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Trading Risk, Market Liquidity, and Convergence Trading in the Interest Rate Swap Spread

- Trading activity is generally considered to be a stabilizing force in markets; however, trading risk can sometimes lead to behavior that has the opposite effect.
- An analysis of the interest rate swap market finds stabilizing as well as destabilizing forces attributable to leveraged trading activity. The study considers how convergence trading risk affects market liquidity and asset price volatility by examining the interest rate swap spread and the volume of repo contracts.
- The swap spread tends to converge to its normal level more slowly when traders are weakened by losses, while higher trading risk can cause the spread to diverge from that level.
- Convergence trading typically absorbs shocks, but an unusually large shock can be amplified when traders close out positions prematurely. Destabilizing shocks in the swap spread are associated with a fall in repo volume consistent with the premature closing out of trading positions. Repo volume also falls in response to convergence trading losses.

1. Introduction

The notion that markets are self-stabilizing is a basic precept in economics and finance. Research and policy decisions are often guided by the view that arbitrage and speculative activity move market prices toward fundamentally rational values. For example, consider a decision on whether central banks or bank regulators should intervene before a severe market disturbance propagates widely to the rest of the financial system. Such a decision may rest on a judgment of how quickly the effects of the disturbance would be countered by equilibrating market forces exerted by investors taking the longer view.

While most economists accept the view that markets are self-stabilizing in the long run, a well-established body of research exists on the ways in which destabilizing dynamics can persist in markets. For instance, studies on the limits of arbitrage show how external as well as internal constraints on trading activity can weaken the stabilizing role of speculators. Offering an example of external constraints, Shleifer and Vishny (1997) argue that agency problems in the management of investment funds will constrain arbitrage activity by depriving arbitrageurs of capital when large shocks move asset prices away from fundamental values. In an analysis of internal constraints on trading activity, Xiong (2001) shows that convergence traders with logarithmic utility functions usually trade in ways that stabilize markets, but they may trade in a way

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that amplifies market shocks if the shocks are large enough to deplete their capital. When such traders suffer severe capital losses, they hunker down and "unwind" their convergence trade positions—that is, close out the positions—driving prices further in the same direction as the initial shock. In another line of analysis, Adrian (2004) argues that in the presence of uncertainty, the difficulty of distinguishing permanent from transitory shocks in asset prices can cause arbitrageurs to trade in ways that can either reduce or raise asset price volatility. These and other studies on the limits of arbitrage suggest how trading activity stabilizes markets most of the time but, on occasion, it can amplify price volatility.

This article analyzes empirical evidence on the limits of arbitrage in the interest rate swap market as well as on how trading risk can affect market liquidity and amplify shocks in asset prices. We study these issues in terms of the behavior of the interest rate swap spread—the spread between the interest rate swap and Treasury interest rates—and the volume of repurchase, or repo, contracts. The type of trading activity we examine is convergence trading, in which speculators trade on the expectation that asset prices will converge to normal, or fundamental, levels. Convergence trades typically move prices toward fundamental levels and stabilize markets. By countering and smoothing price shocks, the trading flows of convergence traders can potentially enhance market liquidity. However, if convergence trades are unwound prematurely, asset prices would tend to diverge further from their fundamental values rather than converge to them. A premature unwinding of these trades can occur when concerns about trading risks are more pronounced, and trading counterparties refuse to roll over positions or internal risk managers instruct traders to close out their positions. In this instance, a form of positive feedback can emerge through which trading risk amplifies asset price shocks.

Our analysis finds both stabilizing and destabilizing forces in the behavior of the interest rate swap spread and the volume of repo contracts that can be attributed to leveraged trading activity. Although the swap spread does tend to converge to its fundamental level, our findings are consistent with the argument that the spread converges more slowly when traders have been weakened by trading losses, and that higher trading risk can cause the spread to diverge from its fundamental level. We also find that repo volume is affected by trading losses and reflects shocks that destabilize the swap spread. The behavior of repo volume suggests how risk in trading activity can affect market liquidity and asset price volatility.

We begin by discussing briefly the significance of the interest rate swap market and the literature on the economic and financial risk factors that determine the interest rate swap spread. In Section 3, the data used in our analysis are presented. Section 4 describes convergence trading on the swap spread. Section 5 looks at the empirical evidence on the limits of arbitrage in the swap market and considers how the convergence of the swap spread to its fundamental level is affected by the capital, or endowments, of convergence traders. In Section 6, we consider how the variability in repo contract volume might be associated with convergence trading activity and examine the empirical relationships among shocks in trading activity, repo volume, and the swap spread.

2. The Interest Rate Swap Market

The interest rate swap market is one of the most important fixed-income markets for the trading and hedging of interest rate risk. It is used by nonfinancial firms in the management of the interest rate risk of their corporate debt. Likewise, financial firms use the swap market intensively to hedge the difference in the interest rate exposure of their assets and liabilities. The liquidity of the swap market also underpins the residential mortgage market in the United States, providing real benefits to the household sector. If the swap market was less liquid, lenders in the mortgage market would find it more difficult and expensive to manage the interest rate risk in fixed-rate mortgages; consequently, they would demand higher mortgage interest rates as compensation. Because of the extensive use of interest rate swaps, the volatility of the swap spread can impact a wide range of market participants. The use of swaps by market participants to meet their hedging objectives depends on a stable relationship between the interest rate swap rate and other interest rates; convergence trading activity that stabilizes the swap spread therefore can have wide-ranging benefits to the economy.

In research on the determinants of the swap spread, Lang, Litzenberger, and Luchuan (1998) investigate how hedging demand for interest rate swaps influences the spread and how the spread is affected by corporate bond spreads and the business cycle. In a complementary analysis, Duffie and Singleton (1997) show that variation in the swap spread is attributable both to credit risk and liquidity risk. Following that line of study, Liu, Longstaff, and Mandell (2002) obtain a similar result and quantify the size of the two risk factors. They find that the swap spread depends both on the credit risk of banks quoting LIBOR (the London Interbank Offered Rate) in the Eurodollar loan market and on the liquidity of Treasury securities. Furthermore, the authors conclude that much of the variability of the spread is associated with changes in the liquidity premium in Treasury security prices.

All of these papers investigate the fundamental economic and financial risk factors that determine the swap spread. In contrast, this article analyzes how variables associated with trading activity might influence the spread's stability. Furthermore, we explore how quantity variables—in this case, the volume of repo contracts—are related to the variation in financial asset prices. By examining how variables associated with trading activity are linked to shocks in the swap spread, our study is potentially related to the literature on time-varying risk premia, which may provide an alternative explanation of our results. Although a complete study of the interrelationships among trading shocks, liquidity shocks, and changes in risk premia is beyond the scope of this article, our analysis of trading activity may help future research determine how time-varying risk premia might be associated with the behavior of traders and arbitrageurs.

3. Data

Our analysis uses a range of fixed-income yields and quantity data (Table 1). The repo volume data consist of all overnight and continuing repurchase positions at primary dealers. They cover almost the entire repo market because every repo transaction has a dealer on one side of it.[1] Ideally, we would use data on repo positions in Treasury securities only, but disaggregated data on Treasury repos do not exist for a sufficiently long sample period. We have a long time series only for aggregate repo positions. (In any event, the predominant repo contract is a repo on Treasury securities. See Adrian and Fleming [2005] for a discussion of the repo data, the role of repos in the financing of investments, and the role of repos in the Treasury securities market.)

We use gross repo volume—the sum of dealers' repo and reverse-repo positions—because a convergence trade could involve either a repo or a reverse repo in the data, depending on whether the position was taken by a dealer or a customer of the dealer. Convergence trades are conducted by customers such as hedge funds, which transact with dealers, and by the dealers' own proprietary trading desks. A short Treasury position could appear either as a repo or a reverse repo in the data depending on whether the short position was established by a customer or a dealer. This fact prevents us from associating disaggregated repo and reverse-repo positions with the direction of an arbitrage trade. Thus, we must use gross repo positions, and can only ask whether the spread converges without regard to whether it is falling or rising to its fundamental level.

Our measure of repo volume is the deviation from its one-year moving average. This measure is used to filter out the normal growth of the market and isolate shocks in repo volume that might be associated with shocks in trading activity. By this definition, a fall in repo volume signifies a decrease relative to its moving average.

For the swap spread, we use the average of the five- and ten-year swaps to capture more trading activity in the swap market. Because we use aggregate repo data, a broad measure of swap rates would align better with the repo data.

The analysis is performed using monthly (month-average) data because trading positions in interest rate swaps are generally intended to be held for relatively long periods due to their transaction costs.[2] Such costs would cause frequent adjustments of swap positions to reduce trading profits significantly, and we would not expect to find any results in daily data. While signs of convergence trading in weekly data

[1] While in principle the data would capture the entire market, in practice they do not because a few market makers are not participants in the reporting system.

Table 1

Data and Variable Definitions

s	Average of the five- and ten-year swap spreads.
S^F	Fundamental swap spread.
s^f	Observable component of the fundamental swap spread.
w	Direction of the deviation of the swap spread from its observable fundamental level, $w_t = \lvert s_t^f - s_t \rvert / (s_t^f - s_t)$.
π_t	Trading income in period t as a function of the position established in period $t-1$, $\pi_t = \Delta s_t w_{t-1}$.
y	Index of monthly returns of fixed-income arbitrage hedge funds (the Credit Suisse First Boston/Tremont Fixed-Income Arbitrage Index).
RP	Overnight and continuing gross repo positions at primary dealers: the sum of the dealers' repo and reverse-repo positions. The variable is measured as the deviation of repo volume from its one-year moving average (in units of one trillion).
r	Repo interest rate.
A	Spread of the A-rated corporate bond rate over the ten-year Treasury interest rate.
Tr	Average of five- and ten-year Treasury interest rates.
Tr^{10}	Ten-year Treasury interest rate.
UnEmp	Unemployment rate.
Data frequency	Monthly (month average) through year-end 2004. The repo volume data are available only at a weekly frequency of Wednesday observations. For consistency with the repo data, we derive the monthly averages of all other variables from weekly Wednesday observations. The sample period is 1996-2004, as the repo interest rate data are available only from 1996.

might be expected, the estimates at that frequency yielded ambiguous results.[3]

4. Convergence Trades on the Interest Rate Swap Spread

Our analysis rests on a supposition that the swap spread is determined by fundamental economic and financial variables and by the "arbitrage" activity of convergence traders. The convergence traders form an expectation of the fundamental level of the spread and trade in an attempt to profit from that expectation. If the spread is above its expected fundamental level, a trader anticipating that the spread will fall toward that level will put in place a position that will gain if the expectation materializes.

In terms of the instruments used in a convergence trade, if the swap spread is above its fundamental level, a trader who expects the spread to fall would take a long position in an interest rate swap and a short position in a Treasury security. Such a combination of long and short positions is insulated from parallel changes in the level of swap and Treasury interest rates, but it would gain if the rates moved relative to each other as expected. If the spread between the rates fell, with the swap rate falling relative to the Treasury rate, the long swap position would gain value relative to the short Treasury position and the trader would earn the difference by closing out the position.[4]

The transactions in a convergence trade, if they are in large enough volume, would normally cause the swap spread to converge to its fundamental level by exerting a counter force to shocks that causes the spread to diverge from its fundamental level. In the case of an initial shock that drives the spread above its normal level, establishing the long position in the swap would put downward pressure on the swap rate, while selling Treasuries to establish the short Treasury position would tend to cause Treasury yields to rise. Both transactions would exert downward pressure on the spread, countering the effect of the initial shock. These relationships are explained further in Box 1.

When a convergence trade is unwound, the spread tends to move in the direction opposite the move that resulted from putting the position in place. In the previous example, the transactions to unwind the trade would cause the swap rate to rise and the Treasury yield to fall, and the spread would widen in the absence of other shocks (Box 1). In order to unwind the

Box 1

Convergence Trades and the Change in the Swap Spread

Tables 1 and 2 below show the market impact of a convergence trade undertaken by a sufficiently large number of traders to affect market prices. The scenario depicted is that of a swap spread above its fundamental level, in which a trader expects the spread to fall back to that level. In this case, the convergence trade is a long swap position and a short Treasury position.

When the trader establishes the position (Table 1), the swap spread converges to its fundamental level; when the trader unwinds the position (Table 2), the swap spread diverges from its fundamental level—rising further above it.

Conversely, when the swap spread is below its fundamental level, the convergence trade position is the reverse of what we just described, and it has an opposite market impact on prices and rates.

Table 1

Establishing a Convergence Trade Position When the Swap Spread Is above Its Fundamental Level

	Position	Adding to Position	Market Price Impact	Interest Rate Change	Spread Change
Swap	Long	Buy[a]	Rise	Fall	Fall
Treasury	Short	Sell	Fall	Rise	

Table 2

Closing Out a Convergence Trade Position When the Swap Spread Is above Its Fundamental Level

	Position	Closing Out of Position	Market Price Impact	Interest Rate Change	Spread Change
Swap	Long	Sell[a]	Fall	Rise	Rise
Treasury	Short	Buy	Rise	Fall	

[a]To buy a swap, as represented in Table 1, means to contract to receive the fixed rate in a new swap. In this instance, when more market participants than usual are seeking to receive the swap rate, the market impact is a downward pressure on the swap rate and a rise in the mark-to-market value of outstanding swaps. The sale of a swap, as represented in Table 2, has the opposite effects of a buy.

[2]The bid-ask spread of interest rate swaps is significantly larger than that of Treasury securities. Furthermore, unwinding a swap before its maturity date may entail transaction costs in settling on a close-out value with the counterparty. Other transaction costs arise from the expense of managing collateral flows to cover margin requirements. Further transaction costs arise from the nature of transaction processing and settlement in over-the-counter (OTC) derivatives. (See the discussion of transaction processing and settlement in Bank for International Settlements [1998]. While automation and electronic trading systems have changed some of the details presented in that study, the general features of OTC derivatives trading remain the same.)

[3]The data frequency in our analysis is limited to at most weekly observations because the repo volume data are available only weekly. Using weekly data, in some cases we obtained similar results, as in the weekly analogue of the results in Table 4. However, in other cases our results were not statistically significant.

[4]A fall in the swap rate would cause the present value of the swap to increase, while a rise in the Treasury rate would cause the price of the Treasury security to fall. Thus, the asset (the long position in a swap) gains value while the value of the liability (the short position in a Treasury security) falls.

position at a profit, a convergence trader typically would wait until shocks in the direction opposite the initial upward shock bring the spread down to a level that allows the trade to be closed out profitably. In this case, convergence trading would stabilize the spread by exerting a countervailing force to shocks in the spread. However, if the convergence trade position is unwound prematurely—before the spread falls toward its fundamental level—the spread would tend to widen further as a result of the unwound trade (Box 1).

A premature unwinding of the position causes volatility in the spread in the sense that the spread diverges from its fundamental level instead of converging to it. Furthermore, a lower than usual level of convergence trading could also lead to volatility, as the market would be more vulnerable to shocks if traders who would otherwise stabilize the spread stay on the sidelines. Before examining the empirical relationship between shocks in the swap spread and a contraction of trading activity, we look at how the endowments of traders affect the spread's convergence to its fundamental level.

5. Limits of Arbitrage and the Swap Spread

How do trading profits affect the strength of arbitrage activity? In the model used in our analysis, we test the hypotheses that less convergence trading occurs when traders' endowments have been impaired. For instance, losses will deplete capital used to fund the margin and collateral required to establish trading positions; when such collateral constraints are binding, we would expect to find less trading activity. Alternatively, large losses may make traders more risk averse, as in Xiong (2001). Thus, significant losses would suggest a lower level of convergence trading, and consequently a slower convergence of the swap spread to its fundamental level. Here, we study the empirical evidence on such swap spread behavior.

To examine the limits of arbitrage in the swap market, we use an equation that reflects the determinants of the swap spread as described above. The swap spread tends to converge to a value that we call its "fundamental" level, and the rate of convergence depends in part on the amount of convergence trading.

(1) $$s_t = \lambda S_t^F + (1-\lambda)s_{t-1} + \mu_t ,$$

where s is the observed spread, S^F is the fundamental spread, μ is a random residual, and the size of the convergence coefficient (λ) depends on the amount of convergence trading, with $0 \le \lambda \le 1$. With perfect and unlimited arbitrage, we have $\lambda = 1$; with limits to arbitrage, we have $\lambda < 1$. Furthermore, as we discussed, we would expect λ to be smaller when convergence traders are less active. Rearranging terms in equation 1, we have

(2) $$\Delta s_t = \lambda(S_t^F - s_{t-1}) + \mu_t .$$

If the fundamental spread (S^F) is determined by observable and unobservable variables, we can rewrite equation 2 in terms of observable variables. To this end, let $S_t^F = ax_t + \varepsilon_t$, where x is the set of observable variables and ε is unobservable. Equation 2 can then be rewritten as

(3) $$\Delta s_t = \lambda(ax_t - s_{t-1}) + \nu_t ,$$

where $\nu_t = \lambda\varepsilon_t + \mu_t$. For this discussion, it would be convenient to denote the observable component of the fundamental swap spread concisely—say, by s_t^f, where $s_t^f = ax_t$.

In estimating equation 3, we treat the coefficient λ as state dependent. Specifically, it depends on the amount of trading activity.

5.1 The Level of Trading Activity

The level of trading activity is assumed to be lower when traders have been weakened by trading losses. In particular, losses will deplete capital used to fund the margin and collateral required to establish trading positions. In addition, depleted capital levels may tighten risk management constraints on trading positions, as will occur when value-at-risk limits on trading positions are defined relative to capital. In our estimation of equation 3, we infer trading income and the level of trading activity using three different approaches.

1. Trading income and the change in the spread. In this approach, trading gains and losses are derived from the change in the swap spread and an inferred trading position. In particular, if the spread is below its expected fundamental level, a trader anticipating that the spread will rise will put in place a position that will gain if the expectation materializes. If the spread subsequently rises, profits are earned, but the position loses if the spread falls. Thus, traders earn profits when the spread converges to its expected fundamental level and suffer losses when the spread diverges.

More precisely, in establishing a trading position at period $t-1$, traders observe the observable component of the fundamental spread and its deviation from the actual spread ($s_{t-1}^f - s_{t-1}$) in period $t-1$. After the position has been established, the subsequent change in the spread in period t

then determines trading income in period t. We write this relationship as

$$\pi_t = \Delta s_t \cdot w_{t-1},$$

where π is trading income and $w_{t-1} = |s^f_{t-1} - s_{t-1}| / (s^f_{t-1} - s_{t-1})$ is the sign of $(s^f_{t-1} - s_{t-1})$ and indicates the direction of the trading position. Together, the change in the spread and the trading position determine the position's gain or loss.

In the conjecture on the limits of arbitrage, the convergence coefficient (λ) is expected to be smaller when traders have been weakened by losses in the previous period. In particular,

$$\lambda_t(\pi^H_{t-1}) > \lambda_t(\pi^L_{t-1}) \text{ when } \pi^H_{t-1} > 0 \text{ and } \pi^L_{t-1} < 0 .$$

2. The earnings of hedge funds and trading activity. The endowments of convergence traders could also be inferred from the returns of fixed-income arbitrage hedge funds. Here, we assume that after hedge funds suffer losses, less arbitrage trading occurs in the next period.

Let y_{t-1} denote the earnings of fixed-income arbitrage hedge funds in the previous period; the convergence coefficient (λ) is conjectured to depend on y_{t-1} as

$$\lambda_t(y^H_{t-1}) > \lambda_t(y^L_{t-1}) \text{ when } y^H_{t-1} > 0 \text{ and } y^L_{t-1} < 0 .$$

3. Repo volume and trading activity. In this approach, the level of trading activity is inferred from the change in repo volume. Because repo contracts are used in convergence trading, we might expect a fall in repo volume to signal trading losses. In particular, significant trading losses might force a close-out of trading positions that would be reflected in falling repo volume. Accordingly, if a decline in repo volume occurred when traders have been weakened by losses, we would expect less convergence trading and a smaller convergence coefficient (λ) when repo volume falls.

If ΔRP denotes the change in the volume of repos outstanding, we would expect

$$\lambda(\Delta RP^H) > \lambda(\Delta RP^L) \text{ when } \Delta RP^H > 0 \text{ and } \Delta RP^L < 0 .$$

5.2 The Fundamental Swap Spread

We now specify the relationship between the fundamental swap spread and its observable determinants. The model of the fundamental spread is adapted from Lang, Litzenberger, and Luchuan (1998), who examine the fundamental economic and financial variables that determine the swap spread. Following their lead, we define the equation

$$(4) \quad S^F_t = \alpha_1 + \alpha_2 A_t + \alpha_3 Tr_t + \alpha_4 UnEmp_t + \alpha_5 \Delta r_t + \varepsilon_t ,$$

where A is the A-rated corporate bond spread over the ten-year Treasury rate, Tr is the average of the five- and ten-year Treasury interest rates, $UnEmp$ is the unemployment rate, r is the repo interest rate, and ε is an unobservable random shock.[5] In this model of the fundamental swap spread, we assume that the corporate bond spread is an exogenous variable, as it is an index of economywide bond prices and may be influenced by a broader set of forces than those that affect the swap market. While we make this assumption here, the nature of the interrelationship between the swap spread and the bond spread remains an open question and is a topic for future research.[6]

5.3 Estimation Results for the Limits of Arbitrage

In estimating our model, we substitute the fundamental swap spread (equation 4) into the observed swap spread (equation 2) and estimate all the coefficients jointly (equation 3). We estimate three versions of equation 3 using different indicators of the level of trading activity as described above. The regression results are presented in Table 2. In Models 1 and 2, trading activity is inferred from trading income, which in Model 1 is derived from the change in the spread and the inferred trading position, while in Model 2 it is inferred from the earnings of fixed-income arbitrage hedge funds. In Model 3, trading activity is inferred from the volume of repo contracts.

All three regressions in Table 2 yield similar results, with similar coefficients in each row and similar differences

[5]In addition to using the spread of the A-rated corporate bond over the Treasury rate, we also used the spread of the BBB-rated corporate bond over the AAA-rated bond yield. We obtained similar results employing this specification, but we found lower levels of statistical significance. For the long-term Treasury rate, we used the ten-year rate and the average of the five- and ten-year rates, arriving at similar results both times. In addition to the variables described in Lang, Litzenberger, and Luchuan (1998), we found that the repo rate also influences the swap spread. An alternative specification of the shock in the repo rate (Δr) can be defined as the difference between the levels of the repo rate and the three-month Treasury rate. We obtained similar results using both specifications of the repo rate shock. In an alternative specification of the fundamental swap spread, we represented the fundamental spread by the twelve-month moving average of the swap spread plus the shock in the repo rate. We obtained the same results here as we did using the macro variables model of the fundamental spread, but we found lower levels of statistical significance.

[6]In a preliminary analysis of an extended model that included the corporate bond spread as an endogenous variable, we obtained the same results as we did using the model in this article. This issue deserves further study, however, before one draws conclusions about the nature of the interrelationship between the corporate bond and swap spreads. In a related topic, research by Collin-Dufresne and Solnik (2001) provides insight on the spread between LIBOR bond yields and swap rates.

Table 2

Regression Results for Convergence of the Swap Spread Conditional on the Level of Trading Activity

	Model 1	Model 2	Model 3
	Trading Income Inferred from Lagged Change in Spread	Trading Income Inferred from Hedge Fund Earnings	Trading Income Inferred from Repo Volume
$z_t(\alpha x_t - s_{t-1})$	0.322 (se=0.080, p=0.000)	0.253 (se=0.060, p=0.000)	0.339 (se=0.082, p=0.000)
$(1-z_t)(\alpha x_t - s_{t-1})$	0.092 (se=0.074, p=0.217)	0.152 (se=0.132, p=0.252)	0.055 (se=0.061, p=0.371)
const. (α_1)	1.147 (p=0.000)	1.089 (p=0.018)	0.295 (p=0.514)
A	0.289 (p=0.000)	0.290 (p=0.000)	0.365 (p=0.000)
Tr	0.054 (p=0.000)	0.055 (p=0.134)	0.126 (p=0.006)
$UnEmp$	-0.279 (p=0.000)	-0.269 (p=0.000)	-0.212 (p=0.000)
Δr	0.370 (p=0.000)	0.372 (p=0.003)	0.487 (p=0.002)
Adjusted R^2	0.155	0.119	0.176

Source: Author's calculations.

Notes: Regression results for the equation

$$\Delta s_t = \lambda^p z_t(\alpha x_t - s_{t-1}) + \lambda^n (1-z_t)(\alpha x_t - s_{t-1}) + \upsilon_t ,$$

with

$$\alpha x_t = \alpha_1 + \alpha_2 A_t + \alpha_3 Tr_t + \alpha_4 UnEmp_t + \alpha_5 \Delta r_t ,$$

$z_t = 1$ if $q_t > 0$ and 0 otherwise,

where

in Model 1: $q_t = \pi_{t-1} = \Delta s_{t-1} w_{t-2}$ (derived trading income, where w_{t-2} indicates the direction of the trading position),

in Model 2: $q_t = y_{t-1}$ (earnings of fixed-income arbitrage hedge funds),

in Model 3: $q_t = \Delta RP_{t-1}$ (change in repo volume),[a]

and $w_t = \left| s_t^f - s_t \right| / (s_t^f - s_t), s_t^f = \alpha x_t$.

In the regression, all coefficients are estimated jointly. Standard errors (se) and p-values are in parentheses, with Newey-West standard errors and covariance. The sample period is 1996-2004.

[a]In this case, we assume that when traders suffer losses, trading positions are closed out and repo volume falls. We obtain similar results for both current and lagged changes in repo volume. The results reported in the table are for a lagged change in repo volume.

between rows. The estimated convergence coefficient (λ) is indeed less than 1, a result consistent with less than perfect arbitrage in the market. Furthermore, the coefficient is smaller when the inferred level of trading activity is lower, as can be seen from a comparison of the table's top two rows, where the second row represents the case of less active traders. In an F-test of whether the difference between the convergence coefficients in the two cases is statistically significant, we find that it is in the first and third models but not in the second. Nevertheless, even in the second model, we find that the convergence coefficient is statistically significant for a higher level of trading activity, but not for less active traders. Thus, we have strong results in the first and third models but a weaker result in the second.

In terms of the limits to arbitrage, the similar results across the three measures of trading activity and trading income support the argument that the amount of convergence trading depends on traders' endowments. If trading losses lead to a retreat of convergence traders, the swap spread would converge more slowly to its fundamental level. We indeed find such a relationship between inferred trading losses and the speed of convergence of the swap spread.

6. Shocks in Trading Activity, Repo Volume, and the Swap Spread

Here, we examine how trading shocks can affect the swap spread in ways beyond the effects of limits to arbitrage that slow the convergence of the spread to its fundamental level. In particular, we look at how shocks in trading activity can heighten volatility in the swap spread.

6.1 Convergence Trading and the Volume of Repurchase Contracts

The analysis requires a signal of shocks in trading activity. For this indicator, we use the volume of repo contracts because one leg of a convergence trade on the swap spread is a position in Treasury securities that would normally involve a transaction in the repo market. Thus, even though data on convergence trading positions do not exist, large changes in these positions may be reflected in changes in repo market variables. While the behavior of aggregate repo volume is driven by multiple trading and financing motivations, we might still expect some of the variation in repo volume to be associated with convergence trading on the swap spread given the large size of the swap market.[7] Accordingly, we seek an empirical relationship between the behavior of the swap spread and repo volume that would be consistent with the effects of shocks in convergence trading.

6.2 Trading Shocks and the Swap Spread

To analyze how trading shocks might affect the volatility of the swap spread, we add to the equation for the change in the swap spread the proxy variable for trading activity: the volume of repo contracts. In our view, a contraction of trading positions will be reflected in a fall in repo volume, while a premature unwinding of convergence trading positions will disturb the swap spread. Thus, we would expect to find a relationship between a fall in repo volume and disturbances in the spread.

We expect a fall in repo volume to be associated with a swap spread diverging from its fundamental level. For instance, when the spread is above its fundamental level, convergence traders will establish a position that would gain from a falling spread. Unwinding the position prematurely, however, will cause the spread to rise further above its fundamental level rather than converge to it (Box 1, Table 2). Such a trading shock will destabilize the swap spread in the sense that the spread will diverge from its fundamental level instead of converge to it.

To identify the direction of the impact on the swap spread of a trading position contraction, we weight repo volume by the sign of the deviation of the swap spread from its fundamental level. This conditioning adjustment is necessary because the unwinding of a position could cause either a rising or falling swap spread, depending on the direction of the position. The sign of the deviation of the spread from its fundamental level allows the identification of the price impact because that deviation determines the direction of the trading position.

In formal terms, to infer the direction of convergence trades put in place in period *t*, we use the indicator variable $w_t = |s_t^f - s_t| / (s_t^f - s_t)$, the sign of the deviation of the swap spread from its observable fundamental level. As an indicator of the direction of the convergence trade position put in place in period *t*, the variable w_t informs us of the market impact of an unwinding of the position in the next period.

If the position established in period $t-1$ is closed out in period *t*, the resulting fall in repo volume in period *t* conditioned by w_{t-1} captures the impact on the spread in period *t*. This specification leads to a modification of equation 3 through the addition of the volume of repo contracts,

$$(5)\quad \Delta s_t = \beta^0 \Delta RP_t + \beta^1\big|_{\Delta RP<0} \Delta RP_t w_{t-1} + \lambda(ax_t - s_{t-1}) + \nu_t .$$

In this equation, β^0 is a coefficient for a baseline effect of repo volume, and the trading shock effect is captured by β^1. To isolate the effect of the premature closing out of positions, we restrict the trading shock coefficient (β^1) to the conditional case of falling repo volume.[8] As mentioned above, in the trading shock term, w_{t-1} converts a fall in repo volume into the appropriate impact on the spread: either an upward or downward shock depending on the position being unwound. With the conditioning variable *w* on repo volume, we expect the trading shock coefficient (β^1) to be positive (see Box 2 for more details). As before, we expect the convergence coefficient (λ) to be less than 1 as well as to be smaller when traders have suffered losses.

Before proceeding with the estimation of equation 5, we consider the possibility of a simultaneous relationship between

[7] In April 2004, the U.S. dollar interest rate swap market had average daily trading volume of $195 billion of notional amount (Bank for International Settlements 2005). By comparison, over the same period, the average daily trading volume in Treasury coupon securities (notes and bonds) by primary dealers was $449 billion, according to the Federal Reserve Bank of New York (http://www.newyorkfed.org/markets/statrel.html).

[8] We also estimated a variation of the restriction on the trading shock coefficient using separate coefficients for rising and falling repo volume; we obtained the same results as we did using the specification in equation 5. The estimated coefficient for falling repo volume was the same as the result using equation 5, while the estimated coefficient restricted to rising repo volume was not statistically different from zero.

Box 2

Derivation of the Sign of β^1

The fall in repo volume that occurs when a trading position is closed out signifies that the change in repo volume is negative, while the change in the spread depends on the direction of the position (in particular, if speculators took positions on whether the spread would fall or rise, which in turn depends on whether the spread was above or below its fundamental level).

If the swap spread is above its fundamental level, the weight w is negative; the results in Box 1, Table 2, show that the change in the spread is positive. Therefore, the change in the spread is positive, as is the weighted change in *RP* (see table below).

If the swap spread is below its fundamental level, the weight w is positive; the converse case in Box 1 indicates that the change in the spread is negative. Therefore, the change in the spread is negative, as is the weighted change in *RP* (see table below).

In all cases, a positive relationship therefore exists between the change in the swap spread and the weighted change in repos outstanding.

Relationship between a Change in the Swap Spread and the Weighted Change in Repo Volume

Swap Spread	w	ΔRP	ΔS	$\beta^1 = \Delta s / \Delta RP \cdot w$
Above fundamental level	(-)	(-)	(+)	(+)
Below fundamental level	(+)	(-)	(-)	(+)

Notes: (+) denotes a positive value; (-) denotes a negative value.
$w = |s^f - s| / (s^f - s)$.

repo volume and the swap spread. In addition to the effect of repo volume on the swap spread in equation 5, the swap spread in turn could influence repo volume through its effect on trading gains and losses.

6.3 Trading Losses and Repo Volume

We now consider the possibility that repo volume is affected by trading losses if such losses lead to a contraction of trading positions and thus a fall in repo volume. In leveraged trading activity such as repo or derivatives transactions, a trading loss would create a credit exposure with the trader's counterparty. When the exposure reaches some threshold level, the counterparty may demand to close out the position or call for collateral to cover its exposure. If the additional collateral is not provided, the position would be closed out. In this scenario, we would expect repo volume to fall when traders suffer significant losses.

Alternatively, a trading firm's internal risk management discipline could also lead to the same relationship between losses and repo volume. A trading loss that exceeds a loss limit would trigger a risk management instruction to close out the losing position, with the same observed relationship occurring between trading losses and repo volume as in the counterparty credit risk scenario.

In an initial test of the relationship between repo volume and trading income, we express the relationship as

$$(6) \qquad \Delta RP_t = \psi + \gamma^0 \pi_t + \gamma^1 \pi_{t-1} + \kappa \Delta Tr_t^{10} + \varphi_t ,$$

where π is trading income, Tr^{10} is the ten-year Treasury interest rate, and φ_t is an unobserved random residual. The ten-year Treasury rate is included to account for the effect of the interest rate environment on the repo market.[9] In addition, we include both current and lagged trading income. If traders unwind their positions when they experience losses, both ΔRP and π would be negative and the coefficient on trading income (γ) would be positive.

In the exploratory estimate of the relationship between repo volume and trading income (equation 6), we use the earnings of fixed-income arbitrage hedge funds as a proxy for trading income. The estimation results confirm the presence of such a relationship (Table 3). In column 1, the regression seeks a relationship between repo volume and trading income, and we find a statistically significant positive coefficient on trading income for both current and lagged hedge fund earnings. In column 2, to test whether trading losses lead to a contraction of repo volume, we condition the coefficient on trading income upon gains versus losses. Trading losses are indeed found to have the conjectured effect on repo volume, with statistically significant positive coefficients on trading income under the restriction of trading losses.

6.4 Trading Losses, Repo Volume, and the Swap Spread

Our model using repo volume considers the possibility of a simultaneous relationship between repo volume and the swap spread. In addition to the effect of repo volume on the swap spread (equation 5), the swap spread could in turn influence repo volume through its effect on trading gains and losses (equation 6). We now account for such a relationship between the two variables.[10]

[9] The ten-year to three-month term spread could also be used in this equation; it would yield similar results.

Table 3

Regression Results for Repo Volume and Trading Losses

	Unconditional Coefficient	Conditional Coefficient
const. (ψ)	-0.011 (p=0.000)	-0.018 (0.020)
y_t	0.006 (p=0.026)	
y_{t-1}	0.014 (p=0.000)	
$y_t\|_{y_t>0}$		0.008 (p=0.337)
$y_t\|_{y_t<0}$		0.005 (p=0.060)
$y_{t-1}\|_{y_{t-1}>0}$		0.019 (p=0.007)
$y_{t-1}\|_{y_{t-1}<0}$		0.012 (p=0.000)
ΔTr_t^{10}	-0.059 (p=0.000)	-0.059 (p=0.000)
Adjusted R^2	0.329	0.322

Source: Author's calculations.

Notes: Regression results for the equations

$$\Delta RP_t = \psi + \gamma^0 y_t + \gamma^1 y_{t-1} + \kappa \Delta Tr^{10}{}_t + \varphi_t$$

and

$$\Delta RP_t = \psi + \gamma^{01}|_{y_t>0} y_t + \gamma^{02}|_{y_t<0} y_t + \gamma^{11}|_{y_{t-1}>0} y_{t-1} + \gamma^{12}|_{y_{t-1}<0} y_{t-1} + \kappa \Delta Tr_t^{10} + \varphi_t ,$$

where

y = earnings of fixed-income arbitrage hedge funds.

p-values are in parentheses, with Newey-West standard errors and covariance. The sample period is 1996-2004.

If we define trading income endogenously, as we do in the expression $\pi_t = \Delta s_t w_{t-1}$, substituting for trading income in equation 6 leads to

$$(7)\ \Delta RP_t = \psi + \tau \Delta s_t + \gamma^0 \Delta s_t w_{t-1} + \gamma^1 \Delta s_{t-1} w_{t-2} + \kappa \Delta Tr_t^{10} + \varphi_t ,$$

where, in addition to substituting for trading income, we include the swap spread by itself to capture a baseline relationship between repo volume and the swap spread. In this equation, trading gains and losses depend on whether the swap spread is moving toward or away from its fundamental level. A converging spread leads to gains while a diverging spread results in losses.

This equation, combined with the swap spread equation (equation 5), gives us a simultaneous-equations model in which trading shocks, as reflected in repo volume, affect the swap spread, while shocks in the swap spread cause trading losses and the closing out of trading positions that in turn lead to a fall in repo volume.

Bringing together equations 5 and 7 gives us the following model of the swap spread and repo volume

$$(8)\ \Delta s_t = \beta^0 \Delta RP_t + \beta^1|_{\Delta RP<0} \Delta RP_t w_{t-1} + \lambda(ax_t - s_{t-1}) + \nu_t$$

$$(9)\ \Delta RP_t = \psi + \tau \Delta s_t + \gamma^0 \Delta s_t w_{t-1} + \gamma^1 \Delta s_{t-1} w_{t-2} + \kappa \Delta Tr_t^{10} + \varphi_t ,$$

with $ax_t = \alpha_1 + \alpha_2 A_t + \alpha_3 Tr_t + \alpha_4 UnEmp_t + \alpha_5 \Delta r_t$, where equations 8 and 9, respectively, are equations 5 and 7 relabeled.

6.5 Estimation Results of the Simultaneous-Equations Model

We estimate equations 8 and 9 using two-stage least squares; we estimate the coefficients of the fundamental swap spread jointly with the other coefficients. The results are presented in Table 4.

We find using the equation for the change in the swap spread (Table 4, column 1), as we did using the single-equation model, that the convergence coefficient is smaller when the inferred level of trading activity is lower. This relationship occurs when trading has been unprofitable (compare rows 3 and 4). In row 2, we find a statistically significant positive coefficient for falling repo volume, indicating that the swap spread diverges from its fundamental level when repo volume falls.[11] This result is consistent with the argument about the effect on the swap spread of unwinding trading positions. Furthermore, for the repo volume equation (column 2), we find that repo volume varies directly with trading income (note the statistically significant positive coefficient in row 6), which would occur if traders unwound their positions when they suffered losses.

These results are consistent with the argument that shocks in the swap spread are associated with trading risk. The swap spread tends to diverge from its fundamental value when repo volume falls, and repo volume tends to fall when convergence traders experience losses.

[10] A simultaneous relationship between repo volume and the repo interest rate might also be possible. In tests of simultaneity, however, we found no sign of such a relationship among the repo market variables. A more general model with repo volume would also include other trading activity that involves the repo market—for instance, carry trades, trading on corporate bond spreads, and mortgage-backed securities trades. Such a large-scale model of trading activity, however, is beyond the scope of this article.

[11] As discussed in footnote 8, we also estimated a variation of the model with separate coefficients for rising and falling repo volume; we obtained the same results as we did using the specification in Table 4.

Table 4

Regression Results for the Swap Spread, Repo Volume, and Trading Losses

	Δs	ΔRP
ΔRP_t	0.108 (p=0.472)	
$\Delta RP_t\, w_{t-1}\|_{\Delta RP<0}$	0.949 (p=0.000)	
$(\alpha x_t - s_{t-1})\|_{\pi_{t-1}>0}$	0.411 (se=0.087, p=0.000)	
$(\alpha x_t - s_{t-1})\|_{\pi_{t-1}<0}$	0.198 (se=0.064, p=0.003)	
Δs_t		0.009 (p=0.902)
$\Delta s_t w_{t-1}$		0.242 (p=0.001)
$\Delta s_{t-1} w_{t-2}$		0.020 (p=0.805)
ΔTr_t^{10}		-0.047 (p=0.009)
const. (α_1, ψ)	1.226 (p=0.000)	-0.001 (0.862)
A	0.287 (p=0.000)	
Tr	0.046 (p=0.063)	
$UnEmp$	-0.290 (p=0.000)	
Δr	0.310 (p=0.002)	
Adjusted R^2	0.206	0.110

Source: Author's calculations.

Notes: We use two-stage least squares regression results for the equations

$$\Delta S_t = \beta_0 \Delta RP_t + \beta^1\big|_{\Delta RP<0} \Delta RP_t\, w_{t-1} + \lambda^P\big|_{\pi_{t-1}>0}(\alpha x_t - s_{t-1}) + \lambda^n\big|_{\pi_{t-1}<0}(\alpha x_t - s_{t-1}) + \upsilon_t\,,$$

$$\Delta RP_t = \psi + \tau \Delta s_t + \gamma^0 \Delta s_t w_{t-1} + \gamma^1 \Delta s_{t-1} w_{t-2} + \kappa \Delta Tr_t^{10} + \varphi_t\,,$$

with

$$\alpha x_t = \alpha_1 + \alpha_2 A_t + \alpha_3 Tr_t + \alpha_4 UnEmp_t + \alpha_5 \Delta r_t\,,$$

$$w_t = \left|s_t^f - s_t\right| / (s_t^f - s_t),$$

$$s_t^f = \alpha x_t,$$

$$\pi_{t-1} = \Delta s_{t-1} w_{t-2}.$$

Standard errors (se) and p-values are in parentheses, with Newey-West standard errors and covariance. The sample period is 1996-2004.

Convergence trading usually stabilizes the swap spread because traders take positions that counter shocks to the spread in a buy-low/sell-high speculation that maintains market liquidity. The results in this section, however, suggest that large shocks can be amplified by the premature unwinding of convergence trades. Generally, traders unwind their inventory when shocks in a direction opposite the initial shock enable them to close out their positions profitably in a controlled fashion, smoothing out liquidity shocks as they do so. If convergence trades are unwound prematurely, though, they impact market liquidity and can cause the spread to diverge from its fundamental level rather than converge to it. When traders take positions that counter shocks in the spread, the inventory built up in those positions overhangs the market and becomes a potentially destabilizing force, even though the change in that inventory usually stabilizes the spread. Although speculative trading normally absorbs shocks as traders execute their buy-low/sell-high strategies, the untimely liquidation of the accumulated trading positions can release back into the market the shocks that had been absorbed by that inventory.

7. Conclusion

This study offers evidence of stabilizing as well as destabilizing forces in the behavior of the interest rate swap spread that might be attributable to speculative trading activity. Our results are consistent with the argument that the swap spread converges more slowly to its fundamental level when the capital, or endowments, of traders has been impaired by trading losses. Furthermore, while convergence traders tend to stabilize the swap spread, we also find evidence of how trading risk can sometimes cause the spread to diverge from its fundamental level.

Our results suggest that convergence trading typically absorbs shocks, but an unusually large shock can be amplified by the premature unwinding of traders' positions. Destabilizing shocks in the swap spread are found to be associated with a fall in the volume of repo contracts in a way that is consistent with an unwinding of trading positions. We also find that repo volume drops in response to losses in convergence trading. Together, these results are consistent with the argument that trading risk, as reflected in fluctuations of repo volume, on occasion can destabilize the swap spread.

Although other explanations of the relationship between shocks in repo volume and the swap spread might ultimately be put forth, our results suggest that it would be worthwhile to pursue further research on how shocks in trading activity affect spreads in fixed-income markets.

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