Implementing Fair Value Pricing

Ananth Madhavan*

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* ITG Inc., 380 Madison Avenue, New York, NY 10017, Tel: (212)-444-6361; E-mail: amadhava@itginc.com

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Abstract

Mutual fund transactions occur at the fund's Net Asset Value (NAV), typically computed at 4:00 p.m. Eastern Time using closing prices for the day. For funds whose securities trade on a foreign exchange that close before the US market, this convention can result in stale prices. Some short-term speculators take advantage of stale prices, trading on information signals observed after the close of the foreign market and before the US market closes, earning substantial profits at the expense of long-term shareholders. Fair value models, that suggest adjustments to the closing prices of foreign securities based on information after the foreign market closes, provide a solution to the "mutual fund timing" problem. Simultaneously, fair value pricing allows mutual fund complexes to comply with the SEC's view that the Investment Company Act of 1940 requires funds to use fair value procedures when significant events subsequent to foreign market closes result in stale closing prices. This article examines international equity fair value pricing, paying particular attention to model selection, empirical testing, and issues of practical implementation at the fund complex level.

Introduction

US mutual fund transactions occur at the fund's Net Asset Value (NAV), which is typically computed at 4:00 p.m. Eastern Time ("ET"), on the basis of the closing prices for each stock on the day. For funds whose securities trade on a foreign exchange that close before the US market closes this convention can result in stale prices. Indeed, in the case of US mutual funds holding Japanese stocks, as much as 15 hours can elapse from the close in Tokyo at 1:00 a.m. ET (3:00 p.m. in Japan) to the US close at 4:00 p.m. Stale prices allow short-term speculators to trade on information signals observed after the close of the foreign market and before the US market closes, a practice known as mutual fund timing. Although risky, mutual fund timing can yield potentially large profits to speculators, profits that are at the expense of long-term shareholders.[1]

Funds concerned about the losses to such "arbitrage" often use a variety of restrictions and fees to discourage mutual fund timing, but these may have limited effectiveness and often are unpopular with long-term fund holders. For example, Zitzewitz (2001) finds that short-term trading fees are not sufficient to eliminate speculative trading entirely. Similar remarks apply to other restrictions, such as limitations on the number of transactions and minimum holding periods. Consequently, some forward-looking mutual funds have implemented increasingly sophisticated fair value pricing models to adjust fund NAVs based upon information flows after the close of the foreign market.

From a regulatory perspective, the United States Securities and Exchange Commission ("SEC") has issued statements concerning fair value pricing for international equity securities.[2] The SEC's position (Scheidt (2001)) is quite clear in this regard:

> *If the fund determines that a significant event has occurred since the closing of the foreign exchange or market, but before the fund's NAV calculation, then the*

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[1] See Chalmers, Edelein and Kadlec (2001), Zitzewitz (2000), Bhargava, Bose and Dubofsky (1998), and Greene and Hodges (2002). The latter report excess returns of 10-20 percent. Boudoukh, Richardson, Subrahmanyam and Whitelaw (2002) mention at least 16 hedge fund companies covering 30 specific funds whose stated strategy is "mutual fund timing."

[2] Scheidt (1999) and (2001). The term "fair value" pricing as used in this paper refers to adjusting prices of non-US securities to reflect information flows after foreign closes. The term "fair value" is also used in the mutual fund industry to cover all pricing not based on readily available market prices. Securities might be fair valued in the event of a general or specific trading halt on a market or because there are never reliable market quotations for a security. This paper does not address these other situations where fair value procedures may be used.

closing price for that security would not be considered a 'readily available' market quotation, and the fund must value the security pursuant to a fair value pricing methodology.

Indeed, in the view of the SEC, fair value pricing is the logical application of the Investment Company Act of 1940, which places a regulatory obligation on funds and their directors to make a good faith determination of the fair value of the funds' portfolio securities when market quotations are not readily available. The SEC staff has long permitted funds to adjust last-trade foreign equity prices to reflect more recent information, as long as the potential for doing so is disclosed in the fund prospectus. However, funds must have a coherent and defensible process for fair value pricing to address the questions of whether foreign market closing prices represent reliable market quotations. So, fair value models help international mutual funds alleviate the "arbitrage" problem while also satisfying their regulatory obligations. However, the implementation of a fair value model poses several unique challenges, which are the subject of this article.

First, the fund must make the build versus buy decision. While a home grown solution is attractive in some dimensions, internal development can be costly and difficult to maintain for funds without the appropriate infrastructure for data and model building. As Rahl's (2002) survey's sample demonstrates, only 13 percent of funds use some kind of adjustments. But even if they do so, not all mutual funds (see Bullard (2001)) adjust NAVs in a systematic or effective manner. Another practical consideration favors an external solution: The process of calculating a fund's NAV usually begins at 4:00 p.m. ET, after the US market has closed, and funds are required to compute NAV on a daily basis. The purpose of a fair value model is to suggest adjustments to the prices of international stocks given the information observed between the close of the foreign market and 4:00 p.m. ET. In order to do so, the fair value model must produce reliable estimates of adjustments for a wide universe of assets within a two-hour period. Again, few fund complexes are set up to ensure reliable delivery of adjustments for a universe of several thousand stocks within such a short time window. Commercial solutions are currently provided by ITG Inc. and Interactive Data (IDC), a division of Financial Times.

Second, the implementation of fair value pricing requires evaluating competing models. This, however, is non-trivial because of differences in structure and methodology, and we devote some time to this issue. The most important measure of model performance is a proven ability to

reduce arbitrage profits from timing strategies on a timely and reliable basis through accurate pricing.

Third, once a model has been selected, the fund must formulate policies on the appropriate use of fair value models. As with all other pricing issues, the SEC's view is that ultimate responsibility for any fair value pricing lies with the fund's board of directors or trustees, who typically delegate day-to-day responsibility to the fund's manager or administrator. The manager or administrator has several important decisions to make. One important consideration is the return threshold at which the fund will apply a fair value model to adjust the price of an international security. Specifically, the need for fair value pricing is greatest when there is a large US market movement and intuitively one would expect fair value models to perform best on such days. Applying a fair value adjustment for price changes above a minimum threshold is also consistent with the SEC's view that they should be adjusted for "significant events." Other important considerations include the approach to extreme outliers, data availability and reliability, and procedures to ensure adjustments are made in a systematic and consistent manner.

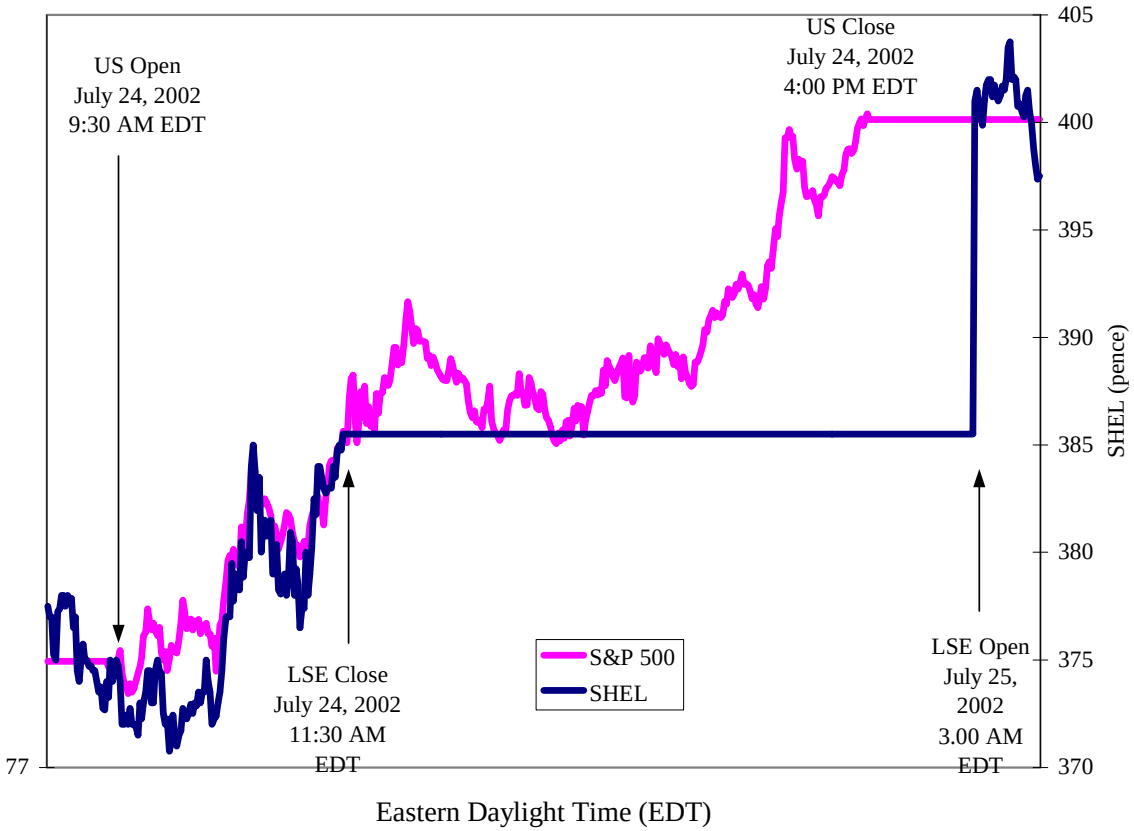
Finally, the fund must deal with the complex task of explaining its pricing policies to trustees, fundholders, and other stakeholders. Fair value pricing can introduce unintended tracking error for a fund relative to a public benchmark based on closing prices, simply because the benchmark or index is computed using stale closing foreign prices. Similarly, fair value pricing might generate "flips" in daily return rankings relative to peers, especially if other funds are not adjusting their NAVs using the same methodology, or worse yet, not adjusting them at all. Some new shareholders might feel disadvantaged by policies, especially if they purchase shares following a positive US market movement.

Nevertheless, we expect the clear benefits of fair value adjustments (See, e.g., Goetzmann, Ivkovich, and Rouwenhorst (2000), for an excellent discussion in this regard) to lead to the rapid adoption of fair value pricing models throughout the industry. In addition, the use of models provides a systematic and consistent method to adjust prices and allows mutual fund complexes to comply with SEC guidance regarding stale quotations.

An Illustrative Example

Consider as an example, Shell Transport & Trading Company, PLC (SHEL) on July 24, 2002. The stock closed at 385.5 pence on the London Stock Exchange (LSE) at 11:30 a.m. Eastern Daylight Time (EDT). As shown in figure 1, the S&P 500 Index (normalized to equal the closing price of SHEL at 11:30 EDT) rose continued to rise by 4.6% over the US trading day. The following day, on July 25, 2002, SHEL opened up 4.02%.

Figure 1
Stock Prices for SHEL on July 24-25, 2002



The stale price of SHEL provides an opportunity to short-term speculators. It is precisely this activity that fair value models attempt to discourage, by adjusting the price at which US mutual funds would value similar stocks in computing fund NAV at the end of the day. In this case, the fair value model of ITG Inc. indicated an adjustment of 3.95%. Although adjusting one stock in a mutual fund portfolio would likely not create an impact to its overall NAV for the day, multiple security adjustments for a given move in the US market could impact a fund's NAV.

Types of Models

A variety of different models exist to try to capture the underlying value of a foreign security that is not traded. Since there is no direct observation on the fair value price of a foreign stock at 4:00 p.m. ET, the next day's opening price is commonly used as a proxy. Of course, events occurring between 4:00 p.m. ET and opening of a foreign market might change stock valuations, but are unlikely to introduce a systematic bias.

The logical starting point for a fair value model is a stock-specific multi-factor equation:

$$r_i = \sum_{k=1}^{K} f_k b_{ik} + e_i, \tag{1}$$

where r_i is the return from the close of the stock in the foreign market to its open the next day, f_k is the return of a factor k that is observed after the foreign close to 4pm ET, β_{ik} the beta of stock i relative to factor k, and ε_i is an idiosyncratic shock. The factors are chosen to best capture the unobserved change in value, including intraday US market or sector movements, etc.

The key point to note about the multifactor model (1) is that the loadings are stock specific, so that each security's adjustment is made individually as the SEC guidance suggests is advisable. The choice of factors might also vary from stock to stock, or might be selected on the basis of the statistical significance of the coefficient estimates. For example, for a thinly traded stock, the factors might be the US intraday market return (from the close of the foreign market to the US close at 4pm ET) and the corresponding returns to the stock's sector or industry. For an active stock, such as Vodafone Group PLC, an actively traded American Depository Receipt (ADR) exists, which might form an additional factor.

The security-specific multifactor model of equation (1) represents a "bottom-up" approach to fair value pricing. This approach has advantages over a seemingly simpler "top-down" approach where a single regression model for the overnight return of the portfolio is used as proxy for the ?whole. In particular, a top-down regression model at the portfolio level might generate erroneous fair value adjustments when the fund's composition shifts because these changes could alter the portfolio's sensitivity to the factors under consideration. The bottom-up approach, since it recreates the beta of the portfolio on a security-by-security basis, will always capture the current portfolio sensitivities to the factor exposures.

The multifactor model is also readily generalized. Since fair value considerations are particularly important on days with large market moves, it is useful to consider non-linear models. For example, consider a simple switching model

$$r_i = \begin{cases} b_i^m m + b_i^s s_j + e, & if \quad |m| \le c; \\ (b_i^m + d_i^m)m + (b_i^s + d_i^s)s_j + e, & if \quad |m| > c. \end{cases} \tag{2}$$

This model assumes the sensitivities of stock return r_i to the market (m) and the sector (s) are β_i^m and β_i^s if the market return, m, is less than the threshold c in magnitude. However, when the market fluctuates significantly, the sensitivities become $\beta_i^m+\delta_i^m$ and $\beta_i^s+\delta_i^s$ respectively. In this case, the model, although non-linear in returns, can still be estimated as a linear regression. Certainly, multiple thresholds can be specified leading to more complicated model structures, but not necessarily better out-of-sample performance.

Finally, we generalize the approach further to consider hierarchical or nested models, where the choice of model depends on whether the coefficients are estimated with statistical reliability. One might, for example, consider first estimating the switching model given by equation (2) and then, if the estimates were deemed unreliable, estimating simpler models that offer more robust coefficient estimates based on equation (1).

Issues in Fair Value Modeling

Given the many factors that might be included in a fair value model (e.g., US intra-day market and sector returns, index futures returns, currency returns, etc.) to capture information signals after the foreign market close, we need to select factors based on a set of principles including:

- **Economic Logic -** factors must be intuitive and interpretable.
- **Performance -** both in and out-of-sample.
- **Parsimony -** More factors do not necessarily improve forecasts, because extraneous factors add noise, rather than information and do not necessarily improve out-of-sample performance.

Once a set of candidate factors have been selected and models estimated, the investment manager must choose among the various models. But how do we determine the "best" model.

The criterion we believe is most important in selecting a fair value model solves the portfolio manager's problem, i.e., provides the biggest reduction in gains to short-term speculators. Specifically, the approach taken is to compute the returns to short-term speculators with and without a fair value model. A correctly specified Fair Value Model ("FVM") should significantly decrease these arbitrage opportunities as measured out-of-sample. A metric for arbitrage profits can be constructed as the average return to a speculator who purchases the fund if the intraday US return is positive and sells if this return is negative. Formally, we define:

$$\textit{Arbitrage Return without FVM} = \frac{1}{T}\sum_{m\geq 0} q_t - \frac{1}{T}\sum_{m<0} q_t, \tag{3}$$

$$\textit{Arbitrage Return with FVM} = \frac{1}{T}\sum_{m\geq 0} (q_t - \hat{q}_t) + \frac{1}{T}\sum_{m<0} (\hat{q}_t - q_t), \tag{4}$$

where T is the number of out-of-sample periods, q_t is the overnight return of an international *fund* at time *t*, and $\hat{q}_t$ is the forecasted return by the fair value model based on the fund's holdings. Then, we define the reduction in arbitrage profits to be:

Arb Reduction = 1– (*Arbitrage Return with FVM / Arbitrage Return without FVM*) (5)

So, if the arbitrage return without a FV model is, say, 2% and the use of a fair value model reduces this to 0.5%, the arbitrage reduction is 1—(0.5/2) = 75%. Note that because this measure is estimated out-of-sample, the measured reduction could exceed 100%. Other metrics, including the correlation of forecast and actual returns, absolute pricing errors, etc. should also be examined. In practice, however, these metrics are highly correlated and consequently we focus on the arbitrage statistic in equation (5).

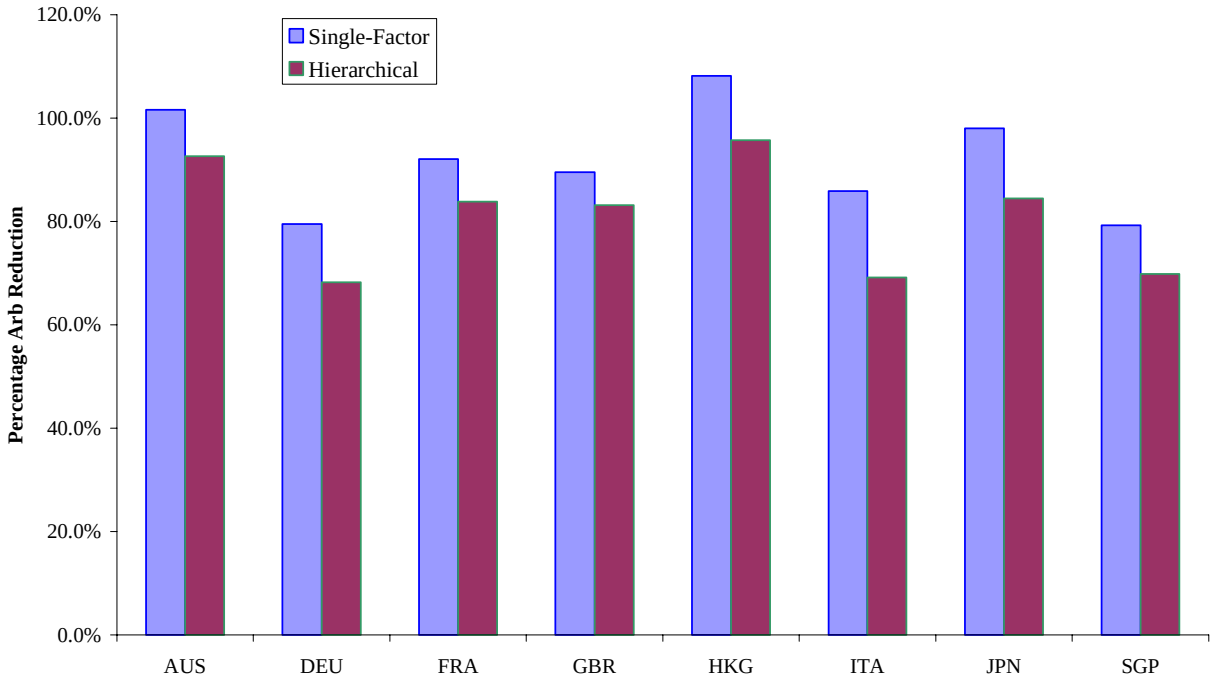
Tests of Models

The next implementation challenge is to test models out of sample, and examine the results using the criteria above. Here, we report statistics based on tests performed by ITG Inc. which developed a fair value model. A brief summary of the data sources and methodology used by ITG Inc. is as follows: Overnight returns of foreign stocks are computed using Bloomberg daily price data, adjusted for corporate actions. The Bloomberg primary exchange and primary security flags are used to determine which stocks listed in a given country are in fact stocks whose primary market is the particular country being examined. The database covers Australia (AUS), Germany (DEU), France (FRA), United Kingdom (GBR), Hong Kong (HKG), Italy

(ITA), Japan (JPN), and Singapore (SGP). The sample period is January 18-December 31, 2001; for Hong Kong and Singapore, the period goes from May 2-December 31, 2001. We define a "US Market Return" as the market capitalization-weighted return of Russell 1000® stocks between the closing of a foreign market and the US closing. In empirical tests, this measure performed better than other market proxies, including the returns of the S&P 500 index and Wilshire 5000 index. A total of over 10,000 securities are covered in the testing universe. Models were estimated over 80 days and out-of-sample forecasts were performed for 180 days going forward.

We considered a simple one-factor model and a complicated hierarchical model two models against the naïve (do nothing) benchmark. As shown in figure 2, the use of a model offers considerable improvement relative to doing nothing, but among the various models, even the simplest model does very well.

Figure 2
Reduction in Losses to Speculators Across Different Models



In fact, for this particular test, the simplest model actually performed the best on an out-of-sample basis. For some countries, the reduction in arbitrage profits is dramatic. Overall, there is

91.7% reduction in losses to speculators. It should be noted that these results assume that the fair value prices were used even for small price movements. When the ARB measure is computed only on days when the US market movement was greater in magnitude than half of the standard deviation of the daily market return, the corresponding reduction in arbitrage profits using the fair value model is 84.2%.[3]

Other Modeling Considerations

The success of relatively simple models in eliminating a large fraction of potential arbitrage profits does not imply that fair value modeling itself is a simple matter. For example, the presence of a US traded ADRs might allow for a more precise estimate of fair value for a foreign stock. Specifically, we need to compute not only the intraday ADR return in the US market, but also adjust this for possible foreign exchange movements. For instance, if an ADR moves up by 1% during the day, but the dollar depreciates by 1%, we would expect no change in the foreign stock price, on average.

Figure 3 below plots the intraday currency adjusted returns of the ADR for Vodafone Group and the subsequent overnight return in London. As can be seen from the plot, the fit is very close. Indeed, a simple linear regression explains over 70% of the overnight variation in the stock. While these results are promising, the use of ADRs in fair value modeling is not without difficulty. Liquidity across markets, foreign ownership restrictions, and index membership can create deviations that persist for long periods of time. Even for Vodafone, the relationship, although close, is not perfect, and a 1% change in the intraday ADR price (net currency movements) induces a 0.91% change in the overnight price. For less active ADRs, liquidity and non-synchronous trading introduce noise into the estimates and create additional difficulties. Clearly, the use of ADR returns must be evaluated carefully on the basis of empirical research.

In a similar manner, factors such as country ETFs might provide additional explanatory power. Boudoukh et. al. (2002) discuss some of these issues. There are also multi-country effects, relating to the international transmission of volatility. Events in the US and Europe, for example, might affect Japanese stocks.

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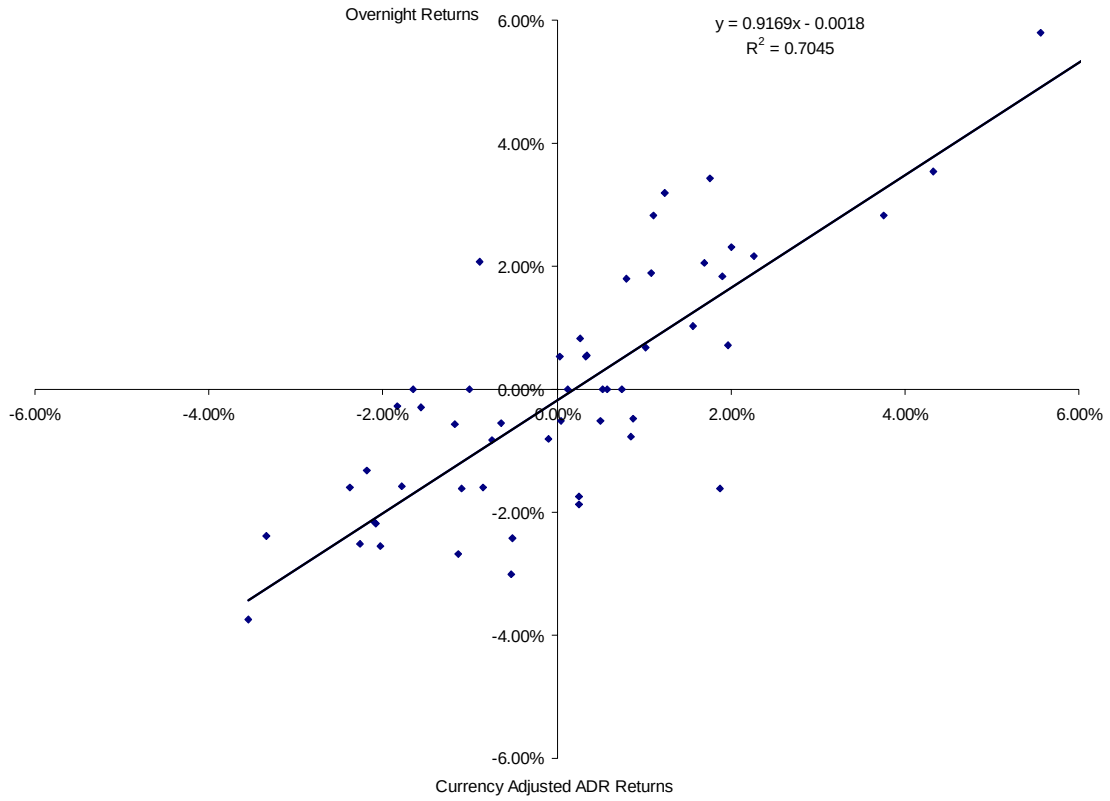
[3] The surviving observations cover approximately 60% of the total number of trading days. Note that the average arbitrage profit on these days was 1.4% versus 0.8% on all days.

Figure 3
ADR Adjusted Returns v. Overnight Returns for Vodafone Group PLC: 6/12-8/30, 2002



Derivatives on international markets (e.g., the Nikkei 225 futures contracts) trading while the foreign market is closed might provide valuable information signals about fair value. For example, Craig, Dravid and Richardson (1995) examined the relationship between Nikkei futures/warrants traded in the US and close-to-open Nikkei returns in Japan. They found that non-US-based derivatives trading in the US are efficient predictors of the opening move of the international market. Moreover, they found that, once the non-US-based derivative return is taken into account, US stock return indexes do not provide incremental information.

Finally, other factors such as currency returns, etc. might also prove helpful. Fair value research is an ongoing process. But for a fund manager, the most pressing issues have to do with practical considerations, a topic to which we now turn.

Practical Considerations

Several practical considerations determine the choice of model. In particular, implementation requires a consideration of the following issues:

- The model must run soon after the close at 4:00 ET
- All adjustments to fund prices must be reviewed by a manager
- The universe covered must be sufficiently broad (10,000+ stocks)
- Complex models are more prone to failure through data errors/unavailability
- Estimated factor loadings (betas), inputs, and outputs must be "reasonable"
- An optimal threshold for application must be determined
- Tracking error arising from stale benchmarks

The first four considerations, although critical, do not require much comment. However, the last three points require some discussion.

Outliers

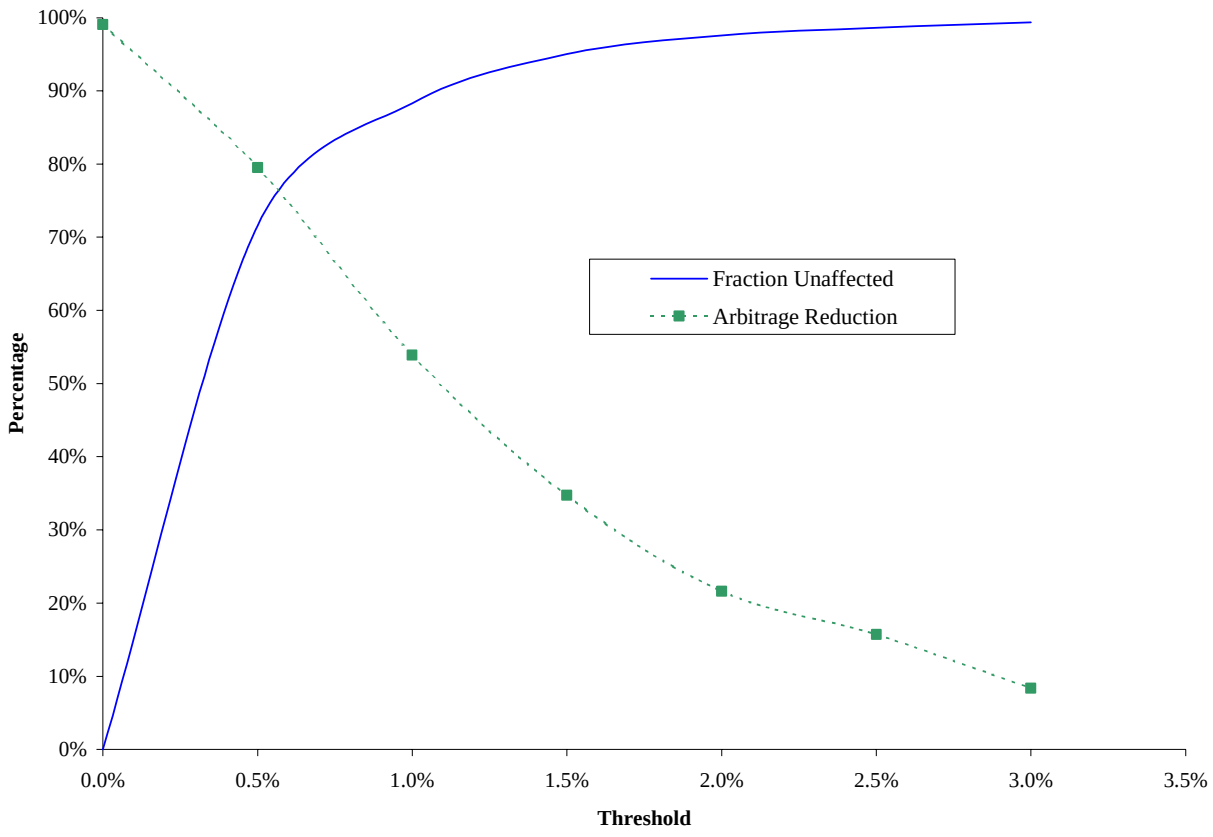
Given that the model will run on some 10,000 odd securities individually, it is possible that by pure chance, we will get some unreasonable factor loading (beta) estimates. In turn, these extreme betas might give rise to unwarranted fair value adjustments. The simplest approach to resolving these issues, for example, capping or omitting the fair value estimates for outlier securities, runs counter to a systematic, quantitative approach. Methods to filter outliers can be applied as an alternative to prevent unreasonable adjustments. A better approach, for example, is to use various methods to adjust the estimated betas directly. In particular, Bayesian procedures or other statistical tools (Stein shrinkage) can ameliorate the problem in a more scientific manner.

Thresholds

Applying a fair value model to all securities on a daily basis is complicated because most funds will want to review any suggested fair value changes. Accordingly, some funds use FV models *only* for securities whose *predicted* fair value prices depart from their closing price by more than a critical threshold level (this is also consistent with the SEC's statements that fair value pricing may be necessary in the context of "significant" events). So, if the threshold is 3%, the model will be applied only to those stocks whose predicted (absolute) overnight return is greater than 3%. Applying a security-specific threshold is more appealing than using a market-

based threshold because there might be events that are relevant only to certain countries or sectors. But how is the optimal threshold determined? To examine this issue more closely, we examined a portfolio of the FTSE 100 stocks from 4/16-8/22, 2002, a total of 8,388 observations. We computed the reduction in overall (fund) speculators' profits as defined in equation (5) at each threshold level using the ITG Fair Value Model. Figure 4 below illustrates the results. The horizontal axis represents the various threshold levels against which are shown (1) the reduction in arbitrage profits, in percent, and (2) the fraction of the universe that does *not* require adjustment.

Figure 4
Percentage of Fair Value Adjustments for FTSE 100



The highest reduction in losses to speculators comes at the lowest threshold. A 1% threshold is sufficient to eliminate 50% of the arbitrage profits in the FTSE 100 portfolio. These figures are highly conservative because the FTSE 100 stocks are high capitalization stocks that

are less volatile than the typical international stock. Also, the UK market closes at 11:30 ET, so the window of time for a speculator to profit from stale prices is accordingly much smaller than for, say, an Asian stock. Lower volatility and a shorter non-trading window implies fewer opportunities for speculators to profit from short term trading strategies. For the typical global fund, which holds less liquid securities in both European and Asian markets, the arbitrage reduction will be much larger for any given threshold level.

But there is a tradeoff, as illustrated in figure 4. The fraction of securities that are not subject to price adjustments climbs rapidly with the threshold. In figure 4, for example, the use of a 1% threshold implies that on a typical day 12% of the FTSE 100 requires adjustment. For a large international fund with many stocks, however, the use of a low threshold implies that a substantial number of securities would likely be adjusted on a daily basis. Moreover, the primary reduction in arbitrage gains is on days with large price movements, exactly when a fair value model is applied under a high threshold. Finally, fewer adjustments made on large market movement days helps ensure the transparency of closing prices, a key factor when making fair value adjustments. In short, a "good" threshold strikes a balance between performance and the costs of manual intervention, and realistic considerations would suggest a level of 2-3% for the average international fund.

Tracking Error

One other consideration requires mention in this regard. Fair value pricing can introduce unintended tracking error for a fund relative to its benchmark. If a fund uses fair value adjustments, but the public benchmark is based on closing prices, then there will likely be greater performance dispersion simply because the benchmark is using stale foreign prices to calculate its index price. Likewise, short-term performance can be distorted if different fund complexes adopt different fair value methodologies. These effects should reverse the next day, but fair value pricing nonetheless complicates the evaluation of fund performance. One solution to this problem is for index providers to also compute fair value adjusted benchmarks. This requires some agreement on the form of the fair value model and its implementation.

Conclusions

A rigorous, consistently applied, fair value model is a highly effective tool in reducing arbitrage profits and market timing. The use of this tool simultaneously helps a fund complex comply with SEC guidance regarding fund pricing. No "market standard" model has yet to emerge as providing the 100% solution to accurately reflecting the 4:00 p.m. ET market value for international stocks. This is an ongoing area of research, but even relatively simple factor models effectively reduce arbitrage profits. One of the benefits of a simpler factor model is that it is practical to implement. This is important given the need for mutual fund complexes to produce reliable, error-free price adjustments in a short time window. It also enables one to easily interpret the daily results and explain why adjustments in certain stocks are needed. Apart from deciding on which fair value model to use, fund complexes need to determine the appropriate use of fair value pricing. There is a tradeoff to be made between the expected reduction in arbitrage opportunity that is generated by using a lower threshold for fair value adjustments, and keeping the number of adjustments to the actual closing prices down in order to preserve price transparency.

Despite the clear benefit to long term shareholders of using fair value pricing, there are issues of implementation that are currently problematic. Public benchmark providers have yet to produce fair-value adjusted indices. This potentially exaggerates the true tracking-error of a fund. Different fund groups are implementing different fair value models. This results in distortions of one-day returns between funds. Greater customer education will be required in order to explain these differences until a common standard for adjustments is formulated.

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