Flight-to-Quality and Asymmetric Volatility Responses in US Treasuries*

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Flight-to-quality during times of financial crisis is a feature of financial markets. Here, a simple strategic model demonstrates that some preference asymmetry is sufficient to generate endogenous flight-to-quality from an emerging stock market to US Treasury bonds. The empirical evidence from a TARCH model supports the significance of emerging equity market shocks in accounting for the asymmetric properties of US Treasuries across the maturity structure. This effect is found to be more pronounced since the turn of the 21st century.

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1. Introduction

The existence of sign asymmetries in volatility dynamics suggests that a standard class of ARCH models is misspecified, as they assume that positive and negative shocks elicit an equivalent response from the market. Alternative models explicitly incorporate this stylized characteristic into the conditional variance equation; for a survey see Diebold and Lopez (1995). Popular asymmetric ARCH model parameterizations include EGARCH, GJR-GARCH and TARCH (see Nelson, 1991, Glosten, Jagannathan and Runkle, 1993 and Zakoian, 1994). Asymmetric GARCH models have been applied to a wide range of financial markets data and significant evidence of sign asymmetries in volatility dynamics has been documented[1].

While ARCH methodology is atheoretical, a literature has emerged which provides an economic explanation for sign asymmetries[2]. Negative sign asymmetries in stock market responses have been attributed to the leverage effect (see Black, 1976, Christie, 1982, Nelson, 1991) or to the presence of time-varying risk premia; French, Schwert and Stambaugh (1987). In foreign exchange markets, uncertainty created by central bank intervention have been suggested as an explanation for negative sign bias (see McKenzie,

[1] A size asymmetry has also been observed whereby ‘large’ shocks produce a disproportionately greater response from the market when compared to ‘small’ innovations. Unlike sign bias, size asymmetry is not thought to be confined to a particular class of asset and may thus be present in any speculative asset price series. As the focus of this paper is on explaining sign bias, the size bias assumption is not formally considered.

[2] Although the literature has attempted to provide an economic rationale for ARCH effects, precise links have proved difficult to capture. See Goodhart and O'Hara (1997, p. 93), Ackert and Racine (1997) and Diebold and Lopez (1995) for a discussion of the atheoretic nature of the ARCH processes.

2002). More recently, evidence of a perverse positive asymmetry in gold and bond market volatility dynamics has emerged (see Tully and Lucey, 2006 and De Goeij and Marquering, 2004, 2006 respectively). In this case, the volatility response to a positive shock exceeds the response to a negative shock of the same magnitude. Gulko (2002) provides evidence that the positive correlations between US equity and Treasury returns decouples during periods of market stress.

The purpose of this paper is to provide insights into the nature and causes of *positive* sign asymmetry in bond market volatility dynamics. We argue that this bias is the direct result of fund managers' portfolio allocation decisions made during times of uncertainty. Specifically, in Section 2 we model a world where managers allocate their funds across two different asset classes, one of which is a relatively high-risk asset and the other is relatively low-risk. The asset allocation decision is made in the face of uncertainty about the state of the world in the next period.

The model assumes an independent and exogenous negative price shock occurs in the high-risk asset market, which is governed by the standard asymmetric volatility dynamics. Rational fund managers will respond to this negative price shock by seeking a safe haven for their assets, that is a flight-to-quality takes place. The additional demand for the low risk asset may generate a positive price shock as prices adjust to clear the market. In the next period, the high risk asset market (which suffered the negative price shock) experiences a relatively large volatility response. This perpetuates the uncertainty faced by fund managers, so the flight-to-quality from the emerging equity market continues. Further inflows of funds to the safe haven induce a similarly disproportionately large volatility response, as prices in the low risk market respond to the additional demand. Thus, the low risk asset market exhibits a positive sign asymmetry - a positive price shock in the low risk asset may generate a disproportionately large volatility response, caused by the flight-to-quality. This theoretical model may be viewed as building on attempts to explain flight-to-quality events related to work by Hartmann, Straetmans and de Vries (2004), Pavlova and Rigobon (2007) and Vayanos (2004).

In the international context, an increase in volatility within an economy or a region (such as South East Asia, or even the emerging markets sector as a whole, during the 1997 currency crisis), may lead to an international flight-to-quality. One obvious candidate for the safe haven of choice among international fund managers is the US bond market. In this case, a positive price shock in the US bond market is followed by relatively high volatility as the economic turmoil and uncertainty abroad continues. Section 3 of this paper empirically validates our theoretical model using emerging stock market and US Treasury data.

2. A strategic model of flight-to-quality

We present a two-stage $(t = 0$ and $t = 1)$ two-player $(i = \{1,2\})$ investment game of incomplete and symmetric information. In the first stage, fund managers 1 and 2 choose the proportion of their wealth to invest in an unspecified emerging stock market and the US Treasury bond market.

In the first stage $(t = 0)$, each player i chooses the proportion of their unit wealth to invest in the emerging market and in US Treasuries. The players' decision at $t = 0$ occurs before the state of the emerging stock market is realized and is irreversible. Denoting the respective proportions by p_i^S and p_i^B, and assuming player i must be fully invested implies $p_i^S + p_i^B = 1$. Letting $p_i^S = p_i$ and $p_i^B = 1 - p_i$, and ruling out short sales so that p_i and $1 - p_i$ cannot be negative then implies that p_i constitutes player i's mixed strategy. Equivalently, mixed strategies can also be thought of as a continuum of small investors uniformly distributed on the unit interval, a proportion p and $1 - p$ of which only play S and B.

In the second stage $(t = 1)$, there are two mutually exclusive states of the world about which players are equally uncertain at $t = 0$. The *non-crisis* state occurring with prior probability $1 - q$, and the *crisis* state realized with prior probability q. The fund managers receive their payoffs upon the state realization at $t = 1$. Table 1 gives the payoffs conditional on both the non-crisis and crisis states, where a and b are positive constants such that $a < b$[3].

The expected payoffs of fund manager 1 under pure strategies S_1 and B_1 are

$$E\pi_1^S = q[-p_2 - a(1 - p_2)] + (1 - q)[p_2 + b(1 - p_2)] \quad (1)$$

$$E\pi_1^B = q[bp_2 + 1 - p_2] + (1 - q)[-ap_2 - (1 - p_2)].$$

[TABLE 1 HERE]

Under risk-neutrality, equating expected payoffs yields the equilibrium share of fund manager 2's wealth invested in the emerging stock market

[3] There is little loss of generality if *b* is restricted to 1, provided the restriction *a*<*b* is preserved. The implication would be that the emerging stock market offers the same return to any investor in each state.

$$p_2^* = \frac{1+b-q(a+b+2)}{b-a}. \quad (2)$$

Similarly, fund manager 2's identical optimization problem yields 1's optimal asset allocation ($p_1^*, 1-p_1^*$). As the payoffs are symmetrical across players, $p_1^* = p_2^*$ and we subsequently drop the subscript i.

From equation (2), the response of the emerging market share of each fund manager's portfolio to a change in the crisis probability is just

$$\frac{\partial p^*}{\partial q} = -\frac{a+b+2}{b-a} < 0. \quad (3)$$

Note that for $b > a$, a rise in q results in a fall in emerging stock market investment and more demand for US Treasury bonds. Equation (3) suggests that the asset switch from emerging market equity to US Treasuries is decreasing in $b-a$. This is consistent with the symmetric case discussed above: if $b = a$ the equilibrium is in dominant strategies and $\partial p_2^* / \partial q$ is not well-defined. The range of crisis probabilities for which the asset allocation p^* is completely mixed requires that $0 < p^* < 1$ in equation (2). This yields the following subset of $q \in (0,1)$

$$q_{\min} = \frac{b}{a+b+2} < q < \frac{1+b}{a+b+2} = q^{\max}. \quad (4)$$

It is clear that the lower bound $(q_{\min})$ can be arbitrarily close to zero, while the upper bound $(q^{\max})$ is less than one, provided $a > -1$. The limit of the upper bound as $b \to a$ is 0.5, coinciding with the "knife-edge" value in the symmetric case $q^* = \frac{1}{2}$. This limiting behavior of mixed strategies is a good illustration that the existence of some preference asymmetry is crucial for the fund managers to be invested in both assets.

2.1. Stochastic beliefs and flight-to-quality

Repeated play of the above two-stage game can produce endogenous flight-to-quality. Specifically, suppose that crisis beliefs evolve over time following an AR(1) process which is common knowledge to both fund managers

$$q_t = \rho q_{t-1} + \eta_t \tag{5}$$

where $\eta \sim (0, \sigma_\eta)$ is iid white noise and $0 < \rho < 1$. The players use the most recent q_t value each time they have to make an investment decision, and the resulting change in their asset allocation is given by equation (2).

Now suppose that in period T the shock realization η_T is large enough such that $q_T > q^{\max}$. For example, this could happen if, *following* an (unpredictable) financial crisis in the emerging market at $T-1$, fund managers come to believe that next period $q_T = 1$. Then mixed strategies cannot be sustained in equilibrium, and both players switch to the strictly dominant strategy of holding only US Treasuries and no emerging market equity, i.e. $p_T^* = 0$. We define such a discontinuous change in the asset allocation following a large increase in q to be a *flight-to-quality* event.

Therefore, our framework implies an updating of the asset mix depending on whether the q_t realizations violate inequalities (4). If both inequalities are satisfied, the asset reallocation is gradual (incremental). However, if there is an upward assessment of an emerging market crisis occurring next period such that $q_t > q^{\max}$, both fund managers will switch to holding only US Treasuries. Conversely, if fund managers revise downwards their belief of a crisis occurring next period, such that $q_t < q_{\min}$, then they will both invest only in emerging market equity. The relative frequency of flight-to-quality events can thus be numerically assessed by considering: (i) the starting crisis probability value q_0, (ii) the payoffs a and b determining the $q_{\min}$ and $q^{\max}$ thresholds, (iii) the postulated probability distribution of shocks η_t, and (iv) the AR(1) coefficient ρ driving the persistence of beliefs about a crisis 1-period-ahead.

The above dynamic asset reallocation allows linking negative price shocks to future volatility. In this way, the market response to the shocks generates further transfers of wealth, which in turn feed into investors' beliefs.

3. Empirical application

We argue that the sign asymmetry in the low-risk bond market may be accounted for by flight-to-quality from high-risk assets. While shocks to literally any market in which foreigners invest may generate a flight-to-quality, recent history suggests a more obvious candidate. In the early 1990s, most developed economies were experiencing a recession and expected returns from investment were low. In an attempt to improve their return on equity, many international fund managers began to seek out alternative investment opportunities. Coincidentally, over this same period, many developing countries were liberalizing their capital markets. This gave foreigners unprecedented access to a wide range of new and potentially high yielding investment opportunities; see Harvey (1998).

These factors combined to create a situation where capital flows to emerging markets grew substantially in a remarkably short period of time. To highlight this trend, Figure 1 presents World Bank data on the net portfolio equity flows to the emerging markets sector. Prior to 1985, portfolio equity flows were frequently net outflows and quite small in magnitude (typical values were between US$1m and US$5m). From 1986 to 1993, however, a change took place as emerging equity markets found favor with international fund managers. Over this period, billions of dollars of capital were invested in local equity markets, primarily in Latin American and later in South East Asia. The average annual growth of equity portfolio flows to emerging equity markets over this period was 172% and, at their peak in 1993, indirect investment accounted for almost 40% of all foreign investment in the emerging markets sector. The 1994 Mexican Peso crisis temporarily dampened international fund managers' enthusiasm for the emerging markets sector and the flows of equity to emerging markets abated. A resurgence of capital flows to emerging equity markets occurred in the second half of 1995. However, renewed enthusiasm for the sector was to prove short lived – the 1997 currency crisis sent share markets crashing and portfolio equity flows were negative for both the Latin American and East Asian regions over this period. Post currency crisis, strong returns in the more traditional avenues for investment diverted fund managers' attention away from the emerging markets sector. More recently, there has been a resurgence of interest in emerging markets, caused in part by the poor performance of the US share market and the spectacular emergence of the Chinese economy.

[FIGURE 1 HERE]

3.1. Econometric methodology

Where asymmetric effects are thought to be present in the volatility response dynamics of a series, an appropriate approach is to fit an asymmetric GARCH model. In the case of bond market returns, DeGoeij and Marquering (2006) suggest macroeconomic news announcements are important in modeling asymmetry. Whilst a wide variety of news announcements exist, Kim, McKenzie and Faff (2004), Goldberg and Leonard (2003), Jones, Lamont and Lumsdaine (1998) and Fleming and Remolona (1997) suggest that unemployment (UN), price (CPI) and retail sales (RS) news are most relevant to bond markets. As such, a dummy variable (D) can be included in both the mean and variance equations to capture the effect of these news announcements on returns and volatility[4]. Motivated by Zakoian (1994), we specify a *threshold* ARCH (*TARCH*) type model for returns to a bond with a maturity of i at time t, r_{it}, in which the errors of the mean equation

$$r_{it} = c_{i0} + \sum_{n=1}^{P} c_i r_{i,t-n} + b_{1i} D^{CPI} + b_{2i} D^{RS} + b_{3i} D^{UN} + \varepsilon_{it} \qquad (6)$$

are specified as $\varepsilon_{it} \sim i.i.d.(0, h_t)$ and the conditional variance equation is of the form[5]

$$h_{it} = \alpha_{0i} + \alpha_{1i}\varepsilon_{i,t-1}^2 + \alpha_{2i} h_{i,t-1} + \beta_{1i} D^{CPI} + \beta_{2i} D^{RS} + \beta_{3i} D^{UN} + \chi_{1i} D_1 \varepsilon_{i,t-1}^2, \qquad (7)$$

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[4] National consumer price index (CPI) data (U.S. city averages) are released monthly at 08:30EST by the Bureau of Labor Statistics, approximately 2 weeks after the reference period. Nominal retail sales (RS) announcements are released approximately two weeks after month-end at 08:30EST by the U.S. Department of Commerce, Economics & Statistics Administration. This series measures sales of retail establishments, adjusted for normal seasonal variation, holidays, and trading-day differences. Announcements relating to the whole economy unemployment rate (U) are released at 08:30EST in the first week after month-end by the Bureau of Labor Statistics.

[5] EGARCH specifications were also tried in the empirical application, while the results were qualitatively similar, the TARCH specification provided a better fit to the data. Further, a GED and t-distribution were also considered and the results are qualitatively unchanged to those presented.

where D_1 is a dummy variable which takes on a value of unity where $\varepsilon_{t-1} < 0$ and zero otherwise. A nonzero asymmetry coefficient (χ_1) in the TARCH model indicates the presence of sign bias in the volatility response mechanism insomuchas the variance following a negative shock is greater by a factor of $\chi_1 \varepsilon_{t-1}^2$.

The univariate TARCH model of equation (7) may be modified to account for the potential source of the asymmetry. Consider the source of the shock in the high risk market to come from returns in emerging equity markets, r_{st}, which also evolves with a TARCH structure, but has asymmetric effects on the bond market volatility returns. The full model is specified as

$$r_{it} = c_{i0} + \sum_{n=1}^{P} c_i r_{i,t-n} + b_{1i} D^{CPI} + b_{2i} D^{RS} + b_{3i} D^{UN} + \varepsilon_{it} \tag{8}$$

$$r_{st} = c_{s0} + \sum_{n=1}^{P} c_s r_{s,t-n} + b_{1s} D^{CPI} + b_{2s} D^{RS} + b_{3s} D^{UN} + \varepsilon_{st} \tag{9}$$

$$h_{it} = \alpha_{0i} + \alpha_{1i} \varepsilon_{i,t-1}^2 + \alpha_{2i} h_{i,t-1} + \beta_{1i} D^{CPI} + \beta_{2i} D^{RS} + \beta_{3i} D^{UN} + \chi_{1i} D_1 \varepsilon_{i,t-1}^2 + \chi_{2i} D_2 \varepsilon_{s,t-1}^2 \tag{10}$$

$$h_{st} = \alpha_{0s} + \alpha_{1s} \varepsilon_{s,t-1}^2 + \alpha_{2s} h_{s,t-1} + \beta_{1s} D^{CPI} + \beta_{2s} D^{RS} + \beta_{3s} D^{UN} + \chi_{1s} D_1 \varepsilon_{s,t-1}^2 \tag{11}$$

where D_2 is a dummy with value unity when $\varepsilon_{st} < 0$, represents the presence of the negative shocks from the emerging markets returns, r_{st} after controlling for own asymmetry, with impact χ_{2i} on bond market return r_{it} of maturity i at time t. A multivariate TARCH model would be a preferred measure of capturing the dynamics of the model specified in equations (8) to (11). However, as a first step, a two-step procedure whereby the residuals from the emerging market r_{st} are included as an extra regressor in returns for the bond markets, will produce consistent but inefficient estimates. A bootstrap procedure could be used to produce appropriate test statistic critical values, however, the results in the following sections show that the strength of the effects are such that this is unlikely to affect the interpretation of the results. A full multivariate TARCH specification is an ongoing research agenda.

The flight-to-quality hypothesis suggests that the asymmetry term, χ_2, should be significant and of the same sign as χ_1. As there are many different markets from which fund managers may take flight during times of turmoil however, it is not expected that χ_1 will be fully accounted for by any one risky market based asymmetry term. As such, the own market asymmetry term is expected to be lower with the inclusion of the second asymmetry term, but not necessarily insignificant. One possible solution would be to include multiple asymmetry terms, each of which captures shocks to a particular high risk asset market. However, the means of including a number of different equity markets is complicated by the well-known commonalities between the indices, see for example Solnik (1974). Unless this can be accounted the inclusion of multiple equity markets leads to multicollinearity, here a number of different emerging market indices are considered as potential indicators for emerging market conditions.

3.2. The data

The data considered in this paper are US Treasury bill and bond yields sourced from the Federal Reserve Bank of St. Louis, Federal Reserve Economic Data (FRED) database[6]. Daily data for 3 and 6 month bills as well as 1, 2, 3, 5 and 10 year bonds are sampled over the period February, 1994 to the end of September, 2005 (the longest sample period containing both the bond and emerging market stock price indices used in this study). For the purposes of analysis, each of these bond yield series is transformed using a difference filter and descriptive statistics for these data are presented in Table 2. The mean change in bond yield is negative over the sample period for all maturities and the 5 and 10 year bonds experienced the greatest average fall in yield across the entire sample period. The maximum rise in yield is 0.58 for the 3 month note, while the largest fall in yields is -0.85 for the 6 month note. It is interesting to observe that while the largest rise and fall in the data are found in the short maturity data, the longer maturity bond exhibited the greatest standard deviation of changes in yields. All of the data are negatively skewed and fail the Jarque-Bera test of normality. First order serial correlation is also a significant feature of all of the data and the Treasury note and 1 year data also exhibits significant autocorrelation for longer lags.

Before estimating any asymmetric model, it is appropriate to test for ARCH effects in the data. To this end, Engle's (1982) LM test for ARCH effects is estimated for each data

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[6] To test the veracity of our data, bond and bill yield information were also sampled from Datastream as well as the GovPX database (see Fleming, 1997, for details of the US bond market and the GovPX database). The results presented in this paper were consistent across each of these different datasets. The FRED data is chosen as the focus of analysis as it is available over the longest sample period and it is also the most readily accessible by researchers.

series and significant evidence of ARCH effects is found in all of the data. Table 2 presents the estimated skewness coefficient of the standardized residuals for a GARCH(1,1) model fitted to each data series. The 3 month and 1 year securities exhibit negative skewness in the residuals, while all other maturities possess positive skewness. To the extent that the results of the ARCH LM test suggest volatility clustering is a feature of this data, the presence of skewness in the residuals infers that the volatility responses are potentially characterized by asymmetric responses. A more formal test of asymmetry is provided by Engle and Ng (1993). Standardized residuals from a univariate GARCH(1,1) of returns for asset i are denoted z_{it} and used to estimate the following

$$z_{it}^2 = \lambda + \theta_1 (S_t^-) + \upsilon_{t,} \tag{12}$$

where S_t^- is a dummy variable that takes on a value of unity if the lagged residuals from the GARCH(1,1) model are negative and zero otherwise. The sign bias test relates to the statistical significance of θ_1. Where the test statistic for this regressor is significant, then positive and negative shocks have a differential impact on volatility[7].

While the Engle and Ng test is a convenient way to test for asymmetry, it does possess low power in the detection of asymmetric effects. As such, the results may be considered indicative, rather than definitive, proof of the presence or absence of leverage effects.

The univariate equation (12) is estimated for each data series and the relevant model output is compactly summarized in Table 2. The sign bias coefficient is significant for the

[7] The Engle and Ng (1993) test may easily be extended to include a test for size bias, i.e. a test of asymmetry in the volatility response to large and small innovations. While the focus of this paper is on sign bias, the authors can report evidence of size bias in the data especially for the longer dated maturities.

1 year bond as well as the 3 month maturity, albeit at only 10%. Thus, limited evidence can be found to suggest that bond markets are characterized by volatility asymmetries.

The TARCH augmented model of equation (6) is estimated for each of the seven bond yield return series over the whole data sample period and the results are presented in Table 3. For the mean equation, the lagged dependent variable is significant for the 2 year and longer maturities. Price announcement dates generated a negative and significant coefficient for every bond maturity. Retail sales and unemployment announcement dates are insignificant except for the latter in the three month data. In the variance equation, retail sales and unemployment announcements are generally significant. Retail sales announcement days are associated with lower volatility on average, while the opposite is true for unemployment announcements. There are two possible interpretations that can be assigned to these estimated news impact coefficients. On the one hand, an insignificant coefficient suggests that the relevant variable is not important for bond pricing. On the other hand, an alternative interpretation of an insignificant coefficient is that the news release typically accords with market expectations and so no response is observed. The latter interpretation is deemed more likely, given a number of related papers have documented significant responses to the unexpected component of the announcement (see, for example, Balduzzi, Elton and Green, 2001 and Kim, McKenzie and Faff, 2004)[8].

In terms of the volatility dynamics, all of the ARCH and GARCH terms are statistically significant and sum to be less than unity. A check of the error terms reveals a

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[8] The signs and significance levels of the macroeconomic news announcement variables are qualitatively consistent across all models estimated. As such, further discussion of the mean equation is omitted for the sake of brevity.

general absence of serial correlation. The threshold term is positive and significant for the 3 and 6 month notes as well as the 1 year bond. To understand the intuition behind this result, recall that the data is expressed as yields. The flight-to-quality hypothesis suggests that a negative bond yield shock (positive bond price shock) should lead to a greater volatility response compared to a shock of the opposite sign. Thus, a positive and significant coefficient associated with the negative shock asymmetry term, χ_1 is indicative of a perverse volatility asymmetry[9]. Of the longer dated Treasuries, the asymmetry term is insignificant for the 2, 3, 5 and 10 year bonds. One possible interpretation of this result is to suggest that fund managers engage in a 'flight-to-cash' rather than a 'flight-to-quality'. That is, international fund managers prefer to ride out the period of turmoil in the safe haven of short dated securities.

3.3. Two-step modeling of asymmetries in bond market volatility

The analysis of the previous section clearly establishes the presence of negative sign asymmetry in short term Treasury volatility. The central hypothesis of this paper is that these asymmetric responses are driven by exogenous shocks which cause a flight-to-quality. To test this proposition, the TARCH model may be augmented to include an additional asymmetry term which is driven by past negative return shocks to a high risk market. As a starting point for the analysis, a general emerging markets index is considered. To this end, the returns to the Morgan Stanley Capital International MSCI

[9] The GoxPX database provides both yields and prices for the Treasury bill data and to check the results, EGARCH models were fitted to the price data. As expected, a positive volatility asymmetry coefficient is estimated which confirms that a negative yield volatility asymmetry is equivalent to a positive price volatility asymmetry.

Emerging Markets Index (US$) is sampled and the descriptive statistics are presented in Panel B of Table 5. A TARCH model is fitted to this dataset and the errors are used to create a threshold term which appears in the conditional variance equation of the bond market, i.e. equation (10).[10] The estimation results are presented in Table 4.

The ARCH and GARCH terms are positive and significant across all of the models estimated. Further, the emerging market asymmetry term is positive and significant for all maturities except the 3 year rate (significant at the 10% level) and the 10 year rate. Thus, the sign of the coefficient is as expected and suggests that negative price shocks in the emerging markets sector are associated with greater volatility in the bond market. The inclusion of an asymmetry term driven by emerging market volatility, at least partially, accounts for some of the volatility asymmetry in bond markets, demonstrated by the fall in coefficients, α_{2i} for $i = 3$ *month*, 6 *month* and 1 *year* maturities, lending support to the flight-to-quality hypothesis.

It is worth noting that the 10 year bond market possesses some unique characteristics, which may cause the estimation results to differ from the other maturities considered. On one side of the market, Asian foreign exchange management programs as well as US pension and managed fund investments add to long bond demand. On the other side of the market, long bonds have been in short supply, in particular following the US budget surpluses in 1998 - 2001. Further complicating the picture has been the emergence of alternative sources of supply in the semi-government long term debt markets to

[10] To conserve space, the estimation results for these TARCH models are not presented. All models estimated are robust to the usual tests of rationality and significance.

accommodate the demand for longer dated maturities, in particular mortgage backed securities.

The emerging market indirect foreign investment flows presented in Figure 1 reveal that the bulk of the capital flow has been to South East Asia and Latin America. Each region may generate its own shocks which determine the flight-to-quality, rather than shocks to the emerging markets sector as a whole driving fund managers to a safe haven. To this end, the US dollar Datastream Asia ex-Japan stock market index and the HSBC Latin America 100 index are sampled (the descriptive statistics for each series is presented in Panel B of Table 2). A TARCH model is estimated for each series and the residuals used to generate an asymmetry term that is included in the variance equation for the bond data, as per equation (10). The estimation results for the Asia index are presented in Table 5 and the Asian market negative price shock term is positive and significant for the short term notes as well as the 1 and 5 year bonds. The own variance asymmetry coefficient is positive and significant for the 3 shortest maturities, and a comparison to the standard TARCH results of Table 3, indicates that they are lower in each instance. It is interesting to note that they are not as low as where the emerging markets index is specified. This would tend to suggest that while shocks to the Asian market explain some of the observed asymmetry in bond markets, they are but one factor, and the use of a broad emerging markets index successfully captures more of the shocks.

To further investigate this point, a volatility asymmetry term driven by the shocks to Latin America is specified and the estimation results are presented in Table 6. A similar pattern emerges which is consistent with the Asian market index results. The emerging market asymmetry term is positive and significant for all maturities, except the 10 year bond. The own variance asymmetry term is lower for each of the 3 and 6 month as well as the one year bonds compared to the standard TARCH model and the latter is no longer significant. Comparing these results to the general emerging markets index results and the Treasury note own asymmetry coefficients are not as low as where the aggregate emerging markets index is specified. These results serve to reinforce the observation that an aggregate index captures elements of volatility in both the Latin American and Asian region.

As an extension to this finding, it is interesting to consider the information content of an even broader market index such as a global share price index. To this end, returns to the MSCI World index are sampled (descriptive statistics for this series are presented in Panel B of Table 2). The augmented model of equation (12) is estimated where negative shocks to the World index are used to generate an asymmetry term which is included in the variance equation of the bond market returns data. The estimation results are presented in Table 7 and the 3 and 6 month own variance asymmetry terms are positive and significant. Comparing the estimated size of the χ coefficients reveals that they are not uniquely lower when compared to the standard TARCH model. Further, the World market asymmetry term is significant for six of the seven bonds and is unexpectedly insignificant for the 3 month data. In general, these results are less supportive of the flight-to-quality hypothesis compared to the emerging market index results. Potentially the inclusion of an index which extends its scope beyond the emerging markets sector, introduces shocks which are not relevant to the decision of fund managers to engage in a flight-to-quality.

As an alternative to emerging stock market shocks driving a flight-to-quality consider whether shocks to emerging bond market shocks create a similar pattern. Returns to the MSCI Emerging Markets Sovereign Bond Index are sampled and the descriptive statistics for this data are presented in Panel B of Table 2. A standard TARCH model is fitted and the residuals are used to generate an asymmetry term which appears in the TARCH model fitted to the bond market data. The estimation results are presented in Table 8 and the exogenous asymmetry term is negative for all maturities and significant in the case of the 2 year and longer maturities. The negative sign is unexpected and suggests that negative shocks in emerging bond markets are associated with lower volatility in US bond markets. The own variance asymmetry term is similar to those estimated for the standard TARCH model both in terms of signs and significance. Thus, these results suggest that it is shocks to emerging share markets which are the primary factor.

3.4. Bond market asymmetry after 1997-1998

As previously discussed there was a dramatic increase in capital flows to the emerging markets sector during the 1990's. The evidence above suggests that shocks to the emerging markets sector may be responsible for causing a flight-to-quality which manifests itself as a perverse volatility asymmetry in bond data. To further investigate this finding, consider whether the flight-to-quality phenomenon varies over time. One reason why this might be the case relates to the exposure of the emerging markets sector to a flight-to-quality. As more funds are directed into the emerging markets sector, shocks to the risky market may generate greater flight of funds and so, exacerbate the effects of the flight-to-quality on the bond market. Alternatively, the results may be sensitive to the types of shocks experienced in a given period. For example, the first half of the sample period experienced a number of significant shocks, most notably the 1997 Asian currency crisis, the 1998 Russian bond market default and subsequent LTCM failure as well as the speculative attacks on the Hong Kong dollar.

To investigate the robustness of the findings thus far, the tumultuous period is excluded and the model re-estimated over a truncated subperiod beginning January, 1999. The estimation results for the standard TARCH model are summarized in Panel B of Table 3. The most salient point to note is that greater evidence of perverse volatility asymmetry in the data. The asymmetry term is positive and significant for all bonds except for the 5 and 10 year maturity at the 10% level. This result is interesting as it suggests that the perverse asymmetry is more common in the recent data.

The extent to which the flight-to-quality phenomenon can explain this asymmetry may be investigated by including an additional asymmetry term which is driven by exogenous negative shocks in the emerging markets sector. The estimation results for the emerging (Asia, Latin America) markets sector are presented in Panel B of Table 5 (6, 7 respectively). The asymmetry term for the emerging markets index is positive and significant for all maturities except the 10 year. Further, the own variance asymmetry term is insignificant in all cases. Where Asian and Latin America are considered individually, the results are very similar in that the emerging market asymmetry term is positive and generally significant across all maturities except the 10 year data. Further, the own variance asymmetry term is universally insignificant except for the 3 month data where Asia is the origin of the shocks. Shocks to the World index are presented in Panel B of Table 8 and generate a similar set of results. Where the emerging markets bond index is considered (Panel B of Table 9), the own variance asymmetry term is similar to the standard TARCH model results and only the 10 year emerging market bond index asymmetry terms is significant. This result reinforces the total sample period results, which suggest that it is shocks to emerging stock markets which are relevant to the flight-to-quality phenomenon.

In general, the subperiod results indicate that the strength and nature of the asymmetry in the US bond market has changed over time. Post-1998, the evidence of a perverse positive sign asymmetry in bond market data is more apparent. Further, shocks in the emerging stock market sector are a significant determinant of these positive asymmetries. One possible interpretation of these results is that fund managers have learned from their 1997 -- 1998 experiences about the perils of holding on to emerging market shares when trouble strikes. The increased presence of positive sign asymmetries may indicate that fund managers are now more willing to leave emerging markets at the first sign of trouble, as a loss avoidance mechanism, and head to US Treasuries until the trouble subsides and investment prospects improve.

4. Conclusion

This paper presented a theoretical model explaining how flight-to-quality could be endogenously generated in a simple two fund manager scenario. When fund managers have a choice between a high risk and safe haven asset, the prospect of a crisis with an associated bad payoff, will change the fund manager’s portfolio allocation, depending on assessment of the probability of a crisis event. The outcome (crisis/no crisis) may be such that mixed investment strategies cannot be sustained in equilibrium, resulting in a flight-to-quality.

The model is supported by empirical evidence from the behavior of US Treasury bonds in the presence of higher volatility in emerging equity markets. Empirical evidence on the US Treasury bonds revealed asymmetric volatility responses to price shocks, in the opposite direction to other asset markets. Specifically, a positive price shock to US Treasuries is associated with higher volatility. In other markets, such as emerging stocks, the reverse occurs – higher volatility is associated with negative price shocks. Incorporating the behavior of the emerging stock markets with the US Treasuries, under the guise of a flight-to-quality as suggested by the theoretical model, revealed that a substantial portion of the higher volatility observed in US Treasuries following a positive price shock can be associated with emerging stock market volatility (and price drops). The 'safe haven' function of the US Treasury market results in its different behavior from other asset markets.

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Table 1

Payoffs for investment strategies

Non-crisis subgame $[1-q]$

		Fund manager 2	
		$S_2(p_2)$	$B_2(1-p_2)$
Fund manager 1	$S_1(p_1)$	1, 1	$b, -a$
	$B_1(1-p_1)$	$-a, b$	-1, -1

Crisis subgame $[q]$

		Fund manager 2	
		$S_2(p_2)$	$B_2(1-p_2)$
Fund manager 1	$S_1(p_1)$	-1, -1	$-a, b$
	$B_1(1-p_1)$	$b, -a$	1, 1

Table 2

Descriptive statistics for changes in bond yields and equity returns

	Panel A: US Treasuries						
	3month	6month	1year	2year	3year	5year	10year
Mean	0.0001	0.0002	0.0001	0.0001	-0.0001	-0.0003	-0.0005
Max	0.5800	0.2700	0.3300	0.3600	0.4000	0.4100	0.3900
Min	-0.2500	-0.4800	-0.5000	-0.5400	-0.5000	-0.3800	-0.2300
Std Dev	0.0475	0.0428	0.0489	0.0611	0.6360	0.0641	0.0598
Skewness	-0.39	-0.69	-0.47	-0.06	0.13	0.25	0.40
Kurtosis	26.39	15.59	11.27	7.57	6.76	5.74	5.33
Jarque-Bera	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
p_1	0.058	0.072	0.060	0.044	0.046	0.045	0.039
p_2	0.099	0.083	-0.034	-0.024	-0.016	-0.018	-0.018
Skew of std. res	-0.2818	0.1311	-0.0372	0.0456	0.0958	0.1362	0.2923
Sign bias test	0.1731	0.1901	0.1912	0.1161	-0.0378	-0.0527	-0.1179

	Panel B: Other Data				
	Emerging Markets	Asia	Latin America	MSCI World	MSCI Emerging Bond Index
Mean	0.0051	0.0027	0.0136	0.2100	0.0365
Max	4.7718	8.0503	14.0194	4.6038	6.6199
Min	-7.4247	-8.5841	-14.1343	-4.5212	-6.0257
Std. Dev	1.0221	1.0652	1.6376	0.8210	0.8518
Skewness	-0.62	-0.23	-0.30	-0.15	-0.27
Kurtosis	7.00	9.51	12.06	5.90	9.14
Jarque-Bera	0.0000	0.0000	0.0000	0.0000	0.0000
p_1	0.279	0.176	0.164	0.161	0.122
p_2	-0.015	-0.003	-0.011	-0.049	0.046
Skew of std. res	-0.3675	-0.3713	-0.4523	-0.2996	-0.2695
Sign bias test	0.2440	0.2216	0.4317	0.2336	0.1612

Table 3

TGARCH estimates for baseline model (*t*-statistics)

parameter	3month	6month	1year	2year	3year	5year	10year
			Panel A: Total sample: 1994 - 2005				
b_1	-0.0087	-0.0075	-0.0092	-0.0115	-0.0115	-0.0098	-0.0105
	(-4.00)	(-2.97)	(-3.10)	(-2.77)	(-2.68)	(-1.58)	(-2.51)
b_2	-0.0027	-0.0039	-0.0022	-0.0017	-0.0018	-0.0012	-0.0020
	(-1.08)	(-1.56)	(-0.76)	(-0.41)	(-0.44)	(-0.29)	(-0.47)
b_3	0.0047	0.0039	-0.0020	0.0011	0.0029	0.0018	0.0016
	(2.42)	(1.58)	(-0.65)	(0.30)	(0.73)	(0.45)	(0.40)
α_1	0.1290	0.0963	0.0523	0.0371	0.0272	0.0253	0.0329
	(14.78)	(11.59)	(8.82)	(7.14)	(5.93)	(5.56)	(5.85)
χ_1	0.1166	0.0289	0.0193	0.0067	0.0109	0.0078	-0.0014
	(9.21)	(3.10)	(2.68)	(1.10)	(1.94)	(1.44)	(-0.20)
α_2	0.8398	0.8812	0.9202	0.9430	0.9554	0.9590	0.9463
	(149.69)	(119.62)	(163.97)	(148.87)	(172.94)	(168.24)	(116.42)
β_1	-0.0001	-0.0001	-0.0001	-0.0004	-0.0004	-0.0004	-0.0004
	(-3.08)	(-1.63)	(-0.48)	(-1.73)	(-1.36)	(-1.38)	(-1.56)
β_2	-0.0001	-0.0003	-0.0006	-0.0005	-0.0009	-0.0009	-0.0005
	(-3.12)	(-5.09)	(-5.37)	(-2.03)	(-3.06)	(-2.92)	(-1.89)
β_3	0.0000	0.0004	0.0007	0.0009	0.0011	0.0011	0.0010
	(0.09)	(5.96)	(6.22)	(5.17)	(5.39)	(5.43)	(5.25)
			Panel B: Subperiod: 1999 - 2005				
b_1	-0.0139	-0.0079	-0.0083	-0.0106	-0.0099	-0.0111	-0.0090
	(-8.09)	(-2.59)	(-2.08)	(-1.96)	(-1.73)	(-1.85)	(-1.56)
b_2	0.0061	0.0011	0.0055	0.0138	0.0155	0.0146	0.0141
	(2.10)	(0.36)	(1.27)	(2.34)	(2.51)	(2.35)	(2.30)
b_3	0.0062	-0.0028	-0.0079	-0.0095	-0.0094	-0.0087	-0.0057
	(2.94)	(-1.01)	(-2.13)	(-1.90)	(-1.80)	(-1.63)	(-1.10)
α_1	0.0564	0.1101	0.0733	0.0233	0.0180	0.0227	0.0291
	(8.72)	(9.27)	(5.09)	(3.61)	(2.95)	(3.44)	(3.77)
χ_1	0.3200	0.0254	0.0427	0.0157	0.0184	0.0114	0.0043
	(12.48)	(1.92)	(2.25)	(2.02)	(2.43)	(1.37)	(0.43)
α_2	0.8302	0.8707	0.8710	0.9573	0.9641	0.9612	0.9514
	(90.88)	(78.15)	(52.49)	(141.94)	(145.59)	(127.01)	(94.60)
β_1	-0.0004	-0.0000	-0.0002	-0.0004	-0.0006	-0.0008	-0.0006
	(-13.65)	(0.29)	(-1.17)	(-1.42)	(-1.68)	(-1.93)	(-1.53)
β_2	-0.0000	-0.0003	-0.0004	-0.0005	-0.0007	-0.0006	-0.0002
	(-1.03)	(-5.82)	(-2.67)	(-1.41)	(-1.86)	(-1.44)	(-0.40)
β_3	-0.0001	0.0003	0.0007	0.0009	0.0010	0.0010	0.0009
	(-1.52)	(3.36)	(4.62)	(3.32)	(3.45)	(3.37)	(3.26)

Table 4

TGARCH estimates with Emerging Markets EMBI dummy (t-statistics)

parameter	3month	6month	1year	2year	3year	5year	10year
Panel A: Total sample: 1994 - 2005							
b_1	-0.0070	-0.0076	-0.0093	-0.0100	-0.0114	-0.0115	-0.0105
	(-2.90)	(-2.94)	(-3.10)	(-2.54)	(-2.75)	(-2.68)	(-2.51)
b_2	-0.0022	-0.0033	-0.0018	-0.0011	-0.0015	-0.0009	-0.0019
	(-1.27)	(-1.36)	(-0.60)	(-0.27)	(-0.34)	(-0.20)	(-0.44)
b_3	0.0065	0.0039	-0.0022	0.0015	0.0030	0.0020	0.0015
	(2.26)	(1.58)	(-0.71)	(0.41)	(0.78)	(0.49)	(0.38)
α_1	0.1885	0.0926	0.0530	0.0382	0.0284	0.0265	0.0332
	(15.00)	(11.49)	(8.92)	(7.60)	(6.32)	(6.02)	(6.06)
χ_1	0.0455	0.0199	0.0097	0.0000	0.0069	0.0031	-0.0038
	(2.63)	(2.21)	(1.33)	(0.00)	(1.19)	(0.55)	(-0.23)
α_2	0.7286	0.8861	0.9231	0.9448	0.9560	0.9604	0.9475
	(111.7)	(127.21)	(168.29)	(155.06)	(172.85)	(176.05)	(118.65)
β_1	0.0000	-0.0000	-0.0001	-0.0005	-0.0004	-0.0004	-0.0004
	(0.71)	(-0.63)	(-0.41)	(-1.88)	(-1.50)	(-1.45)	(-1.55)
β_2	-0.0005	-0.0003	-0.0006	-0.0005	-0.0009	-0.0009	-0.0006
	(-29.65)	(-5.16)	(-5.28)	(-2.06)	(-3.06)	(-2.89)	(-1.97)
β_3	0.0000	0.0004	0.0006	0.0009	0.0011	0.0011	0.0010
	(0.55)	(6.02)	(5.51)	(4.98)	(5.49)	(5.25)	(5.22)
χ_2	0.0122	0.0020	0.0018	0.0016	0.0008	0.0011	0.0006
	(19.09)	(5.11)	(4.67)	(2.94)	(1.92)	(2.35)	(1.27)
Panel B: Subperiod: 1999 - 2005							
b_1	-0.0136	-0.0075	-0.0070	-0.0080	-0.0057	-0.0055	-0.0082
	(-3.87)	(-2.38)	(-1.73)	(-1.22)	(-0.87)	(-0.73)	(-1.38)
b_2	0.0029	0.0017	0.0054	0.0165	0.0183	0.0204	0.0147
	(0.84)	(0.58)	(1.24)	(2.19)	(2.33)	(2.26)	(2.40)
b_3	0.0062	-0.003	-0.0090	-0.0062	-0.0035	-0.0050	-0.0054
	(1.55)	(-1.02)	(-2.39)	(-0.86)	(-0.45)	(-0.39)	(-1.06)
α_1	0.2300	0.0973	0.0877	0.0883	0.0982	0.0174	0.0262
	(8.00)	(2.12)	(4.53)	(3.65)	(3.79)	(1.00)	(3.73)
χ_1	0.0513	0.0042	0.0391	-0.0038	-0.0029	0.0075	0.0022
	(1.38)	(0.34)	(1.53)	(-0.11)	(-0.08)	(0.27)	(0.23)
α_2	0.7272	0.8826	0.8165	0.4905	0.5209	-0.1626	0.9573
	(59.9)	(92.37)	(37.23)	(8.38)	(8.62)	(-3.15)	(104.39)
β_1	-0.0003	-0.0001	-0.0002	-0.0003	-0.0006	0.0003	0.0006
	(-3.69)	(-1.48)	(-1.44)	(-0.76)	(-1.28)	(0.50)	(1.68)
β_2	-0.0005	-0.0003	-0.0002	0.0012	0.0014	0.0016	-0.0002
	(-6.45)	(-5.10)	(-1.34)	(1.78)	(2.03)	(2.04)	(-0.60)
β_3	-0.0002	0.0003	0.0007	0.0032	0.0038	0.0084	0.0009
	(-1.57)	(3.47)	(4.73)	(5.48)	(5.75)	(4.20)	(3.02)
χ_2	0.0193	0.0041	0.0087	0.0415	0.0351	0.0368	0.0017
	(14.98)	(7.32)	(7.12)	(8.54)	(7.03)	(5.04)	(1.69)

Table 5

TGARCH estimates with Asian EMBI dummy (t-statistics)

parameter	3month	6month	1year	2year	3year	5year	10year
			Panel A: Total sample: 1994 - 2005				
b_1	-0.0084	-0.0077	-0.0095	-0.0100	-0.0112	-0.0105	-0.0102
	(-3.81)	(-2.98)	(-3.17)	(-2.54)	(-2.71)	(-1.67)	(-2.44)
b_2	-0.0029	-0.0035	-0.0019	-0.0016	-0.0020	0.0005	-0.0020
	(-1.18)	(-1.40)	(-0.65)	(-0.40)	(-0.48)	(0.08)	(-0.48)
b_3	0.0031	0.0038	-0.0020	0.0012	0.0027	0.0065	0.0013
	(1.48)	(1.51)	(-0.66)	(0.32)	(0.68)	(0.66)	(0.33)
α_1	0.1247	0.0923	0.0524	0.0376	0.0280	0.0238	0.0334
	(14.19)	(11.54)	(8.78)	(7.03)	(5.88)	(1.88)	(5.28)
χ_1	0.0807	0.0209	0.0157	0.0063	0.0114	0.0017	-0.0008
	(6.74)	(2.30)	(2.16)	(1.02)	(1.93)	(0.08)	(-0.10)
α_2	0.8435	0.8869	0.9216	0.9424	0.9534	-0.0059	0.9433
	(151.87)	(126.8)	(157.28)	(138.96)	(156.92)	(-0.34)	(110.06)
β_1	-0.0001	-0.0001	-0.0001	-0.0004	-0.0004	0.0011	-0.0004
	(-1.73)	(-0.97)	(-0.44)	(-1.71)	(-1.26)	(2.19)	(-1.45)
β_2	-0.0002	-0.0003	-0.0006	-0.0005	-0.0009	0.0027	-0.0005
	(-3.59)	(-4.96)	(-5.28)	(-2.06)	(-3.13)	(3.80)	(-1.81)
β_3	-0.0001	0.0004	0.0006	0.0009	0.0011	0.0084	0.0011
	(-2.60)	(5.92)	(5.73)	(5.17)	(5.61)	(6.21)	(5.35)
χ_2	0.0045	0.0016	0.0009	0.0000	-0.0004	0.0174	-0.0007
	(13.67)	(4.78)	(2.79)	(0.08)	(-1.03)	(5.47)	(-1.56)
			Panel B: Subperiod: 1999 - 2005				
b_1	-0.0107	-0.0076	-0.0072	-0.0072	-0.0052	-0.0060	-0.0087
	(-4.51)	(-2.44)	(-1.82)	(-0.99)	(-0.71)	(-0.80)	(-1.47)
b_2	-0.0240	0.0012	0.0047	0.0172	0.019	0.0189	0.0145
	(-0.83)	(0.39)	(1.08)	(2.26)	(2.32)	(2.08)	(2.23)
b_3	0.0016	-0.0034	-0.0086	-0.0104	-0.0086	-0.0052	-0.0057
	(0.69)	(-1.17)	(-2.16)	(-0.84)	(-0.66)	(-0.40)	(-1.12)
α_1	0.1336	0.0948	0.1104	0.0319	0.0373	0.0158	0.0271
	(10.51)	(8.88)	(4.80)	(2.10)	(2.14)	(0.90)	(3.66)
χ_1	0.0958	-0.0003	0.0412	0.0107	0.0242	0.0128	0.0049
	(5.88)	(-0.02)	(1.36)	(0.35)	(0.76)	(0.45)	(0.50)
α_2	0.8225	0.8901	0.7546	-0.0935	-0.1059	-0.1485	-0.9549
	(92.5)	(102.26)	(26.71)	(-8.05)	(-4.89)	(-3.00)	(-99.22)
β_1	-0.0001	0.0001	-0.0002	0.0002	-0.0001	0.0003	-0.0006
	(-1.19)	(0.93)	(-1.50)	(0.52)	(-0.14)	(0.57)	(-1.58)
β_2	-0.0001	-0.0003	-0.0001	0.0010	0.0013	0.0018	-0.0002
	(-3.12)	(-4.68)	(-0.31)	(1.34)	(1.63)	(2.18)	(-0.46)
β_3	-0.0001	0.0003	0.0008	0.0076	0.0088	0.0086	0.0009
	(-1.33)	(3.40)	(5.69)	(4.53)	(4.74)	(4.24)	(3.10)
χ_2	0.0061	0.0034	0.0109	0.0513	0.0489	0.0295	0.0005
	(14.41)	(7.13)	(9.35)	(8.10)	(6.95)	(4.93)	(0.51)

Table 6

TGARCH estimates with Latin American EMBI dummy (t-statistics)

parameter	3month	6month	1year	2year	3year	5year	10year
Panel A: Total sample: 1994 - 2005							
b_1	-0.0072	-0.0076	-0.0089	-0.0096	-0.0111	-0.0112	-0.0103
	(-2.95)	(-3.02)	(-2.96)	(-2.45)	(-2.69)	(-2.62)	(-2.47)
b_2	-0.0024	-0.0031	-0.0018	0.0008	-0.0010	-0.0004	-0.0015
	(-1.50)	(-1.25)	(-0.59)	(0.16)	(-0.23)	(-0.10)	(-0.35)
b_3	0.005	0.0039	-0.0025	0.0042	0.0030	0.0019	0.0014
	(1.64)	(1.54)	(-0.83)	(0.35)	(0.77)	(0.47)	(0.36)
α_1	0.2062	0.0940	0.0536	0.0378	0.0279	0.0264	0.0330
	(15.2)	(11.27)	(8.71)	(7.59)	(6.34)	(6.05)	(6.11)
χ_1	0.0666	0.0200	0.0080	-0.0016	0.0050	0.0012	-0.0053
	(3.31)	(2.12)	(1.05)	(-0.26)	(0.90)	(0.22)	(-0.73)
α_2	0.6657	0.8784	0.9195	0.9454	0.9575	0.9613	0.9486
	(68.05)	(116.91)	(166.01)	(161.12)	(183.82)	(186.59)	(124.09)
β_1	0.0000	-0.0001	-0.0001	-0.0005	-0.0004	-0.0004	-0.0004
	(0.00)	(-0.96)	(-0.70)	(-2.00)	(-1.58)	(-1.53)	(-1.47)
β_2	-0.0007	-0.0003	-0.0006	-0.0005	-0.0009	-0.0009	-0.0006
	(-22.79)	(-5.18)	(-5.03)	(-2.08)	(-3.15)	(-2.99)	(-2.07)
β_3	0.0001	0.0004	0.0006	0.0009	0.0011	0.0011	0.0010
	(1.04)	(6.07)	(5.60)	(4.93)	(5.50)	(5.27)	(5.24)
χ_2	0.0067	0.0014	0.0013	0.0009	0.0006	0.0006	0.0004
	(17.58)	(6.33)	(6.04)	(3.70)	(3.00)	(3.24)	(1.84)
Panel B: Subperiod: 1999 - 2005							
b_1	-0.0130	-0.0079	-0.0073	-0.0089	-0.0085	-0.0097	-0.0085
	(-3.68)	(-2.54)	(-1.81)	(-1.58)	(-1.47)	(-1.62)	(-1.47)
b_2	0.0021	0.0023	0.0056	0.0151	0.0166	0.0158	0.0148
	(0.57)	(0.75)	(1.25)	(2.53)	(2.68)	(2.52)	(2.40)
b_3	0.0031	-0.0031	-0.0092	-0.0085	-0.0080	-0.0072	-0.0056
	(0.91)	(-1.03)	(-2.36)	(-1.75)	(-1.58)	(-1.38)	(-1.10)
α_1	0.2223	0.1036	0.0929	0.0243	0.0155	0.0191	0.0254
	(8.95)	(8.42)	(4.80)	(3.63)	(2.82)	(3.33)	(3.65)
χ_1	0.0564	0.0145	0.0536	0.0107	0.0157	0.0092	0.0046
	(1.85)	(1.07)	(1.93)	(1.31)	(2.20)	(1.22)	(0.49)
α_2	0.7439	0.8616	0.7948	0.9577	0.9695	0.9682	0.9573
	(61.84)	(73.00)	(35.37)	(130.88)	(163.29)	(147.94)	(108.17)
β_1	-0.0002	-0.0001	-0.0003	-0.0005	-0.0007	-0.0009	-0.0006
	(-2.58)	(1.00)	(-1.96)	(-1.73)	(-2.06)	(-2.23)	(-1.66)
β_2	-0.0002	-0.0003	-0.0001	-0.0006	-0.0008	-0.0007	-0.0002
	(-3.25)	(-5.12)	(-0.74)	(-1.67)	(-2.18)	(-1.67)	(-0.59)
β_3	0.0000	0.0003	0.0007	0.0007	0.0008	0.0008	0.0008
	(0.19)	(3.79)	(4.84)	(2.66)	(2.63)	(2.49)	(2.95)
χ_2	0.0098	0.0027	0.0046	0.0015	0.0013	0.0014	0.0008
	(15.15)	(7.81)	(6.91)	(2.96)	(2.73)	(2.58)	(1.36)

Table 7

TGARCH estimates with S&P500 dummy (t-statistics)

parameter	3month	6month	1year	2year	3year	5year	10year
			Panel A: Total sample: 1994 - 2005				
b_1	-0.0113	-0.0074	-0.0088	-0.0094	-0.0111	-0.0111	-0.0105
	(-3.84)	(-2.92)	(-2.99)	(-2.44)	(-2.69)	(-2.61)	(-2.53)
b_2	-0.0002	-0.0037	-0.0023	-0.0018	-0.0019	-0.0016	-0.0025
	(-0.06)	(-1.50)	(-0.79)	(-0.45)	(-0.47)	(-0.38)	(-0.59)
b_3	0.0215	0.0040	-0.0017	0.0017	0.0033	0.0021	0.0019
	(4.13)	(1.61)	(-0.56)	(0.47)	(0.86)	(0.55)	(0.48)
α_1	0.1127	0.0949	0.0502	0.0355	0.0271	0.0245	0.0309
	(9.34)	(11.72)	(9.31)	(7.78)	(6.39)	(6.09)	(6.13)
χ_1	0.0333	0.0219	0.0067	-0.0024	0.0044	0.0015	-0.0076
	(1.73)	(2.41)	(1.00)	(-0.43)	(0.81)	(0.29)	(-1.05)
α_2	0.8511	0.8854	0.9290	0.9499	0.9585	0.9628	0.9501
	(100.12)	(125.5)	(178.1)	(173.12)	(186.05)	(196.52)	(129.68)
β_1	-0.0004	-0.0001	-0.0001	-0.0005	-0.0004	-0.0004	-0.0004
	(-4.24)	(-1.42)	(-0.54)	(-1.98)	(-1.49)	(-1.36)	(-1.48)
β_2	-0.0012	-0.0003	-0.0006	-0.0006	-0.0009	-0.0008	-0.0005
	(-10.44)	(-4.88)	(-5.41)	(-2.22)	(-3.06)	(-2.82)	(-1.88)
β_3	0.0004	0.0004	0.0006	0.0009	0.0011	0.0010	0.0009
	(2.33)	(6.06)	(5.93)	(4.89)	(5.39)	(5.10)	(4.98)
χ_2	0.0145	0.0012	0.0023	0.0031	0.0021	0.0027	0.0025
	(8.56)	(2.98)	(4.16)	(4.03)	(3.03)	(4.12)	(3.35)
			Panel B: Subperiod: 1999 - 2005				
b_1	-0.0117	-0.0076	-0.0082	-0.0099	-0.0094	-0.0107	-0.0091
	(-5.93)	(-2.50)	(-2.04)	(-1.85)	(-1.68)	(-1.85)	(-1.61)
b_2	0.0037	0.0014	0.0056	0.0144	0.0158	0.0143	0.0137
	(1.21)	(0.46)	(1.35)	(2.43)	(2.52)	(2.27)	(2.22)
b_3	0.0071	-0.0026	-0.0074	-0.0080	-0.0077	-0.0068	-0.0048
	(2.87)	(-0.92)	(-2.01)	(-1.65)	(-1.52)	(-1.32)	(-0.97)
α_1	0.0069	0.1079	0.0707	0.0292	0.0198	0.0221	0.0247
	(3.02)	(9.36)	(5.06)	(4.19)	(3.23)	(3.60)	(3.60)
χ_1	0.3001	0.0104	0.0166	-0.0019	0.0068	-0.0039	-0.0079
	(15.54)	(0.82)	(0.95)	(-0.21)	(0.82)	(-0.45)	(-0.78)
α_2	0.8528	0.8776	0.8845	0.9541	0.9655	0.9662	0.9584
	(94.34)	(84.41)	(60.48)	(126.00)	(144.01)	(142.60)	(110.24)
β_1	-0.0004	0.0000	-0.0001	-0.0005	-0.0007	-0.0008	-0.0005
	(-18.20)	(0.29)	(-0.99)	(-1.76)	(-2.05)	(-1.98)	(-1.31)
β_2	-0.0001	-0.0003	-0.0005	-0.0006	-0.0009	-0.0007	-0.0003
	(-2.59)	(-5.16)	(-2.96)	(-1.87)	(-2.25)	(-1.85)	(-0.75)
β_3	-0.0002	0.0003	0.0006	0.0009	0.0010	0.0010	0.0009
	(-3.25)	(3.53)	(4.35)	(3.59)	(3.49)	(3.49)	(3.39)
χ_2	-0.0007	0.0015	0.0037	0.0041	0.0029	0.0041	0.0040
	(-4.64)	(3.06)	(3.00)	(3.06)	(2.66)	(3.57)	(3.22)

Table 8

TGARCH estimates with MSCI World dummy (t-statistics)

parameter	3month	6month	1year	2year	3year	5year	10year
			Panel A: Total sample: 1994 - 2005				
b_1	-0.0087	-0.0074	-0.0090	-0.0096	-0.0111	-0.0112	-0.0106
	(-4.01)	(-2.94)	(-3.05)	(-2.47)	(-2.70)	(-2.63)	(-2.55)
b_2	-0.0027	-0.0038	-0.0023	-0.0018	-0.0019	-0.0016	-0.0024
	(-1.12)	(-1.52)	(-0.78)	(-0.45)	(-0.45)	(-0.37)	(-0.57)
b_3	0.0047	0.0039	-0.0017	0.0021	0.0036	0.0027	0.0021
	(2.43)	(1.59)	(-0.55)	(0.56)	(0.95)	(0.69)	(0.55)
α_1	0.1289	0.0960	0.0514	0.0369	0.0282	0.0259	0.0318
	(14.72)	(11.69)	(9.20)	(7.77)	(6.48)	(6.10)	(6.09)
χ_1	0.1198	0.0236	0.0035	-0.0059	0.0018	-0.0016	-0.0100
	(8.99)	(2.52)	(0.51)	(-0.99)	(0.32)	(-0.30)	(-1.35)
α_2	0.8385	0.8838	0.9282	0.9476	0.9573	0.9610	0.9491
	(146.84)	(122.44)	(169.03)	(163.93)	(180.09)	(183.60)	(124.61)
β_1	-0.0001	-0.0001	-0.0001	-0.0005	-0.0004	-0.0004	-0.0004
	(-2.96)	(-1.44)	(-0.52)	(-1.94)	(-1.47)	(-1.27)	(-1.38)
β_2	-0.0002	-0.0003	-0.0006	-0.0005	-0.0009	-0.0080	-0.0006
	(-3.46)	(-4.85)	(-5.33)	(-2.09)	(-3.00)	(-2.75)	(-1.95)
β_3	0.0000	0.0004	0.0006	0.0009	0.0011	0.0010	0.0010
	(0.10)	(6.03)	(5.88)	(5.04)	(5.51)	(5.1)8	(5.06)
χ_2	-0.0003	0.0012	0.0043	0.0061	0.0042	0.0050	0.0045
	(-0.86)	(2.08)	(5.68)	(4.98)	(3.76)	(4.37)	(3.48)
			Panel B: Subperiod: 1999 - 2005				
b_1	-0.0199	-0.0077	-0.0081	-0.0093	-0.0088	-0.0100	-0.0087
	(-5.01)	(-2.50)	(-2.02)	(-1.71)	(-1.56)	(-1.72)	(-1.53)
b_2	0.0047	0.0013	0.0057	0.0147	0.0160	0.0145	0.0139
	(0.89)	(0.42)	(1.36)	(2.45)	(2.54)	(2.29)	(2.26)
b_3	0.0097	-0.0026	-0.0074	-0.0072	-0.0070	-0.0057	-0.0045
	(1.10)	(-0.92)	(-2.01)	(-1.50)	(-1.39)	(-1.12)	(-0.90)
α_1	0.0382	0.1095	0.0743	0.0315	0.0202	0.0217	0.0240
	(2.16)	(9.39)	(4.80)	(4.20)	(3.21)	(3.46)	(3.48)
χ_1	0.0664	0.0107	0.0128	-0.0078	0.0043	-0.0062	-0.0075
	(2.94)	(0.82)	(0.67)	(-0.79)	(0.50)	(-0.71)	(-0.75)
α_2	0.7980	0.8775	0.8753	0.9489	0.9640	0.9655	0.9586
	(36.90)	(84.90)	(52.08)	(112.42)	(137.21)	(132.33)	(104.04)
β_1	-0.0010	0.0000	-0.0001	-0.0005	-0.0007	-0.0007	-0.0005
	(-5.21)	(0.33)	(-0.99)	(-1.62)	(-1.93)	(-1.80)	(-1.28)
β_2	-0.0012	-0.0003	-0.0004	-0.0006	-0.0008	-0.0007	-0.0003
	(-5.34)	(-5.15)	(-2.61)	(-1.70)	(-2.21)	(-1.75)	(-0.75)
β_3	-0.0002	0.0003	0.0006	0.0009	0.0010	0.0010	0.0009
	(-0.44)	(3.48)	(4.35)	(3.60)	(3.45)	(3.33)	(3.24)
χ_2	0.0308	0.0017	0.0090	0.0090	0.0057	0.0072	0.0060
	(7.34)	(2.41)	(4.21)	(4.24)	(3.23)	(3.77)	(3.00)

Table 9

TGARCH estimates with MSCI Emerging Market Bonds dummy (t-statistics)

parameter	3month	6month	1year	2year	3year	5year	10year
			Panel A: Total sample: 1994 - 2005				
b_1	-0.0083	-0.0067	-0.0073	-0.0046	-0.0065	-0.0083	-0.0083
	(-3.88)	(-2.59)	(-2.44)	(-1.20)	(-1.55)	(-1.90)	(-1.89)
b_2	-0.0013	-0.0024	0.0003	0.0056	0.0052	0.0044	0.0044
	(-0.50)	(-0.93)	(0.11)	(1.39)	(1.22)	(0.98)	(0.97)
b_3	0.0034	0.0018	-0.0036	-0.0009	0.0022	0.0017	0.0016
	(1.70)	(0.71)	(-1.15)	(-0.22)	(0.52)	(0.38)	(0.38)
α_1	0.1291	0.0874	0.0455	0.0434	0.0360	0.0297	0.0329
	(13.25)	(9.52)	(6.98)	(7.32)	(6.07)	(5.23)	(5.12)
χ_1	0.1485	0.0548	0.0375	0.0134	0.0157	0.0096	0.0019
	(9.57)	(4.65)	(3.87)	(1.71)	(1.89)	(1.28)	(0.23)
α_2	0.8223	0.8678	0.9089	0.9283	0.9379	0.9496	0.9421
	(111.29)	(97.10)	(133.94)	(134.73)	(127.89)	(123.50)	(95.08)
β_1	-0.0001	-0.0001	-0.0001	-0.0005	-0.0004	-0.0005	-0.0004
	(-2.73)	(-1.64)	(-0.47)	(-2.14)	(-1.43)	(-1.69)	(-1.42)
β_2	-0.0001	-0.0003	-0.0005	-0.0004	-0.0007	-0.0008	-0.0005
	(-2.41)	(-3.76)	(-4.01)	(-1.58)	(-2.61)	(-2.62)	(-1.70)
β_3	0.0000	0.0003	0.0005	0.0009	0.0012	0.0011	0.0011
	(0.32)	(4.60)	(4.60)	(4.33)	(5.06)	(4.80)	(5.02)
χ_2	-0.0008	-0.0003	-0.0006	-0.0028	-0.0027	-0.0017	-0.0015
	(-1.54)	(-0.65)	(-1.63)	(-9.31)	(-5.09)	(-2.73)	(-2.26)
			Panel B: Subperiod: 1999 - 2005				
b_1	-0.0120	-0.0081	-0.0083	-0.0103	-0.0096	-0.0110	-0.0093
	(-3.29)	(-2.82)	(-2.04)	(-1.85)	(-1.64)	(-1.78)	(-1.58)
b_2	0.0074	0.0014	0.0055	0.0141	0.0159	0.0148	0.0140
	(1.78)	(0.46)	(1.28)	(2.35)	(2.53)	(2.34)	(2.25)
b_3	0.0261	-0.0026	-0.0080	-0.0093	-0.0091	-0.0091	-0.0062
	(4.45)	(-0.95)	(-2.13)	(-1.86)	(-1.76)	(-1.71)	(-1.21)
α_1	0.0436	0.1133	0.0732	0.0236	0.0172	0.0218	0.0285
	(3.82)	(9.48)	(5.01)	(3.66)	(2.85)	(3.36)	(3.75)
χ_1	0.2137	0.0258	0.0430	0.0144	0.0173	0.0111	0.0044
	(8.87)	(1.94)	(2.23)	(1.82)	(2.31)	(1.38)	(0.46)
α_2	0.8073	0.8684	0.8707	0.9583	0.9667	0.9644	0.9561
	(49.08)	(79.06)	(52.32)	(141.32)	(147.32)	(130.55)	(103.67)
β_1	-0.0009	-0.0000	-0.0002	-0.0005	-0.0006	-0.0007	-0.0005
	(-8.49)	(-0.73)	(-1.16)	(-1.60)	(-1.81)	(-1.90)	(-1.32)
β_2	-0.0014	-0.0004	-0.0004	-0.0005	-0.0008	-0.0006	-0.0002
	(-20.60)	(-6.22)	(-2.66)	(-1.47)	(-1.97)	(-1.56)	(-0.49)
β_3	0.0002	0.0002	0.0007	0.0008	0.0010	0.0010	0.0010
	(0.79)	(3.05)	(4.48)	(3.03)	(3.12)	(3.18)	(3.32)
χ_2	0.0008	0.0012	0.0001	-0.0009	-0.0011	-0.0020	-0.0033
	(0.81)	(1.89)	(0.06)	(-0.60)	(-0.70)	(-1.21)	(-2.06)

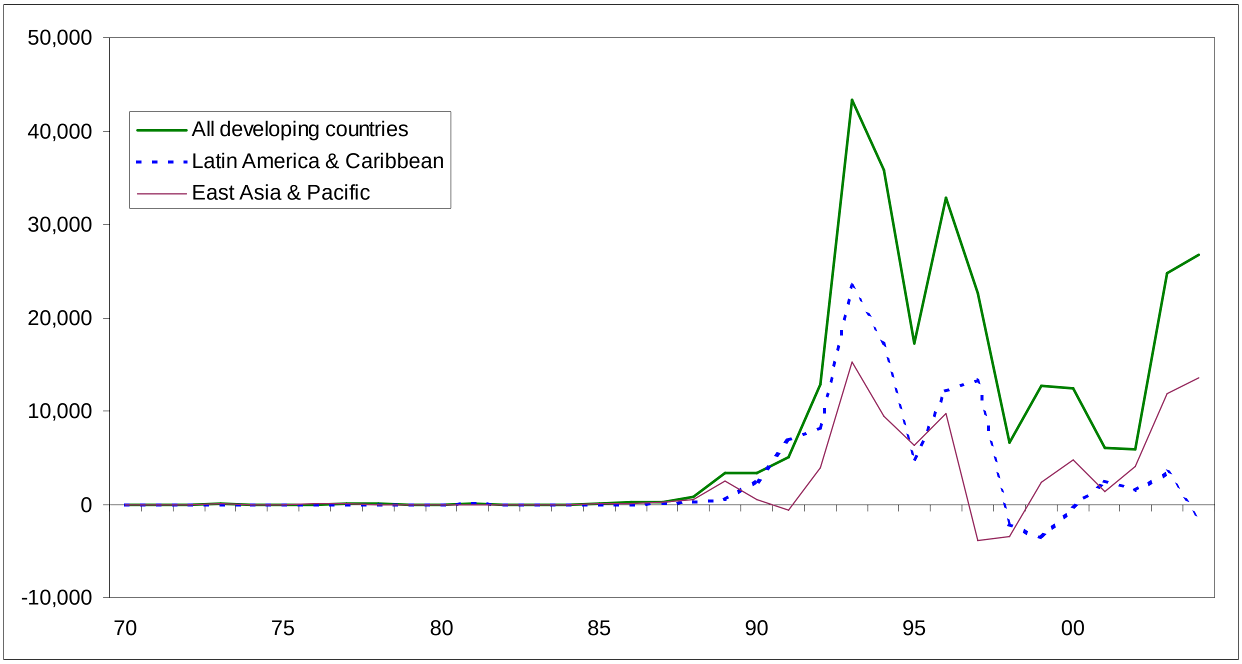

Figure 1. Portfolio Equity Flows to Emerging Markets Sector (US$m)