Financial Econometrics Research Centre

WORKING PAPERS SERIES

WP02-09

Noise Training, Costly Arbitrage and Asset Prices: evidence from closed-end funds

Gordon Gemmill and Dylan Thomas

Noise-Trading, Costly Arbitrage, and Asset Prices: Evidence from Closed End Funds

GORDON GEMMILL and DYLAN C. THOMAS*

ABSTRACT

If arbitrage is costly and noise traders are active, asset prices may deviate from fundamental values for long periods of time. We use a sample of 158 closed-end funds to show that noise-trader sentiment, as proxied by retail-investor flows, leads to fluctuations in the discount. Nevertheless, we reject the hypothesis that noise-trader risk is the cause of the long-run discount. Instead we find that funds which are more difficult to arbitrage have larger discounts, due to: (i) the censoring of the discount by the arbitrage bounds, and (ii) the freedom of managers to increase charges when arbitrage is costly.

* Faculty of Finance, City University Business School, London. We would like to thank the editor, Richard Green, and especially the anonymous referee for constructive suggestions in improving the paper. Other helpful comments were made by Meziane Lasfer, Mark Salmon and seminar participants at City University, Maastricht University and the European Financial Management Association (June 2000).

DeLong, Shleifer, Summers, and Waldmann (1990) (hereafter DSSW) describe a market as a contest between arbitrageurs, whose expectations are rational, and noise traders, whose expectations are based on sentiment. Not only does an arbitrageur have to manage the fundamental risk on a position, but he (she) also bears "the risk that noise traders' beliefs will not revert to their mean for a long time and might in the meantime become even more extreme" (DSSW, page 704). The result is that the price of an asset may fluctuate in a band around fundamental value, the width of the band depending on the cost of arbitrage and the number of noise traders. Furthermore, if noise-trader risk is systematic (rather than idiosyncratic), it will need to be rewarded and the asset price will trade at a discount to fundamental value.

Closed-end funds provide an ideal laboratory in which to test for the impact of noise trading: They frequently sell at a discount to net-asset value; and they are predominantly held by small investors, whose trading is likely to be based on sentiment. Lee, Shleifer, and Thaler (1991) (hereafter LST) argue that the discount moves in a similar way to returns on small firms, indicating a common small-investor risk factor, but this is disputed by Chen, Kan, and Miller (1993), Brauer (1993), and Elton, Gruber, and Busse (1998).

In this paper we use a relatively large sample of closed-end funds in the U.K. to explore what causes a discount and what causes it to fluctuate. Our key finding is that closed-end-fund discounts are the result of the dynamic interplay between noise traders on the one hand and rational arbitrageurs on the other. Consistent with the noise-trader model of DSSW and LST, we find that changes in discounts are a function of time-varying noise-trader demand (as proxied by retail fund flows). Contrary to the noise-trader model, discounts are not larger for funds which have more discount risk. Rather, the level of the discount is driven primarily by arbitrage costs and managerial expenses.

In the first part of the paper we argue that the *existence of a discount* is a rational phenomenon. We demonstrate why arbitrage may be more effective in curtailing the development of a premium than of a discount, leading on average to a discount. We also show how the present value of agency costs can lead to a discount, but one which is not sensitive to changes in interest rates. A sample of 158 U.K. equity funds is used to test these propositions as well as the alternative noise-trader hypothesis.

In the second part of the paper we examine whether noise-trader sentiment can explain *fluctuations in the discount*. We find that monthly flows of retail investment into particular sectors are closely related to changes in sector discounts. We also find over 30 years that there have been smaller discounts when retail investors have held more shares. It therefore appears that small-investor sentiment not only affects the discount in the short-term but may also influence its level over periods of several years.

While the application in this paper is to U.K. equity funds, it would be surprising if the same factors were not influential in the U.S. Both countries have experienced a large average discount over the last three decades (18 percent in the U.K. and 14 percent in the U.S.) and in both the discount has ranged from less than five percent to more than 35 percent – see Figure 1. A particular advantage of using U.K. data is that the number of closed-end equity funds is much larger than in the U.S. [1]

{INSERT FIGURE 1 ABOUT HERE}

This paper is written in five sections. In Section I, we establish which factors might cause a discount. In Section II, we introduce the sample and note its changing composition over time, as funds are launched or wound-up. In Section III, we use this sample to make cross-section tests of the factors determining the average discount. In Section IV, we examine why prices fluctuate and test for the influence of noise-trader demand using data on flows. In Section V, the conclusions and implications of this research are drawn together.

We define the premium as (share price – net asset value)/(net asset value) and the discount as a negative premium. For example, if the share price is 90 and the net asset value is 100, the premium is -10 percent and the discount is +10 percent.

I. Determinants of the Long-Run, Equilibrium Level of the Discount

The aim of this section is to establish those factors which might cause a discount to exist in the long-run and to develop testable hypotheses. The factors to be considered include arbitrage bounds, agency costs, and systematic noise.

A. Arbitrage Bounds and the Discount

We begin by assuming that the discount is subject to fluctuations and examine how arbitrage leads to bounds at upper and lower levels. *The upper bound* (for example a discount of +30 percent) arises in two ways. The first way is a traditional arbitrage in which shares in the closed-end fund are purchased and the underlying assets are sold short. The expected profit on such an arbitrage which has a holding period of T years is:

$$E(profit)_T = -P_0(1 + r_{fb} - div_p)^T + NAV_0(1 + r_{fl} - div_{nav})^T \qquad (1)$$

where P_0 is the share price of the fund, r_{fb} is the risk-free borrowing rate, div_p is the dividend yield on the share, r_{fl} is the risk-free lending rate, and div_{nav} is the dividend yield on the underlying portfolio. The first component on the right-hand side is the cost of buying and holding the closed-end fund share; the second component is the benefit from holding the short position in the underlying assets.

This arbitrage is not undertaken until the discount is large enough to cover both lost interest and replication risk.[2] The higher the interest rates, the higher will be the bound, because of the increased carrying costs. If the long position in the fund gives a higher dividend yield than is paid out on the short position (i.e., if $div_p > div_{nav}$), then the bound may be reduced. There may therefore be tighter bounds for funds with higher dividend yields, as argued by Pontiff (1996).

For the empirical work, we estimate the difficulty of this arbitrage by regressing monthly net-asset-value returns of each fund (from January 1992 to May 1998) on the returns of the FTSE100, NK225, and S&P500 indices and then using the residual variance (in percent) as a measure of replication risk.[3] For example, the replication risk for the Edinburgh U.K. Tracker Fund is only 5.4 percent, whereas the replication risk for the Montanaro U.K. Smaller Fund is 93.4 percent.

The second way in which an upper bound arises is that funds which trade at large discounts are likely to become targets for re-organization or winding-up, with repayment to shareholders at the net-asset value.[4] The chance of "open-ending" is a powerful force which prevents the discount from becoming very large. Like a spring being placed under tension, the further it is pushed the more strongly it recoils. One way of considering this effect is to view shareholders as having an "open-ending put option", which moves into-the-money as the discount increases and the probability of exercise simultaneously rises. This is analogous to the chance that an underperforming company will be taken over and has an impact on price even if the event does not subsequently occur (Wansley, Roenfeldt, and Cooley (1983)).[5]

Traditional arbitrage is expensive and open-ending is strongly resisted by two influential parties: The incumbent managers, whose jobs are at risk; and blockholders, who obtain private benefits from the status quo (as described by Barclay, Holderness, and Pontiff (1993)). The result is that the discount can often reach 30 percent before the upper bound is reached.

The lower bound to the discount (i.e., a limit to the premium) arises from the relative ease with which new funds can be issued. For example, Levis and Thomas (1995) indicate that during a "hot" period in the U.K. it only takes a few weeks for new issues to be made. U.S. evidence that new issues are carefully timed is given by LST and by Burch and Hanley (1996). The result is that the lower bound lies somewhere around a discount of negative five percent.[6] In making a new issue, the organizing managers are implementing an arbitrage in which the overvalued shares are sold (to the public) and the portfolio is purchased. The managers are able to capture a small risk-free profit because of their new mandate. There is also evidence from the U.S. that the underwriters, who may be associated with the managers, retain most of their six to eight percent fee (Hanley et al. (1996)).

The upper and lower bounds thus restrict the discount to an approximate channel of +30 percent to negative five percent. Because the lower bound of negative five percent constrains the right-hand part of the distribution more than the upper bound of +30 percent constrains the left-hand part of the distribution, the mean of the distribution is affected. This is illustrated in Figure 2. If the net-asset value and price are initially lognormally distributed (before constraints), then the discount (measured as their ratio) will also be lognormal. Assuming a 25 percent annual volatility for both net-asset value and price and a correlation of 0.9, the resulting volatility of the unconstrained discount is 11.2 percent. The censoring of the distribution (within the +30 percent to negative five percent range) would, under these conditions, result in an average discount of +5.87 percent. [7]

{INSERT FIGURE 2 ABOUT HERE}

If censoring is present, it should manifest itself empirically in two different ways. First, funds which are easier to replicate should have smaller discounts, because less replication risk will reduce the upper bound while leaving the lower bound (which depends on making new issues) virtually unaffected. This is tested in the cross-section regressions of Section III. Second, the probability distribution of a fund's discount should exhibit a particular shape, consistent with Figure 2: The tails should be cut off, giving low kurtosis; and the distribution should be skewed, because of the more severe constraint on the lower side than on the upper. This is tested at the beginning of Section III.

B. Agency Costs and the Discount

The view that the discount is the present value of deadweight agency costs is an old one (Ingersoll, 1976), but it does not have much empirical support (e.g., Malkiel (1977, 1995)). LST and Pontiff (1996) both reject the simple expenses hypothesis because discounts are not sensitive to the level of interest rates. Agency costs could lead either to a discount or a premium, depending on whether higher management expenses are more than offset by superior performance. As a preliminary, we estimate a simple market model of excess net-asset-value returns on each of the 158 funds as a linear function of excess returns on its relevant index, using monthly data for the period December 1991 to May 1998. The resulting Jensen's alphas are significantly negatively related in cross-section to expense ratios. [8] This indicates that larger expense ratios are not justified by superior contemporaneous performance in our sample. [9]

If expenses are a constant proportion of contemporaneous cashflows, then it is trivial to show that the discount equals that proportion (see Appendix A; also Ammer (1990) and Kumar and Noronha (1992)). Formally, we may write:

$$DIS_0 = \frac{X_0}{C_0} \tag{2}$$

where DIS is discount, X is expenses, C is cashflow, and the subscript denotes time.

If we apply this formula to the 20 oldest funds in our sample over 1992 to 1997, it predicts a value-weighted discount of 12.0 percent (see Table I, penultimate row). This is reasonably close to the observed discount of 9.9 percent, especially if some allowance is made for the convenience of delegating management. However for the 20 youngest funds in our sample, the model implies a discount of 27.1 percent, compared with the observed discount of only 1.25 percent (see Table I, final row). Clearly something is wrong with the simple expenses theory.

{INSERT TABLE I ABOUT HERE}

The problem is that the ratio of expenses-to-cashflow is not constant over the life of a fund, but declines with age. When new funds are launched they have both high expenses and low cashflows. It is therefore more realistic to argue that the discount on a fund reflects the *long-term* expenses-to-cashflow ratio rather than its level today (just as the market price of a company reflects its long-term ability to pay dividends and not its dividend today). While the long-term expenses-to-cashflow ratio is not observable, it can be proxied by the current expenses-to-NAV ratio (where NAV is net asset value). We therefore re-write Equation (2) as:

$$DIS_0 = \theta \frac{X_0}{NAV_0} \tag{3}$$

where θ (>0) is a constant across all closed-end funds. Equation (3) implies that the discount will be larger for funds which have larger expenses-to-NAV ratios (hereafter called expense ratios).

C. Taxes, Illiquid Stock and the Discount

Malkiel (1977, 1995) argues that the discount is an illusion, because the net-asset value of a fund is overstated due to potential capital-gains tax and to illiquidity of assets. However, tax cannot explain the U.K. discount as it has not been levied on closed-end funds since 1980. With respect to illiquid stock, Draper and Paudyal (1991) find the effect to be insignificant in the U.K.. In addition, when a closed-end fund is open-ended, the share price rises to the net-asset value in both the U.S. and the U.K., so the net-asset value does not appear to be overstated (Brauer (1984,1988) for the U.S., and Draper (1989) and Minio-Paluello (1998) for the U.K.). We therefore omit these factors from our study.

D. Other Factors which Potentially Increase the Discount: Old Age, Small Size, and Systematic Noise

Three other factors may affect the discount and need to be taken into account in a cross-sectional analysis. First, new funds are issued in "hot periods" when sentiment for a particular sector is positive. If this sentiment persists for a year or two, then the age of a fund may be positively related to its discount. As noted, the 20 oldest funds have a discount of 9.90 percent and the 20 youngest of 1.25 percent, which is consistent with this argument.

Second, large funds enjoy a liquidity premium because they can be traded rapidly and with a low bid/ask cost. At the same time, fund size will affect the expense ratio due to economies of scale, so it may also have an indirect effect on the discount via lower expenses.

Third, as DSSW argue, systematic noise which cannot be diversified will require a reward, reflected in a discount. We have confirmed for our U.K. sample that changes in discounts tend to move in harmony. We have then estimated a simple regression of changes in the discount for each of the 158 funds on changes in the average value-weighted discount. If systematic noise is the cause of the discount, the size of the discount on a fund should be related to its "discount beta". We test for this relationship.

II. Sample of Funds and Changes in its Composition over Time

Annual data have been assembled from the accounts of 158 U.K.-traded closed-end funds for the years 1991 to 1997 and monthly data have been collected for prices and net-asset values from Datastream for the period December 1991 to May 1998. The chosen funds are those for which the allocation to particular sectors can be matched perfectly between closed-end funds and open-end funds (using the classification by Cazenove & Co. for closed-end funds and by the Association of Unit Trusts and Investment Funds for open-end funds). We include all funds which exist in the 1991 to 1997 period and which have at least two years of accounting data. Details of the average discounts, expense ratios, dividend yields, and sizes of the closed-end funds, categorized by the eleven investment sectors, are given in Table I. The average fund has a net asset value of £126 million ($189 million) and, on a value-weighted basis, a yield of 4.10 percent per annum, an expense ratio of 0.86 percent and a discount of 7.32 percent.

During the sample period, 19 funds disappear and 54 funds are started. Table II makes comparisons of disappearing/new funds with the rest of the sample. The expenses for terminated funds are not significantly higher than for surviving funds, being 1.279 percent and 1.217 percent per annum respectively (see row 2, columns 1 to 2 of the table). By contrast, the expenses for new funds are significantly higher than for old funds (at the 0.1 percent level), being 1.427 percent and 1.119 percent per annum respectively (see row 2, columns 3 to 4 of the table). Similarly, the discounts on funds which disappear are not different from those on surviving funds (6.559 percent versus 5.973 percent), but new funds have significantly smaller discounts (at the 0.1 percent level) than old funds, 3.317 percent as compared with 7.458 percent. In summary, new funds have both high expenses and small discounts.

{INSERT TABLE II ABOUT HERE}

III. Empirical Tests

At first we test whether the distribution of the discount shows evidence of being squeezed asymmetrically, consistent with the presence of upper and lower bounds. If censoring is present, we expect to find: (i) the distribution is skewed to the right, because of the asymmetry; and (ii) the tails of the distribution are cut off, leading to reduced kurtosis relative to the distributions for prices and net-asset values. In order to avoid any new-issue bias, the sample is limited to the 20 oldest funds from the sample of 158 funds.

Table III reports how many of the 20 funds have discount distributions showing skewness, kurtosis, and non-normality. Consistent with asymmetry of censoring, 10 of the discount distributions show right-skewness, compared with only five of the net-asset-value distributions and five of the price distributions. Consistent with the tails being cut off, only six of the discount distributions show excess kurtosis, compared with eight of the net-asset-value distributions and 10 of the price distributions. Combining skewness and kurtosis, only five of the discount distributions show significant non-normality (according to the Jarque-Bera test at the five percent significance level), compared with 10 of the net-asset-value distributions and 11 of the price distributions.

{INSERT TABLE III ABOUT HERE}

There is therefore some evidence that the upper and lower arbitrage bounds re-shape the discount distribution. At the same time, censoring has the convenient effect of making the distribution of the discount more normal than it would otherwise be. Considering the whole set of 158 funds, 28 percent of the distributions of the individual fund discounts are significantly non-normal, which is comparable to 25 percent of the distributions of net-asset-value returns but contrasts with 56 percent of the distributions of price-returns. This suggests that further analysis of the discount data can proceed without an explicit correction for censoring.

We estimate a cross-section regression of the form:

$$\begin{aligned} DISCOUNT_i = {} & a + bEXPENSE_i + cBETADISC_i + d\log(AGE_i) + eRESERR_i \\ & + fDIV_i + g\log(SIZE_i) + error_i \end{aligned} \tag{4}$$

where the discount (DISCOUNT), expense ratio (EXPENSE), and dividend yield (DIV) are measured as averages over the seven years, BETADISC is the individual fund sensitivity to the value-weighted average discount and represents a systematic noise factor, age (AGE) is measured in years, RESERR is the residual error from a replicating regression of fund net-asset-value returns on market indices, and SIZE is the average market value of a fund over the sample period. The subscript *i* denotes company. From the theory, we expect to find positive values for coefficients *b* (expenses), *c* (noise factor), *d* (log age), and *e* (replication risk); negative values are expected for *f* (dividend yield) and *g* (log size).

The data are averaged over the seven years available, rather than considered year-by-year, because the aim is to explain differences in long-run average discounts across funds rather than short-run variation. [10] Dummy variables for sectors are not included because much of the variation in factors is larger between sectors than within them.

The estimated coefficients of the equation are given in column 1 of Table IV. [11] The results indicate that all of the variables are significant at the one percent level, except size which is significant at the five percent level. However, one of these variables has an unexpected sign: Funds which bear more systematic noise risk (BETADISC) have significantly smaller (rather than larger) discounts. Because the noise-factor variable is measured with error, we have repeated the analysis with Fama-McBeth regressions on data grouped into 16 classes by size of noise factor. The result is unchanged. [12] This leads us to reject very clearly the view of LST that noise trading is a priced factor which causes the discount.

{INSERT TABLE IV ABOUT HERE}

The significantly negative sign on the noise factor is a puzzle, for it seems implausible that investors actively seek exposure to funds with more non-diversifiable discount-risk. [13] We therefore exclude the BETADISC variable and the revised results are given in column 2 of Table IV. Log of age, replication risk, and log of size remain significant at the 1 percent level, but the dividend yield is only significant at the 10 percent level and the expense ratio is no longer significant. The significant variables may be considered in turn: (i) The coefficient on log of age indicates that for each one percent increase there is a 0.04 percentage point increase in the discount. This implies, for example, that the average three-year-old fund has a discount which is 1.62 percentage points larger than the average two-year-old fund. (ii) The positive relationship of discount to replication risk is consistent with our hypothesis that the discount is larger if the upper arbitrage bound is higher and it confirms previous U.S. and U.K. empirical results (Pontiff (1996) and Dimson and Minio-Kozerski (1998)). (iii) The importance of size has been noted in many other studies. (iv) The result on dividend yield is consistent with Pontiff.

The surprise is that larger expenses are not significantly associated with a larger discount, but this appears to be because of collinearity among the explanatory variables. Expenses are large for funds which are new, difficult to replicate and small. The simple correlation of expense ratios with each of these variables (see Table V) exceeds 0.5 in absolute value. By contrast the simple correlation of the discount with other variables exceeds 0.12 in absolute value with only one other variable, age of fund. A multiple regression confirms the significant relationship of each of these variables to expenses, as reported in column 3 of Table IV. It is therefore clear that three variables which are most closely related to the size of the discount log of age, replication risk, and log of size are also closely related to the expense ratio.[14]

{INSERT TABLE V ABOUT HERE}

The reason why management expenses are not directly related to the discount in the cross-section is due to new funds. These are launched in hot periods when there are negative discounts and this provides managers with the opportunity to charge high expenses. The positive sentiment towards new funds at the time masks the potentially negative impact of their high expenses. If a parsimonious regression is run of the discount as a function of expense ratio and age of fund only, the expense ratio is significantly related to the discount at the 1 percent level (see column 4 of Table IV).

The conclusions from this cross-sectional analysis are as follows. We find no support for the hypothesis that noise-trading is a priced factor which is rewarded by the discount. Instead we find that a fund's discount depends mainly on how costly it is to arbitrage. Funds which are small, difficult to replicate, and have low dividend yields have large discounts. Difficulty of replication increases the discount because it raises the upper arbitrage bound, while leaving the lower bound unchanged. Higher management expenses also contribute to a larger discount, although this relationship is masked by the collinearity of expenses with age of fund and cost of arbitrage.

IV. Investor Sentiment and the Discount in Time Series

A. Investor Sentiment and the Sector Discount

Having considered why there is a long-term discount, the focus now shifts to explaining why the discount changes over time. We hypothesise that the discounts on closed-end funds are moved from equilibrium by flows of money, which reflect the "sentiment" of small investors rather than fundamentals. This hypothesis is controversial. For example, Warther (1995, pp. 232 to 233, italics added) notes: "The popular press regularly quotes analysts who declare that mutual fund flows are the new indicator of investor sentiment. *It is therefore curious that fund flows have no discernible relation to closed-end fund discounts*, which are another often-cited measure of investor sentiment".[15]

We use monthly time-series data for January 1992 to March 1998 for the 158 closed-end funds in our sample. Data are available (from the trade organization representing managers) on retail-investor flows into/out-of open-end funds by investment sector.[16] We group the closed-end funds into equivalent sectors and use the value-weighted average discount for each sector as the variable to be explained. The sectors and numbers of companies in each are listed in Table I.

Figures 3a and 3b are representative plots for two sectors (Japan and North America) which suggest that there is a very strong negative impact of retail flows on the discount. Plots for other sectors are similar. We hypothesize that the discount and retail flows are co-determined. While retail flows may affect the discount, it may also be the case that a small (or negative) discount attracts flows. We therefore proceed by testing whether there is a cointegrating relationship between the level of discount and retail-investor flows, of the general form:

$$DISCOUNT_{jt} = a + bFLOW_{jt} + V_{jt} \tag{5}$$

where DISCOUNT is the sector discount, FLOW is the monthly retail inflow/outflow to open-end funds in the same sector (standardized by the total market value at the beginning of each month of open-end funds investing in that sector), V is a disturbance term, subscript j denotes sector, and subscript t denotes month.

{INSERT FIGURES 3a AND 3b ABOUT HERE}

Equation (5) is an equilibrium (long-run) relationship which is estimated with short-run (monthly) data. Partial autocorrelations and Augmented Dickey-Fuller tests confirm that flows and discounts cannot be distinguished from I(1) processes for each of the eleven sectors.[17] We then test for cointegration, using the procedure of

Johansen (1995). The likelihood ratio test rejects the hypothesis of no cointegration at the one percent level for all sectors (Table VI, column 1). The coefficients of the cointegrating equation (5) are estimated for each of the 11 sectors and also a two-equation Vector Error Correction (VEC) model, using maximum likelihood methods. The change in interest rates is stationary and introduced as an exogenous variable.[18]

{INSERT TABLE VI ABOUT HERE}

The two VEC equations are of the form:

$$\Delta DISCOUNT_{jt} = c + d(DISCOUNT_{jt-1} - a - bFLOW_{jt-1}) + e\Delta INT_t + error_{jt} \quad (6)$$

and

$$\Delta FLOW_{jt} = f + g(DISCOUNT_{jt-1} - a - bFLOW_{jt-1}) + h\Delta INT_t + error_{jt} \quad (7)$$

where the terms in parentheses on the right-hand-side are feedbacks from (5), the so-called error-correction terms, and ΔINT is the change in interest rates.

The estimated coefficients for the cointegrating equation (5) for each sector are listed in Table VI, columns 2 and 3. In all 11 sectors there is a negative long-run relationship between retail-investor flows and the discount; the relationship is significant (at the five percent level or better) for eight of the 11 sectors.[19] Together with the evidence on the existence of cointegration, this is the most important result of the time-series analysis. In contrast to the statement by Warther (1995), we find that *retail-investment flows in the U.K. have a clearly discernible relationship to closed-end-fund discounts.*

The estimated coefficients of the VEC equations are given in Appendix B.[20] Two results are worthy of note. First, the coefficient on change in interest rate is not significant in any equation, which is consistent with all previous U.S. and U.K.

studies. Second, for all 11 sectors the error-correction comes via the coefficient *g* in (7) and not via the coefficient *d* in (6). In other words, it appears that the adjustment to equilibrium comes initially from an adjustment to flows rather than an adjustment to the discount.[21]

In order to measure the speed of adjustment, a shock was administered to flows and its impact on the level of discount imputed. Column 4 of Table VI indicates that about half of the adjustment (range 40 percent to 63 percent) is completed after two months. This is consistent with retail investors becoming interested in a particular sector and large inflows occurring, driving up the premium on existing closed-end funds. The countervailing response in the form of new issues takes only a month or two.

In summary, the cointegration analysis indicates a highly significant relationship between retail-investor flows and closed-end-fund discounts. This is strong evidence in favor of the hypothesis that retail-investor sentiment is responsible for movements of the discount.

B. Long-run Impact of Small-investor Holdings on the Discount

It remains to explain why the average discount moves so much over periods of several years, e.g., from 22 percent in January 1986 to four percent in January 1994. A cursory examination of Figure 1 indicates that there is an increasing trend in the discount to the mid-1970s, followed by a long diminishing trend to the mid-1990s. Because these trends are extremely long, the analysis of this section can only be suggestive rather than conclusive.

Consistent with the previous section, we hypothesize that the discount depends on the flow of investment from small shareholders. To test this hypothesis, we use annual data on the proportion of shares held by retail investors in Foreign and

Colonial Investment Trust from 1970 to 1999. Foreign and Colonial is the largest U.K. closed-end fund over this period and representative of the whole universe: Its monthly discount tracks the average discount for all funds with a correlation of +0.94.

Figure 4 plots the proportion of the fund's shares held by retail investors and the annual average premium (negative discount) over the 30 years. The correlation is +0.83. If a linear relationship between the two variables is assumed, when retail investors hold half of the shares, the discount is five percent; when retail investors reduce their holdings to one quarter of the shares, the discount rises to 25 percent.

{INSERT FIGURE 4 ABOUT HERE}

This analysis is consistent with there being swings in small-investor sentiment which persist for several years, as retail investors build-up and reduce their holdings (of this representative closed-end fund). It suggests that sentiment may not only cause short-term swings in discounts on individual funds, but also long-term swings in the average discount for all funds.

V. Conclusions

This paper has examined how noise trading and costly arbitrage interact to cause asset prices to deviate from fundamental values. The focus has been on closed-end funds because they have transparent prices and values. We have addressed two particular questions: Why there are fluctuations of the price relative to net-asset value (i.e., why there are fluctuations of the discount), and why there is an average discount in the long-run.

In relation to fluctuations of the discount, we find that they are strongly influenced by small-investor sentiment from month-to-month and possibly from year-to-year. Using disaggregated flows to 11 individual U.K. sectors over 75 months, we show that retail flows to a particular sector have a very significant influence on the contemporaneous level of the discount. Noise generated by small investors does affect asset prices. We also find, over the last 30 years, that when small investors reduce their holdings of the largest U.K. closed-end fund, its discount tends to widen. The implication is that noise may have a low-frequency, as well as a high-frequency, impact on asset prices.

In relation to the existence of a long-run discount on closed-end funds, we find that it is not an anomaly. Noise trading causes a fund's price to move relative to net-asset value, but that movement is constrained by upper and lower arbitrages. For a fund which is difficult to replicate, it is possible for a large discount to develop before arbitrage or open-ending is profitable. By contrast, a large premium does not exist for very long because new issues can be launched quickly, which is profitable for the managers. The interaction between noise and arbitrage, the former moving the price and the latter constraining its movement to a particular channel, leads to the existence of a discount. In addition, when arbitrage is costly the managers have the freedom to set relatively high charges and this contributes to the discount.

Cross-sectional data on 158 U.K. funds over 1991 to 1997 confirm that the discount is large for funds which are expensive to arbitrage, i.e., for those which are difficult to replicate, are small, and have low dividend yields. Such funds also have high management expenses. The hypothesis that the discount is the result of a priced sentiment factor, along the lines suggested by DSSW and LST, is not supported in the cross-section. Noise traders do not appear to "generate their own rewards".

Many questions remain for further research. Investor sentiment may be related to the level of the stockmarket, but what causes investor sentiment to become so positive that new issues of closed-end funds are possible? One possible answer would be if other avenues for specialized investment do not exist at the time, so small investors worry about the potential opportunity loss from not investing immediately. However, rationality would also require that small investors in new funds are well informed, whereas there is evidence from both the U.S. and U.K. that they are not (see Hanley, Lee and Seguin (1996) and Gemmill and Thomas (1997)). In this we concur with LST who observe that "closed-end funds are a device by which smart entrepreneurs take advantage of a less-sophisticated public" (page 84). The matter is important, because it implies that tighter regulation of financial services may be desirable.

Another potential line of research concerns the governance and open-ending of funds. U.S. research indicates that funds with less independent directors have higher expenses (Dann, Del Guercio, and Partch (2000)), suggesting a conflict between shareholders and the board. It is surprising that wide levels of discount can persist for such long periods without a takeover occurring. Barclay, Holderness, and Pontiff (1993) relate this to friendly blockholders who resist open-ending, but another possibility is that management groups have interlocking directorships, leading to implicit collusion across funds (Rowe and Davidson (1999)). Anecdotal evidence in the U.K. indicates that fund managers do not engage in predatory behavior for fear that other managers will not support their new issues thereafter. Much more might be revealed in this area.

Finally, it would be interesting to replicate our cross-sectional tests with U.S. data and thereby verify, in a different environment, that it is the interplay of noise, arbitrage, and expenses which causes closed-end funds to trade at market prices that are less than fundamental values.

REFERENCES

Ammer, John, 1990, Expenses, yields and excess returns: New evidence on closed-end fund discounts from the U.K., Discussion paper 108, Financial Markets Group, London School of Economics.

Barclay, Michael J., Clifford G. Holderness, and Jeffrey Pontiff, 1993, Private benefits from block ownership and discounts on closed-end funds, *Journal of Financial Economics* 33, 263-291.

Brauer, Greggory A., 1984, Open-ending closed-end funds, *Journal of Financial Economics* 13, 491-507.

Brauer, Greggory A., 1988, Closed-end fund shares' abnormal returns and the information content of discounts and premiums, *Journal of Finance* 43, 113-127.

Brauer, Greggory A., 1993, Investor sentiment and the closed-end fund puzzle: A 7 percent solution, *Journal of Financial Services Research* 7, 199-216.

Burch, Timothy, and Kathleen Weiss Hanley, 1996, When are closed-end funds open? Rights offers as a response to premiums , Working paper, University of Maryland.

Chay, Jong-Boon, and Charles A.Trzcinka, 1999, Managerial performance and the cross-sectional pricing of closed-end funds, *Journal of Financial Economics* 52, 379-408.

Chen, Nai-Fu, Raymond Kan, and Merton Miller, 1993, Are the discounts on closed-end funds a sentiment index? *Journal of Finance* 48, 795-800.

Coles, Jeffrey L., Jose Suay, and Denise Woodbury, 2000, Fund advisor compensation in closed-end funds, *Journal of Finance* 55, 1385-1414.

Dann, Larry Y., Diane Del Guercio, and Megan Partch, 2000, Governance and boards of directors in closed-end investment companies, Working paper, University of Oregon.

Delong, J. Bradford, Andrei Shleifer, Lawrence Summers, and Robert J. Waldmann, 1990, Noise trader risk in financial markets, *Journal of Political Economy* 98, 703-738.

Dimson, Elroy, and Carolina Minio-Kozerski, 1998, The closed-end fund discount and performance persistence, Working paper, London Business School.

Dimson, Elroy, and Carolina Minio-Kozerski, 1999, Closed-end funds: A survey, *Financial Markets Institutions and Instruments* 9, 1-41.

Draper, Paul, 1989, *The Investment Trust Industry in the U.K.: An Empirical Analysis* (Gower Press, London).

Draper, Paul, and Krishna Paudyal, 1991, The investment trust discount revisited, *Journal of Business Finance and Accounting* 18, 791-806.

Elton, Edwin, Martin J. Gruber, and Jeffrey A. Busse, 1998, Do investors care about sentiment? *Journal of Business* 71, 477-500.

Gemmill, Gordon, and Dylan C.Thomas, 1997, Warrants on the London Stock Exchange: Pricing bias and investor confusion, *European Finance Review* 1, 31-49.

Goetzmann,William N., Massimo Massa, and K.Geert Rouwenhorst, 2000, Behavioral factors in mutual fund flows, Working paper, International Center for Finance, Yale University.

Hanley, Kathleen Weiss, Charles M.C. Lee, and Paul J. Seguin, 1996, The marketing of closed-end fund IPOs: Evidence from transactions data, *Journal of Financial Intermediation* 5, 127-159.

Ingersoll, Jonathan, 1976, A theoretical and empirical investigation of the dual purpose funds, *Journal of Financial Economics* 3, 81-123.

Johansen, Soren, 1995, *Likelihood-based Inference in Cointegrated Vector Autoregressive Models* (Oxford University Press, Oxford).

Kumar, Raman, and Gregory N. Noronha, 1992, A re-examination of the relationship between closed-end fund discounts and expenses, *Journal of Financial Research* 15, 139-147.

Lee, Charles, Andrei Shleifer, and Richard Thaler, 1991, Investor sentiment and the closed-end fund puzzle, *Journal of Finance* 46, 75-109.

Levis, Mario, and Dylan C. Thomas, 1995, Investment trust IPOs: Issuing behavior and price performance, *Journal of Banking and Finance* 19, 1437-1458.

Malkiel, Burton G., 1977, The valuation of closed-end investment company shares, *Journal of Finance* 32 , 847-859.

Malkiel, Burton G., 1995, The structure of closed-end fund discounts revisited, *Journal of Portfolio Management* 21, 32-38.

Margrabe,William, 1978, The value of an option to exchange one asset for another, *Journal of Finance* 33, 177-186.

Minio-Paluello, Carolina, 1998, *The U.K. Closed-End Fund Discount*, Ph.D. thesis, London Business School.

Pontiff, Jeffrey, 1996, Costly arbitrage: Evidence from closed-end funds, *Quarterly Journal of Economics* 111, 1135-1151.

Rowe,Wei Wang, and Wallace N. Davidson, 1999, Do the boards of directors and blockholders protect closed-end fund shareholders from excessive expenses? Working paper, University of Nebraska.

Wansley, James W., Rodney L. Roenfeldt, and Philip P. Cooley, 1983, Abnormal returns from merger profiles, *Journal of Financial and Quantitative Analysis* 18, 149-163.

Warther,Vincent A., 1995, Aggregate mutual fund flows and security returns, *Journal of Financial Economics* 39, 209-235.

Endnotes

[1] There have been more than 300 U.K.-traded closed-end equity funds in existence thoughout the 1990s, as compared with less than 100 in the U.S. Closed-end funds are about 25 percent of the value of open-end funds in the U.K., whereas in the U.S. they are only two percent of the value of open-end funds (Dimson and Minio-Kozerski (1999)).

[2] Impediments to the arbitrage are: (a) the exact composition of the underlying portfolio is not known so there is some uncertainty about the required short position; (b) the interest received on the short position, r_{fl} , may be much less than that paid on the long position, r_{fb}; and (c) the length of time for which the position needs to be held is unknown.

[3] A similar approach is used by Pontiff (1996) and Dimson and Minio-Kozerski (1998).

[4] For example, Brauer (1984) finds that 14 U.S. funds which open-end have discounts which are 7.4 percent more on average than for a matched equivalent sample, when measured one year in advance of the event.

[5] A note on the value of the open-ending put, based on Margrabe's (1978) model for the exchange of assets, is available from the authors.

[6] Strictly speaking, this is not an arbitrage bound unless well-informed investors buy the IPO and sell the portfolio, reversing the position after the issue.

[7] The new mean of 5.87 percent is found by integrating over the censored distribution, assuming that the discount is a continuous random walk and does not "stick" at the bounds.

[8] A plot is available from the authors on request. We are grateful to James Govan for making this test.

[9] A slightly different aspect of agency is whether funds which have low discounts perform better than other funds. Chay and Trzcinka (1999) show that U.S. funds with smaller discounts thereafter have superior net-asset-value performance, but this does not appear to happen in the U.K. (Dimson and Minio-Kozerski (1998)). The marginal compensation of managers also has an influence on the discount in the U.S. (Coles, Suay, and Woodbury (2000)), but the magnitude is small. In our sample, there is no evidence of a relationship between the discount and performance over the whole December 1991 to May 1998 period.

[10] We have tested for the impact of using a different measure of the long-run discount, based upon an autoregression of the discount from month to month. The new measure has an 80 percent correlation with the simple average discount and if it is used the results are not changed substantially.

[11] Equation (4) has been estimated with weighted least squares, in order to take account of heteroskedasticity. The weighting variable used is the volatility of the discount from monthly data, which is likely to be a particularly good proxy (when squared) for the error variance. If a White correction is used instead, the results are not significantly changed.

[12] In a Fama-McBeth regression with all of the above variables, the coefficient of BETADISC is negative and significant at the 10 percent level. In a regression with Log of Age, Residual Error, and BETADISC on the right-hand side, the coefficient on BETADISC is negative and significant at the 0.1 percent level.

[13] If the simple volatility of a fund's discount is used instead of the discount beta, its coefficient is negative but not significant.

[14] There is consistency here with a recent U.S. study by Rowe and Davidson (1999) which finds expenses to be high for young, small funds, and also finds that the simple correlation of expenses and the discount is negative.

[15] There is recent evidence that flows have a large impact on the variance of daily returns for open-end funds (Goetzmann, Massa, and Rouwenhorst (2000)), sugggesting the presence of very short-term sentiment.

[16] The organization is the Association of Unit Trusts and Investment Funds (AUTIF), which represents all managers of U.K.-quoted open-end funds. Every month each manager of a fund is required to submit data on the flows into/out-of that fund, following criteria laid-down by AUTIF. The classification is by investment category and also by retail/institutional flows.

[17] In theory, neither of these variables can be I(1) because their variances are bounded. In practice, they cannot be distinguished from I(1) variables in this sample. We are grateful to Mark Salmon for clarifying this point.

[18] ADF tests confirm that the interest rate behaves as a first-order process and hence is stationary in first differences. However, because of mean-reversion the variance of the interest rate is also bounded and so the comment made in the preceding footnote applies. The three-month sterling inter-bank rate is used.

[19] If two outliers are excluded from flows in the Emerging Markets sector, it also has a significant (five percent) coefficient, making nine out of 11 sectors significant.

[20] As noted at the base of Appendix B, dummy variables were used as extra exogenous variables for the U.K. Composite and U.K. Income sectors, to account for March and April tax-related flows.

[21] Granger causality tests reject the hypothesis that lagged flows cause the discount for all of the sectors. The tests also reject the hypothesis that lagged discounts cause flows for 10 of the 11 sectors, the exception being Japan.

Table I
Descriptive Statistics on Companies by Sector

The table shows statistics for the population of 158 cbsed-end equity funds traded on the London Stock Exchange in the period 1991 to 1997 and which have at least two years of accounting data. Statistics are given for the funds grouped in different ways: by investment sector, for the complete sample, for the 20 oldest funds, and for the 20 youngest funds. Averages are unweighted, unless stated otherwise. The discount is measured as (net asset value – share price)/(net asset value) using month-end data from December 1991 to December 1997. The expense ratio is annual expenses divided by net asset value. Price and NAV data are from Datastream; all other data come from the annual financial statements.

Sector	Number of Funds in the Sample	Average Discount 12/91-12/97 %	Average Expense Ratio 1991-97 %	Average Dividend Yield 1991-97 %	Average Net Asset Value of Fund 1991-97 $m.	Average of Expenses/Cashflow 1991-97 %
Emerging Markets	22	2.86	1.85	2.83	113	40.61
Europe	28	8.76	1.37	2.92	149	33.91
Far East w/out Japan	15	6.94	1.83	2.97	96	40.10
Far East with Japan	5	6.27	0.94	3.30	518	21.10
International (growth and income)	21	11.86	0.75	3.70	351	20.87
Japan	12	-0.65	1.28	1.02	138	55.13
North America	5	7.16	0.94	1.75	215	40.82
Property	3	6.47	1.12	4.49	132	22.24
U.K. Income	16	0.67	0.91	7.49	186	11.37
U.K. Smaller	29	6.43	1.20	4.11	119	24.75
U.K. Composite (growth and general)	13	6.28	0.69	5.18	374	15.61
ALL FUNDS unweighted	158	6.04	1.22	3.73	189	28.21
ALL FUNDS value-weighted	158	7.32	0.86	4.10	189	19.82
20 OLDEST FUNDS value-weighted	20	9.90	0.57	5.02	530	12.02
20 YOUNGEST FUNDS value-weighted	20	1.25	1.18	3.47	93	27.13

Table II
Pairwise Comparisons of Expenses and Discounts for Disappearing versus Surviving and New versus Old Funds

The table shows expense and discount data for disappearing-versus-surviving and old-versus-new funds. The sample is drawn from the population of 158 closed-end equity funds traded on the London Stock Exchange in the period 1991 to 1997 and for which at least two years of accounting data are available. Disappearing funds are those which, for any reason, cease to trade during the sample period; new funds are those which are launched in the sample period. The discount is measured as (net asset value – share price)/(net asset value). The expense ratio is annual expenses divided by net asset value.

Category	**Disappear-ing Funds**	**Surviving Funds**	**New Funds**	**Old Funds**
Number in class	19	139	54	104
Average expense in % per annum	1.279	1.217	1.427	1.119
Standard deviation	0.454	0.549	0.401	0.570
Probability from two-tailed t-test with unequal variances	**0.591**		**0.000**	
Number in class	19	139	54	104
Average discount in %	6.559	5.973	3.317	7.458
Standard deviation	7.948	5.620	5.215	5.788
Probability from two-tailed t-test with unequal variances	**0.759**		**0.000**	

Table III
Frequency Distributions for Prices, Net-Asset Values, and Discounts for the 20 Oldest Funds in the Sample

The table gives the number of funds (out of 20) showing each characteristic (skewness, kurtosis, non-normality). The sample comprises the 20 oldest closed-end funds drawn from the 158 closed-end equity funds traded on the London Stock Exchange in the period 1991 to 1997. Monthly fund prices and NAVs are obtained from Datastream.

Characteristic	Number of Companies Showing the Characteristic		
	Discount Level	Net-Asset Value Level	Price Level
Skewness >0	10	5	5
Net kurtosis > 0	6	8	10
JB statistic 5 % significant	5	10	11

Table IV
Results from Cross-Sectional Regressions to Explain Which Factors Affect the Discount and Which Factors Affect Management Expenses

The table reports cross-sectional regressions for 158 closed-end equity funds traded on the London Stock Exchange in the period 1991 to 1997. Data are averaged for each fund over the sample period. The first column (1) reports a regression of the discount on the full set of explanatory variables. The second column (2) repeats the regression of the first column with the noise-risk beta excluded as an independent variable. The third column (3) reports a regression of expense ratios on other fund attributes. The fourth column (4) reports a parsimonious regression of the discount against the expense ratio and age only. The discount is measured as (net asset value – share price)/(net asset value). The expense ratio is annual expenses divided by net asset value. The individual fund noise beta is the individual fund sensitivity to the value-weighted average discount of the funds in the sample; the replication risk is the residual error from a regression of NAV returns on market indices. Numbers in parentheses are t-values. The symbol * denotes significance at the five percent level and ** denotes significance at the 1 percent level.

Dependent Variable Independent Variables	Average Discount (1)	Average Discount (2)	Expense Ratio (3)	Average Discount (4)
Constant	+0.049 (0.81)	+0.152* (2.48)	+0.029** (5.51)	-0.055** (2.64)
Expense Ratio	+2.992** (2.98)	+0.263 (0.29)		+3.037** (3.51)
Noise Risk Beta	-0.029** (5.03)			
Log of Age	+0.040** (8.77)	+0.039** (8.09)	-0.0011** (2.93)	+0.030** (6.10)
Replication Risk	+0.087** (4.16)	+0.096** (4.27)	+0.0081** (6.25)	
Dividend Yield	-0.0073** (3.60)	-0.0039 (1.89)		
Log of Size	-0.011* (2.11)	-0.022** (4.14)	-0.0016** (3.08)	
R^2 (weighted)	0.52	0.44		0.28
R^2 (unweighted)	0.34	0.27	0.55	0.18
Weighting variable (or procedure for hetero-skedasticity)	Volatility of Discount	Volatility of Discount	(White standard errors)	Volatility of Discount

Table V
Correlation Matrix for Variables in Cross-Sectional Analysis

The table shows the correlations between the average discount (computed monthly over the period 1991 to 1997) of 158 closed-end equity funds traded on the London Stock Exchange and other fund-specific variables computed over the same time period. The discount is measured as (net asset value – share price)/(net asset value). The expense ratio is annual expenses divided by net asset value. The individual fund noise beta is the individual fund sensitivity to the value-weighted average discount of the funds in the sample; the replication risk is the residual error from a regression of NAV returns on market indices. Each cell in the table is a simple correlation.

	Discount	Expense Ratio	Log of Age	Repli-cation Risk	Dividend Yield	Log of Size
Discount	1	-.093	+.398	+.124	-.049	+.037
Expense Ratio		1	-.582	+.592	-.220	-.599
Log of Age			1	-.426	+.296	+.581
Replication Risk				1	-.319	-.392
Dividend Yield					1	+.115
Log of Size						1

Table VI
Results from Cointegration Analysis of Time Series for Discount and Flow of Retail Investment

Sector	Likelihood Ratio for Test of No Cointegration (1 % critical value = 20.04) (1)	Coefficient on Retail Flows in Cointegrating Equation (2)	Constant in Cointegrating Equation (3)	Proportion of Total Response of Premium after Two Months to a Shock to Flows (4)
Emerging Markets	30.45	-11.28 (1.62)	+ 6.11	63 %
Europe	20.96	-61.57 (0.53)	+12.30	43 %
Far East w/out Japan	36.30	-28.52 (4.25)**	+ 6.48	72 %
Far East with Japan	28.58	-13.64 (3.73)**	+ 8.59	53 %
International	20.79	- 8.99 (3.31)**	+13.53	40 %
Japan	34.68	- 9.34 (7.43)**	+ 1.77	63 %
North America	32.85	-23.97 (3.48)**	+ 6.97	61 %
Property	21.74	-11.29 (2.49)*	+17.09	42 %
U.K. Income	20.67	-26.44 (3.70)**	+10.80	50 %
U.K. Smaller	24.81	-25.31 (2.45)*	+13.81	45 %
U.K. Composite	22.67	-36.91 (1.62)	+23.89	49 %

The first column of the table shows the results of a Johansen test for cointegration of retail flows to open-end funds and the discount on closed-end funds in the same investment sector, using monthly data over the period January 1992 to March 1998. The data on retail flows to open-end funds by sector come from AUTIF, the body which represents all managers of U.K.-quoted open-end funds. The data on closed-end funds comprise the discounts of 158 funds (traded on the London Stock Exchange), classified into the same 11 investment sectors as the open-end data. Columns 2 and 3 of the table give the coefficients from the estimated cointegrating equation. Column 4 gives the proportion of a shock to retail investment flows which is reflected in the premium within two months. Numbers in parentheses are asymptotic t values. The symbol * denotes significant at the five percent level and ** denotes significant at the one percent level.

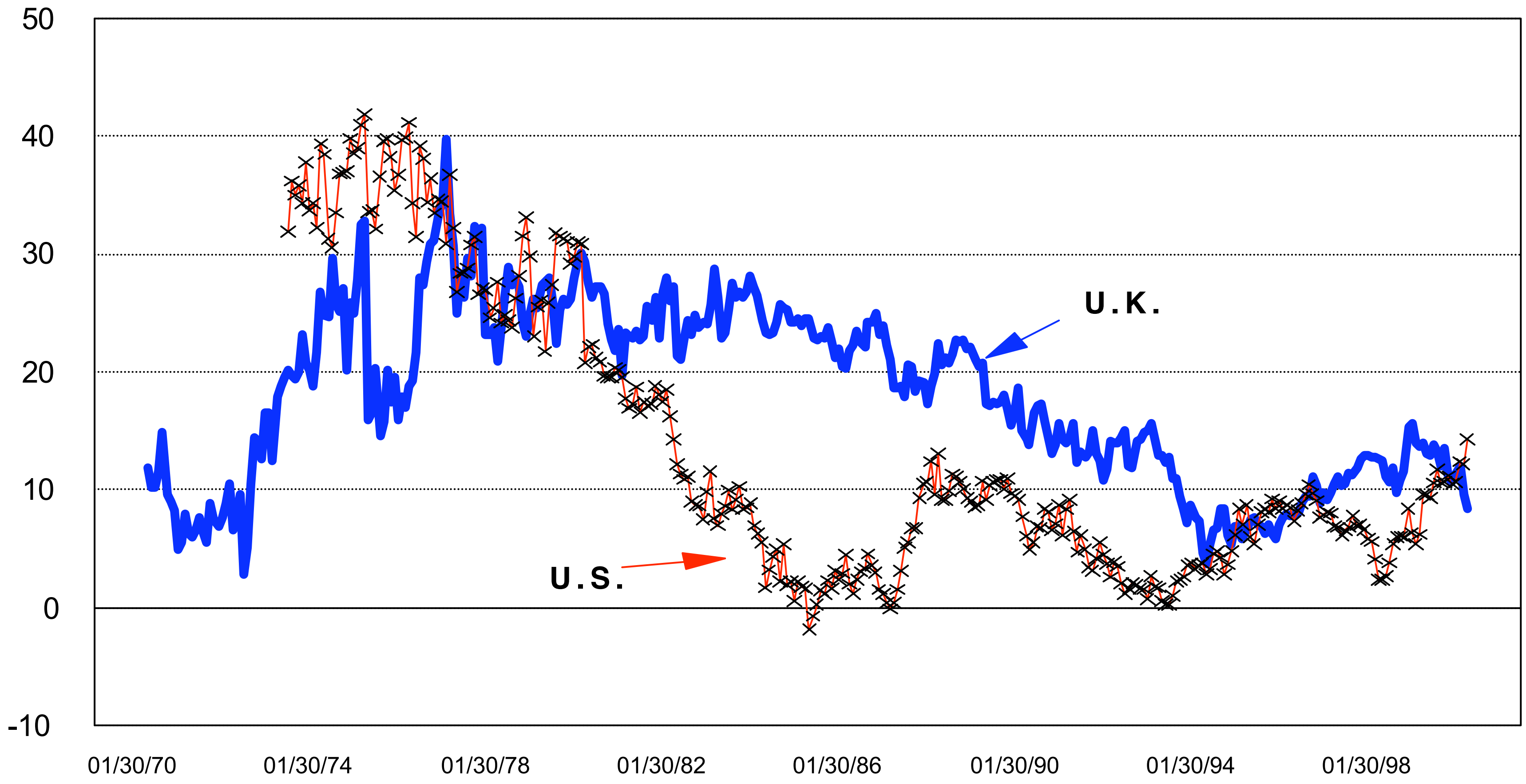

Figure 1. The discounts on U.K. and U.S. closed-end funds. The figure plots the discount to net-asset value over the period January 1970 to December 1999. Data for U.K. are from Datastream. Data for the U.S. are from CDA Wiesenberger to the end of 1998, and thereafter from Lipper.

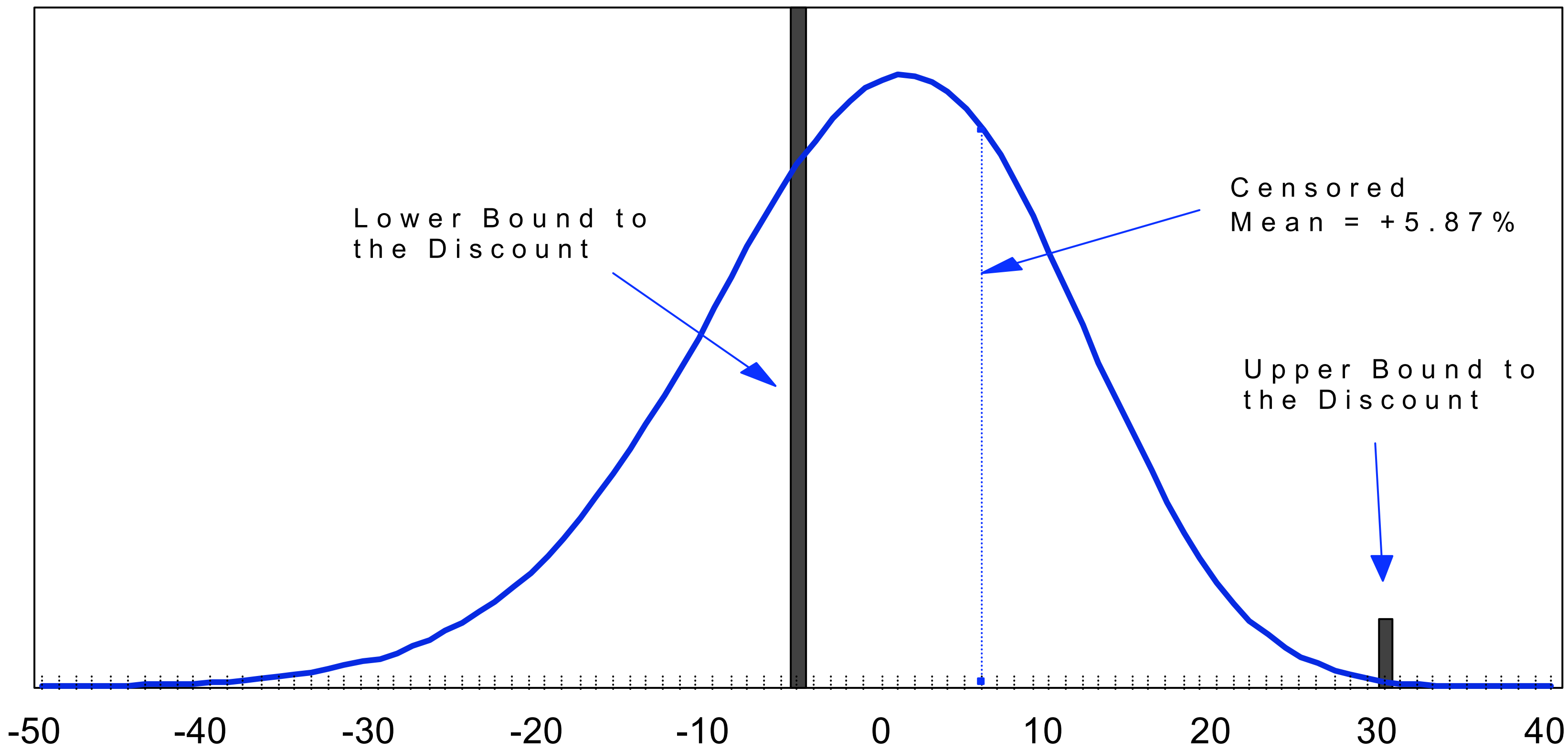

Figure 2. The censored distribution of the discount. The figure demonstrates how arbitrages may censor the distribution of the discount. A lognormal distribution with a mean of zero and standard deviation of 11.2 percent is plotted, upon which are imposed an upper bound of 30 percent and a lower bound of minus five percent. The result is that the mean of the distribution changes from zero to +5.87 percent.

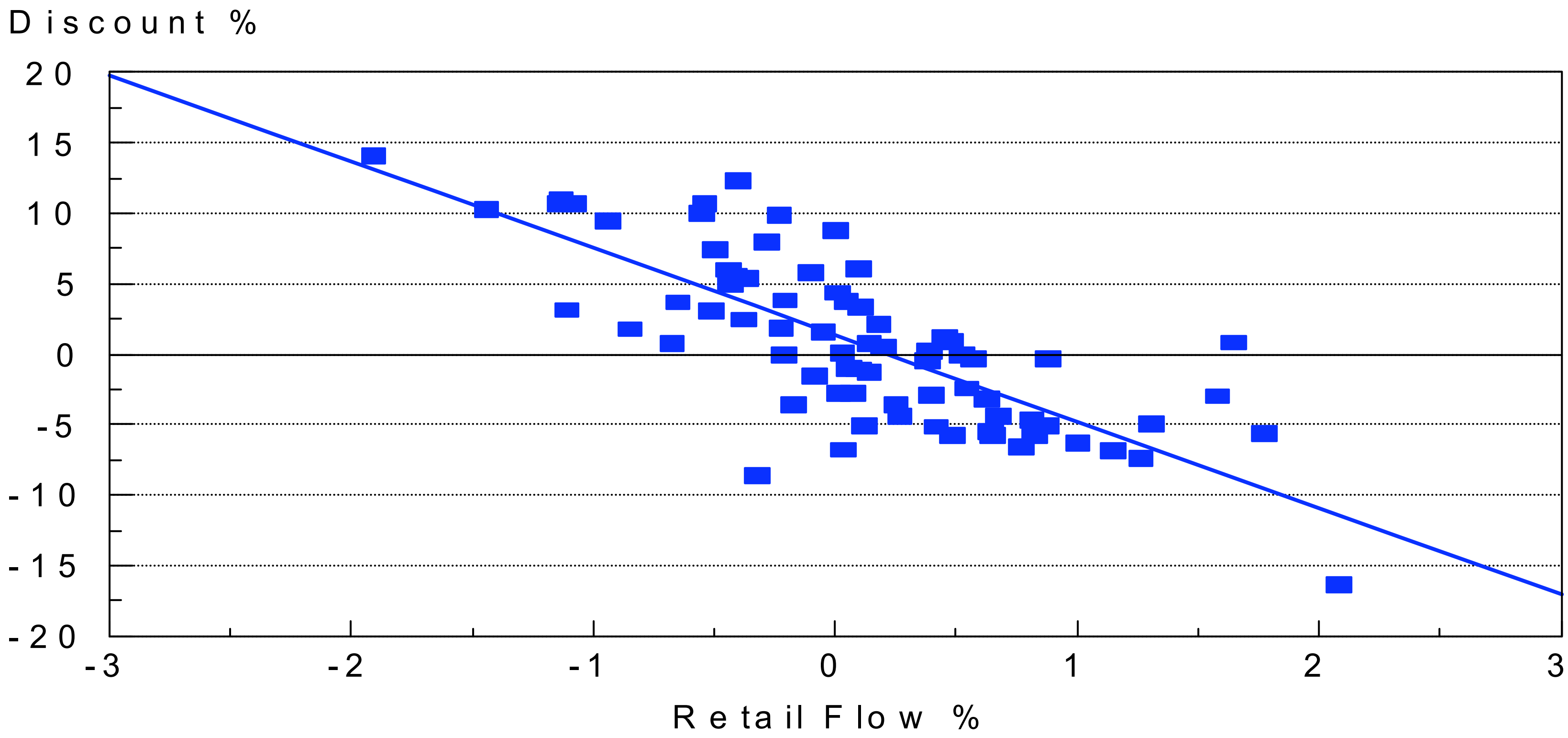

Figure 3a. The relationship for the Japanese sector between retail flows to open-end funds and the discount on closed-end funds. The value-weighted discounts of U.K. closed-end funds investing in Japan at the end of each month (January 1992 to March 1998) are plotted against the contemporaneous retail-investor flows to U.K. open-end funds investing in the same sector. The monthly flows are standardized by the market value of the open-end funds at the beginning of every month. The data on the discounts are for the 12 Japanese funds in this study. The data on open-end retail flows are from the Association of Unit Trusts and Investment Funds.

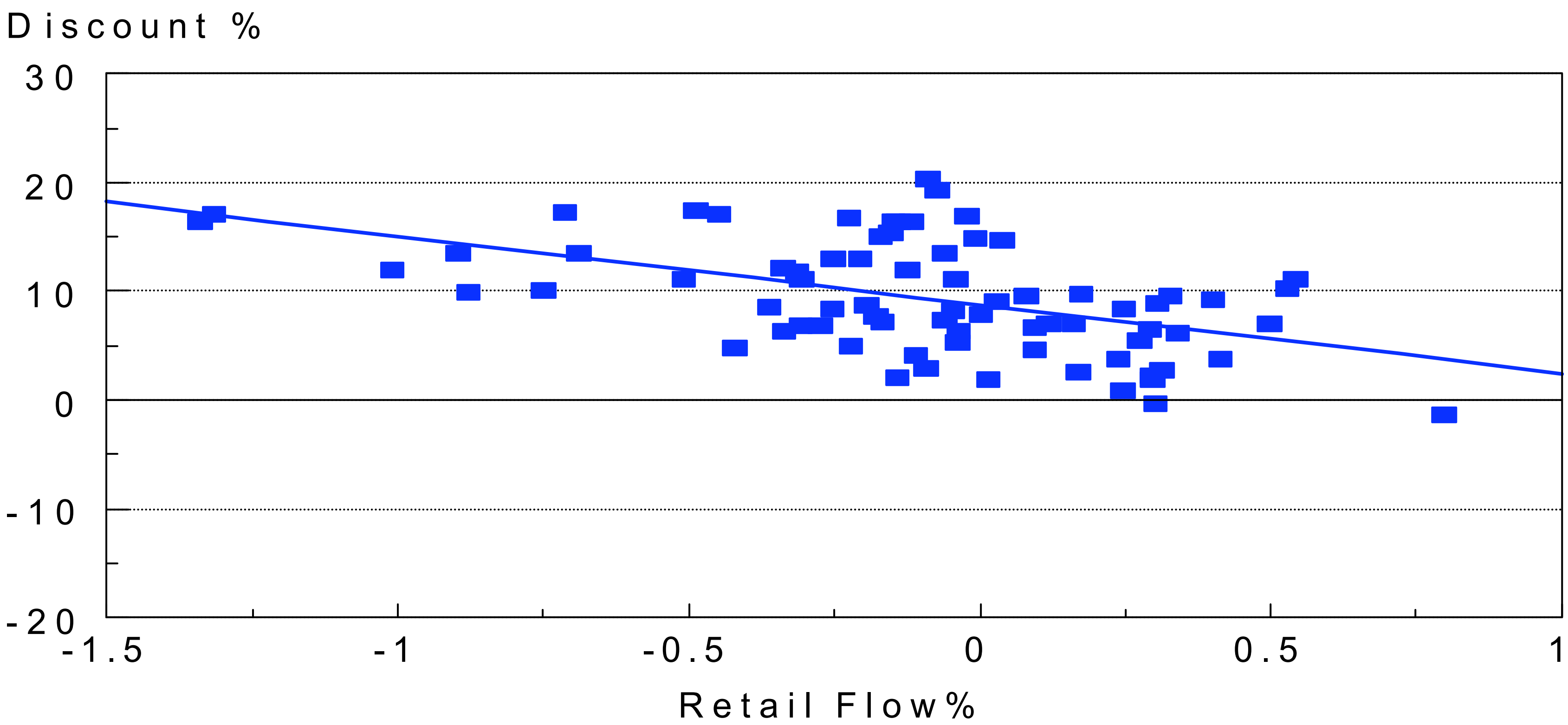

Figure 3b. The relationship for the North American sector between retail flows to open-end funds and the discount on closed-end funds. The value-weighted discounts of U.K. closed-end funds investing in North America at the end of each month (January 1992 to March 1998) are plotted against the contemporaneous retail-investor flows to U.K. open-end funds investing in the same sector. The monthly flows are standardized by the market value of the open-end funds at the beginning of every month. The data on the discounts are for the five North American (U.S. and Canada) funds in this study. The data on open-end retail flows are from the Association of Unit Trusts and Investment Funds.

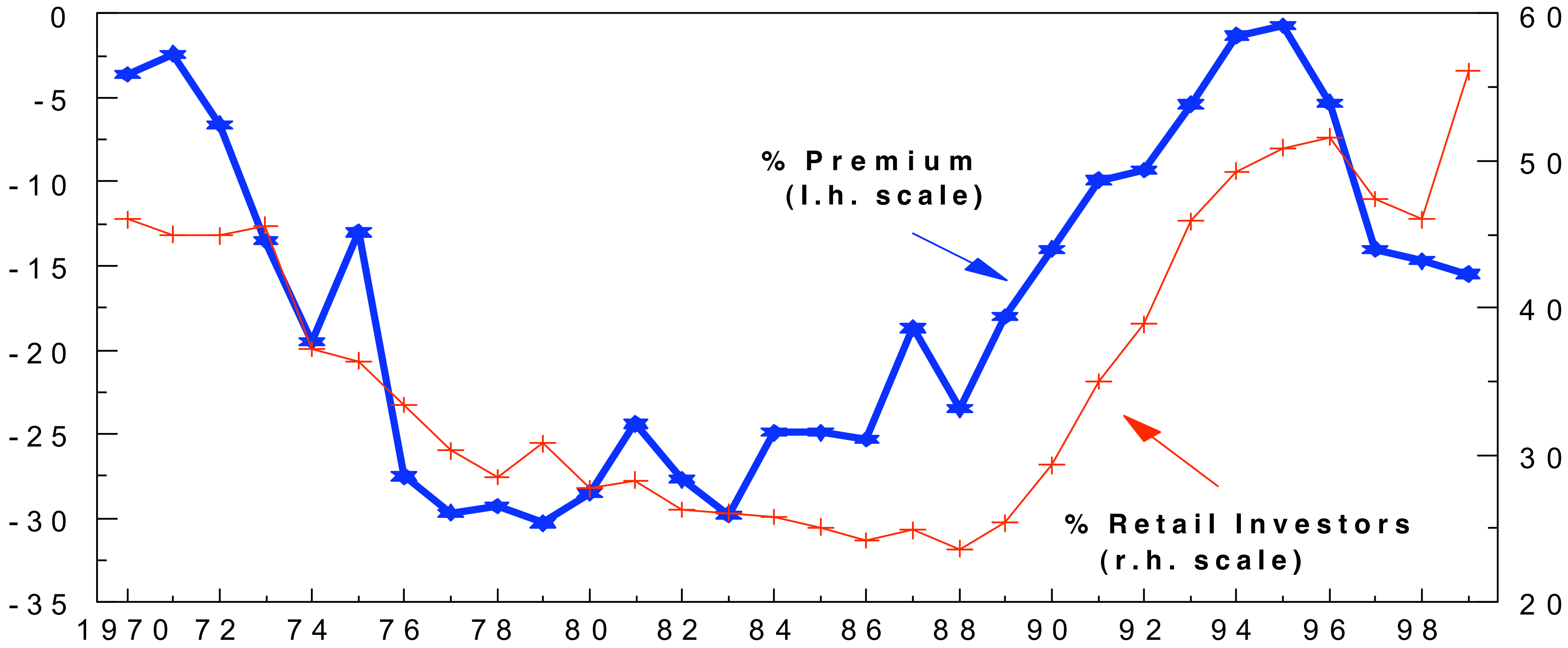

Figure 4. The premium on the Foreign & Colonial Investment Trust and the proportion of fund equity held by retail investors, 1970 to 1999. The data on the discount are from Datastream; the data on retail-investor holdings are from Foreign & Colonial Asset Management.

Appendix A: The Discount and Expenses

From the fundamental theorem that a portfolio of shares is worth the present value of future distributable cash flows, we have the expression for a fund's net-asset value:

$$NAV_0 = \sum_t C_t /(1+r)^t \tag{A1}$$

where C is expected cash flow (i.e., payouts to shareholders holding the fund's underlying portfolio), *r* is required rate of return and *t* is a time subscript. The market value of a closed-end fund may be written as:

$$P_0 = \sum_t (C_t - X_t)/(1+r)^t \tag{A2}$$

where P is market price and X is expenses. Defining the discount as

$$DIS_0 = (NAV_0 - P_0)/NAV_0 \tag{A3}$$

and using this definition with (A1) and (A2) we may write:

$$DIS_0 = \frac{\sum_t K_t C_t /(1+r)^t}{\sum_t C_t /(1+r)^t} \tag{A4}$$

where K_t is the ratio of expenses to cash flow in period t $(= X_t / C_t)$. If this ratio is constant in each period, then we have the very simple result that the discount on a closed-end fund must be constant and equal to the expense-to-cashflow ratio at time zero, i.e.,

$$DIS_0 = \frac{X_0}{C_0}. \tag{A5}$$

Appendix B: Coefficients on Vector-Error-Correction Equations for Monthly Change in Discount and Change in Flow

	Equation (6) for Δ(Discount)				Equation (7) for Δ(Flow)			
Sector	V_{t-1}	Constant	Δ(Intrate)	R^2	V_{t-1}	Constant	Δ(Intrate)	R^2
Emerging	.0145	-.9429	.1216	.015	.0573	1.1855	-.01733	.318
	(.85)	(.49)	(.44)		(5.75)	(1.07)	(1.08)	
Europe	.0155	-.0360	-.3756	.013	-.0070	.0300	.2208	.213
	(.69)	(.15)	(.54)		(4.28)	(.65)	(1.55)	
Far East	.0160	-.0634	-.4504	.006	.0258	-.0177	-.1619	.357
w/out Japan	(.47)	(.21)	(.49)		(6.25)	(.48)	(1.44)	
Far East	-.0773	-.0140	.3006	.037	.0331	-.0071	-.0981	.195
with Japan	(.04)	(.05)	(.35)		(4.14)	(.14)	(.67)	
International	-.0706	.0069	-.0409	.044	.0357	.0068	.0038	.160
	(1.81)	(.06)	(.12)		(3.66)	(.24)	(.04)	
Japan	.0059	-.1789	.3626	.001	.0683	-.0314	.0480	.269
	(.06)	(.42)	(.28)		(5.09)	(.52)	(.26)	
North	-.0427	.0734	.0734	.024	.0237	.00096	.0296	.265
America	(1.24)	(1.24)	(.26)		(5.04)	(.25)	(.25)	
Property	-.0267	.2472	-.0436	.012	.0324	.0125	.1129	.195
	(.87)	(.52)	(.03)		(4.09)	(.13)	(.30)	
U.K.	-.025	-.0633	-.2457	.054	.0179	-.0545	.0211	.509
Income	(1.06)	(.04)	(.50)		(5.81)	(2.32)	(.33)	
U.K.	.0421	.0031	.4233	.003	.0162	-.0024	.0070	.181
Smaller	(1.44)	(.02)	(.70)		(3.87)	(.08)	(.08)	
U.K.	.0012	.0597	.1392	.007	.0133	-.0455	.0452	.513
Composite	(.07)	(.35)	(.29)		(5.69)	(1.88)	(.68)	

The table gives the estimated coefficients for the vector-error-correction model (equations (6) and (7) of the main text). The numbers in parentheses are asymptotic *t*-values. The only coefficients which are significant at the one percent level are those on V_{t-1} in the Δ(Flow) equations. The equations for the U.K. Composite and U.K. Income sectors also include dummy variables for the months of March and April in order to reflect tax-induced investment in these months.

List of other working papers:

2002

1. Paolo Zaffaroni, Gaussian inference on Certain Long-Range Dependent Volatility Models, WP02-12
2. Paolo Zaffaroni, Aggregation and Memory of Models of Changing Volatility, WP02-11
3. Jerry Coakley, Ana-Maria Fuertes and Andrew Wood, Reinterpreting the Real Exchange Rate - Yield Diffential Nexus, WP02-10
4. Gordon Gemmill and Dylan Thomas , Noise Training, Costly Arbitrage and Asset Prices: evidence from closed-end funds, WP02-09
5. Gordon Gemmill, Testing Merton's Model for Credit Spreads on Zero-Coupon Bonds, WP02-08
6. George Christodoulakis and Steve Satchell, On th Evolution of Global Style Factors in the MSCI Universe of Assets, WP02-07
7. George Christodoulakis, Sharp Style Analysis in the MSCI Sector Portfolios: A Monte Caro Integration Approach, WP02-06
8. George Christodoulakis, Generating Composite Volatility Forecasts with Random Factor Betas, WP02-05
9. Claudia Riveiro and Nick Webber, Valuing Path Dependent Options in the Variance-Gamma Model by Monte Carlo with a Gamma Bridge, WP02-04
10. Christian Pedersen and Soosung Hwang, On Empirical Risk Measurement with Asymmetric Returns Data, WP02-03
11. Roy Batchelor and Ismail Orgakcioglu, Event-related GARCH: the impact of stock dividends in Turkey, WP02-02
12. George Albanis and Roy Batchelor, Combining Heterogeneous Classifiers for Stock Selection, WP02-01

2001

1. Soosung Hwang and Steve Satchell , GARCH Model with Cross-sectional Volatility; GARCHX Models, WP01-16
2. Soosung Hwang and Steve Satchell, Tracking Error: Ex-Ante versus Ex-Post Measures, WP01-15
3. Soosung Hwang and Steve Satchell, The Asset Allocation Decision in a Loss Aversion World, WP01-14
4. Soosung Hwang and Mark Salmon, An Analysis of Performance Measures Using Copulae, WP01-13
5. Soosung Hwang and Mark Salmon, A New Measure of Herding and Empirical Evidence, WP01-12
6. Richard Lewin and Steve Satchell, The Derivation of New Model of Equity Duration, WP01-11
7. Massimiliano Marcellino and Mark Salmon, Robust Decision Theory and the Lucas Critique, WP01-10
8. Jerry Coakley, Ana-Maria Fuertes and Maria-Teresa Perez, Numerical Issues in Threshold Autoregressive Modelling of Time Series, WP01-09
9. Jerry Coakley, Ana-Maria Fuertes and Ron Smith, Small Sample Properties of Panel Time-series Estimators with I(1) Errors, WP01-08
10. Jerry Coakley and Ana-Maria Fuertes, The Felsdtein-Horioka Puzzle is Not as Bad as You Think, WP01-07
11. Jerry Coakley and Ana-Maria Fuertes, Rethinking the Forward Premium Puzzle in a Non-linear Framework, WP01-06
12. George Christodoulakis, Co-Volatility and Correlation Clustering: A Multivariate Correlated ARCH Framework, WP01-05

13. Frank Critchley, Paul Marriott and Mark Salmon, On Preferred Point Geometry in Statistics, WP01-04
14. Eric Bouyé and Nicolas Gaussel and Mark Salmon, Investigating Dynamic Dependence Using Copulae, WP01-03
15. Eric Bouyé, Multivariate Extremes at Work for Portfolio Risk Measurement, WP01-02
16. Erick Bouyé, Vado Durrleman, Ashkan Nikeghbali, Gael Riboulet and Thierry Roncalli, Copulas: an Open Field for Risk Management, WP01-01

2000

1. Soosung Hwang and Steve Satchell , Valuing Information Using Utility Functions, WP00-06
2. Soosung Hwang, Properties of Cross-sectional Volatility, WP00-05
3. Soosung Hwang and Steve Satchell, Calculating the Miss-specification in Beta from Using a Proxy for the Market Portfolio, WP00-04
4. Laun Middleton and Stephen Satchell, Deriving the APT when the Number of Factors is Unknown, WP00-03
5. George A. Christodoulakis and Steve Satchell, Evolving Systems of Financial Returns: Auto-Regressive Conditional Beta, WP00-02
6. Christian S. Pedersen and Stephen Satchell, Evaluating the Performance of Nearest Neighbour Algorithms when Forecasting US Industry Returns, WP00-01

1999

1. Yin-Wong Cheung, Menzie Chinn and Ian Marsh, How do UK-Based Foreign Exchange Dealers Think Their Market Operates?, WP99-21
2. Soosung Hwang, John Knight and Stephen Satchell, Forecasting Volatility using LINEX Loss Functions, WP99-20
3. Soosung Hwang and Steve Satchell, Improved Testing for the Efficiency of Asset Pricing Theories in Linear Factor Models, WP99-19
4. Soosung Hwang and Stephen Satchell, The Disappearance of Style in the US Equity Market, WP99-18
5. Soosung Hwang and Stephen Satchell, Modelling Emerging Market Risk Premia Using Higher Moments, WP99-17
6. Soosung Hwang and Stephen Satchell, Market Risk and the Concept of Fundamental Volatility: Measuring Volatility Across Asset and Derivative Markets and Testing for the Impact of Derivatives Markets on Financial Markets, WP99-16
7. Soosung Hwang, The Effects of Systematic Sampling and Temporal Aggregation on Discrete Time Long Memory Processes and their Finite Sample Properties, WP99-15
8. Ronald MacDonald and Ian Marsh, Currency Spillovers and Tri-Polarity: a Simultaneous Model of the US Dollar, German Mark and Japanese Yen, WP99-14
9. Robert Hillman, Forecasting Inflation with a Non-linear Output Gap Model, WP99-13
10. Robert Hillman and Mark Salmon , From Market Micro-structure to Macro Fundamentals: is there Predictability in the Dollar-Deutsche Mark Exchange Rate?, WP99-12
11. Renzo Avesani, Giampiero Gallo and Mark Salmon, On the Evolution of Credibility and Flexible Exchange Rate Target Zones, WP99-11
12. Paul Marriott and Mark Salmon, An Introduction to Differential Geometry in Econometrics, WP99-10
13. Mark Dixon, Anthony Ledford and Paul Marriott, Finite Sample Inference for Extreme Value Distributions, WP99-09
14. Ian Marsh and David Power, A Panel-Based Investigation into the Relationship Between Stock Prices and Dividends, WP99-08
15. Ian Marsh, An Analysis of the Performance of European Foreign Exchange Forecasters, WP99-07
16. Frank Critchley, Paul Marriott and Mark Salmon, An Elementary Account of Amari's Expected Geometry, WP99-06
17. Demos Tambakis and Anne-Sophie Van Royen, Bootstrap Predictability of Daily Exchange Rates in ARMA Models, WP99-05
18. Christopher Neely and Paul Weller, Technical Analysis and Central Bank Intervention, WP99-04
19. Christopher Neely and Paul Weller, Predictability in International Asset Returns: A Re-examination, WP99-03

20. Christopher Neely and Paul Weller, Intraday Technical Trading in the Foreign Exchange Market, WP99-02
21. Anthony Hall, Soosung Hwang and Stephen Satchell, Using Bayesian Variable Selection Methods to Choose Style Factors in Global Stock Return Models, WP99-01

1998

1. Soosung Hwang and Stephen Satchell, Implied Volatility Forecasting: A Compaison of Different Procedures Including Fractionally Integrated Models with Applications to UK Equity Options, WP98-05
2. Roy Batchelor and David Peel, Rationality Testing under Asymmetric Loss, WP98-04
3. Roy Batchelor, Forecasting T-Bill Yields: Accuracy versus Profitability, WP98-03
4. Adam Kurpiel and Thierry Roncalli , Option Hedging with Stochastic Volatility, WP98-02
5. Adam Kurpiel and Thierry Roncalli, Hopscotch Methods for Two State Financial Models, WP98-01