ETF arbitrage: Intraday evidence

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ABSTRACT

We use two extremely liquid S&P 500 ETFs to analyze the prevailing trading conditions when mispricing allowing arbitrage opportunities is created. While these ETFs are not perfect substitutes, our correlation and error correction results suggest investors view them as close substitutes. Spreads increase just before arbitrage opportunities, consistent with a decrease in liquidity. Order imbalance increases as markets become more one-sided and spread changes become more volatile which suggests an increase in liquidity risk. The price deviations are followed by a tendency to quickly correct back towards parity.

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1. Introduction

Arbitrage is frequently described as one of the most important principles in finance. Numerous papers report situations of mispricing which appear to allow for arbitrage profits to be made (e.g. Froot and Dabora, 1999; Mitchell et al., 2002; Gagnon and Andrew Karolyi, 2010; Alsayed and McGroarty, 2012).[1] Others point out that arbitrage is rarely, if ever, as risk-free and costless as the text-book definition suggests (e.g. De Long et al., 1990; Shleifer and Vishny, 1997). Much less is known about the intraday market characteristics that exist when arbitrage opportunities are created. It is this "microstructure of arbitrage" strand of the literature that we contribute to.

We consider mispricing between the SPDR Trust (ticker SPY) and iShare (ticker IVV).[2] The price deviations which result in the

creation and removal of arbitrage opportunities are caused by purchases and sales of the ETFs in normal trading hours. This setting is ideal for an arbitrage microstructure study. Mispricing is easily identified and ETFs can be simply purchased and sold by all investors.[3] Other aspects of ETF arbitrage have been considered in the literature previously. Engle and Sarkar (2006) and Ackert and Tian (2000) report fluctuations in the mispricing or tracking error of ETFs relative to their underlying index. Engle and Sarkar (2006) note the creation/redemption feature of ETFs, which allows investors to exchange ETFs for stocks in the underlying index by submitting an order that is executed at the end of the day, results in smaller deviations than in closed end funds which do not have this feature. Moreover, Richie et al. (2008) find the SPY can be used to exploit mispricing between the S&P 500 cash index and futures contracts.

Our evidence suggests that a fall in liquidity combined with an increase in liquidity risk contribute to the arbitrage opportunities. We show spreads increase prior to arbitrage opportunities, which is consistent with a decline in liquidity. Order imbalance increases, which is consistent with the market becoming more one-sided. The standard deviation of spread changes increases which is indicative of an increase in liquidity risk. Trade value also increases which, according to Johnson (2008), is evidence of an increase in liquidity volatility. Johnson (2008) explains the positive relation between liquidity risk and volume as follows (p. 411) "Intuitively, large changes in liquidity cannot occur without a lot of population

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[1] The strategies used to capture this mispricing are variously referred to as "convergence trading", "pairs trading", and "statistical arbitrage." Papers applying these strategies include: Gatev et al. (2003), Engleberg et al. (2010) and Hogan et al. (2004). Theoretical papers include Xiong (2001) and Bondarenko (2003).

[2] Vanguard listed an S&P 500 ETF in September 2010, but we do not include this in our analysis due to insufficient data. There are few other ETF pairs that track the same instrument. Where these do exist, the volume is typically heavily concentrated in one of the pairs, leaving relatively long intraday periods with no trading in the more illiquid security, which is problematic for a microstructure study such as this. An exception is the two ETFs on Gold.

[3] Dolvin (2010) shows the closing prices of the IVV and SPY sometimes deviate enough to allow arbitrage profits.

flux, and a small amount of flux must imply a small change." Lastly, the standard deviation of trade-to-trade returns increases.

There are few, if any, market settings that are completely free of limits to arbitrage, which include the risks and costs that effect the removal of mispricing. There are certainly risks and costs involved in exploiting ETF mispricing, but we suggest these are considerably smaller than those that exist in other settings. We discuss these in more detail below but first consider the question of whether our results are inconsistent with the Efficient Market Hypothesis. We address this in relation to Jensen's (1978) version of this hypothesis which relates to the lack of economic profits after risk and costs. It is likely the arbitrage profits are in part compensation for the fundamental and convergence risks we identify below. It is also possible the profits are compensation for information costs. Grossman and Stiglitz (1976, 1980) note that acquiring information is a costly process and that arbitrageurs need to be compensated for restoring prices to efficient levels. Another possibility is that there are costs or risk factors that have not yet received attention in the literature and the profits we document are also compensation for these. In any case, our results do not necessarily contradict the Efficient Market Hypothesis as described by Jensen (1978). Moreover, the fact that the mispricing is quickly removed implies investors who want to pursue the opportunities are able to do so, which in turn suggests there are not permanent barriers that prevent this mispricing being exploited. Our results may also lend support to the Adaptive Market Hypothesis of Lo (2004) which suggests that evolutionary processes can help explain what we observe in financial markets. Under this hypothesis the returns we document may be economic profits which arise from time to time and can viewed as the "food source on which market participants depend for their survival" (p. 23).[4]

The S&P 500 ETFs are natural choices for an arbitrage microstructure study that considers the role liquidity plays in mispricing for a number of reasons. They are highly liquid and widely followed. A large number of investors track these instruments and trade them (e.g. Elton et al., 2002). The SPDR Trust (ticker SPY) is more liquid than any stock and the iShare (ticker IVV) is also highly liquid (above the 99th percentile of CRSP stocks based on value traded and below the 1st percentile based on spread). Any arbitrage opportunities can therefore be easily exploited. Secondly, it is well accepted that the risk to uninformed investors of trading against an investor with private or asymmetric information is considerably lower for investments in ETFs compared to investment in individual stocks.[5] This means that intraday changes in spreads are relatively (compared to stocks) more likely to be driven by liquidity changes than asymmetric information.

Thirdly, "convergence risk" is much lower than in most arbitrage settings. John Maynard Keynes once remarked "the market can stay irrational longer than you can stay solvent."[6] This creates a risk for arbitrageurs as simply identifying and trading on mispricing does not mean profits will be made quickly or at all.[7] The SPY and IVV compete for investor funds. Their ability to closely track the underlying index is an important aspect of this so the management of each fund have an incentive to minimize tracking error. Moreover,

as Engle and Sarkar (2006) note, institutional investors can exchange each ETF for the underlying stocks. Larger ETF price divergence creates more incentive for this activity.

Another risk of arbitrage is fundamental risk. This refers to the fact the two assets are not perfect substitutes or identical in all respects. It is extremely difficult to find assets that are completely identical. Dual class shares are likely to have different voting rights (e.g. Schultz and Shive, 2010). Dual listed stocks in different countries are frequently subject to different institutional features such as liquidity differences and index inclusion in one country (e.g. Froot and Dabora, 1999). Short-selling constraints in one country may play a role and there may also be "tax-induced investor heterogeneity" (e.g. Froot and Dabora, 1999, p. 215).

While minimized, fundamental risk does exist in our market setting. The SPY and IVV both have the aim of mirroring the S&P 500 index, but there may be small differences in the composition of the basket of securities each ETF uses to track the S&P 500. However, our results suggest fundamental risk is not a major concern. We show NAV differences are generally smaller than the mispricing. There is no positive relation between the incidence of arbitrage opportunities and differences between the NAVs of the ETFs. There is also no statistically significant relation between the size of arbitrage profits and NAV differences. Moreover, the error correction results suggest that price deviations between the two ETFs result in convergence. When the price of each ETF deviates from that of the S&P 500 index or the other ETF the error correction mechanism pulls the ETF price back to the index level (other ETF price) in the next minute. Buyer-initiated trades are more common than seller-initiated trades in the underpriced ETF and seller-initiated trades are more prevalent than buyer-initiated trades in the overpriced ETF. This, together with the rapid removal of arbitrage profits (median time of 1–2 min), is further evidence that price deviations are seen as worth pursuing by investors.

We generate impulse results for the SPY and IVV to a unit shock in the S&P 500 index level. These show that the SPY responds more quickly which suggests that differences in price discovery times maybe one source of the mispricing we document. The results showing a decline in liquidity and an increase in liquidity risk imply that what might be termed "microstructure noise is another source of the mispricing.

We focus on mispricing of 0.2% and above (net of spreads). However, we also consider lower thresholds (0.1% and 0.15%). The mispricing we document is not a common occurrence. When the 0.2% threshold is used we find just 183 instances over the 2001–2010 periods. Ninety (93) of these involve the SPY (IVV) trading at a higher price than the IVV (SPY). Median profits are 0.27% in both instances, while mean profits are 0.33% (0.32%) when the SPY (IVV) is initially trading at a premium. Mispricing is generally removed quickly. The median duration is 2.27 (0.92) minutes when the SPY (IVV) is trading at a premium. There are some outliers in the length of time it takes for arbitrage profits to be removed as some arbitrage opportunities occur late in the afternoon on a Friday.[8] This pushes the mean durations to 86.46 (3.92) minutes when the SPY (IVV) is trading at a premium. The mean (median) p.a. profits, which we calculate by summing profits within a calendar year and then taking the mean (median) across years, are 6.57% (5.31%) after spreads. These compare favorably to the profits that have been attributed to other trading strategies. For instance, momentum profits from the Jegadeesh and Titman (1993) long-short strategy are often stated as being approximately 12% p.a., but this is prior to transaction costs. Lesmond et al. (2004) note that much of this profitability comes from transactions in small illiquid stocks

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[4] We thank an anonymous referee for suggesting we consider the literature cited in this paragraph.
[5] See Hamm (2011) footnote 1.
[6] http://www.maynardkeynes.org/keynes-the-speculator.html.
[7] Different aspects of this arbitrage risk have been documented. De Long et al. (1990), focus on the risk of further price divergence due to the actions of irrational "noise" traders. Abreu and Brunnermeier (2002, p. 343) highlight that arbitrageurs still face synchronization risk or "uncertainty regarding the timing of the price correction" even when noise traders are not present. Mitchell et al. (2002) refer to "horizon risk", and Shleifer and Vishny (1997) highlight the "margin risk" of leveraged positions having to be liquidated due to margin calls before the final convergence occurs.

[8] We adopt the conservative assumption that positions are only closed in normal business hours.