Heterogeneous Beliefs, Short-Sale Constraints 
and the Closed-End Fund Puzzle

Zhiguang Cao  
Shanghai University of Finance and Economics, China

Richard D. F. Harris*  
University of Exeter, UK

Junmin Yang  
Shanghai Institute of Foreign Trade, China

Paper No: 11/04  
November 2011

Abstract

In this paper, we develop a theoretical model to explain the well-established empirical regularities that have been documented in the literature on closed-end funds (CEFs). In the presence of heterogeneous beliefs and short-sale constraints, both the CEF price and the price of the assets that it holds can be decomposed into two parts: fundamental value and the value of the re-sale option. Generally, the value of the re-sale option of trading a CEF is smaller than that of trading the assets that it holds, and so a CEF typically sells at a discount relative to its net asset value (NAV). We develop a number of testable hypotheses based on the theoretical model concerning CEF discounts, the volatility of belief differences, diversification, the co-movement of the discount across CEFs, the excess volatility of CEF returns, and the returns on small stocks. We test these hypotheses using data on the Chinese CEF market and find that there is considerable support for the theoretical model.

Keywords: Speculation; Closed-end fund puzzle; Excess volatility; Chinese markets.

JEL classification: G12, G14

*Corresponding author. Xfi Centre for Finance and Investment, University of Exeter, Streatham Court, Rennes Drive, Exeter EX4 4ST, UK, phone: +44 (0) 1392 263215, email: R.D.F.Harris@exeter.ac.uk.
1. Introduction

There are a number of well-documented empirical regularities associated with the trading of closed-end funds (CEFs). First, CEFs typically start trading at a premium to their net asset value (NAV). Second, over time, CEFs typically sell at a discount to their NAV. Third, the premium or discount fluctuates over time and is positively correlated across CEFs. Fourth, the discount tends to zero as the CEF approaches liquidation. Fifth, the returns on CEFs tend to be more volatile than the returns on their NAV.¹

A variety of theories and models have been proposed to explain these regularities, some of which can be thought of ‘rational’, and others ‘behavioral’. All are able to predict at least some of the regularities described above, but none appear to offer a complete explanation of the CEF puzzle. In the rational framework, potential explanations include agency costs, illiquidity, capital gains tax and performance theory. The agency cost argument is that there exist moral hazard and adverse selection problems in relation to the management of the CEF that give rise to costs that must be borne by the CEF’s investors. These costs are reflected in a lower fund value in order to compensate the CEF’s investors. Boudreaux (1973) suggests that the discount is caused by management fees, and this idea is supported by Ross (2002). However, management fees are a constant fraction of NAV, and so this would not explain why the discount varies over time. Berk and Stanton (2007) suggest that investors’ expectations of the fund manager’s ability vary over time which, when combined with long-term compensation contracts, explain the time-variation in the discount. But even if there exist time-varying agency costs, it is not clear that the degree of time-variation in these

¹The first four of these regularities are summarized by Lee, Shleifer and Thaler (1991), and the fifth is studied by Pontiff (1997).
costs would be sufficient to explain the scale of the time-variation that is observed in the discount. Moreover, the agency cost explanation is inconsistent with the initial premium that CEFs typically experience.

Cherkes (2003) and Cherkes, Sagi and Stanton (2009) investigate the liquidity benefits provided by CEFs. They argue that CEFs tend to hold illiquid securities, while the shares of the CEFs themselves are relatively liquid, thus a premium or discount naturally arises from the tradeoff between the liquidity benefits of a CEF and the fees associated with its management. Chan, Jain and Xia (2008) emphasize the role of liquidity in explaining the premium or discount associated with country funds. While many funds surely provide a liquidity advantage, this argument would not apply to those CEFs that comprise only liquid assets, which also tend to trade at a discount to their NAV (see, for example, Lee, Shleifer and Thaler, 1990a).

In the presence of capital gains tax, a CEF may sell at a discount to its NAV because the calculation of the CEF’s NAV ignores this tax. However, discounts are also seen in CEFs that trade in markets that are not subject to capital gains tax. In addition, Malkiel (1977) finds that tax liabilities account for only a small fraction of discounts. Constantinides (1984) develops a tax-timing theory, and argues that the purchase of any taxable security confers on its owner a tax-timing option in the reporting of capital gains and losses. Since a portfolio of options is more valuable than an option on the corresponding portfolio (see, for example, Merton, 1973), the tax-timing value of owning shares of a CEF is likely to be less than that of direct ownership of the assets held by the CEF. Brickley, Manaster, and Schallheim (1991) apply the tax-timing theory to the CEF puzzle, and this approach is also supported by Kim (1994).
Tax-timing theory explains discounts on CEFs, but it does not explain why funds might sell at a premium, or why funds sell at a discount when capital gains taxes are not paid.\(^2\)

Within the behavioral framework, De Long, Shleifer, Summers and Waldmann (1990) propose a model in which noise traders create additional risk in the market for CEFs, and so rational investors require a higher return to compensate for this additional risk, which depresses CEF prices. Relatedly, Lee, Shleifer and Thaler (1991) employ investor sentiment to explain the CEF puzzle in the US market. They argue that CEFs are usually introduced when noise traders are over-optimistic, so CEFs initially trade at a premium to their NAV. In the US market, CEFs are held primarily by individuals, who are more likely than institutional investors to be noise traders. Under the De Long et al. (1990) model, these noise traders create additional risk over the risk of the assets that the CEF comprises. This additional risk is incorporated into the price of the CEF, and so it sells at a discount. Lee et al. (1991) suggest that sentiment among individuals tends to be positively correlated, so discounts on various funds tend to be positively correlated over time. As the fund approaches its maturity date, the additional risk created by noise traders approaches zero, so discounts narrow and eventually disappear. Other studies, such as Neal and Wheatley (1998) and Bodurtha, Kim and Lee (1995) also provide support for the behavioral explanation of the CEF puzzle. However, while the behavioral approach appears to work for the US market, the stylized evidence from other markets does not fit easily into the behavioral framework. For example, in China, CEFs were primarily held by individuals before March 2000, and by institutions after that date.

\(^2\)Further potential explanations for the CEF puzzle within the rational framework include market segmentation (Chan, Jain and Xia, 2008), asymmetric information (Grullon and Wang, 2001) and stochastic turnover risk (Xu, 2003).
According to the behavioral approach, this would imply that the discount that arises from the additional risk caused by noise traders should have reduced. In fact, the converse is true: the discount on Chinese CEFs was negligible before March 2000 (indeed, in some cases, CEFs were trading at a premium to their NAV), but significantly larger after March 2000. Moreover, the behavioral approach suggests that discounts on CEFs should be negatively correlated with the returns on small stocks, but this has been challenged by other researchers (see, for example, Chen, Kan and Miller, 1993; Eltonet al., 1998; Gemmill and Thomas, 2002; Doukas, 2004). This suggests that in some markets at least, the CEF puzzle is not easily explained by noise trading by individual investors.

In this paper, we propose an alternative explanation for the closed-end fund puzzle, which also fits into the behavioral framework. The explanation is based on the approach of Scheinkman and Xiong (2005) who consider the decomposition of the price of an asset into two components representing fundamental value and speculative value, respectively. In particular, they show that when short-selling is constrained and investors have heterogeneous beliefs, a rational investor may pay more for an asset than its fundamental value because ownership of the asset provides the rational investor with the opportunity to sell the asset to another investor who has a higher valuation of the asset’s fundamental value than his own. This speculative component of the asset price comes from trading and represents an American option, where the underlying asset is the difference in beliefs between the owner of the asset and other, potentially misinformed investors. The value of the speculative component is increasing in the volatility of the belief difference between investors, which itself is reflected in the trading volume of the asset.
Here we use a similar approach to explain the CEF puzzle. In particular, we develop a model in which we decompose both the price of a CEF and its NAV into a fundamental component and a speculative component. Since the fundamental component is the same for the CEF and its NAV (i.e. the present value of the expected future cash flows of the shares that the CEF holds), the discount in the value of the CEF over its NAV reflects different speculative components, which are in turn related to the relative volatility of belief differences between the CEF and the underlying shares, and hence to differences in the volume of trading. Belief differences arise from different groups of investors receiving different signals about fundamental value. A CEF usually holds a portfolio of equities and, as a result of diversification, its fundamentals are typically less volatile than any of the individual equities that it holds. Thus, the American option of trading a CEF is typically less valuable than that of trading any of the individual equities, which causes the discount on the CEF. Our approach differs from that of Scheinkman and Xiong (2005) in several important respects. First, our model provides a very much simpler characterization of the re-sale option. In particular, only two parameters, namely belief differences and the volatility of belief differences, are used to measure the option value. Second, the size of the signal noise plays an important role in our model, and indeed we show that its impact on the option value is quadratic, which implies that while small amounts of signal noise increases the speculative value of an asset, and hence also its price, larger amounts of signal noise can lead to a reduction in an asset’s speculative value and its price. Third, we develop a number of testable hypotheses based on the theoretical model. These hypotheses concern CEF discounts, the volatility of belief
differences, diversification, the co-movement of the discount across CEFs, the excess volatility of CEF returns, and the returns on small stocks.

We test the hypotheses that we develop using data on the Chinese CEF market. The use of Chinese CEF data reflects several important considerations. First, the average discount on CEFs in the Chinese market is very significantly larger than in other markets. For example, the average discount of CEFs in the Chinese market over the period 2000-2009 is about 30%, compared to 6% in the US for the period 1986-2006 (see Cherkes et al., 2009). Second, short selling is prohibited in the Chinese equity market, even for institutional investors. This is in contrast with other markets, such as in the US or Europe, where short-selling is allowed but may be costly. Although a version of our model would apply when short selling is allowed but costly, it is instructive to consider the more extreme case where short-selling is not allowed. Third, the heterogeneity of beliefs among investors is more likely to be large and volatile, since the market is dominated by individual investors. Fourth, capital gains taxes are not imposed in Chinese stock markets, and management fees and custody charges are the same across most funds. This allows us to rule out explanations for the CEF puzzle related to taxation and agency costs. The use of Chinese CEF data thus provides an ideal opportunity to test the theory that we develop.

The remainder of the paper is organized as follows. In Section 2, we describe the theoretical model used to explain the CEF discount and derive the testable implications of the model. Section 3 reports the results of the empirical analysis. Section 4 concludes.

---

3The China Securities Regulatory Commission (CSRC) enacted ‘Regulations on Pilot Program of Margin Financing and Stock Borrowing/Lending by Securities Companies’ in June 2006, but it only came into effect on March 31, 2010 and even then, investors were able to take short positions in only 90 stocks.
2. Theoretical Background

2.1 Heterogeneous Beliefs and Asset Prices

Miller (1977) shows that if there are heterogeneous beliefs among investors and short-selling is not permitted, the equilibrium price of an asset reflects the opinion of the more optimistic investors, and thus the asset would be overvalued. Harrison and Kreps (1978) extend Miller's model to a multi-period setting and show that if an investor believes that he can resell an asset at a higher price to another, more optimistic investor in the future, then he would pay more than the fundamental value of the asset, which is equivalent to the value that he would pay if he held the asset indefinitely. The difference between the price that an investor is willing to pay and the fundamental value of the asset reflects speculative value.

Scheinkman and Xiong (2003) analyze this speculative value in a continuous time framework. They consider a market in which short-sales are not allowed and only a single asset is traded. Investors are divided into two groups: those that own the asset and those that do not, and over time, these two groups exchange positions by trading the asset. At any point in time, the asset is held by the more optimistic investors because they are willing to pay a higher price for the asset in line with their optimistic beliefs. Scheinkman and Xiong introduce overconfidence to generate the heterogeneous beliefs between the two groups and derive the analytical solution to the speculative value of the asset price, which is the value of an American option. This speculative value is positively related to the volatility of the belief difference between the two groups, and to the trading volume of the asset: the more volatile the belief difference, the more trading there is between the two groups of investors and so the higher the trading volume. In this model, therefore, turnover mainly reflects speculation rather than liquidity,
and the level of turnover is positively associated with speculative value. Mei, Scheinkman and Xiong (2009) employ this theory to explain the substantial price differences between the Chinese A and B markets, whose single most important difference is in the currency in which the shares are traded, but which are both subject to short-selling restrictions. Specifically, they argue that since turnover is significantly higher in the A market than the B market, shares that trade simultaneously in the two markets tend to have higher speculative value in the A market than in the B market. Consequently, the price of the shares should be higher in the A market than in the B market.

Based on the above ideas, we develop a parsimonious discrete-time theoretical model of the discount in the CEF market.

2.2 Theoretical Model

Consider a two-period investment horizon with three dates, , and assume that investors are risk-neutral. There is only one unit of risky asset in the market, and it pays at time , where is normally distributed. We set the risk-free rate equal to zero. For simplicity, we assume there are only two groups of investors: group A and group B. We also introduce a behavioral bias, namely overconfidence, which ensures that each group makes decisions based only on the signal that it receives, even though each group also observes the signal that the other group receives. The beliefs of group A and group B at time about the mean and variance of the payoff at time are defined as follows:

\begin{align}
\mu_A(t) &= \text{mean signal received by group A at time } t \\
\sigma_A(t) &= \text{variance of signal received by group A at time } t \\
\mu_B(t) &= \text{mean signal received by group B at time } t \\
\sigma_B(t) &= \text{variance of signal received by group B at time } t 
\end{align}
Where and represent the signals received by group A and B at time , respectively, reflects the fundamental value of the asset for group A, reflects the fundamental value for group B and measures the volatility of the payoff. For convenience, we denote group A as the more optimistic investors at time , so that .

therefore measures the belief difference in fundamental value between the more optimistic investors and less optimistic investors.

At time , group A receives a signal , and group B receives a signal . We assume signals and are unbiased but noisy observations of the payoff .

Where and are i.i.d., and follow a normal distribution with mean zero and variance . Since and are jointly normally distributed, the expectation of conditional on is given by

Where and . Similarly, we have

We first consider the asset price at time when trading between investors is not allowed at time , and so the model reduces to a one-period problem. In this case, the asset price can be viewed as the price that investors are willing to pay if they hold the asset until
maturity. We denote this price $\rho$, and it reflects the fundamental value of the more optimistic investors. Obviously, each investor would bid his reservation price, and so in the presence of competition and short-sale constraints, this price is equal to

$$\rho = \text{(8)}$$

When trading at time $t$ is not allowed, the short-sale constraint ensures that the asset price reflects only the beliefs of the more optimistic investors, and hence the asset is potentially overpriced.

Now we consider the case where trading at time $t$ is allowed. At time $t$, groups A and B receive signals $\text{(9)}$ and $\text{(9)}$, respectively. The fundamental value of the asset at time $t$ is as viewed by group A and as viewed by group B. If trading is allowed at time $t$, then in the presence of short-sale constraints, the asset price at time $t$ is equal to

$$\rho = \text{(9)}$$

Naturally, when trading is allowed at time $t$, the asset price at time $t$ satisfies

$$\rho = \text{(10)}$$

We rewrite (10) as

$$\rho = \text{(11)}$$

where

$$\rho = \text{(12)}$$
Here can be viewed as the value of the re-sale option for group A, and this value comes from trading, so we refer to it as the asset’s speculative value. In addition, is the price that investors in group A are willing to pay when trading at time is not allowed, and can be viewed as the fundamental value of the asset for group A. Thus, we decompose the asset price into two parts, namely fundamental value and speculative value.

**Proposition 1**

*The value of the re-sale option , and satisfies*

\[ \text{(13)} \]

*Where , which measures the belief difference between group A and group B, and , which measures the volatility of the belief difference. and are the probability density function and cumulative distribution function of the standard normal distribution, respectively.***

**Proof:** See Appendix A1.

is the value of the re-sale option to investors in group A, and reflects the fact that they can sell the asset to investors in group B at a higher price than their own fundamental evaluation at time . The value of the re-sale option comes from trading in the presence of the short-sale constraint and heterogeneous beliefs. Note that increases with the volatility of the belief difference, , and decreases with the level of the belief difference, . Define , then the asset price can also be written as

\[ \text{(14)} \]
Where can be viewed as the value of the re-sale option for investors in group B. Also increases with the volatility of the belief difference, but unlike, it increases with the level of the belief difference.

**Proposition 2**

*The value of the re-sale option increases with the size of the signal noise when*, and decreases with when.

**Proof:** See Appendix A2

Proposition 2 shows that the signal noise can increase or decrease the value of the re-sale option, depending on its size relative to the uncertainty of the asset’s payoff. When an asset’s payoff is highly uncertain, the signal noise tends to increase the value of the re-sale option, but when an asset’s payoff is less uncertain, it tends to decrease the value of the re-sale option.

**2.3 Speculative Value and CEFs**

We now apply the results derived in the previous section to model the CEF discount. The NAV of a CEF is equal to the market value of the assets under management per share of the CEF. The managed assets usually comprise a diversified portfolio; for simplicity we assume this is an equally-weighted portfolio. According to (11), we have

\begin{equation}
\text{where}
\end{equation}
is the NAV of the CEF at time \( t \)

is the fundamental value of asset \( i \) as viewed by investors in asset \( i \)

is the equally-weighted average fundamental value of the assets managed by the CEF

is the value of the re-sale option for asset \( i \)

is the equally-weighted average value of the re-sale options

is the share price of the CEF

is the fundamental value of asset \( i \) as viewed by investors in the CEF

is the equally-weighted average fundamental value of the CEF’s holdings as viewed by investors in the CEF

is the value of the re-sale option for the CEF

If the investors in the CEF are the same as the investors in the underlying assets managed by the CEF, then we have \( \text{ and } \). Thus the difference between the price of a CEF and its NAV can be written as

\[- \quad \text{(17)}\]

**Proposition 3**

*If investors’ beliefs about the variance of the payoff across individual assets are the same, i.e., \( \), and the correlation coefficient between the payoffs of asset \( i \) and \( j \), \( \), then the value of the option from trading a diversified and equally-weighted portfolio is less than that from trading any individual asset.*
Proof: See appendix A3.

2.4 Discussion

*The CEF Discount*

Diversification ensures that the variance of the portfolio's payoff, , is less than the average variance of the individual assets’ payoffs, , and thus Proposition 1 and Proposition 3 imply that the value of the option arising from trading a CEF is typically less than the average value of the options arising from trading individual assets, i.e., . Naturally, if the investors in a CEF are the same as the investors in each of the underlying assets managed by the CEF, then CEFs usually trade at a discount.

*Excess Volatility in CEF Returns*

Consider now the volatility of and . A CEF can also be viewed as a single asset, and we can assume that is not very different from the average variance across individual assets, , thus typically holds. Additionally, the value of the re-sale option of trading a CEF is typically more volatile than the average value of the re-sale option of trading its underlying assets. Ignoring the effect of the covariance between the fundamental value and the re-sale option value, the share price of a CEF is typically more volatile than its NAV.\footnote{The difference between the variances of the CEF and its NAV can be written as \( \text{var} = \text{var} + 2 \text{cov} + \text{cov} \), where \( \text{cov} \) is the average covariance between the speculative value of individual assets and the fundamental value of the underlying portfolio managed by the CEF. Typically, , and so it would normally be the case that . Below, we show empirically that the effect of ignoring the covariance of the fundamental value and the re-sale option value is minimal.}
**CEF Discounts and Liquidation**

The speculative value of the CEF approaches zero when the fund liquidates or open-ends. At expiration, shareholders of the CEF acquire the CEF’s holdings and hence also the speculative value of those holdings. Consequently, the discount narrows as the CEF’s liquidation approaches.

**The Correlation of Discounts among CEFs**

Discounts across CEFs are positively correlated. From (14) we can see that there are two reasons for this. First, different CEFs have similar investor structure, i.e., they are held by investors affected by common factors. This causes the speculative value of CEFs to be positively correlated and so their re-sale option values are also positively correlated. Second, different CEFs hold some assets in common, which leads to a positive correlation between the re-sale option values of the assets held by CEFs.

**The Initial CEF Premium**

Lee et al. (1991) attribute the initial premium that CEFs commonly experience to market timing, i.e. CEFs are normally started during periods when noise traders are considered to be over-optimistic. In our model, the initial premium of CEFs is explained by a similar, though distinct mechanism. We attribute the premium on CEFs to the marketing activities taken by the CEFs’ sponsors. Successful marketing attracts more investors, especially those with short-term investment horizons, which leads to high CEF turnover. This in turn leads to high speculative value relative to the speculative value of the underlying assets, which causes the CEF discount to narrow, and even become negative. Also, investors have less information
about newly created CEFs than they do about established CEFs. This may increase the volatility of belief differences among investors, which again causes the speculative value of CEFs to increase.

3. Empirical Evidence from the Chinese Stock Market

In this section, we provide supportive evidence for the theory developed in the previous section, based on the Chinese CEF market. As discussed in the introduction, the Chinese market provides an ideal opportunity to test the theory owing to the size of the CEF discount and the fact that short-selling is effectively prohibited. We first define the hypotheses to be tested and describe the data used in the analysis. We then outline the empirical methodology. Finally, we report the results of the empirical analysis.

3.1 Empirical Hypotheses

First, we test whether heterogeneous beliefs affect the discounts on CEFs. According to the model, the discount on a CEF should be positively correlated with the speculative value of the underlying assets managed by the CEF, and negatively correlated with the speculative value of the CEF itself. Proposition 1 indicates that speculative value increases with the volatility of the belief difference. Heterogeneous beliefs are not observable, but various proxy variables have been suggested in the literature, including the volatility of predictions made by professionals (Harris and Raviv, 1993; Graham and Harvey, 1996; Diether, Malloy and Scherbina, 2002), the volatility of returns (Danielsen and Sorescu, 2001), the volatility of the residuals from a market model of returns (Shalen, 1993), turnover (Kaul and Lipson, 1994; Boehme, Danielsen and Sorescu, 2006; Scheinkman and Xiong, 2003; Mei, Scheinkman and
Xiong, 2009), and the open interest on futures contracts (Bessembinder, Chan and Seguin, 1996). Given the constraints on data availability in the Chinese market, we use turnover to proxy the volatility of belief differences. We therefore test the following hypothesis:

**Hypothesis 1a:** The CEF discount increases with the turnover of the underlying assets managed by the CEF, and decreases with the turnover of the CEF itself.

For robustness, we also test this prediction of the model using an alternative measure, the volatility of returns, which leads to the following hypothesis:

**Hypothesis 1b:** The CEF discount increases with the volatility of the underlying assets managed by the CEF, and decreases with the volatility of the CEF itself.

Second, we investigate the relationship between diversification and the CEF discount. According to Proposition 1, the more diversified the holdings of a CEF, the lower the value of the re-sale option of the CEF, and hence the higher the discount. We proxy the degree of diversification of a CEF by the level of its systematic risk, which we estimate using a market model.

**Hypothesis 2:** The CEF discount increases with the level of systematic risk of the CEF, as measured by the R-squared coefficient in a market model of CEF returns.

Third, we investigate the relationship between belief heterogeneity and the correlation of discounts across CEFs. Specifically, we test whether similarities in the underlying assets between CEFs explain the fact that their discounts tend to move together, and whether the speculative values of different CEFs are positively correlated. This leads to the following hypothesis:
**Hypothesis 3:** The correlation in the change in discount between CEFs increases with the correlation in the change in their NAV, and increases with the correlation in changes in their turnover.

Fourth, we examine the relationship between the belief heterogeneity and excess volatility. Specifically, we test whether the speculative value of CEFs is more volatile than the average speculative value of the underlying assets managed by the CEF.

**Hypothesis 4:** The American option of trading a CEF is more volatile than that of trading the underlying assets managed by the CEF.

Fifth, we investigate the relationship between the returns on small stocks and changes in the discount on CEFs. Lee et al. (1991) suggest that noise mostly created by individual investors explains the discount on a CEF, and that since small stocks are primarily held by individual investors, when individual investors are optimistic about small stocks, they are also optimistic about CEFs, thus the returns on small stocks should be negatively correlated with changes in the discount on CEFs. Similarly, sentiment theory suggests that the more individual traders there are in the CEF market, the greater the discount on CEFs. However, the theory developed in this paper predicts that the more institutional traders there are in the CEF market, the greater the discount on CEFs. Typically, heterogeneous beliefs among institutional investors are less volatile than those among individual investors, and so the re-sale option is more valuable in a market where individual investors dominate than one in which institutional investors dominate. Consequently, the correlation between the returns on small stocks and changes in the discount on CEFs depends on the relative importance of institutional and individual investors. Specifically, we have the following hypotheses:
**Hypothesis 5a:** Returns on small stocks are not correlated with discounts on CEFs when CEFs are primarily held by institutional investors and CEFs hold a large percentage of large stocks.

**Hypothesis 5b:** Returns on small stocks are negatively correlated with discounts on CEFs when CEFs are primarily held by individual investors and CEFs hold a large percentage of large stocks.

**Hypothesis 5c:** Returns on small stocks are positively correlated with discounts on CEFs when CEFs are primarily held by institutional investors and CEFs hold a large percentage of small stocks.

Finally, we explore the relationship between the relative importance of institutional investors in CEFs and the discounts on CEFs. Proposition 2 implies that noise could increase or decrease the value of the re-sale option, depending on the size of noise relative to the uncertainty of the fundamentals, and so could also increase or decrease the asset price. Institutional investors are usually assumed to have advantages in collecting and analyzing information relative to individual investors, and so it is reasonable to assume that the noise defined in (1) and (2) is smaller for institutional investors than it is for individual investors. Proposition 2 therefore predicts that there is a positive relationship between the fraction of institutional investors in the CEF market and the discounts on CEFs. Moreover, Proposition 2 suggests that this relationship is quadratic.

**Hypothesis 6:** The CEF discount increases with the percentage of institutional investors in the CEF, and this relationship is quadratic.
3.2 Data

The empirical analysis uses weekly data, which are collected from Wind, Inc. Owing to the fact that short-sales were allowed after the end of March, 2010, we use data from 1998 up to the end of 2009. In our study, CEFs with less than three years of data were excluded. There are 34 CEFs trading in both the Shanghai and Shenzhen markets at the end of 2009, although four started in only 2009 and one started in only 2008. One other CEF invests mainly in bonds and monetary instruments. There are also two CEFs linked by a special prospectus that allows profits to be distributed between each other by a specific rule. We therefore exclude these eight CEFs, and so our sample comprises 26 equity CEFs, with a maximum sample from April 10, 1998 to December 31, 2009, a total of 587 weekly observations.

Here we describe the calculation of the main variables that are used in the empirical analysis. We define the discount on CEF \( i \) at time \( t \) as

\[
\text{Discount}_i^t = \frac{P_i^t - NAV_i^t}{NAV_i^t}
\]

where

\( P_i^t \) is the share price of CEF \( i \) at time \( t \)

\( NAV_i^t \) is the net asset value per share of CEF \( i \) at time \( t \). Following Lee et al. (1991), we construct a value-weighted index of discounts as follows:

\[
\text{Index}_{\text{Discount}} = \frac{\sum_i \text{Discount}_i^t \cdot W_i^t}{\sum_i W_i^t}
\]

where

__________
is the number of shares of CEF i at time t

is the number of CEFs at time t

Similarly, we construct the value-weighted turnover of CEFs as follows:

\[(20)\]

Where is turnover of CEF i at time t. We also construct the value-weighted turnover of the underlying assets managed by CEFs, denoted by , in the same way. CEFs only report their underlying assets quarterly, so the turnover of their underlying assets is not available at the weekly level. We therefore use the value-weighted turnover of the constituents of the Shanghai Composite Index, which consists of all stocks in Shanghai stock market to calculate .

The volatility of returns of CEF i at date t is calculated using the range-based measure proposed by Rogers and Satchell (1991), which is given by

\[(21)\]

Where , , , are the high, open, low and closing prices of CEF i at date t, respectively. The value-weighted volatility of CEFs is then calculated as

\[(22)\]

\[\text{5 There is no index covering all stocks in both the Shanghai and Shenzhen markets and so we use the index for the larger of the two markets. Using an index for just a single market is at least partly justified by the fact that the Shanghai and Shenzhen stock markets are very highly correlated.} \]
We calculate the value-weighted volatility of the underlying assets managed by CEFs, in the same way. Again, owing to data constraints, we proxy the underlying assets managed by CEFs by all equities available in the Shanghai stock market. Owing to the fact that the investor structure of CEFs in the Chinese market changed significantly around March 2000, we divide the whole sample period into two sub-periods: April 1998 to March 2000, in which individuals dominate the CEF market and April 2000 to December 2009, in which institutional investors dominate the CEF market. Table I presents a brief statistical description of $VWD$, , and for the full sample and the two sub-periods. The means of $VWD$ for the two sub-periods are -0.1352 and 0.2977, respectively, indicating a negative discount (i.e. a premium) during the first sub-period and a positive discount during the second sub-period, on average. The differences between the means of and for the two sub-periods are -0.0268 and 0.0383, respectively, which indicates that there is a positive relationship between $VWD$ and the differences between and . Similarly, the differences between the means of and for the two sub-periods are 0.0015 and 0.0028, respectively, which suggests that when the differences between and widen, the discounts on CEFs do also. Figure 1 depicts $VWD$, and over time from April 1998 to December 2009. From Figure 1 we can see that the discounts on CEFs are mostly negative before 2000, and correspondingly, is higher than . After 2000, CEFs began to sell at a discount, and correspondingly, is mostly lower than during this period.

[Insert Table I here]
Figure 1 shows that when the average turnover of the assets that a CEF holds is greater than the turnover of the CEF itself, the CEF usually sells at a discount, otherwise it sells at a premium. Given the volatility of belief differences is positively related to turnover (Scheinkman and Xiong, 2003; Mei, Scheinkman and Xiong, 2005), the results from Table I and Figure 1 provide informal support for the result of Proposition 1 that the re-sale option value for an asset is positively related to the volatility of the belief difference.

3.3 Methodology

To investigate the relationship between belief heterogeneity and discounts on CEFs, we regress on changes in the proxy variables for heterogeneous beliefs, both for CEFs and their holdings. First, we use to proxy the volatility of belief differences in CEFs and to proxy the volatility of belief differences in their holdings, leading to the following regression model:

(23)

Hypothesis 1a implies that should be positive and should be negative. Second, we use the range-based measure of volatility as a proxy for volatility of belief differences, leading to the following model:

(24)

Hypothesis 1b implies that should be positive and should be negative.

To investigate the relationship between diversification and CEF discounts, we formulate the following panel regression model:
where

\( w \) is the average discount for fund \( i \) in year \( t \)

\( \hat{r} \) is the realized return obtained from a regression of the returns of CEF \( i \) on the returns of the Shanghai Composite Index, using weekly data over the year \( t \), and measures the degree of diversification.

\( \bar{g} \) is the average turnover for fund \( i \) in year \( t \), and is used as a control variable.

\( \alpha \) is the intercept for fund \( i \)

\( \epsilon \) represents unobservable or missing variables that are constant across individual funds at time \( t \), but vary through time.

The use of panel data techniques allows us to remove the effects of \( \epsilon \) and \( \gamma \), and yield unbiased and consistent estimators of \( \beta \) and \( \delta \). Specifically, the following regression is estimated using pooled data:

\[
(26)
\]

where

\( \alpha_i \)

\( \gamma_i \)

\( \beta_i \)

\( \delta_i \)

Hypothesis 2 implies that \( \beta_i \) should be positive in the regression given by (26).
To investigate the relationship between heterogeneous beliefs and the correlation on discounts across CEFs, the following regression is estimated using pooled data:

\[(27)\]

where

- \(\rho_{it}\) is the realized correlation coefficient of change in discounts between fund \(i\) and \(j\) in year \(t\), calculated using weekly data

- \(\rho_{N_{it}}\) is the realized correlation coefficient of the change in NAV between fund \(i\) and \(j\)

- \(\rho_{T_{it}}\) is the realized correlation coefficient of the change in turnover between fund \(i\) and \(j\)

- \(h_{it}\) represents the co-movement of the re-sale option for funds \(i\) and \(j\), while \(\delta_{it}\) measures the similarity in the underlying assets held by CEFs \(i\) and \(j\) and hence captures the co-movement of the re-sale option of the underlying assets. Hypothesis 3 implies that \(\alpha_{it}\) and \(\beta_{it}\) should be positive.

To investigate the relationship between heterogeneous beliefs and excess volatility, we build the following state-space model:

Observation equation:

\[(28)\]

State equation:

\[(29)\]

where

\(\ldots\)
is the average re-sale option value of trading the holdings of CEF $i$ at time $t$, and \( \theta \) is the re-sale option value of trading CEF $i$ at time $t$. \( \alpha, \beta, \gamma, \delta \) are parameters to be estimated. Here \( \epsilon \) is assumed to be unpredictable noise, and \( \alpha, \beta, \gamma \) follow a first-order autoregressive process. After estimating the parameters of the state-space model, the unobservable variables \( \alpha, \beta, \gamma \) are estimated using the Kalman filter. Then the volatilities of the fundamental components and the speculative components are calculated, and the Wilcoxon sign-rank test is used to test whether the speculative value of a CEF is more volatile than the average speculative value of the underlying assets managed by the CEF.

To investigate the relationship between returns on small stocks and discount changes on CEFs, we use the following regression similar to that employed by Lee et al. (1991):

\[
\text{Return}_t = \alpha + \beta \text{Return}_t^{\text{market}} + \gamma \text{Discount}_t + \epsilon
\]

(30)

where

- \( \text{Return}_t \) is the return on the portfolio of smallest stocks at time $t$
- \( \text{Return}_t^{\text{market}} \) is the return on the market portfolio, proxied by the Shanghai Composite Index at time $t$

According to the theory, \( \gamma \) should be positively correlated with changes in fundamental value and changes in speculative value for small stocks, and differences in discounts are positively correlated with changes in speculative value for CEFs’ holdings and negatively correlated with changes in speculative value for the CEFs themselves. Given that the
heterogeneous beliefs of individual investors are not highly correlated with the beliefs of institutional investors, and that individual investors tend to hold small stocks while institutional investors tend to hold big stocks, the theory predicts that:

1. will not be significantly negative when CEFs are primarily held by institutional investors and CEFs hold a large percentage of large stocks.

2. will be significantly negative when CEFs are primarily held by individual investors and CEFs hold a large percentage of large stocks.

3. will be significantly positive when CEFs hold a large percentage of small stocks and CEFs are primarily held by institutional investors.

In order to test these predictions, we divide the full sample of 26 CEFs into four subgroups each year based on the following approach. For each CEF, we firstly regress the returns of the CEF’s NAV on the returns of the biggest stock portfolio and then on the returns of the smallest stock portfolio. Then the ratio of the R-squared coefficients from these two regressions, denoted by , is calculated, and the critical value 1 is used to divide CEFs into two subgroups in each year, i.e., if , then CEF is allocated to group A, otherwise it is allocated to group B. CEFs in group A tend to hold more big stocks than small stocks, while CEFs in group B tend to hold more small stocks than big stocks. Secondly, we repeat this procedure using the CEF in place of its NAV, to yield the ratio of R-squared statistics for each CEF, . Again, a critical value of 1 is used to divide CEFs into two subgroups in each year, i.e., if , then CEF is allocated to group C, otherwise it is allocated to group D. CEFs in group C tend to be held by more institutional investors than
individual investors, and CEFs in group B tend to be held by more individual investors than institutional investors. Finally, we divide all 26 CEFs into four mutually exclusive categories: funds in both groups A and C ( ), funds in both groups A and D ( ), funds in both groups B and C ( ), and funds in both groups B and D ( ). This procedure is undertaken at the end of each year, and the weekly time series of value-weighted discounts for each of the four categories (denoted , , , and ) are calculated. We test the above three predictions by replacing in (27) by , , , and , respectively.

Finally, we use the following pooled regression to investigate the relationship between the relative importance of institutional investors in CEFs and the discounts on CEFs:

(31)

where

is the average percentage of institutional investors in CEF in year

is the time to maturity for fund in year

is a dummy variable for year used to control for missing variables which vary through time, but are constant across CEFs. To avoid multicollinearity, is excluded from the regression.

Since the percentage of institutional investors in CEFs is only available after 2004, we estimate the regression for the period 2004-2009. The theory predicts that the relationship between the percentage of institutional investors and discounts on CEFs is quadratic, and so should be positive and should be negative.
3.4 Empirical Results

Heterogeneous Beliefs and Discounts

Table II reports the results of estimating regression (23) and (24) for the full sample, April 1998 to December 2009. For robustness, the regression is also estimated using volatility in place of turnover as a proxy for heterogeneous beliefs, and the results for these regressions are also reported in the table. The results provide support for Hypotheses 1a and 1b. In particular, the coefficients on and are both positive and statistically significant at conventional significance levels, and the coefficients on and are both significantly negative. We also estimate regression (23) and (24) for the sub-periods from April 1998 to March 2000 and from April 2000 to December 2009, respectively, and the results are similar to those for the full sample reported in Table II. For brevity, we do not report the sub-sample results.

[Insert Table II here]

Diversification and Discounts

Table III reports the results of estimating regression (26). is calculated in each year as long as there are at least 20 weeks’ data available. Consistent with Hypothesis 2, is positive and is negative, and both are statistically significant at conventional significance levels. The fact that is positive provides empirical support for Proposition 1, which states that the re-sale option value is positively related to the volatility of belief differences.

[Insert Table III here]

Heterogeneous Beliefs and the Positive Correlation among Discounts
Table IV presents a brief statistical description of three variables. The correlations are calculated in each year $t$ as long as there are at least 20 weeks’ data available. The mean value of $\rho$ is 0.621, which indicates that discounts on CEFs tend to change together. The mean value of $\phi$ is 0.757, which indicates that CEFs hold many similar underlying assets. Finally, the mean value of $\theta$ is 0.670, which indicates that the value of the re-sale option for individual CEFs tends to change together.

[Insert Table IV here]

Table V shows that $\phi$ and $\omega$ in (27) are positive and statistically significant at conventional significance levels, which is consistent with Hypothesis 3. In particular, it supports the idea that positive correlation among CEF discounts is caused by similarities in the assets that they hold and their investor structure.

[Insert Table V here]

**Heterogeneous Beliefs and Excess Volatility**

Table VI presents the estimates of the state-space model (28) and (29). The $t$-statistics, reported in parentheses, show that the coefficients are statistically significant for most CEFs, and typically both $\beta$ and $\gamma$ are negative.

[Insert Table VI here]

Based on the estimates of the state-space model reported in Table VI, we calculate the variances of $\gamma$, $\omega$, $\rho$, $\phi$, and $\theta$, and the covariances between $\gamma$ and $\omega$, between $\gamma$ and $\rho$, and between $\omega$ and $\phi$. These results, which are reported in Table VII, show that the variance of $\rho$ is usually less than variance of $\phi$, though for several
funds (PUHUI, TIANYUAN, JIUJIA and HONGYANG), the converse is true. The Wilcoxon sign-rank test very strongly rejects the null hypothesis that the variance of is equal to the variance of . Table VII shows that holds for all 26 CEFs, and the Wilcoxon sign-rank test shows that this inequality is highly significant. This supports the idea that the value of the re-sale option of a CEF is typically more volatile than the average value of the re-sale option of its underlying assets, lending support to Hypothesis 4. Note that from Table VII we can see that ) is only slightly larger than ), which indicates that ignoring the effect of this covariance is minimal when we compare the variance of with that of in Section 2.4. Table VII also shows that holds for 24 CEFs, which means that the re-sale option value of a CEF tends to decrease when the re-sale option value of its underlying stocks goes up. and for all 26 CEFs, which means the re-sale option value tends to move together with fundamental value.

[Insert Table VII here]

*The Returns on Small Stocks and Changes in the discounts of CEFs*

Table VIII presents results for regression (30). The coefficient is positive, but not statistically significant at conventional significance levels, which suggests that the returns on small stocks are not correlated with discounts on CEFs in general. Table 8 also presents results when is replaced by , , and . Using , is positive (although not significant), confirming Hypothesis 5a that the correlation between the returns on small stocks and the CEF discount may not be significantly negative when CEFs are primarily held by institutional investors and CEFs hold
a large percentage of large stocks. Using \( \beta \), is negative and statistically significant, confirming Hypothesis 5b that the correlation is significantly negative when CEFs are primarily held by individual investors and CEFs hold a large percentage of large stocks. Finally, using \( \gamma \), is positive and statistically significant, confirming Hypothesis 5c that the correlation is significantly positive when CEFs hold a large percentage of small stocks and CEFs are primarily held by institutional investors. Using \( \delta \), is negative but not statistically significant at conventional significance levels.

[Insert Table VIII here]

The results reported in Table VIII suggest that the noise risk of a CEF created by noise traders – primarily individuals – is not necessary in order to cause discounts on CEFs, contrary to the predictions of investor sentiment theory. Indeed, institutional investors have dominated the Chinese CEF market since March 2000. Moreover, most CEFs in China tend to hold large stocks, which leads to an insignificant relationship between the re-sale option values of CEFs and small stocks, because small stocks are primarily held by individuals.

**Institutional Investors and Discounts on CEFs**

Table IX shows that \( \alpha \) in regression (31) is positive and statistically significant at conventional significance levels, which supports Hypothesis 6 that institutional investors in CEFs tend to decrease the re-sale option value because of their smaller noise size, and increase the discounts on CEFs. The negativity of that \( \gamma \) supports the argument that if the signal noise is sufficiently high, the re-sale option value is reduced. The fact that \( \beta \) is positive again confirms the relationship between discounts and the diversification of CEFs’
portfolios. Additionally, is positive, which is consistent with the empirical finding that discounts on CEFs narrow when they approach maturity.

[Insert Table IX here]

5 Conclusions

In this paper, we develop a model that explains a number of regularities that have been observed in the CEF market. In this model, the price of an asset can be decomposed into two components: one representing fundamental value and another representing speculative value. We show that the difference between the price of the CEF and its NAV depends on the relative size of their speculative value components. Usually, the speculative value of trading a CEF is smaller than that of trading the CEF’s holdings, which explains why CEFs usually sell at a discount. Speculative value comes from belief heterogeneity between investors. If all investors have the same belief about the fundamental value of an asset, then its speculative value is equal zero. Individuals tend to have more heterogeneous beliefs than institutional investors, so speculative value is closely related to individual investors. At this point, our model is similar to investor sentiment theory, which argues that individuals are more likely than institutions to be noise traders. However, we argue that the re-sale option value tends to be higher in a market in which individuals dominate, and so asset prices tend to be higher in a market dominated by individual investors. This is in contrast with investor sentiment theory, which suggests that since noise risk tends to be higher in a market in which individuals dominate, greater compensation has to be paid to rational investors, and thus asset prices tend to be lower. Our empirical analysis shows that institutional investors tend to widen the discounts on CEFs, which supports this prediction of our model. Further support comes from
the fact that discounts on CEFs become larger after 2000, when institutional investors dominate the CEF market in China.
Appendix A1: Proof of Proposition 1

Using (6), we obtain

Define , , then

, , and

Thus,

Define , and − , then

Clearly, , so we obtain

Further, we have

Differentiating, we obtain

So increases with and decreases with .
Appendix A2: Proof of Proposition 2

According to (10), we have

Thus —— when , and —— when . Similarly, we also have
—— when , and —— when .
Appendix A3: Proof of Proposition 3

According to (10), the option value of trading asset $i$ increases with the variance of its payoff, and the option value of trading an equally-weighted portfolio depends on the variance of the portfolio's payoff, given other parameters equal across assets. If the portfolio is sufficiently diversified and the payoffs of the assets are not completely positively correlated, then we have

\[ \text{The above inequality shows that the volatility of a portfolio’s payoff is typically less than that of an individual asset. According to (10), the option value increases with } \sigma^2 \text{, which increases with the volatility of the payoff } \sigma \text{. So the value of option of trading a portfolio is less than that of trading an individual asset.} \]
REFERENCES


Xiong, W., and J. Scheinkman, 2004, Heterogeneous beliefs, speculation and trading in financial markets, working paper.

Xu, Y., 2000, Understanding closed-end fund puzzles-a stochastic turnover perspective, working paper.
Figure 1

Time series of $VWD$, and

The graph plots the evolution of $VWD$, and for the period 1998/4-2009/12 using weekly data.
Table I

Statistical Description

The table reports the minimum, maximum, mean and standard deviation of VWD, and for the periods 1998/4-2000/3, 2000/4-2009/12 and 1998/4-2009/12, respectively.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Period</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>St. dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>VWD</td>
<td>1998/4-2000/3</td>
<td>-0.7533</td>
<td>0.1925</td>
<td>-0.1352</td>
<td>0.2272</td>
</tr>
<tr>
<td></td>
<td>2000/4-2009/12</td>
<td>-0.0236</td>
<td>0.6443</td>
<td>0.2977</td>
<td>0.1636</td>
</tr>
<tr>
<td></td>
<td>1998/4-2009/12</td>
<td>-0.7533</td>
<td>0.6443</td>
<td>0.2239</td>
<td>0.2397</td>
</tr>
</tbody>
</table>

|          | 1998/4-2000/3 | 0.0056  | 0.3215  | 0.0907 | 0.0650  |
|          | 2000/4-2009/12| 0.0083  | 0.3040  | 0.0813 | 0.0521  |
|          | 1998/4-2009/12| 0.0056  | 0.3215  | 0.0829 | 0.0546  |

|          | 1998/4-2000/3 | 0.0062  | 0.9158  | 0.1175 | 0.1439  |
|          | 2000/4-2009/12| 0.0018  | 0.2646  | 0.0430 | 0.0378  |
|          | 1998/4-2009/12| 0.0018  | 0.9158  | 0.0557 | 0.0740  |

|          | 1998/4-2000/3 | 0.0004  | 0.0252  | 0.0042 | 0.0038  |
|          | 2000/4-2009/12| 0.0002  | 0.0403  | 0.0043 | 0.0039  |
|          | 1998/4-2009/12| 0.0002  | 0.0403  | 0.0042 | 0.0039  |

|          | 1998/4-2000/3 | 0.0001  | 0.0512  | 0.0027 | 0.0061  |
|          | 2000/4-2009/12| 0.0000  | 0.0273  | 0.0015 | 0.0029  |
|          | 1998/4-2009/12| 0.0000  | 0.0512  | 0.0017 | 0.0037  |
Table II

Heterogeneous Beliefs and CEF Discounts

The table reports the results from estimating regressions (23) and (24) for the period 1998/4-2009/12 using weekly data. It also reports the results from estimating a regression that includes all four independent variables. The t-statistics are reported in parentheses.

<table>
<thead>
<tr>
<th>Equations</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.0010</td>
<td>0.0012</td>
<td>0.0010</td>
</tr>
<tr>
<td></td>
<td>(0.9113)</td>
<td>(1.0962)</td>
<td>(0.9465)</td>
</tr>
<tr>
<td>0.1657</td>
<td></td>
<td>0.1387</td>
<td></td>
</tr>
<tr>
<td>(4.2278)</td>
<td></td>
<td>(3.4809)</td>
<td></td>
</tr>
<tr>
<td>-0.2112</td>
<td></td>
<td>-0.1574</td>
<td></td>
</tr>
<tr>
<td>(-7.8064)</td>
<td></td>
<td>(-5.0672)</td>
<td></td>
</tr>
<tr>
<td>1.8327</td>
<td></td>
<td>1.1971</td>
<td></td>
</tr>
<tr>
<td>(3.9266)</td>
<td></td>
<td>(2.5250)</td>
<td></td>
</tr>
<tr>
<td>-1.9898</td>
<td></td>
<td>-1.1752</td>
<td></td>
</tr>
<tr>
<td>(-6.7847)</td>
<td></td>
<td>(-3.5153)</td>
<td></td>
</tr>
<tr>
<td>Adjusted</td>
<td>9.48%</td>
<td>7.33%</td>
<td>11.44%</td>
</tr>
</tbody>
</table>
Table III
Diversification and CEF Discounts

The table reports the results from estimating the pooled regression (26) for the period 1998/4-2009/12 using weekly data. The averaged yearly data at year $t$ are constructed using weekly data for that year. Only those CEFs with more than 20 weeks’ data in year $t$ are included in the regression. The t-statistics are reported in parentheses.

<table>
<thead>
<tr>
<th></th>
<th>Constant</th>
<th>$\beta_1$</th>
<th>$\beta_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coefficient</td>
<td>-0.0008</td>
<td>0.0568</td>
<td>-0.3679</td>
</tr>
<tr>
<td></td>
<td>(-0.3650)</td>
<td>(4.5503)</td>
<td>(-3.7239)</td>
</tr>
<tr>
<td>Adjusted $R^2$</td>
<td></td>
<td>14.13%</td>
<td></td>
</tr>
</tbody>
</table>
Table IV
Descriptive Statistics of the Correlation Coefficients

The table reports descriptive statistics for the correlation coefficients of changes in NAV, share price and discount across CEFs for the period 1998 to 2009. The correlation coefficients for year $t$ are calculated using weekly data in that year. Only those CEFs with more than 20 weeks’ data in year $t$ are included in the calculation.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>Std</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-0.4110</td>
<td>0.9836</td>
<td>0.6214</td>
<td>0.2176</td>
</tr>
<tr>
<td></td>
<td>-0.0538</td>
<td>0.9970</td>
<td>0.7566</td>
<td>0.2532</td>
</tr>
<tr>
<td></td>
<td>-0.2560</td>
<td>0.9857</td>
<td>0.6698</td>
<td>0.1599</td>
</tr>
</tbody>
</table>
Table V
Discount Co-Movement across CEFs
The table reports the results from estimating the pooled regression (27) for the period 1998-2009 using annual correlation coefficients. The t-statistics are reported in parentheses.

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>( \alpha )</th>
<th>( \beta_1 )</th>
<th>( \beta_2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coefficient</td>
<td>0.2532</td>
<td>0.3947</td>
<td>0.1038</td>
</tr>
<tr>
<td></td>
<td>(15.0038)</td>
<td>(28.8154)</td>
<td>(4.7858)</td>
</tr>
<tr>
<td>Adjusted R^2</td>
<td>22.73%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


Table VI
Estimates for the State-Space Model
The table presents the results from estimating the state-space model (28) and (29) for each CEF using weekly data from 1998/4 to 2009/12. The t-statistics are reported in parentheses.

<table>
<thead>
<tr>
<th>Fund Name</th>
<th>-0.2967</th>
<th>-0.1999</th>
<th>0.0024</th>
<th>0.0008</th>
<th>0.0017</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(-5.9282)</td>
<td>(-7.5941)</td>
<td>(28.1301)</td>
<td>(13.9024)</td>
<td>(24.3578)</td>
</tr>
<tr>
<td>PUHUI</td>
<td>-0.3198</td>
<td>-0.2523</td>
<td>0.0026</td>
<td>0.0007</td>
<td>0.0010</td>
</tr>
<tr>
<td></td>
<td>(-5.4905)</td>
<td>(-5.7980)</td>
<td>(36.8551)</td>
<td>(12.5435)</td>
<td>(17.3026)</td>
</tr>
<tr>
<td>TONGYI</td>
<td>-0.1572</td>
<td>-0.0843</td>
<td>0.0019</td>
<td>0.0004</td>
<td>0.0008</td>
</tr>
<tr>
<td></td>
<td>(-2.3653)</td>
<td>(-2.1406)</td>
<td>(26.4864)</td>
<td>(8.2644)</td>
<td>(18.2921)</td>
</tr>
<tr>
<td>JINGHONG</td>
<td>-0.3581</td>
<td>-0.3681</td>
<td>0.0029</td>
<td>0.0009</td>
<td>0.0015</td>
</tr>
<tr>
<td></td>
<td>(-7.3739)</td>
<td>(-10.6615)</td>
<td>(30.8141)</td>
<td>(13.4241)</td>
<td>(19.5792)</td>
</tr>
<tr>
<td>YULONG</td>
<td>-0.2947</td>
<td>-0.1347</td>
<td>0.0023</td>
<td>0.0004</td>
<td>0.0011</td>
</tr>
<tr>
<td></td>
<td>(-4.0293)</td>
<td>(-3.9665)</td>
<td>(31.8584)</td>
<td>(7.4071)</td>
<td>(20.5514)</td>
</tr>
<tr>
<td>PUFENG</td>
<td>0.4357</td>
<td>-0.2140</td>
<td>0.0016</td>
<td>0.0003</td>
<td>0.0004</td>
</tr>
<tr>
<td></td>
<td>(8.3004)</td>
<td>(-5.7455)</td>
<td>(30.2741)</td>
<td>(8.1994)</td>
<td>(11.6437)</td>
</tr>
<tr>
<td>TIANYUAN</td>
<td>-0.2231</td>
<td>-0.0344</td>
<td>0.0023</td>
<td>0.0007</td>
<td>0.0009</td>
</tr>
<tr>
<td></td>
<td>(-3.6549)</td>
<td>(-0.7213)</td>
<td>(27.8850)</td>
<td>(14.0348)</td>
<td>(15.6797)</td>
</tr>
<tr>
<td>TONGSHEN</td>
<td>-0.1380</td>
<td>-0.1144</td>
<td>0.0014</td>
<td>0.0004</td>
<td>0.0007</td>
</tr>
<tr>
<td></td>
<td>(-2.0530)</td>
<td>(-2.8185)</td>
<td>(26.9835)</td>
<td>(13.2686)</td>
<td>(20.5019)</td>
</tr>
<tr>
<td>JINGFU</td>
<td>-0.1567</td>
<td>-0.2288</td>
<td>0.0019</td>
<td>0.0005</td>
<td>0.0007</td>
</tr>
<tr>
<td></td>
<td>(-2.1796)</td>
<td>(-5.0254)</td>
<td>(25.1470)</td>
<td>(10.5144)</td>
<td>(13.9853)</td>
</tr>
<tr>
<td>YUZE</td>
<td>0.0501</td>
<td>-0.2387</td>
<td>0.0020</td>
<td>0.0004</td>
<td>0.0017</td>
</tr>
<tr>
<td></td>
<td>(0.6415)</td>
<td>(-8.8476)</td>
<td>(25.2098)</td>
<td>(8.3342)</td>
<td>(23.8885)</td>
</tr>
<tr>
<td>FENGHE</td>
<td>-0.2052</td>
<td>-0.1607</td>
<td>0.0018</td>
<td>0.0004</td>
<td>0.0012</td>
</tr>
<tr>
<td></td>
<td>(-2.4413)</td>
<td>(-4.8267)</td>
<td>(22.7517)</td>
<td>(7.9938)</td>
<td>(15.3113)</td>
</tr>
<tr>
<td>JIUJIA</td>
<td>-0.2295</td>
<td>0.0869</td>
<td>0.0033</td>
<td>0.0012</td>
<td>0.0009</td>
</tr>
<tr>
<td></td>
<td>(-4.1944)</td>
<td>(1.3432)</td>
<td>(24.2574)</td>
<td>(12.7182)</td>
<td>(9.1522)</td>
</tr>
<tr>
<td>HONGYANG</td>
<td>0.1308</td>
<td>-0.3535</td>
<td>0.0016</td>
<td>0.0005</td>
<td>0.0005</td>
</tr>
<tr>
<td></td>
<td>(1.8701)</td>
<td>(-9.8618)</td>
<td>(24.2118)</td>
<td>(8.8260)</td>
<td>(12.2792)</td>
</tr>
<tr>
<td>JINTAI</td>
<td>0.0064</td>
<td>-0.0058</td>
<td>0.0019</td>
<td>0.0007</td>
<td>0.0015</td>
</tr>
<tr>
<td></td>
<td>(0.1088)</td>
<td>(-0.1860)</td>
<td>(25.2297)</td>
<td>(12.3258)</td>
<td>(30.8336)</td>
</tr>
<tr>
<td>TAIHE</td>
<td>-0.3522</td>
<td>-0.1402</td>
<td>0.0019</td>
<td>0.0008</td>
<td>0.0011</td>
</tr>
<tr>
<td>ANXING</td>
<td>0.0073</td>
<td>-0.3778</td>
<td>0.0027</td>
<td>0.0004</td>
<td>0.0013</td>
</tr>
<tr>
<td></td>
<td>(0.0908)</td>
<td>(-19.3133)</td>
<td>(30.8043)</td>
<td>(5.9812)</td>
<td>(19.9039)</td>
</tr>
<tr>
<td>HANSHEN</td>
<td>-0.2432</td>
<td>-0.1300</td>
<td>0.0027</td>
<td>0.0005</td>
<td>0.0010</td>
</tr>
<tr>
<td></td>
<td>(-5.3045)</td>
<td>(-3.8530)</td>
<td>(29.4603)</td>
<td>(8.3451)</td>
<td>(17.9651)</td>
</tr>
<tr>
<td>YUYANG</td>
<td>-0.2038</td>
<td>-0.3178</td>
<td>0.0027</td>
<td>0.0002</td>
<td>0.0016</td>
</tr>
<tr>
<td></td>
<td>(-1.4989)</td>
<td>(-13.1748)</td>
<td>(27.0360)</td>
<td>(2.8330)</td>
<td>(24.3959)</td>
</tr>
<tr>
<td>XINGHUA</td>
<td>-0.1586</td>
<td>-0.2301</td>
<td>0.0022</td>
<td>0.0007</td>
<td>0.0014</td>
</tr>
<tr>
<td>Location</td>
<td>ANSHUN</td>
<td>JINXING</td>
<td>HANXING</td>
<td>XINGHE</td>
<td>TONGQIAN</td>
</tr>
<tr>
<td>------------</td>
<td>----------------</td>
<td>----------------</td>
<td>----------------</td>
<td>----------------</td>
<td>----------------</td>
</tr>
<tr>
<td></td>
<td>0.2864</td>
<td>0.0448</td>
<td>-0.2051</td>
<td>0.1950</td>
<td>-0.2680</td>
</tr>
<tr>
<td></td>
<td>-0.2551</td>
<td>-0.1495</td>
<td>-0.0734</td>
<td>-0.2658</td>
<td>-0.2193</td>
</tr>
<tr>
<td></td>
<td>0.0022</td>
<td>0.0014</td>
<td>0.0012</td>
<td>0.0026</td>
<td>0.0024</td>
</tr>
<tr>
<td></td>
<td>0.0003</td>
<td>0.0006</td>
<td>0.0004</td>
<td>0.0004</td>
<td>0.0006</td>
</tr>
<tr>
<td></td>
<td>0.0010</td>
<td>0.0007</td>
<td>0.0006</td>
<td>0.0006</td>
<td>0.0010</td>
</tr>
<tr>
<td></td>
<td>(5.2213)</td>
<td>(-0.7597)</td>
<td>(-3.6852)</td>
<td>(2.5857)</td>
<td>(-4.2452)</td>
</tr>
<tr>
<td></td>
<td>(-11.3911)</td>
<td>(-2.8758)</td>
<td>(-1.4536)</td>
<td>(-8.4067)</td>
<td>(-4.9097)</td>
</tr>
</tbody>
</table>
Table VII

Variance and Covariance

The table reports estimates of the variances of changes in NAV, share price, average speculative value of trading the underlying assets managed by CEFs and the speculative value of trading CEFs, and the covariances between and , between and , and between and . The unobservable , and are calculated using the Kalman filter, based on the coefficient estimates from the state-space model reported in Table VI.

<table>
<thead>
<tr>
<th>Fund Name</th>
<th>var( )</th>
<th>var( )</th>
<th>var( )</th>
<th>var( )</th>
<th>var( )</th>
<th>cov( )</th>
<th>cov( )</th>
<th>cov( )</th>
</tr>
</thead>
<tbody>
<tr>
<td>KAIYUAN</td>
<td>0.0066</td>
<td>0.0069</td>
<td>0.0036</td>
<td>0.0009</td>
<td>0.0016</td>
<td>0.0011</td>
<td>0.0009</td>
<td>-0.0005</td>
</tr>
<tr>
<td>PUHUI</td>
<td>0.0046</td>
<td>0.0045</td>
<td>0.0024</td>
<td>0.0006</td>
<td>0.0011</td>
<td>0.0008</td>
<td>0.0005</td>
<td>-0.0004</td>
</tr>
<tr>
<td>TONGYI</td>
<td>0.0048</td>
<td>0.0052</td>
<td>0.0026</td>
<td>0.0006</td>
<td>0.0011</td>
<td>0.0008</td>
<td>0.0008</td>
<td>-0.0002</td>
</tr>
<tr>
<td>JINGHONG</td>
<td>0.0051</td>
<td>0.0057</td>
<td>0.0027</td>
<td>0.0007</td>
<td>0.0014</td>
<td>0.0008</td>
<td>0.0008</td>
<td>-0.0004</td>
</tr>
<tr>
<td>YULONG</td>
<td>0.0081</td>
<td>0.0087</td>
<td>0.0048</td>
<td>0.0007</td>
<td>0.0012</td>
<td>0.0013</td>
<td>0.0014</td>
<td>0.0000</td>
</tr>
<tr>
<td>PUFENG</td>
<td>0.0032</td>
<td>0.0030</td>
<td>0.0017</td>
<td>0.0003</td>
<td>0.0006</td>
<td>0.0006</td>
<td>0.0004</td>
<td>-0.0001</td>
</tr>
<tr>
<td>TIANYUAN</td>
<td>0.0051</td>
<td>0.0050</td>
<td>0.0028</td>
<td>0.0005</td>
<td>0.0008</td>
<td>0.0009</td>
<td>0.0007</td>
<td>-0.0002</td>
</tr>
<tr>
<td>TONGSHEN</td>
<td>0.0050</td>
<td>0.0052</td>
<td>0.0028</td>
<td>0.0005</td>
<td>0.0007</td>
<td>0.0009</td>
<td>0.0008</td>
<td>0.0000</td>
</tr>
<tr>
<td>JINGFU</td>
<td>0.0034</td>
<td>0.0036</td>
<td>0.0019</td>
<td>0.0004</td>
<td>0.0007</td>
<td>0.0006</td>
<td>0.0005</td>
<td>-0.0001</td>
</tr>
<tr>
<td>YUZE</td>
<td>0.0072</td>
<td>0.0079</td>
<td>0.0042</td>
<td>0.0007</td>
<td>0.0013</td>
<td>0.0011</td>
<td>0.0012</td>
<td>-0.0002</td>
</tr>
<tr>
<td>FENGHE</td>
<td>0.0096</td>
<td>0.0107</td>
<td>0.0057</td>
<td>0.0007</td>
<td>0.0014</td>
<td>0.0016</td>
<td>0.0018</td>
<td>0.0002</td>
</tr>
<tr>
<td>JIUJIA</td>
<td>0.0116</td>
<td>0.0109</td>
<td>0.0065</td>
<td>0.0010</td>
<td>0.0013</td>
<td>0.0020</td>
<td>0.0016</td>
<td>0.0000</td>
</tr>
<tr>
<td>HONGYANG</td>
<td>0.0036</td>
<td>0.0035</td>
<td>0.0020</td>
<td>0.0003</td>
<td>0.0006</td>
<td>0.0006</td>
<td>0.0005</td>
<td>0.0000</td>
</tr>
<tr>
<td>JINTAI</td>
<td>0.0058</td>
<td>0.0067</td>
<td>0.0032</td>
<td>0.0007</td>
<td>0.0016</td>
<td>0.0010</td>
<td>0.0010</td>
<td>-0.0003</td>
</tr>
<tr>
<td>TAIHE</td>
<td>0.0089</td>
<td>0.0092</td>
<td>0.0050</td>
<td>0.0008</td>
<td>0.0013</td>
<td>0.0016</td>
<td>0.0014</td>
<td>0.0000</td>
</tr>
<tr>
<td>ANXING</td>
<td>0.0046</td>
<td>0.0051</td>
<td>0.0025</td>
<td>0.0006</td>
<td>0.0013</td>
<td>0.0007</td>
<td>0.0007</td>
<td>-0.0004</td>
</tr>
<tr>
<td>HANSHEN</td>
<td>0.0052</td>
<td>0.0053</td>
<td>0.0029</td>
<td>0.0006</td>
<td>0.0009</td>
<td>0.0009</td>
<td>0.0007</td>
<td>-0.0002</td>
</tr>
<tr>
<td>YUYANG</td>
<td>0.0056</td>
<td>0.0059</td>
<td>0.0031</td>
<td>0.0007</td>
<td>0.0014</td>
<td>0.0009</td>
<td>0.0007</td>
<td>-0.0005</td>
</tr>
<tr>
<td>XINGHUA</td>
<td>0.0051</td>
<td>0.0055</td>
<td>0.0028</td>
<td>0.0007</td>
<td>0.0013</td>
<td>0.0008</td>
<td>0.0007</td>
<td>-0.0004</td>
</tr>
<tr>
<td>ANSHUN</td>
<td>0.0049</td>
<td>0.0052</td>
<td>0.0028</td>
<td>0.0005</td>
<td>0.0009</td>
<td>0.0008</td>
<td>0.0007</td>
<td>-0.0001</td>
</tr>
<tr>
<td>JINXING</td>
<td>0.0049</td>
<td>0.0060</td>
<td>0.0028</td>
<td>0.0005</td>
<td>0.0012</td>
<td>0.0008</td>
<td>0.0010</td>
<td>-0.0001</td>
</tr>
<tr>
<td>HANXING</td>
<td>0.0021</td>
<td>0.0022</td>
<td>0.0011</td>
<td>0.0003</td>
<td>0.0005</td>
<td>0.0003</td>
<td>0.0003</td>
<td>-0.0002</td>
</tr>
<tr>
<td>XINGHE</td>
<td>0.0050</td>
<td>0.0031</td>
<td>0.0017</td>
<td>0.0003</td>
<td>0.0006</td>
<td>0.0005</td>
<td>0.0004</td>
<td>-0.0001</td>
</tr>
<tr>
<td>TONGQIAN</td>
<td>0.0062</td>
<td>0.0066</td>
<td>0.0035</td>
<td>0.0006</td>
<td>0.0011</td>
<td>0.0011</td>
<td>0.0010</td>
<td>-0.0001</td>
</tr>
<tr>
<td>KERUI</td>
<td>0.0095</td>
<td>0.0101</td>
<td>0.0054</td>
<td>0.0008</td>
<td>0.0014</td>
<td>0.0017</td>
<td>0.0017</td>
<td>0.0002</td>
</tr>
<tr>
<td>YINFENG</td>
<td>0.0040</td>
<td>0.0042</td>
<td>0.0022</td>
<td>0.0004</td>
<td>0.0008</td>
<td>0.0007</td>
<td>0.0006</td>
<td>-0.0001</td>
</tr>
</tbody>
</table>
Table VIII  
CEF Discounts and the Returns on Small Stocks  
The table presents the results from estimating regression (30) for the period 1998-2009 using weekly data, using , , , or as the dependent variable. The t-statistics are reported in parentheses.

<table>
<thead>
<tr>
<th></th>
<th>Column 1</th>
<th>Column 2</th>
<th>Column 3</th>
<th>Column 4</th>
<th>Column 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.0009</td>
<td>0.0008</td>
<td>0.0033</td>
<td>0.0000</td>
<td>0.0029</td>
</tr>
<tr>
<td></td>
<td>(1.1544)</td>
<td>(1.1179)</td>
<td>(1.4813)</td>
<td>(-0.0480)</td>
<td>(1.3780)</td>
</tr>
<tr>
<td>$\beta_1$</td>
<td>0.0305</td>
<td>0.0437</td>
<td>-0.1231</td>
<td>0.1104</td>
<td>-0.0253</td>
</tr>
<tr>
<td></td>
<td>(1.0593)</td>
<td>(1.4397)</td>
<td>(-2.3914)</td>
<td>(4.1947)</td>
<td>(-0.4114)</td>
</tr>
<tr>
<td>$\beta_2$</td>
<td>0.9889</td>
<td>0.9903</td>
<td>0.9356</td>
<td>0.9404</td>
<td>1.0445</td>
</tr>
<tr>
<td>Adjusted $R^2$</td>
<td>80.41%</td>
<td>80.44%</td>
<td>76.72%</td>
<td>83.96%</td>
<td>86.73%</td>
</tr>
</tbody>
</table>
Table IX
CEF Discounts and the Size of Noise

The table reports the results from estimating regression (31) for the period 2004-2009 using averaged annual data. The t-statistics are reported in parentheses.

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Constant</th>
<th>$\beta_1$</th>
<th>$\beta_2$</th>
<th>$\beta_3$</th>
<th>$\beta_4$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.0560</td>
<td>0.0056</td>
<td>-0.0001</td>
<td>0.1239</td>
<td>0.0049</td>
</tr>
<tr>
<td></td>
<td>(1.2517)</td>
<td>(3.4690)</td>
<td>(-3.7208)</td>
<td>(5.9674)</td>
<td>(2.6824)</td>
</tr>
<tr>
<td>Adjusted $R^2$</td>
<td>87.12%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>