Michael J. Fleming and John R. Sporn

Trading Activity and Price Transparency in the Inflation Swap Market

- Liquidity and price transparency in derivatives markets have become increasingly important concerns, yet a lack of transaction data has made it hard to fully understand how the inflation swap and other derivatives markets work.
- This study uses novel transaction data to shed light on trading activity and price transparency in the rapidly growing U.S. inflation swap market.
- It reveals that the market is reasonably liquid and transparent, despite its over-the-counter nature and low level of trading activity. Transaction prices are typically near widely available end-of-day quoted prices and realized bid-ask spreads are modest.
- The authors also identify concentrations of activity in certain tenors and trade sizes and among certain market participants as well as point to various attributes that explain trade sizes and price deviations.

1. Introduction

An inflation swap is a derivative transaction in which one party agrees to swap fixed payments for floating payments tied to the inflation rate, for a given notional amount and period of time. A "buyer" might therefore agree to pay a per annum rate of 2.47 percent on a $25 million notional amount for ten years in order to receive the rate of inflation for that same time period and amount. Inflation swaps are used by market participants to hedge inflation risk and to speculate on the course of inflation and by market observers more broadly to infer inflation expectations.

Several recent studies have compared the inflation swap rate with breakeven inflation as calculated from Treasury inflation-protected securities (TIPS) and nominal Treasury bonds.[1] The two market-based measures of expected inflation should be equal in the absence of market frictions. In practice, inflation swap rates are almost always higher, with the spread exceeding 100 basis points during the recent financial crisis.

Fleckenstein, Longstaff, and Lustig (forthcoming) attribute this differential to the mispricing of TIPS relative to nominal

[1] Other studies have examined how inflation swaps are priced or have utilized the information in swap rates to make inferences about breakeven inflation. Jarrow and Yildirim (2003) propose an approach for valuing inflation derivatives, which is applied to inflation swaps by Mercurio (2005) and Hinnerich (2008). Krishnamurthy and Vissing-Jorgensen (2011) use changes in inflation swap rates as evidence that the Federal Reserve's quantitative easing increased expected inflation. Rodrigues, Steinberg, and Madar (2009) use swaps to examine the effect of news on breakeven inflation.

Michael J. Fleming is a vice president in the Federal Reserve Bank of New York's Research and Statistics Group; John R. Sporn is a senior analyst in the Bank's Markets Group.

Correspondence: michael.fleming@ny.frb.org

The authors thank Laura Braverman, Darrell Duffie, Glenn Haberbush, Ada Li, Wendy Ng, Johanna Schwab, and seminar participants at the Federal Reserve Bank of New York and at the Commodity Futures Trading Commission 2012 Research Conference for helpful comments. The views expressed are those of the authors and do not necessarily reflect the position of the Federal Reserve Bank of New York or the Federal Reserve System.

Treasury bonds, and not to inflation swaps.[2] In contrast, Christensen and Gillan (2011) argue that the differential comes from a liquidity premium in inflation swaps as well as a liquidity premium in TIPS.[3] While a recent study examines the liquidity of the TIPS market (Fleming and Krishnan 2012), there is virtually no evidence on the liquidity of the inflation swap market.

Aside from past research on inflation swaps, the issues of liquidity and price transparency in derivatives markets more generally have taken on greater import given regulatory efforts under way to improve the transparency of over-the-counter derivatives markets. In particular, the Dodd-Frank Wall Street Reform and Consumer Protection Act calls for the Commodity Futures Trading Commission (CFTC) and Securities and Exchange Commission to promulgate rules that provide for the public availability of over-the-counter derivatives transaction data in real time.[4] To date, the lack of transaction data has impeded the understanding of how the inflation swap and other derivatives markets operate.

In early 2010, the OTC Derivatives Supervisors Group (ODSG), an international body of supervisors with oversight of major over-the-counter derivatives dealers, called for greater post-trade transparency. In response, major derivatives dealers provided the ODSG with access to three months of over-the-counter derivatives transaction data to analyze the implications of enhanced transparency for financial stability. Fleming et al. (2012) examine the data from the interest rate derivatives market, focusing on the four most actively traded products: interest rate swaps, overnight indexed swaps, swaptions, and forward rate agreements.

This article uses the same interest rate derivatives data set to examine trading activity and price transparency in the U.S. inflation swap market. Specifically, we analyze all electronically matched zero-coupon inflation swap trades involving a G14 dealer for a three-month period in 2010.[5] The data source is MarkitSERV, the predominant trade-matching and post-trade processing platform for interest rate derivatives transactions. An analysis of such data can serve as a resource for policymakers considering public reporting and other regulatory initiatives for the derivatives markets and for market participants and observers more generally interested in the workings of the inflation swap market.

We find that relatively few trades occur in the U.S. zero-coupon inflation swap market. Our reasonably comprehensive data set contains only 144 trades (just over two trades per day) over our June 1 to August 31, 2010, sample period. Daily notional trading volume is estimated to average $65 million. In the TIPS market, in comparison, an estimated $5.0 billion per day traded over the same period, on average.[6]

We identify concentrations of activity in certain tenors, with 45 percent of activity at the ten-year tenor, 14 percent at five years, and 1 percent at three years. Trade sizes tend to concentrate as well, with 36 percent of all trades (and 48 percent of "new" trades) having a notional amount of $25 million. Trade sizes are generally larger for new trades and trades that are allocated across subaccounts, and they tend to decrease with tenor. Over half (54 percent) of trades are between G14 dealers, 39 percent are between G14 dealers and other market participants, and 7 percent are between other market participants. The activity in our data set occurs across nine G14 dealers and nine other market participants.

Despite the low level of activity in this over-the-counter market, we find that transaction prices are quite close to widely available end-of-day quoted prices. After we control for tenor and trading day, the standard deviation of rate differences between our transaction rates and the average end-of-day rates quoted by Barclays and Bloomberg is just 3 basis points. The differential tends to decrease with tenor and increase with trade size and for customer trades. Lastly, by comparing trades for which customers pay and receive inflation, we are able to infer a realized bid-ask spread for customers of 3 basis points, which essentially matches the quoted bid-ask spreads reported by dealers.

Our study proceeds as follows. Section 2 describes how inflation swaps work and the market in which they trade. Section 3 discusses the data used in our analysis. Our empirical results are presented in section 4; section 5 concludes.

[2] Haubrich, Pennachi, and Ritchken (2011) similarly conclude that TIPS were underpriced during the financial crisis. Campbell, Shiller, and Viceira (2009) attribute the differential to anomalous liquidity problems in TIPS.

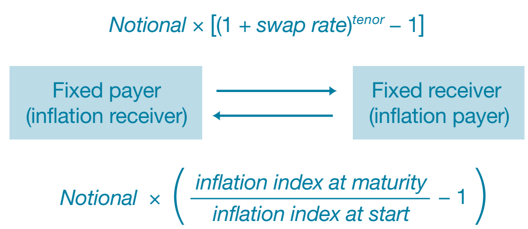
[3] In their argument, the liquidity premium in inflation swaps comes from reduced funding costs for buyers of inflation and hedging costs for sellers of inflation. Lucca and Schaumburg (2011) also note these hedging costs, as well as TIPS liquidity premia, as explanations for the differences in breakeven inflation.

[4] Inflation swaps fall under the jurisdiction of the CFTC, which, as of December 31, 2012, began requiring real-time public reporting of swap transactions.

[5] The G14 dealers are the largest derivatives dealers and, during the period covered by this study, include Bank of America, Barclays, BNP Paribas, Citigroup, Credit Suisse, Deutsche Bank, Goldman Sachs, HSBC, JP Morgan Chase, Morgan Stanley, Royal Bank of Scotland, Société Générale, UBS, and Wells Fargo.

[6] TIPS volume data come from the Federal Reserve's FR 2004 series and cover activity involving the primary government securities dealers (that is, dealers with a trading relationship with the Federal Reserve Bank of New York). Trades between two primary dealers are reported by each dealer and hence are double-counted.

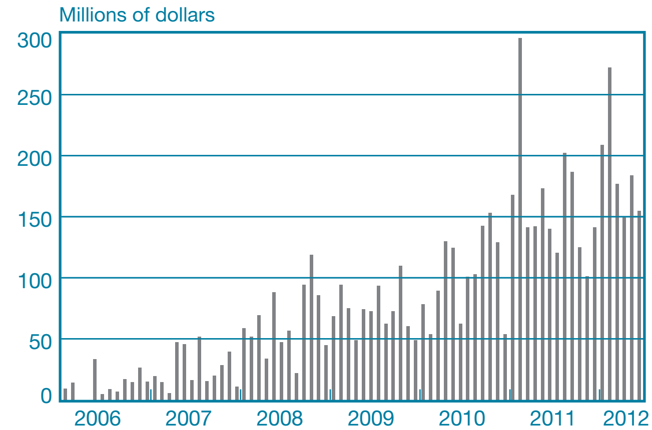
Zero-Coupon Inflation Swap Cash Flows (at Maturity)



Notes: The exhibit shows the cash flows exchanged at maturity by swap counterparties. No cash flows are exchanged at the initiation of a swap.

Chart 1

Daily Inflation Swap Activity over Time



Source: Authors' calculations, based on data from BGC Partners.

Note: The chart plots average daily brokered inflation swap activity by month.

2. Inflation Swaps

An inflation swap is a bilateral derivatives contract in which one party agrees to swap fixed payments for floating payments tied to the inflation rate, for a given notional amount and period of time. The inflation gauge for U.S. dollar inflation swaps is the nonseasonally adjusted consumer price index for urban consumers, the same gauge used for TIPS. The fixed rate (the swap rate) is negotiated in the market, so that the initial value of a trade is zero. As a result, no cash flows are exchanged at inception of a swap.

The exhibit illustrates the cash flows for a zero-coupon inflation swap—the most common inflation swap in the U.S. market. As the name "zero-coupon" swap implies, cash flows are exchanged at maturity of the contract only. In particular, the inflation payer makes a payment to its counterparty in an amount equal to the contract's notional amount times realized inflation over the term of the contract.[7] The fixed payer, in turn, makes a payment in an amount equal to the contract's notional amount times the annually compounded fixed rate. Technically, cash flows are netted, so that only one party makes a net payment to the other; notional amounts are not exchanged at maturity.

Inflation swaps are used to transfer inflation risk. Entities with obligations exposed to inflation, such as pension funds and insurance companies, can hedge that risk by agreeing to receive inflation. Entities with assets exposed to inflation, such as utility companies, can hedge that risk by agreeing to pay inflation. Other entities may choose to take on inflation risk for speculative or diversification purposes. While inflation risk can also be transferred using securities such as TIPS, inflation swaps can be tailored to more precisely meet investor needs because the swap maturity, notional amount, and other terms are agreed upon at the time of the trade.

[7] To be precise, we note that since changes in the consumer price index are only known with a lag, the floating payment is based on inflation over the period starting three months before the start date and ending three months before the termination date.

Inflation swaps trade in a dealer-based over-the-counter market. The predominant market makers are the G14 dealers, which trade with one another and with their customers. In the dealer-customer market, customers can view dealers' indicative two-way prices throughout the day on Bloomberg and receive closing prices from dealers via e-mail. Customers and dealers communicate directly via e-mail and phone and execute trades over the phone.

In the interdealer market, dealers typically trade with one another indirectly via voice brokers. Recently, the brokers have introduced periodic auctions at which dealers can enter their orders to buy or sell contracts of a given tenor at midmarket prices. If a dealer enters an order to buy or sell, other dealers can see that the dealer has expressed interest in trading a particular contract, without knowing if the order is a buy or a sell, and can consider entering their own orders before the auction closes. When the auction closes, contracts for which there is both buying and selling interest are executed at the midpoint between the bid and offer rates in the market.

Evidence suggests that the U.S. inflation swap market has grown quickly in recent years. Data from BGC Partners, a leading broker, indicate that interdealer trading of zero-coupon swaps averaged roughly \$100 million per day in 2010, \$160 million per day in 2011, and \$190 million per day in the first half of 2012 (Chart 1). Data from an informal survey of dealers—accounting for activity with customers as well as activity brokered among dealers—peg the overall market size in April 2012 at roughly \$350 million per day.

While the inflation swap market may be modest in size, it is part of a much larger market for transferring inflation risk. This larger market includes other derivatives products as well as more actively traded TIPS and nominal Treasury securities. The broader market provides a vehicle for pricing inflation swaps and for hedging positions taken in the market. As a result, the modest size of the market is not necessarily a good gauge of the market's liquidity or transparency.

3. Data

Our primary data set is made up of electronically matched inflation swap transactions between June 1 and August 31, 2010, in which a G14 dealer is on at least one side of the resulting position.[8] The data come from MarkitSERV, the predominant trade-matching and post-trade processing platform for interest rate derivatives. The interest rate derivatives data were provided by the dealers to their primary supervisors so that regulators could assess the derivatives market's conduciveness to trade-level public reporting.

The data provided by MarkitSERV are anonymized, with each firm assigned its own code. No information on firm type is provided aside from the code indicating whether a firm is a G14 dealer. Other firms may be customers of G14 dealers, or other dealers not members of the G14. For brevity, we refer to these other firms as "customers."

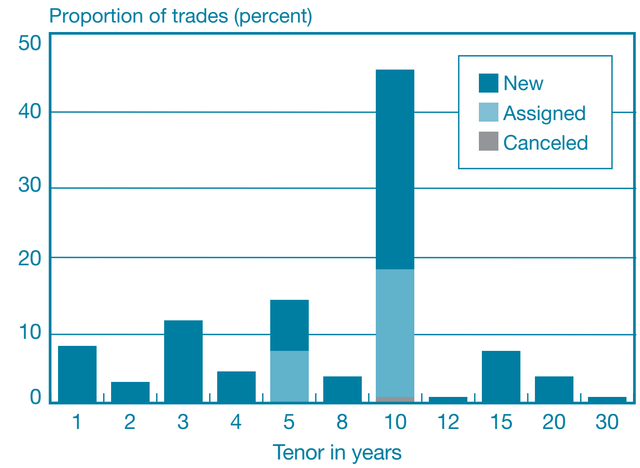
Our data set is fairly comprehensive, but does not cover every transaction in this over-the-counter market. First, it excludes transactions involving a G14 dealer that are not electronically confirmed, which account for about 22 percent of G14 dealer interest rate derivatives transactions (Fleming et al. 2012). Second, it excludes transactions not involving a G14 dealer, which account for about 11 percent of interest rate derivatives notional activity in MarkitSERV (Fleming et al. 2012). Additional information pertinent to the activity covered by our data set is discussed in the appendix.

Our data set contains 144 U.S. dollar zero-coupon inflation swap transactions, or an average of 2.2 transactions over the 65 trading days in our sample.[9] Daily notional trading volume is estimated to average $65 million. Three-quarters (108/144) of the transactions are new trades, 24 percent (35/144) are assignments of existing transactions (whereby one

[8] Because the data set is based on a G14 dealer being a counterparty to the resulting position, it includes assignments of existing positions from a non-G14 dealer to a non-G14 dealer in which a G14 dealer is on the other side, but excludes assignments from a G14 dealer to a non-G14 dealer in which a G14 dealer is not on the other side.

[9] MarkitSERV only supports zero-coupon inflation swaps, so all inflation swaps in the data set are of this type.

Chart 2
Inflation Swap Trading Frequency by Tenor



Source: Authors' calculations, based on data from MarkitSERV.

counterparty to a swap steps out of the deal and assigns its position to a new counterparty), and 1 percent (1/144) are cancelations. One new transaction has a forward start date, for which the accrual period begins two years after the trade date, with the remaining 107 new transactions starting two or three business days after the trade date.

We identify concentrations of inflation swap activity in certain tenors (Chart 2). The ten-year tenor alone accounts for 45 percent (65/144) of activity, followed by tenors of five years (14 percent; 20/144), three years (11 percent; 16/144), one year (8 percent; 11/144), and fifteen years (7 percent; 10/144).[10] There are some differences in tenor by transaction type, with every assigned and canceled trade having an original tenor of five or ten years. In every case, the assigned and canceled trades have a start date less than nine months before the transaction date, so the remaining tenors of such contracts are fairly close to their original tenors.

We also identify a concentration of activity among certain market participants. In particular, 54 percent (78/144) of our trades are between G14 dealers, 39 percent (56/144) are between G14 dealers and customers, and 7 percent (10/144) are between customers. Of the new trades between G14 dealers and customers, the G14 dealer receives fixed 63 percent (19/30) of the time and pays fixed 37 percent (11/30) of the time.[11] New trades in which dealers receive fixed are larger, so that dealers receive fixed for 81 percent of new contract volume. That is, dealers are largely paying inflation and receiving fixed in their interactions with customers.

[10] Note that the original tenor of every trade in our data set is for a round number of years, to the day.

Five of the G14 dealers report no activity over our sample period. The remaining nine dealers transact on both sides of the market. Our data set also shows activity by nine customers, three that trade on both sides of the market, three that only enter transactions to pay fixed, and three that only enter transactions to receive fixed.

Twenty-six (18 percent) of our transactions contain a mutual put break clause. Such clauses provide for set dates at which parties can terminate contracts at current market value, thereby allowing them to mitigate counterparty credit risk associated with mark-to-market balances on long-dated swaps. While 57 percent (82/144) of all trades have a tenor of ten years or more, 85 percent (22/26) of trades with break clauses have such a tenor. G14 dealer trades with customers are more likely to have a break clause (fifteen of fifty-six trades) than are interdealer trades (eleven of seventy-eight).

Seventeen (12 percent) of the trades in our sample period are allocated, whereby a party transacts in a single bulk amount for multiple accounts. All of these allocated trades are new and all involve customers. On average, there are 6.9 allocations related to a primary (or bulk) trade.

Lastly, 55 percent (79/144) of our trades are brokered (accounting for 60 percent of notional volume) and 45 percent (65/144) are executed directly between counterparties. All thirty-six assigned and canceled trades are executed directly, as are twenty-nine of the thirty new customer-dealer trades. All seventy-eight new interdealer trades are brokered, along with one of the thirty new customer-dealer trades.

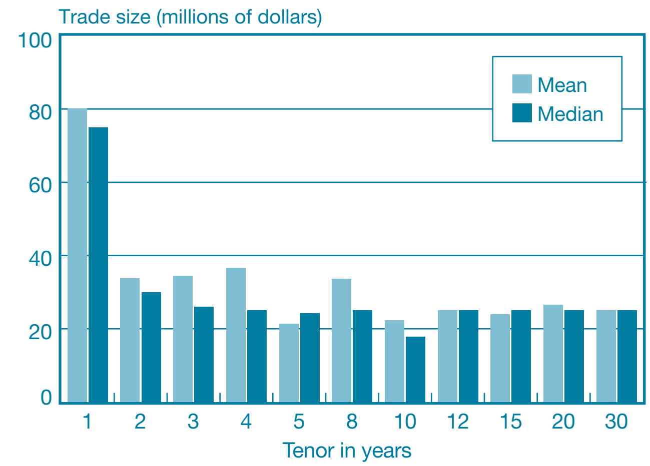
We compare our trading activity figures with figures from BGC Partners as a check on the representativeness of our data set. For our three-month sample period in 2010, BGC reports activity in zero-coupon swaps averaging \$89 million per day. Our overall MarkitSERV average is \$65 million per day, but the more relevant comparison is brokered activity, which averages \$39 million per day. This comparison thereby suggests that our brokered MarkitSERV activity accounts for about 44 percent of all brokered activity (44 percent = \$39 million/\$89 million).

One other data set we utilize comes from an informal survey of dealers on the liquidity of the zero-coupon inflation swap market. In April 2012, we asked seven primary dealers for information on bid-ask spreads, trade sizes, and trades per day for select tenors and across all tenors in both the customer-dealer and interdealer markets.[12] Our primary interest is in bid-ask spread information, since we lack direct information on bid-ask spreads in our transaction data set, but we are also interested in trade size and trade frequency information as a further check on the representativeness of our MarkitSERV data set.

[11] All thirty-five assignments in our data set involve a customer stepping out of its position. For the twenty-five instances in which the assignment is to a G14 dealer, we are able to infer the dealer's side in fourteen cases. Of those fourteen assignments, the G14 dealer stepped in to receive fixed thirteen times and to pay fixed one time.

[12] All seven primary dealers were members of the G14 during our 2010 sample period.

Chart 3
Inflation Swap Trade Size by Tenor



Source: Authors' calculations, based on data from MarkitSERV.

4. Results

4.1 Trade Size

Inflation swap trade size ranges from \$0.2 million to \$294 million, with a mean of \$29.5 million and a median of \$25 million. The most common trade size is \$25 million, accounting for 36 percent (52/144) of all trades. An additional 8 percent (12/144) of observations have a trade size of \$50 million and 3 percent (4/144) each have trade sizes of \$15 million and \$100 million. The remaining 50 percent of trades (72/144) occur in fifty-eight different sizes.

One factor explaining trade size is tenor (Chart 3). Trade size tends to decline with tenor, although the largest distinction seems to be between one-year tenors and longer tenors, with only a weak negative relationship past the one-year point. In other securities and interest rate derivatives markets, in contrast, the negative relationship between tenor and trade size appears stronger across the range of tenors and not so

Table 1

Determinants of Inflation Swap Trade Sizes

	Dependent Variable: Inflation Swap Trade Size					
	All Trades					New Trades
Independent Variables	(1)	(2)	(3)	(4)	(5)	(6)
Constant	4.35***	0.61***	3.23***	2.60***	1.26	4.15***
	(0.57)	(0.14)	(0.19)	(0.24)	(1.54)	(0.52)
Tenor	-0.17***				-0.10**	-0.11**
	(0.06)				(0.05)	(0.05)
New trade		3.12***			2.84**	
		(0.38)			(1.23)	
Customer trade			-0.60		0.22	0.21
			(0.62)		(1.24)	(1.24)
Number of allocations				0.43***	0.34***	0.34***
				(0.09)	(0.08)	(0.08)
Adjusted R^2 (percent)	5.0	14.7	0.0	17.6	29.4	17.1
Number of observations	144	144	144	144	144	108

Source: Authors' calculations, based on data from MarkitSERV.

Notes: The table reports results from regressions of inflation swap trade size on tenor, whether a trade is new or not, whether a trade is a customer trade or not, and the number of allocations. Trade size is measured in tens of millions of dollars (notional amount) and tenor is measured in years. Coefficients are reported with heteroskedasticity-consistent (White) standard errors in parentheses.

*Statistically significant at the 10 percent level.
**Statistically significant at the 5 percent level.
***Statistically significant at the 1 percent level.

dependent on a single point (see, for example, Fleming [2003], Fleming and Krishnan [2012], and Fleming et al. [2012]). In general, the negative relationship is likely explained by the higher rate sensitivity of longer-term instruments.

A second factor explaining trade size is trade status. Assigned and canceled trades tend to be smaller and less consistent in size, perhaps because such trades often reduce the amount of—or assign a share of—the original trade. The average trade size for assigned and canceled trades is just $6.1 million, compared with $37.3 million for new trades. The thirty-six assigned and canceled trades occur across thirty different sizes, with none at $25 million or $50 million. In contrast, 48 percent (52/108) of new trades have a size of $25 million and 11 percent (12/108) $50 million. It follows that the relationship between trade size and tenor is more consistently negative if one examines new trades only.

A third factor explaining trade size is whether or not a trade is allocated. Such trades tend to be larger, with an average size of $67.4 million, almost twice as large as the average for new trades overall. Moreover, all three trades in the data set greater than $100 million are allocated as are three of the four trades of exactly $100 million.

We conduct a regression analysis to better understand the relationships between various variables and trade size (Table 1). Our first four regressions are univariate and demonstrate that the relationships between trade size and tenor, trade type, and number of allocations are all statistically significant. On average, an additional year of tenor cuts $1.7 million from trade size, new trades are $31.2 million larger than other trades, and each allocation boosts trade size by $4.3 million. We also test a specification that includes a dummy variable for customer trades, and find such trades to be smaller than interdealer trades (by $6.0 million), but insignificantly so.

We proceed to employ a multiple-regression analysis to show that the previously identified relationships exist independently of one another. That is, the relationships between trade size and tenor, trade type, and number of allocations remain statistically significant, albeit somewhat weaker in magnitude, when we control for the other variables. Results are similar for the subset of transactions that are new. Still further tests suggest that our basic results reasonably characterize the effects of our data set variables on trade size.[13]

4.2 Price Transparency

Our price transparency analysis examines the relationships among the transaction prices in our data set as well as between the prices in our data set and widely available quoted prices. The purpose of this analysis is three-fold: to understand how close our MarkitSERV transaction prices are to widely available quoted prices, to understand what factors help explain the price differentials, and to provide some insight into the trading costs faced by market participants. We limit this analysis to new trades, which had contract prices negotiated during our sample period, excluding the one new trade with the forward start date.[14]

Visual evidence suggests that the trades in our data set take place at prices close to one another and close to publicly available quoted prices, controlling for tenor and trading day (Chart 4). That is, our MarkitSERV transaction prices look to be within a few basis points of Barclays and Bloomberg quoted prices for a given tenor and trading day. Note that our MarkitSERV prices are from trades throughout the trading day, whereas our Barclays and Bloomberg prices are end-of-day (5 p.m. New York time) midquotes. As a result, one would not expect the MarkitSERV prices to exactly match the other prices even if the inflation swap market were highly transparent and trading costs were negligible.

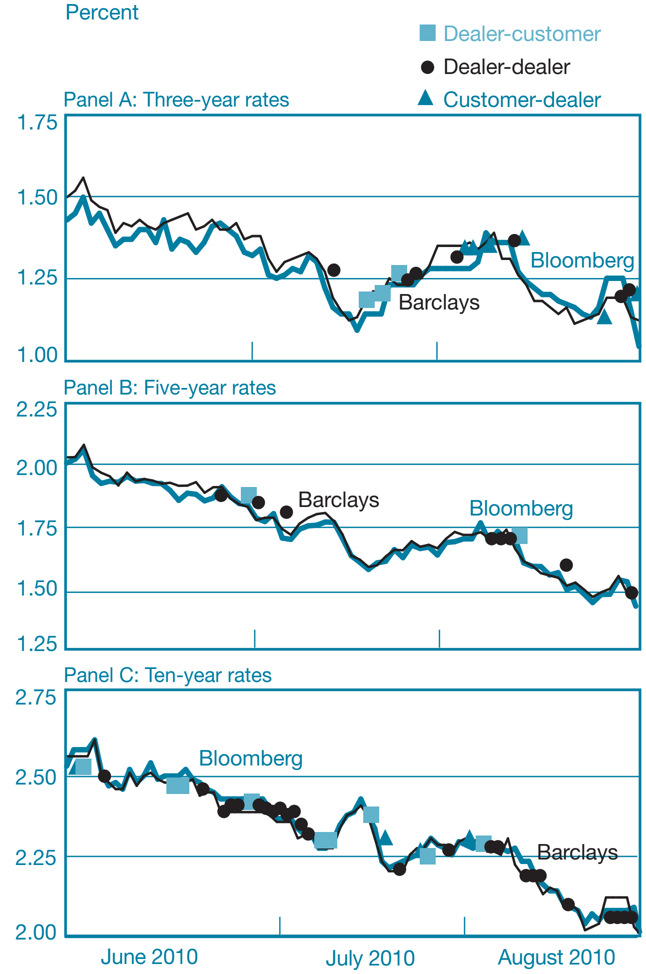
A more formal look at the data confirms the close relationships among inflation swap prices from the various sources (Table 2). The average differences between MarkitSERV and Barclays, MarkitSERV and Bloomberg, and MarkitSERV and the average of Barclays and Bloomberg are all within 1 basis point after we control for tenor and trading day, with standard deviations ranging from 3 to 5 basis points.[15] The standard deviation is lowest when comparing MarkitSERV with the Barclays/Bloomberg average, suggesting that the average better proxies for transaction prices than either source alone does. Also of note is the fact that the largest differentials among the three sources are observed between Barclays and Bloomberg. The largest differences across sources seem to come from the one-year tenor, with prices much tighter for tenors greater than one year.

We proceed to assess whether we can explain the deviations that do occur between MarkitSERV transaction prices and other quoted prices. We do this by regressing the absolute difference between the MarkitSERV price and the average of the Barclays and Bloomberg prices (for the same tenor and trading day) on various independent variables. Our independent variables are:

Chart 4

Inflation Swap Rates

Percent



Source: Authors' calculations, based on data from Barclays, Bloomberg, and MarkitSERV.

Notes: The chart plots transaction prices from MarkitSERV for select tenors, denoted by whether the trades are between G14 dealers (dealer-dealer); between a G14 dealer and a customer, where the G14 dealer pays fixed (dealer-customer); or between a G14 dealer and a customer, where the customer pays fixed (customer-dealer). End-of-day midquotes from Barclays and Bloomberg are also plotted.

[13] We test a specification with a dummy variable for allocated trades, but the continuous variable better fits the data. We also test specifications including dummy variables for whether there is a break clause and whether a trade is brokered, but neither of these additional variables is significant. Lastly, we test whether the results differ for the subset of transactions with a tenor greater than one year. We find that the coefficient for tenor is cut in half and becomes statistically insignificant in such specifications, the results for new trades are little changed, and the coefficient for number of allocations is little changed (but that the *p*-value for that coefficient increases to about 0.10).

[14] A forward start date could be expected to affect pricing and thus make a contract incomparable to prices for contracts without forward start dates.

[15] The standard deviations are only slightly larger (ranging from 4 to 5.5 basis points) when we compare MarkitSERV transaction prices with Barclays and Bloomberg quoted prices from the preceding trading day.

Table 2
Inflation Swap Rate Differential Statistics

	MarkitSERV-Barclays	MarkitSERV-Bloomberg	MarkitSERV-Barclays/Bloomberg Average	Barclays-Bloomberg
Average deviation	-0.6 [0.6]	0.8 [0.4]	0.2 [0.6]	1.5 [-0.1]
Standard deviation	4.9 [2.8]	3.7 [3.2]	3.0 [2.5]	6.1 [3.3]
Number of observations	106 [95]	107 [96]	106 [95]	106 [95]

Sources: Authors' calculations, based on data from Barclays, Bloomberg, and MarkitSERV.

Notes: The table reports statistics for the difference in inflation swap rates among various sources. The comparisons are made by day and tenor for new transactions, excluding forward transactions. Bracketed figures are based on the subsample of transactions with a tenor greater than one year. Comparisons with Barclays have one fewer observation because we have no Barclays rate for the twelve-year tenor trade in our sample. Differences are in basis points.

- *Tenor*: As noted above, rate dispersion among short-dated tenors seems to be higher, even among widely available data sources.
- *Trade size:* Typical bid-ask spreads are commonly valid only for trades up to a certain size, with larger trades requiring a price concession, so price differences may be positively correlated with trade size.
- *Customer trade:* Customer prices might deviate more from other prices if customers face wider bid-ask spreads than dealers do.
- *Time of trade:* As noted, we have end-of-day quoted prices from Barclays and Bloomberg, but intraday transaction prices from MarkitSERV. Given that prices fluctuate over time, one might expect MarkitSERV prices from trades late in the day to be closer to the end-of-day prices reported by other sources.[16]

Our regression analysis indicates significant univariate relationships between the price deviations and our various variables (Table 3). A one-year increase in tenor is associated with a decrease in the price differential of 0.08 basis point. Each $10 million increase in trade size is associated with an increase in the differential of 0.15 basis point. Customer trades tend to have a differential 0.70 basis point larger than interdealer trades have, and each hour closer to the end of the trading day is associated with a reduction in the differential of 0.09 basis point. A multivariate regression analysis on the full sample of new trades shows that the explanatory variables are independently insignificant (albeit jointly significant) when we control for the other variables.

Given the evidence that price deviations are especially large for contracts with a one-year tenor, we repeat the multivariate analysis on the subsample of trades with a tenor greater than one year. These results show an even weaker effect of tenor, confirming the importance of the one-year trades at explaining the tenor effect. Moreover, trade size and customer trade are significant, and of a similar magnitude as in the univariate regressions, so that larger trades and customer trades tend to occur with larger price differentials for the vast majority of new trades, even after we control for other factors. The time of the trade remains insignificant in the last regression.[17]

4.3 Bid-Ask Spreads

We examine spreads between bid and offer prices in the inflation swap market because they provide a measure of the trading costs faced by market participants. If a customer were to engage in a round-trip trade (that is, enter into a contract to pay fixed as well as a contract to received fixed), for example, it could expect to pay the full bid-ask spread. It follows that a customer engaging in a single buy or sell (that is, entering into a contract to pay fixed or receive fixed, but not both) can expect to pay half of the spread. We assess bid-ask spreads in a couple of different ways.

First, we look at the results of our informal dealer survey. As shown in Table 4, dealers report that bid-ask spreads range from 2 to 3 basis points, depending on tenor. Average trade sizes are estimated to range from $25 million to $50 million in the dealer-customer market and $25 million to $35 million in the interdealer market, consistent with the $29.5 million average we find in our MarkitSERV data. The estimated daily trading frequency of 6 in the customer-dealer market plus 5 in the interdealer market exceeds our overall average of 2.2 by five

[16] Time of trade is measured by the hour of the trading day, based on New York time and a twenty-four-hour clock, so that a trade that occurs at 2:11 p.m. New York time is assigned a value of 14. All but one trade in our data set occurs between 7 a.m. and 5 p.m. New York time, with the exception being 2:14 a.m.

[17] We also test specifications including dummy variables for whether there is a break clause and whether a trade is brokered, but neither of these additional variables is statistically significant.

Table 3

Determinants of Absolute Inflation Swap Rate Differentials

	Dependent Variable: Inflation Swap Rate Differential					
	All New Trades					Greater than One Year
Independent Variables	(1)	(2)	(3)	(4)	(5)	(6)
Constant	2.81***	1.60***	1.90***	3.19***	2.87***	2.36***
	(0.48)	(0.28)	(0.26)	(0.66)	(0.95)	(0.80)
Tenor	-0.08*				-0.05	-0.01
	(0.04)				(0.05)	(0.03)
Trade size		0.15**			0.12	0.13**
		(0.07)			(0.08)	(0.06)
Customer trade			0.70*		0.35	0.96**
			(0.42)		(0.47)	(0.39)
Time of trade				-0.09*	-0.07	-0.09
				(0.05)	(0.07)	(0.06)
Adjusted R^2 (percent)	3.6	5.8	1.3	0.4	6.9	15.8
Number of observations	106	106	106	106	106	95

Source: Authors' calculations, based on data from Barclays, Bloomberg, and MarkitSERV.

Notes: The table reports results from regressions of the absolute inflation swap rate differential on tenor, trade size, whether a trade is a customer trade or not, and the time of the trade. The absolute rate differential is calculated as the absolute value of the difference between the transaction rate from MarkitSERV and the average quoted rate from Barclays and Bloomberg for the same tenor and day. The differential is measured in basis points, tenor is measured in years, trade size is measured in tens of millions of dollars (notional amount), and time of trade is measured in hours. The sample includes new trades only and excludes forward transactions. Coefficients are reported with heteroskedasticity-consistent (White) standard errors in parentheses.

*Statistically significant at the 10 percent level.

**Statistically significant at the 5 percent level.

***Statistically significant at the 1 percent level.

times, likely reflecting growth in the market between 2010 and 2012 and our data set's coverage of less than 100 percent of the market. Overall trading activity per day in April 2012 is estimated to be about $350 million.[18]

A second way in which we look at bid-ask spreads is with the MarkitSERV data. While these data do not contain direct information on bid-ask spreads, such spreads can be inferred from transaction data. In particular, if one knows who initiated a trade, then "realized" bid-ask spreads can be calculated as the difference between the price paid by initiating buyers and initiating sellers. While the MarkitSERV database does not contain information on who initiated a trade, we infer that trades involving customers are initiated by customers (thus, it is dealers making markets for customers and not the reverse).

Suppose, then, that a dealer stands ready to pay 2.00 percent fixed on a ten-year inflation swap and receive 2.03 percent on such a swap. If a customer initiates a transaction with the dealer in which it pays fixed, then it will pay 2.03 percent. If the customer initiates a transaction in which it receives fixed, then it will receive 2.00 percent. The difference in fixed rates between the customer's transactions reflects the dealer's bid-ask spread.

In practice, inflation swap customers rarely buy and sell at the same time. However, by comparing the average rates paid by customers with the average rates received by them, one can obtain a measure of customers' realized bid-ask spreads. Such spreads are often calculated for a particular product and day, because price differences across products and price changes over time add noise to such calculations.

To increase the precision of our estimate, we use the Barclays and Bloomberg prices as reference prices for a given tenor and day. That is, for a given tenor and day, we calculate the difference between the MarkitSERV transaction price and the average of the Barclays and Bloomberg quoted prices. We then generate statistics of these differences for instances in which the customer pays fixed and instances in which the

[18] The $350 million represents the (approximate) median of the market sizes as calculated from each dealer's estimates of trade frequency and trade size for individual tenors.

Table 4
Inflation Swap Dealer Survey Results

Panel A: Customer-Dealer Market

	Three-Year	Five-Year	Ten-Year	All Tenors
Bid-ask spread (basis points)	3	2	2	2.2
Trade size (millions of dollars)	50	50	25	37
Trades per day	1	1	2	6

Panel B: Interdealer Market

	Three-Year	Five-Year	Ten-Year	All Tenors
Bid-ask spread (basis points)	3	2.75	2	2.4
Trade size (millions of dollars)	30	25	25	34
Trades per day	1	2	1	5

Source: Authors' calculations, based on an informal survey of primary dealers.

Notes: The table reports the median responses to an informal survey of seven primary dealers on the liquidity of the zero-coupon inflation swap market in April 2012. For "All Tenors," weighted means are first calculated for each dealer before identifying the median across dealers.

customer receives fixed. As a benchmark, we generate similar statistics for interdealer transactions, for which we have no presumption as to the trade initiator.

As expected, we indeed find that the fixed rate tends to be higher when customers are paying fixed than when they are receiving fixed (Table 5). When a customer pays fixed, the MarkitSERV transaction price is 2.4 basis points higher, on average, than the average of the Barclays and Bloomberg quoted prices. When a customer receives fixed, the MarkitSERV price is 0.4 basis point lower, on average, than the average of the Barclays and Bloomberg prices. The difference—that is, the realized bid-ask spread—is estimated to be 2.8 basis points (2.8 = 2.4 - -0.4) and is statistically different from zero at the 1 percent level.[19] This realized bid-ask spread, calculated for customer-dealer trades, is consistent with the typical bid-ask spreads in the customer-dealer market as reported by dealers.[20]

[19] To assess statistical significance, we regress the price differential on dummy variables for interdealer trades, trades in which the customer pays fixed, and trades in which the customer receives fixed. We then test whether the customer trade coefficients are significantly different from one another, using the heteroskedasticity-consistent (White) covariance matrix. As a robustness test, we repeat this analysis using the previous day's Barclays/Bloomberg average price as the reference, and estimate the realized bid-ask spread to be a slightly larger 3.8 basis points.

Table 5
Inflation Swap Rate Differentials by Trade Type

	Interdealer Trade	Customer Pays Fixed	Customer Receives Fixed
Average	-0.3	2.4***	-0.4###
Standard deviation	2.9	2.8	2.2
Number of observations	77	19	10

Source: Authors'calculations, based on data from Barclays, Bloomberg, and MarkitSERV.

Notes: The table reports statistics for inflation swap rate differentials according to the direction and counterparties of a trade. The rate differential is calculated as the transaction rate from MarkitSERV minus the average quoted rate from Barclays and Bloomberg for the same tenor and day and is measured in basis points. The sample includes new trades only and excludes forward transactions. Statistical significance is determined from Wald tests using heteroskedasticity-consistent (White) standard errors.

*A mean for a group of customer transactions is statistically different from the mean for interdealer transactions at the 10 percent level.

**A mean for a group of customer transactions is statistically different from the mean for interdealer transactions at the 5 percent level.

***A mean for a group of customer transactions is statistically different from the mean for interdealer transactions at the 1 percent level.

#The means for the groups of customer transactions are statistically different from one another at the 10 percent level.

##The means for the groups of customer transactions are statistically different from one another at the 5 percent level.

###The means for the groups of customer transactions are statistically different from one another at the 1 percent level.

5. Conclusion

Our analysis of a novel transaction data set uncovers relatively few trades—just over two per day –in the U.S. zero-coupon inflation swap market. Trade sizes, however, are large, averaging almost $30 million. Sizes are generally larger for new trades, especially if they are bulk and allocated across subaccounts, and tend to decrease with contract tenor.

We also identify concentrations of activity—with 45 percent of trades at the ten-year tenor, and 36 percent of all trades (and 48 percent of new ones) for a notional amount of $25 million. Over half the trades (54 percent) are between G14 dealers, 39 percent are between G14 dealers and other market participants, and 7 percent are between other market participants. We identify just eighteen market participants during our study's sample period, made up of nine G14 dealers and nine other market participants.

[20] While dealers report that spreads vary by tenor, and they likely vary by other attributes of a trade, such as trade size, our small sample of customer-dealer trades limits our ability to examine how bid-ask spreads vary with contract terms.

Despite the low level of activity in this over-the-counter market, we find that transaction prices are quite close to widely available end-of-day quoted prices. The differential between transaction prices and end-of-day quoted prices tends to decrease with tenor and increase with trade size and for customer trades. By comparing trades for which customers pay fixed with trades for which they receive fixed, we are able to infer a realized bid-ask spread for customers of 3 basis points, which is consistent with the quoted bid-ask spreads reported by dealers.

In sum, the U.S. inflation swap market appears reasonably liquid and transparent despite the market's over-the-counter nature and modest activity. This likely reflects the fact that the market is part of a larger market for transferring inflation risk that includes TIPS and nominal Treasury securities. As a result, inflation swap positions can be hedged quickly and with low transaction costs using other instruments, and prices of these other instruments can be used to efficiently price inflation swaps, despite modest swap activity.

An earlier version of this article appeared as an appendix to "An Analysis of OTC Interest Rate Derivatives Transactions: Implications for Public Reporting," by Michael Fleming, John Jackson, Ada Li, Asani Sarkar, and Patricia Zobel, Federal Reserve Bank of New York Staff Reports*, no. 557, March 2012.*

Appendix: Additional Information on Our Measure of Inflation Swap Activity

We note in the "Data" section that our data set covers less than 100 percent of activity in the U.S. zero-coupon inflation swap market. Additional factors relevant to the activity covered by our data set and to the measurement of a trade are as follows:

- Our data set is limited to "price-forming" transactions—defined as trades representing new activity—and excludes "non-price-forming" transactions, such as those related to portfolio compression. Fleming et al. (2012) show that the number and volume of non-price-forming trades in the interest rate derivatives market exceed the number and volume of price-forming trades.
- Our data are aggregated to the execution level, and not examined at the allocated level, so that a trade executed by a money manager on behalf of five accounts is counted once. As noted in the "Data" section, 17 of our trades are allocated, with an average of 6.9 allocations per primary (or bulk) trade.
- There appear to be some "spread" trades in our data set, in which a dealer buys an inflation swap of one tenor and sells a swap of another tenor. Such spread trades appear in the MarkitSERV database as two separate transactions, even though they might be thought of as a single transaction.[21]
- It appears that most assigned trades are executed as part of larger transactions. On June 29, 2010, for example, five ten-year swaps of varying sizes—all with a June 4, 2010, start date—were traded from a customer to a dealer and submitted to MarkitSERV within a three-minute period. Overall, the thirty-five assigned trades in our data set occurred with just six unique combinations of counterparties, trade dates, and start dates.

[21] In the six instances of such apparent spread trades, the submission times for the two sides of the trade differ by only one to five minutes. Moreover, in all six instances, the trade size for the longer tenor is for a round amount (for example, $25 million) and the trade size for the shorter tenor is for a larger and nonround amount (for example, $42.25 million), suggesting that the shorter tenor side may be duration-matched to the longer tenor side.

References

Campbell, J. Y., R. Shiller, and L. Viceira. 2009. "Understanding Inflation-Indexed Bond Markets." Brookings Papers on Economic Activity 40, spring: 79-120.

Christensen, J. H. E., and J. M. Gillan. 2011. "Could the U.S. Treasury Benefit from Issuing More TIPS?" Federal Reserve Bank of San Francisco Working Paper no. 2011-16, June.

Fleckenstein, M., F. A. Longstaff, and H. Lustig. Forthcoming. "The TIPS-Treasury Bond Puzzle." Journal of Finance.

Fleming, M. J. 2003. "Measuring Treasury Market Liquidity." Federal Reserve Bank of New York Economic Policy Review 9, no. 3 (September): 83-108.

Fleming, M., J. Jackson, A. Li, A. Sarkar, and P. Zobel. 2012. "An Analysis of OTC Interest Rate Derivatives Transactions: Implications for Public Reporting." Federal Reserve Bank of New York Staff Reports, no. 557, March.

Fleming, M. J., and N. Krishnan. 2012. "The Microstructure of the TIPS Market." Federal Reserve Bank of New York Economic Policy Review 18, no. 1 (March): 27-45.

Haubrich, J. G., G. Pennacchi, and P. Ritchken. 2011. "Inflation Expectations, Real Rates, and Risk Premia: Evidence from Inflation Swaps." Federal Reserve Bank of Cleveland Working Paper no. 11-07, March.

Hinnerich, M. 2008. "Inflation-Indexed Swaps and Swaptions." Journal of Banking and Finance 32, no. 11 (November): 2293-2306.

Jarrow, R., and Y. Yildirim. 2003. "Pricing Treasury Inflation-Protected Securities and Related Derivatives Using an HJM Model." Journal of Financial and Quantitative Analysis 38, no. 2 (June): 409-30.

Krishnamurthy, A., and A. Vissing-Jorgensen. 2011. "The Effects of Quantitative Easing on Interest Rates: Channels and Implications for Policy." Brookings Papers on Economic Activity 43, fall: 215-87.

Lucca, D., and E. Schaumburg. 2011. "What to Make of Market Measures of Inflation Expectations?" Federal Reserve Bank of New York Liberty Street Economics blog post, August 15.

Mercurio, F. 2005. "Pricing Inflation-Indexed Derivatives." Quantitative Finance 5, no. 3: 289-302.

Rodrigues, A. P., M. Steinberg, and L. Madar. 2009. "The Impact of News on the Term Structure of Breakeven Inflation." Unpublished paper, Federal Reserve Bank of New York, September.