



Market uncertainty, expected volatility and the mispricing of S&P 500 index futures



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ABSTRACT

An association between increased index futures mispricing and concurrent index volatility has been reported within several prior studies; in the present study, we argue that expected volatility over an arbitrage horizon also has an adverse effect on the ability and willingness of traders to engage in arbitrage, leading to greater and more persistent futures mispricing. Using the CBOE VIX and its innovation on the concurrent spot volatility as proxies for expected volatility, we present evidence of an increase in S&P 500 index futures mispricing with expected volatility. The impact of the VIX grows exponentially across the distribution of conditional mispricing levels, which suggests that the expectations of heightened future volatility become increasingly detrimental to arbitrage activities when the futures price deviations are enlarged; however, the influence of expected volatility is found to have been reduced during the global financial crisis period, a period during which concurrent volatility overwhelmingly dominated the magnitude of mispricing.

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1. Introduction

Arbitrageurs in the stock index and index futures markets are faced with various forms of uncertainty over and above their transaction costs. An often cited, but rarely analyzed, form of uncertainty is the risk of increased market volatility and the associated change in attitude towards arbitrage risk amongst potential arbitrageurs. In the present study, we argue that index futures mispricing, which is defined as the deviation of actual futures price from its cost-of-carry theoretical value, is related to volatility, not only the concurrent spot volatility (hereafter, concurrent volatility) but also the expected future spot volatility (hereafter, expected volatility) over the arbitrage horizon.

It is noted within the related literature that increased concurrent volatility tends to widen the spot-futures basis, given that futures and spot markets respond to external shocks at different speeds and at different magnitudes.¹ The decision on whether or not to engage in arbitrage is, however, more dependent on expected volatility than on concurrent volatility, essentially because, as will be discussed later, the payoffs of index arbitrage are adversely affected by the expected volatility over the arbitrage horizon. Risk-averse arbitrageurs who anticipate an increase in volatility, require a higher arbitrage return (that is, a larger futures mispricing) before committing to such arbitrage. As a result, futures mispricing may exceed the 'normal' level when arbitrageurs anticipate greater index volatility.

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¹ See, for example, Kawaller et al. (1990), Stoll and Whaley (1990) and Chan (1992).

The influence of volatility on index futures prices is not a new issue. In the Hemler and Longstaff (1991) general equilibrium model for stock index futures prices, it was implied that the volatility of the index return was a vital component in theoretical futures prices, an argument supported by their empirical evidence. Studies examining the difference between actual futures prices and the cost-of-carry theoretical prices have also documented a linkage between volatility and futures prices. For example, Henker and Martens (2005) found a monotonic increase in mispricing across all futures volatility levels, whilst Richie et al. (2008) similarly reported larger (smaller) mean absolute mispricing for high (low) volatility sub-samples. Concurrent volatility, as a control variable in the regression models, has been found in several studies to have significantly positive effects on the magnitude of futures mispricing.²

However, the literature exploring the potential linkage between volatility and futures mispricing has invariably focused on the influence of concurrent volatility, whilst largely ignoring the potential impact of expected volatility. Although high concurrent volatility will tend to widen futures mispricing, it is the expected volatility over the arbitrage horizon which could substantially dampen the willingness of potential arbitrageurs to commit to their proposed arbitrage transactions.

To the best of our knowledge, no research has yet been undertaken with the overall aim of exploring the ways in which futures mispricing is affected by expected volatility over the arbitrage horizon, perhaps because widely-accepted measures of expected volatility have only recently been developed. Our study differs from the prior research in this area since we focus on the influence of the perceived future index volatility, as opposed to the already present (concurrent) volatility.

Using the Chicago Board Options Exchange (CBOE) VIX as a proxy for expected market volatility, a strong association is discernible between the mispricing of S&P 500 futures and expected volatility levels, and indeed, the OLS regressions reveal that the VIX alone is capable of explaining over 10% of the variation in such mispricing. Given that the effects of the VIX remain significant even after removing the common component with concurrent index volatility, the results provide strong support for the determining role of expected volatility on futures mispricing.

The influence of expected volatility is also found to become more pronounced with an increase in mispricing. Using quantile regressions, we find larger and more significant coefficients on the VIX and VIX innovation for higher mispricing quantiles, which implies that an increase in the influence of expected volatility is associated with greater mispricing levels. A similar cross-quantile pattern is found in the impact of the VIX and VIX innovation on the frequency and persistence of no-arbitrage boundary violations. These results are consistent with our supposition that heightened volatility risk during the arbitrage horizon will dampen the willingness of traders to engage in arbitrage, thereby leading to large and persistent futures mispricing.

The effect of the VIX on futures mispricing was found to have been greatly intensified during the recent global financial crisis, exhibiting exponential growth over the mispricing quantiles and a much stronger increasing pattern, as compared to other non-crisis periods. However, this strong association between the VIX and mispricing during the crisis period is found to have been largely attributable to concurrent volatility, and less so to the market expectations of volatility. These findings indicate that futures mispricing during the financial crisis period was overwhelmingly dominated by concurrent volatility, whilst the influence of expected volatility was greatly reduced.

Our research contributes to the literature in at least two ways. Firstly, our findings enhance the knowledge of the factors potentially affecting index futures mispricing.³ As will be discussed in the next section, although an increase in concurrent volatility induces temporary misalignment between spot and futures prices, it is expected volatility which severely impedes arbitrage activities by increasing arbitrage risk; thus, expected volatility can explain futures mispricing beyond the impediment due to concurrent volatility. Despite the fact that expected volatility over the arbitrage horizon appears to be of importance with regard to the decision on whether to engage in arbitrage, there is currently a distinct lack of any direct evidence of this. In this study, we present initial evidence on the effects of expected volatility on deviations in futures prices, thereby contributing to the literature focusing on the limits of index futures arbitrage.

Secondly, the VIX has been found to feature components that can help to explain stock returns (Bollerslev et al., 2009), long-run risk aversion (Drechsler and Yaron, 2011) and disaster risk (Bollerslev and Todorov, 2011). In the present study, we extend the existing literature on the information content of the VIX by showing that its expected volatility component can substantially affect the decisions made by potential arbitrageurs, thereby determining the magnitude, frequency and persistence of index futures mispricing.

The remainder of this paper is organized as follows. A discussion on the ways in which expected volatility adversely affects the final payoffs of index arbitrage over the arbitrage horizon is presented in Section 2, along with the decisions made by arbitrageurs. This is followed in Section 3 by a description of the data sources used for our study and the summary statistics. Empirical evidence on the linkage between the VIX and the mispricing of index futures is subsequently presented in Section 4. Finally, the conclusions drawn from this study are presented in Section 5.

2. Expected volatility and index arbitrage

The theoretical grounding on the linkage between volatility and futures pricing was provided by Hemler and Longstaff (1991), with their general equilibrium model allowing spot index volatility to affect the risk premium for holding futures contracts, consequently determining the theoretical futures prices. They stressed that after accounting for the dividend yield, the difference between the equilibrium futures price and the cost-of-carry forward price is a function of index volatility because the former encompasses

² Examples include Brailsford and Hodgson (1997), Gay and Jung (1999), Fung and Draper (1999) and Draper and Fung (2003).

³ Several issues thoroughly examined in the extant literature include: stale prices in the index (Chung, 1991; Miller et al., 1994), asymmetric information (Fremault, 1991; Kumar and Seppi, 1994), index tracking error (Neal, 1996), short-sales restrictions on the underlying stocks (Gay and Jung, 1999; Yadav and Pope, 1994), stochastic interest rates (Cakici and Chatterjee, 1991; Hemler and Longstaff, 1991) and execution delay due to low liquidity (Chiou et al., 2007; Kamara and Miller, 1995).

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