with matrix invertibility, a property essential for portfolio optimization.

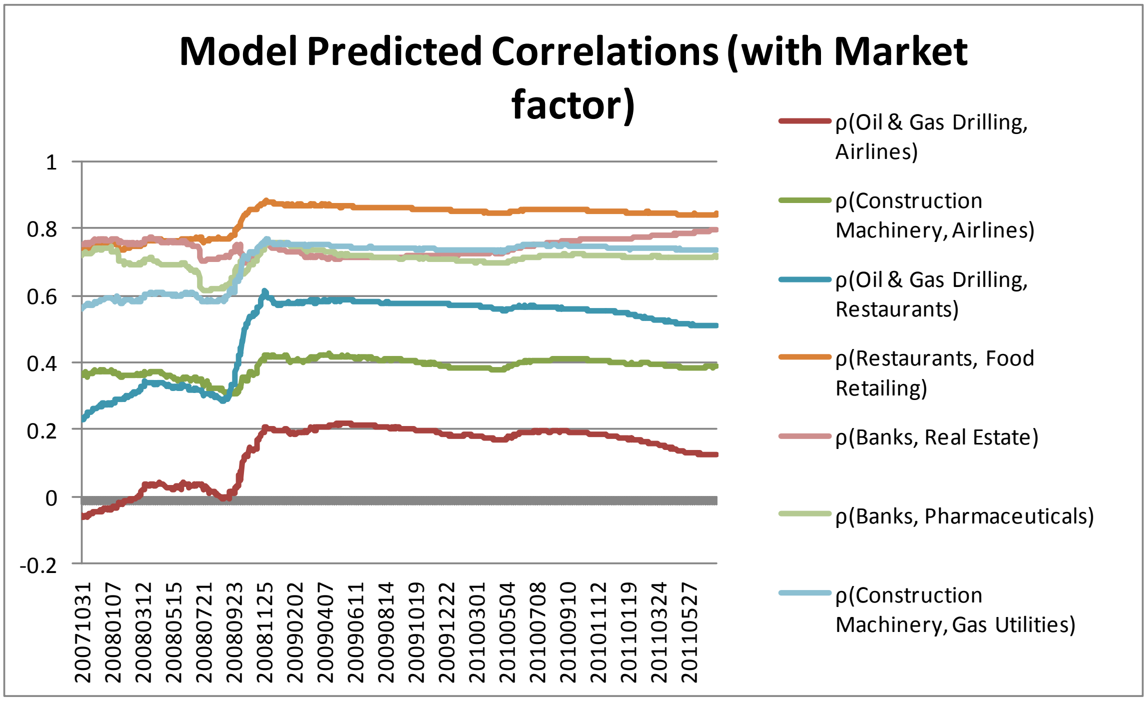
An unfortunate consequence of this need to use a longer half-life for correlation estimates is that factor pair correlations are slower to respond to market changes. In times of crisis as correlations deviate substantially from their norms, estimates based on longer half-lives give increased weight to historical observations and are slower to react to change. In addition, once changes are finally reflected, estimates are slow to return to their pre-crisis levels. See Figure 1 for a time-series of correlation forecasts for several net long industry factor pairs based upon the parameters and dataset of the USE4 model, but re-estimated without the market factor. If we turn our attention to the fall of 2008, a time when realized industry correlations skyrocketed, it is apparent that the model estimated without a market factor was slow to perceive this change. In additional correlation levels have stayed elevated or are even still trending upwards in some cases, despite the fact that there was a period of relative market tranquility following the financial crisis.



The introduction of the country factor in USE4 allows for the correlation of net long industry pairs to evolve more quickly. While USE4 still uses a longer half-life for correlation estimates (as the need for a well conditioned covariance matrix still exists), the correlation between any two model industry factors is now capturing the correlation between two dollar neutral industries. If we were to consider the correlation between two net long industries as we traditionally did in the USE3 model, this would be given by the following expression where $\tilde{f}_i$ denotes return of ***net long*** industry factor portfolio i, f_i denotes the return of dollar neutral industry factor portfolio i, and f_{market} is the return of the cap-weighted market portfolio:

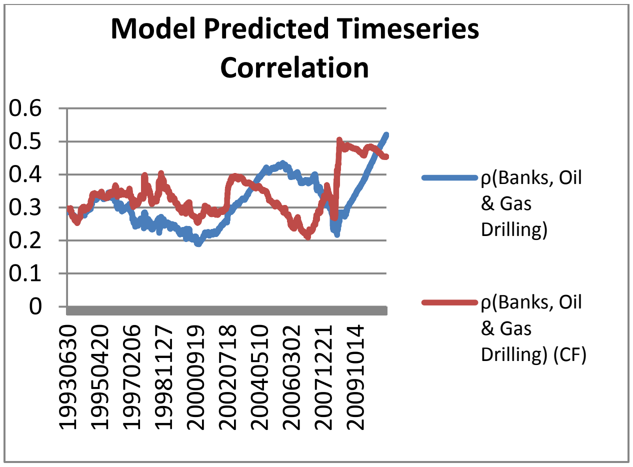
$$\rho(\tilde{f}_i, \tilde{f}_j) = \frac{\sigma^2_{Market} + \rho(f_{market}, f_i) + \rho(f_{market}, f_j) + \rho(f_i, f_j)}{\sqrt{(\sigma^2{}_{market} + \sigma_i^2 + 2\rho(f_{market}, f_i)}\sqrt{(\sigma^2{}_{market} + \sigma_j^2 + 2\rho(f_{market}, f_j)}}$$

Here, the correlation of the net long industry pairs is a direct function of the volatility of the market factor, which is estimated with a shorter half-life and which responds to changes in volatility much more quickly. While stripping out the market return and ensuring that the cap-weighted industry factor returns sum to 0 has no impact on model fit, because factor volatility estimates are more responsive, the introduction of the country factor in USE4 allows for a much timelier evolution of net long industry correlations and consequently more accurate risk forecasts during and following periods of market dislocation. Figure 2 below shows a comparable time-series of net long industry factor correlation estimates, this time estimated using the USE4 model and its market factor. Clearly having the market volatility related portion of the correlation of two net long industries being estimated with a greater decay rate translates to a more responsive correlation estimate for net long industries and portfolios. Not only is the market factor volatility estimated with a shorter half-life, but it is also subject to scaling based on Barra's Volatility Regime Adjustment factor, which ultimately scales factor volatilities based on a time-series of cross-sectional factor bias statistics.[1]



A closer look at a few specific net long industry pairs, taken from USE4 and a variant of USE4 estimated without a country factor, further illustrates this effect. In the fall of 2008, when the realized correlation between US industries spiked across the board, the industry correlation estimates based upon the market factor volatility reflected this upward trend almost immediately and have since begun to subside, while those based on the traditional correlation of net long industry returns trended upwards slowly and didn't peak until mid 2011. The gradual evolution of correlation estimates over time in the old model led to a period of risk underestimation in 2009, followed by a period of overestimation that lingered for the subsequent 2 years, but the introduction of a market factor in USE4 helps to mitigate this effect and provides timelier risk forecasts.

[1] See USE4 Whitepaper for methodological details on Barra's Cross Sectional Volatility Adjustment.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0.4
0.3
0.2
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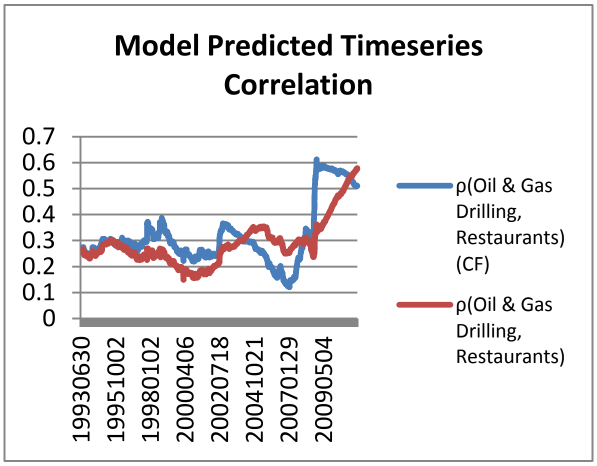
Model Predicted Timeseries Correlation
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