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An Analysis of OTC Interest Rate Derivatives Transactions: Implications for Public Reporting

Appendix: Trading Activity and Price Transparency in the Inflation Swap Market*

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This appendix was written by Michael Fleming and John Sporn. It presents preliminary findings and is being distributed to economists and other interested readers solely to stimulate discussion and elicit comments. The views expressed are those of the authors and are not necessarily reflective of views at the Federal Reserve Bank of New York or the Federal Reserve System. Any errors or omissions are the responsibility of the authors.

An Analysis of OTC Interest Rate Derivatives Transactions: Implications for Public Reporting
Appendix: Trading Activity and Price Transparency in the Inflation Swap Market*
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Abstract

This appendix examines trading activity and price transparency in the U.S. inflation swap market using a novel transaction data set. The data suggest that relatively few trades occur in the market, with our reasonably comprehensive data set of zero-coupon swaps from 2010 containing just over two trades per day, on average. We identify concentrations of activity in certain tenors (ten years) and trade sizes ($25 million), and among certain market participants. Despite the low level of activity in this over-the-counter market, we find that transaction prices are typically quite close to widely available end-of-day quoted prices, and that realized bid-ask spreads are modest. We also identify various attributes that help explain trade sizes and price deviations

Key words: inflation swap, trading activity, liquidity, price transparency, inflation expectations

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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% on a $25 million notional amount for 10 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 noted that the inflation rate inferred from inflation swaps tends to be higher than that inferred from Treasury inflation-protected securities (TIPS), with the spread exceeding 100 basis points during the crisis.[1] Fleckenstein, Longstaff, and Lustig (2012) attribute this differential to the mispricing of TIPS.[2] In contrast, Christensen and Gillen (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

[1] Other studies have examined how inflation swaps are priced or 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.

[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 of sellers of inflation. Lucca and Schaumburg (2011) also note these hedging costs, as well as TIPS liquidity premia, to explain the differences in breakeven inflation.

regulatory efforts underway 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 to promulgate rules that provide for the public availability of swap transaction and pricing data in real-time. To date, the lack of transactions 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 group of supervisors comprised of regulators with supervisory authority 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 transactions data to analyze the implications of enhanced transparency for financial stability. Fleming, Jackson, Li, Sarkar, and Zobel (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 appendix uses the same interest rate derivatives dataset to examine trading activity and price transparency in the U.S. inflation swap market. Specifically, we examine all electronically matched zero-coupon inflation swap trades involving a G14 dealer for a three-month period in 2010.[4] 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 who are considering public reporting and other regulatory initiatives for the derivatives markets and for market

[4] 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.

participants and observers more generally who are 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 dataset 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.[5]

We identify concentrations of activity in certain tenors, with 45% of activity at the 10-year tenor, 14% at 5 years, and 11% at 3 years. Trade sizes tend to concentrate as well, with 36% of all trades (and 48% of "new" trades) for a notional amount of \$25 million. Trade sizes are generally larger for new trades and trades that are allocated across sub-accounts and tend to decrease with tenor. Over half (54%) of trades are between G14 dealers, 39% are between G14 dealers and other market participants, and 7% are between other market participants. The activity in our dataset 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 controlling 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 three 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

[5] TIPS volume comes from the Federal Reserve's FR 2004 series and covers 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 double-counted.

inflation, we are able to infer a realized bid-ask spread for customers of three basis points, which essentially matches the quoted bid-ask spreads reported by dealers.

This appendix 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. Section 4 presents our empirical results. Section 5 concludes.

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 non-seasonally adjusted Consumer Price Index for urban consumers, the same gauge as is 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.

Figure A1 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 equal to the contract's notional amount times realized inflation over the term of the contract.[6] The fixed payer, in turn makes a payment 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.

[6] To be precise, 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 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.

Inflation swaps trade in a dealer-based over-the-counter market. The predominant market makers are the G14 dealers. The G14 dealers 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 email. Customers and dealers communicate directly via email 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 interest 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 a 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, indicates 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 A1). 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 useful to note that 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 dataset 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.[7] The data comes from MarkitSERV, the predominant trade matching and post-trade processing platform for interest rate derivatives. The interest rate derivatives data was 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

[7] Because the dataset 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.

is a G14 dealer. Other firms may be customers of G14 dealers, or other dealers not members of the G14. We refer to these other firms as "customers" for brevity.

Our dataset 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% of G14 dealer IRD transactions (Fleming, et al. (2012)). Second, it excludes transactions not involving a G14 dealer, which account for about 11% of IRD notional activity in MarkitSERV (Fleming, et al. (2012)). Additional information pertinent to the activity covered by our database is discussed in the addendum.

Our dataset 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.[8] Daily notional trading volume is estimated to average $65 million. Three-quarters (108/144) of the transactions are new trades, 24% (35/144) are assignments of existing transactions, and 1% (1/144) are cancellations. One new transaction has a forward start date, for which the accrual period starts 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 A2). The 10-year tenor alone accounts for 45% (65/144) of activity, followed by tenors of 5 years (14%; 20/144), 3 years (11%; 16/144) 1 year (8%; 11/144) and 15 years (7%; 10/144).[9] There are some differences in tenor by transaction type, with every assigned and cancelled trade having an original tenor of 5 or 10 years. In every case, the assigned and cancelled trades

[8] While not the focus of our study, our MarkitSERV data also contains information on 432 euro-denominated inflation swap transactions, 1903 pound sterling-denominated transactions, and 15 Australian dollar-denominated transactions. MarkitSERV only supports zero-coupon inflation swaps, so all inflation swaps in the dataset are of this type.

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

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% (78/144) of our trades are between G14 dealers, 39% (56/144) are between G14 dealers and customers, and 7% (10/144) are between customers. Of the new trades between G14 dealers and customers, the G14 dealer receives fixed 63% (19/30) of the time and pays fixed 37% (11/30) of the time.[10] New trades in which dealers receive fixed are larger, so that dealers receive fixed for 81% of new contract volume. That is, dealers are largely paying inflation and receiving fixed in their interactions with customers.

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

Twenty-six (18%) 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 parties to mitigate counterparty credit risk associated with mark-to-market balances on long-dated swaps. While 57% (82/144) of all trades have a tenor of 10 years or more, 85% (22/26) of trades with break clauses have a tenor of 10 years or more. G14 dealer trades with customers are more likely to have a break clause (15 of 56 trades) than interdealer trades (11 of 78).

Seventeen (12%) 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

[10] All 35 assignments in our database involve a customer stepping out of their position. For the 25 instances in which the assignment is to a G14 dealer, we are able to infer the dealer's side in 14 cases. Of those 14 assignments, the G14 dealer stepped in to receive fixed 13 times and to pay fixed one time.

and all involve customers. On average, there are 6.9 allocations related to a primary (or bulk) trade.

Lastly, 55% (79/144) of our trades are brokered (accounting for 60% of notional volume) and 45% (65/144) are executed directly between counterparties. All 36 assigned and cancelled trades are executed directly as are 29 of the 30 new customer-dealer trades. All 78 new interdealer trades are brokered along with one of the 30 new customer-dealer trades.

We compare our trading activity figures to figures from BGC Partners as a check on the representativeness of our dataset. 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% of all brokered activity (44% = $39 million/$89 million).

One other dataset 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.[11] Our primary interest is in bid-ask spread information, since we lack direct information on bid-ask spreads in our transactions dataset, but we are also interested in the trade size and trade frequency information as a further check on the representativeness of our MarkitSERV dataset.

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

4. Results

a. 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% (52/144) of all trades. An additional 8% (12/144) of observations have a trade size of $50 million, and 3% (4/144) each have trade sizes of $15 million and $100 million. The remaining 50% of trades (72/144) occur in 58 different sizes.

One factor in explaining trade size is tenor (Chart A3). Trade size tends to decline with tenor, although the largest distinction seems to be between 1-year tenors and longer tenors, with only a weak negative relationship past the 1-year point. In other securities and IRD markets, in contrast, the negative relationship between tenor and trade size appears stronger across the range of tenors and not so dependent on a single point (e.g., 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 in explaining trade size is trade status. Assigned and cancelled 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 cancelled trades is just $6.1 million, versus $37.3 million for new trades. The 36 assigned and cancelled trades occur across 30 different sizes, with none at $25 million or $50 million. In contrast, 48% (52/108) of new trades have a size of $25 million and 11% (12/108) have a size of $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 in explaining trade size is whether a trade is allocated or not. Allocated 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 dataset greater than $100 million in size 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 A1). 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 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 controlling 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 dataset variables on trade size.[12]

[12] 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).

b. Price Transparency

Our price transparency analysis examines the relationships among the transaction prices in our dataset as well as between the prices in our dataset 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.[13]

Visual evidence suggests that the trades in our dataset take place at prices close to one another and close to publicly available quoted prices, controlling for tenor and trading day (Charts A4A, A4B, and A4C). 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 pm 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.

Looking at the data more formally confirms the close relationships among inflation swap prices from the various sources (Table A2). The average differences between MarkitSERV and Barclays, MarkitSERV and Bloomberg, and MarkitSERV and the average of Barclays and Bloomberg are all within one basis point after controlling for tenor and

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

trading day, with standard deviations ranging from 3 to 5 basis points.[14] The standard deviation is lowest when comparing MarkitSERV to the Barclays/Bloomberg average, suggesting that the average better proxies for transaction prices than either source alone. Also of note is that the largest differentials among the three sources are observed between Barclays and Bloomberg. The largest differences across sources seem to come from the 1-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:

- *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 only valid 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.
- *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.[15]

Our regression analysis indicates significant univariate relationships between the price deviations and our various variables (Table A3). A one-year increase in tenor is associated

[14] The standard deviations are only slightly larger (ranging from 4 to 5.5 basis points) when comparing MarkitSERV transaction prices to Barclays and Bloomberg quoted prices from the preceding trading day.
[15] Time of trade is measured by the hour of the trading day, based on New York time and a 24-hour clock, so that a trade that occurs at 2:11 pm New York time is assigned a value of 14. All but one trade in our dataset occurs between 7 am and 5 pm New York time, with the exception occurring at 2:14 am.

with a decrease in the price differential of 0.08 basis points. Each $10 million increase in trade size is associated with an increase in the differential of 0.15 basis points. Customer trades tend to have a differential 0.70 basis points larger than interdealer trades, and each hour closer to the end of the trading day is associated with a reduction in the differential of 0.09 basis points.

A multivariate regression analysis on the full sample of new trades shows that the explanatory variables are independently insignificant when controlling for the other variables. However, given the evidence that price deviations are especially large for contracts with a 1-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 1-year trades at explaining the tenor effect. Moreover, trade size and customer trade are here 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 controlling for other factors. The time of the trade remains insignificant in the last regression.[16]

c. 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

[16] 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.

receive fixed, but not both) can expect to pay half of the spread. We assess bid-ask spreads in a couple different ways.

First, we look at the results of our informal dealer survey. As shown in Table A4, 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 to $50 million in the dealer-customer market and $25 to $35 million in the interdealer market, consistent with the $29.5 million average we find in our MarkitSERV data. Estimated daily trading frequency of six in the customer-dealer market plus five in the interdealer market exceeds our overall average of 2.2 by five times, likely reflecting the growth in the market between 2010 and 2012 and by our dataset covering less than 100% of the market. Overall trading activity per day in April 2012 is estimated to be about $350 million.[17]

A second way we look at bid-ask spreads is with the MarkitSERV data. While our MarkitSERV data does not contain direct information on bid-ask spreads, such spreads can be inferred from transactions 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 (so that it is dealers making markets to customers and not the reverse).

Suppose, then, that a dealer stands ready to pay 2.00% fixed on a 10-year inflation swap and receive 2.03% on such a swap. If a customer initiates a transaction with the dealer in which it pays fixed, then it will pay 2.03%. If the customer initiates a transaction in which

[17] 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.

it receives fixed, then it will receive 2.00%. The difference in the 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 looking at the average rates paid by customers and comparing to the average rates received by customers, 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.

In our case, 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 customer receives fixed. As a benchmark, we generate similar statistics for interdealer transactions, for which we have no presumption as to who initiates the trade.

As expected, we do indeed find that the fixed rate tends to be higher when customers are paying fixed than when they are receiving fixed (Table A5). 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 points 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% level.[18] This

[18] To assess statistical significance, we regress the price differential on dummy variables for interdealer trades, trades where the customer pays fixed, and trades where 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

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.[19]

5. Conclusion

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

We identify concentrations of activity, with 45% of trades at the 10-year tenor, and 36% of all trades (and 48% of new trades) for a notional amount of $25 million. Over half (54%) of trades are between G14 dealers, 39% are between G14 dealers and other market participants, and 7% are between other market participants. We identify just 18 market participants during this appendix's sample period, made up of 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. 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 to trades for which customers receive fixed, we are able to infer a

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.

[19] 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.

realized bid-ask spread for customers of three 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 transactions costs using other instruments, and prices of these other instruments can be used to efficiently price inflation swaps despite modest swap activity.

Addendum – Additional Information on Our Measure of Inflation Swap Activity

We note in the data section that our database covers less than 100% of activity in the U.S. zero-coupon inflation swap market. Additional factors relevant to the activity covered by our dataset and how a trade is measured are as follows:

- Our dataset 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, rather than at the allocated level, so that a trade executed by a money manager on behalf of five accounts gets 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 database, 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.[20]

- It appears that most assigned trades are executed as a part of larger transactions. On June 29, 2010, for example, five 10-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 35 assigned trades in our database occurred with just six unique combinations of counterparties, trade dates, and start dates.

[20] 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 (e.g., $25 million) and the trade size for the shorter tenor is for a larger and non-round amount (e.g., $42.25 million), suggesting that the shorter tenor side may be duration matched to the longer tenor side.

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Table A1: Determinants of Inflation Swap Trade Sizes

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

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 hetroskedasticity consistent (White) standard errors in parentheses. One-, two-, and three-asterisks indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively.
Source: Authors' calculations, based on data from MarkitSERV.

Table A2: 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]

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 12-year tenor trade in our sample. Differences are in basis points.
Source: Authors' calculations, based on data from Barclays, Bloomberg, and MarkitSERV.

Table A3: Determinants of Absolute Inflation Swap Rate Differentials

	Dependent Variable: Inflation Swap Rate Differential					
Independent	All New Trades					> 1 yr
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	3.6%	5.8%	1.3%	0.4%	6.9%	15.8%
Number of observations	106	106	106	106	106	95

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 hetroskedasticity consistent (White) standard errors in parentheses. One-, two-, and three- asterisks indicate statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively.
Source: Authors' calculations, based on data from Barclays, Bloomberg, and MarkitSERV.

Table A4: Inflation Swap Dealer Survey Results

Panel A: Customer-Dealer Market				
	3-Year	5-Year	10-Year	All Tenors
Bid-ask spread	3 basis points	2 basis points	2 basis points	2.2 basis points
Trade size	$50 million	$50 million	$25 million	$37 million
Trades per day	1	1	2	6

Panel B: Interdealer Market				
	3-Year	5-Year	10-Year	All Tenors
Bid-ask spread	3 basis points	2.75 basis points	2 basis points	2.4 basis points
Trade size	$30 million	$25 million	$25 million	$34 million
Trades per day	1	2	1	5

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 of 2012. For "all tenors," weighted means are first calculated for each dealer before identifying the median across dealers.
Source: Authors' calculations, based on an informal survey of primary dealers.

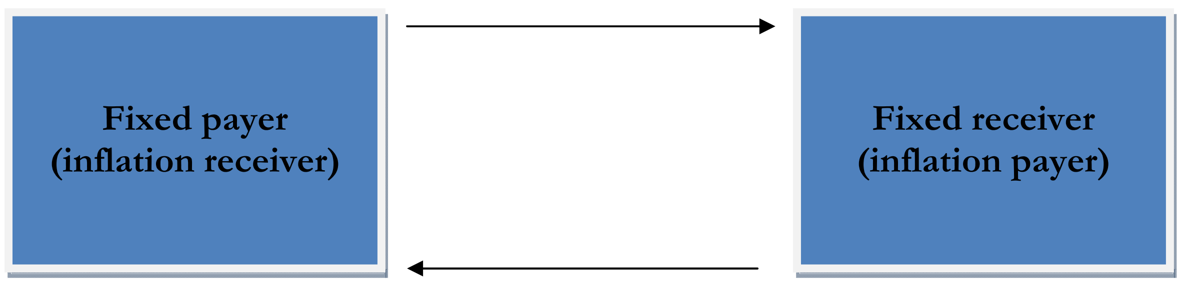
Table A5: Inflation Swap Rate Differentials by Trade Type

	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

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. One-, two-, and three- asterisks indicate that a mean for a group of customer transactions is statistically different from the mean for the interdealer transactions at the 10 percent, 5 percent, and 1 percent levels, respectively. One-, two-, and three- pound signs indicate that the means for the groups of customer transactions are statistically different from one another at the 10 percent, 5 percent, and 1 percent levels, respectively. Statistical significance is determined from Wald tests using heteroskedasticity consistent (White) standard errors.
Source: Authors' calculations, based on data from Barclays, Bloomberg, and MarkitSERV.

Figure A1: Zero-Coupon Inflation Swap Cash Flows (at Maturity)

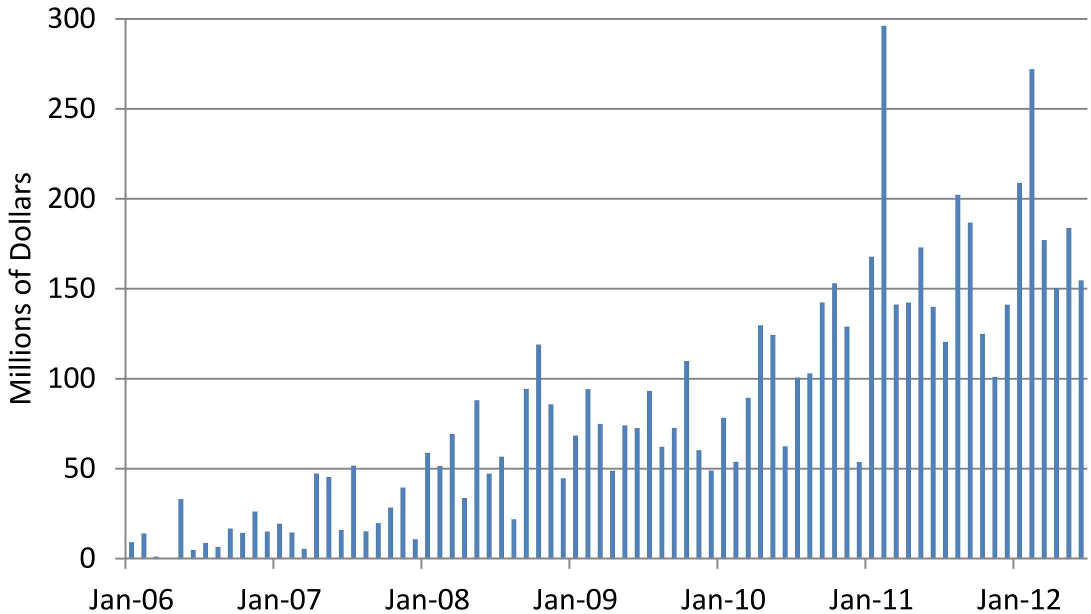
$$Notional \times [(1 + swap\ rate)^{tenor} - 1]$$



$$Notional \times \left({inflation\ index\ at\ maturity}/{inflation\ index\ at\ start} - 1 \right)$$

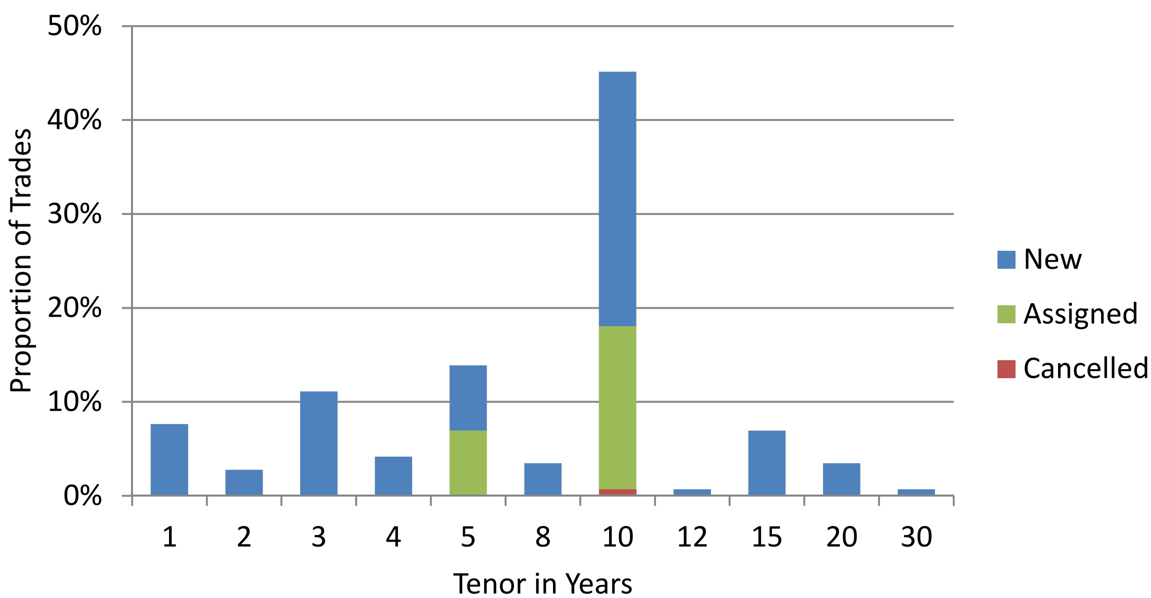
Note: The figure shows the cash flows exchanged at maturity by swap counterparties. No cash flows are exchanged at the initiation of a swap.

Chart A1: Daily Inflation Swap Activity over Time



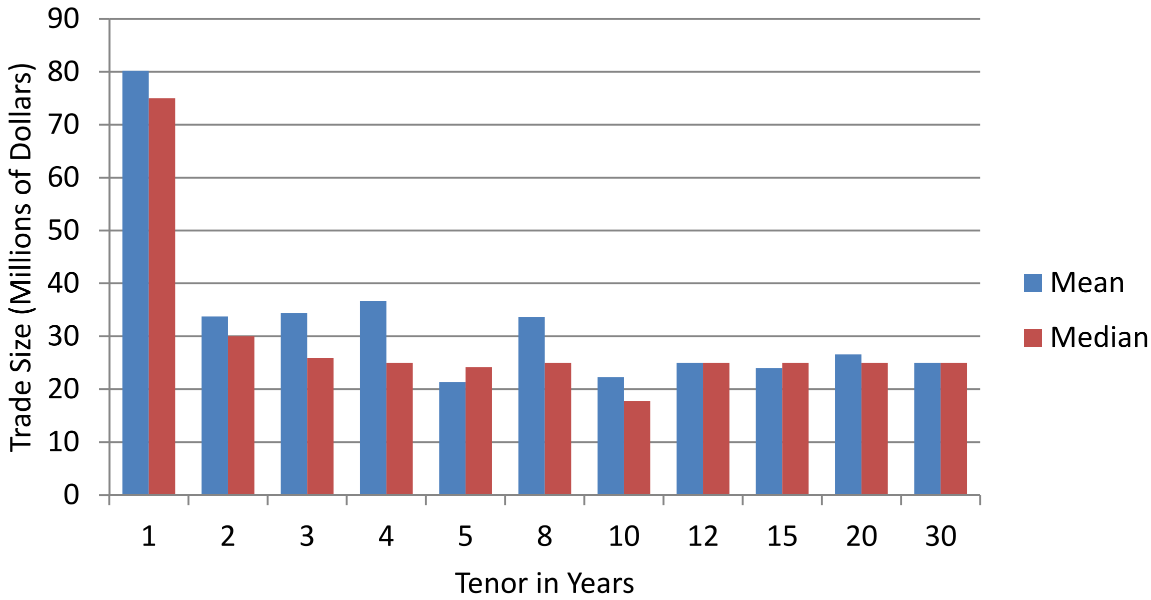
Note: The chart plots average daily brokered inflation swap activity by month.
Source: Authors' calculations, based on data from BGC Partners.

Chart A2: Inflation Swap Trading Frequency by Tenor



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

Chart A3: Inflation Swap Trade Sizes by Tenor



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

Chart A4A: 3-Year Inflation Swap Rates

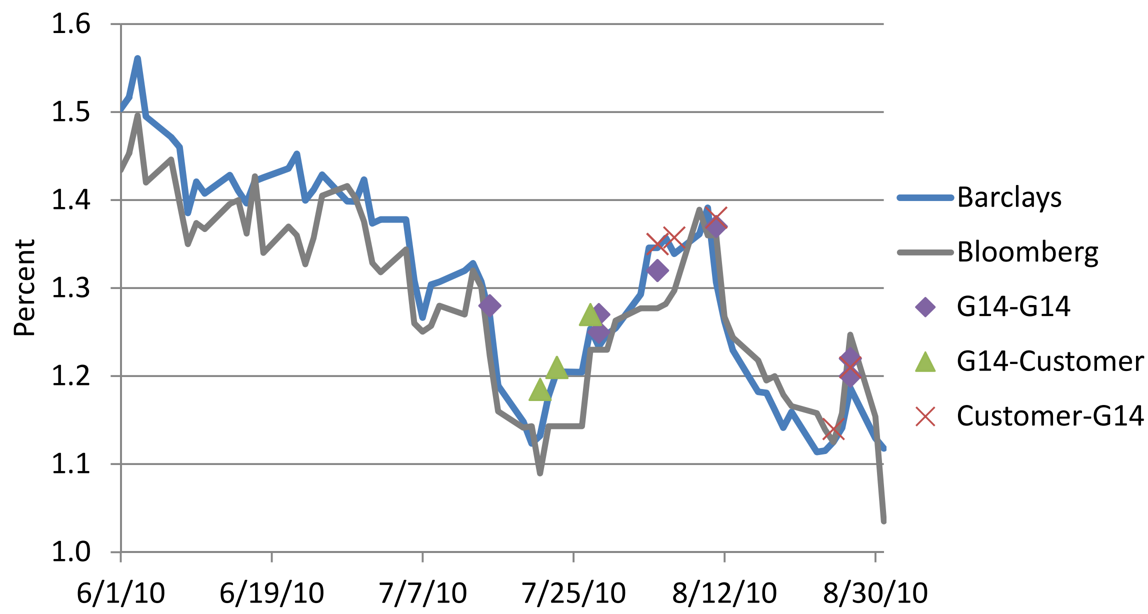


Chart A4B: 5-Year Inflation Swap Rates

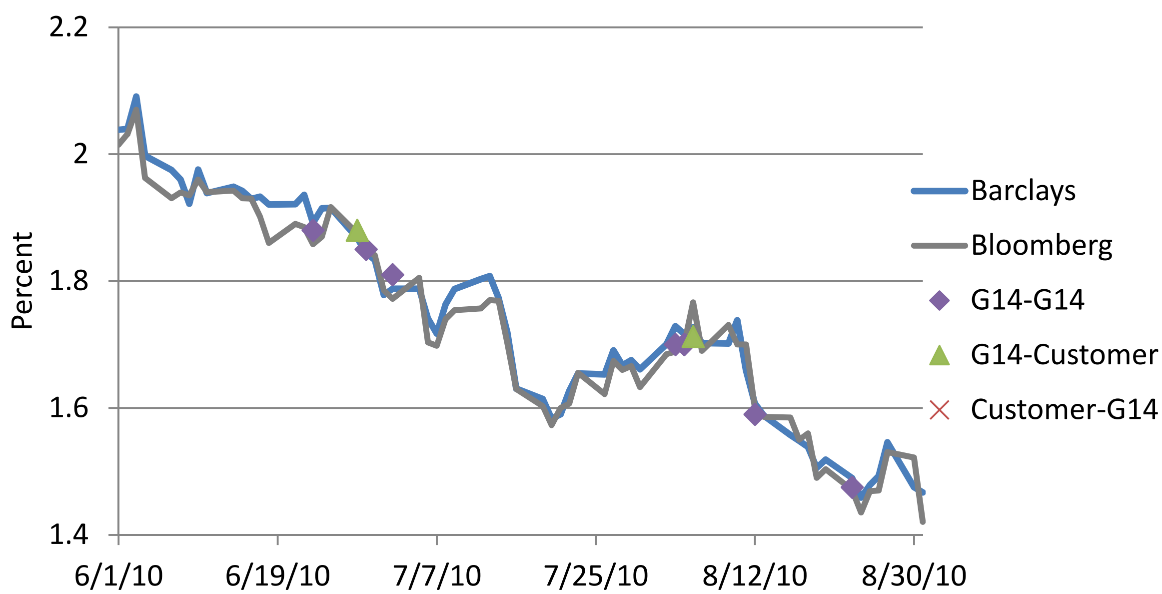
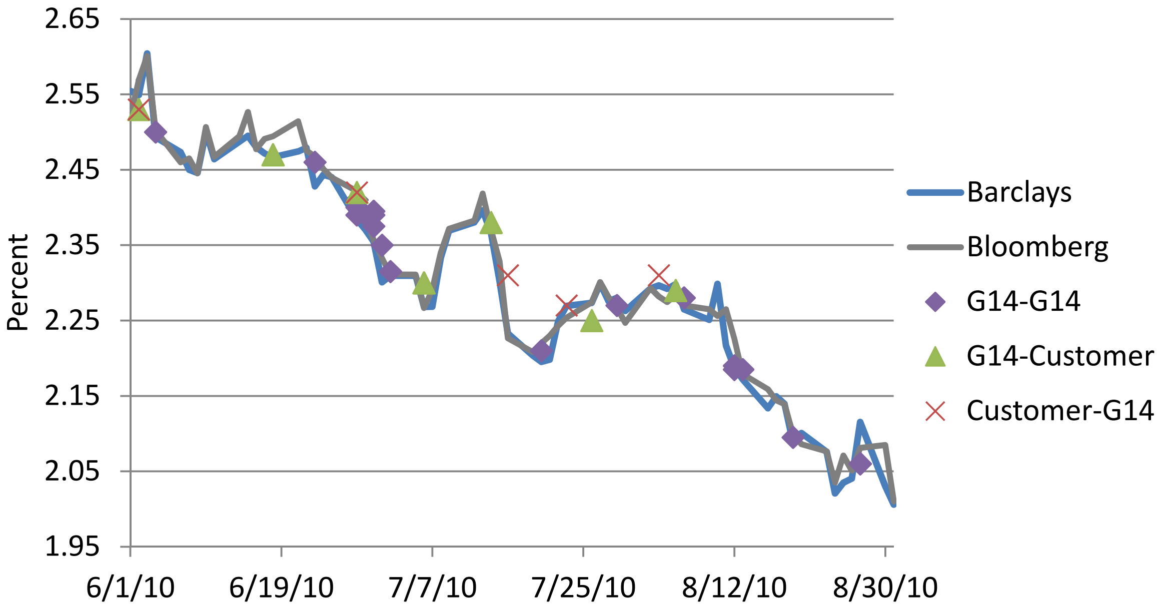


Chart A4C: 10-Year Inflation Swap Rates



Notes: The charts plot transaction prices from MarkitSERV for select tenors, denoted by whether the trades are between G14 dealers (G14-G14), between a G14 dealer and a customer where the G14 dealer pays fixed (G14-Customer) or between a G14 dealer and a customer where the customer pays fixed (Customer-G14). End-of-day midquotes from Barclays and Bloomberg are also plotted for MarkitSERV transaction days.
Source: Authors' calculations, based on data from Barclays, Bloomberg, and MarkitSERV.