U.S. Treasury Auction Yields Before and During Quantitative Easing: Market Factors vs. Auction-Specific Factors

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U.S. Treasury Auction Yields Before and During Quantitative Easing: Market Factors vs. Auction-Specific Factors

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Abstract

We construct a dataset for every U.S. Treasury auction from 2003 to 2012. We find that market factors known before the auction -- FedFunds rate, S&P, VIX -- are all significant for the auction high-yield, but the relationships differ before vs. during QE and between Bond and Bills auctions. Auction-specific innovations matter for the auction high-yield. Bills auctions have a forecastable component based on information from the previous auction of that maturity. Bidder types may differ systematically. Indirect bidders in the Bond auctions may bid relatively 'low' compared to the average bid and Primary Dealers may bid 'high'. These relationships differ before vs. during QE. These results suggest that quantitative easing implemented in the secondary market has affected the auction market for U.S. Treasury securities.

JEL: E43,E58, F34,F49

Key words: Federal Reserve, quantitative easing, foreign official, Dutch auction, US Treasury securities

I. Introduction

The secondary market for U.S. Treasury securities is large, global, and actively traded. Some $11 trillion of U.S. debt was outstanding in 2012, of which foreign investors held $5.2 trillion. Cross-border trading in long-term Treasury securities peaked at nearly $5 trillion (monthly rate) in late 2011. Since 2009, the Federal Reserve has also been an important actor in the secondary market for US Treasury securities, accounting for a greatest share of net purchases in 2011, and holding $1.7 trillion at year-end 2012. [1] In comparison, the auction market is small.[2]

Using our dataset on every U.S. Treasury auction from May 2003 to year-end 2012, we investigate factors underpinning the high yield at the auctions. Are auction high-yields driven mostly by prevailing market conditions known in advance of the auction? Is the auction yield for a specific instrument best predicted by the previous-day's market-yield for a similar-maturity instrument, as the efficient market hypothesis would suggest? Do day-of-auction specific factors, such as bid-cover ratio and type of bidder (such as foreign bidders) have any significant effect on the auction high-yield? Finally, does the auction market behave differently before versus after the Fed began its extraordinary monetary policy of intervention into the secondary-market for long-term U.S. Treasury securities and forward guidance on the short-term policy rate?

We find that market structural factors known the day before the auction, such as the fed-funds rate, the value of alternative investments (S&P), and market volatility (VIX) are all significant for the auction high-yield, and that the relationships are different before and during QE. Information embodied in the previous auction of a specific maturity is correlated with the auction high-yield for Bills, implying that the Bills auctions have a forecastable component. Auction day innovations, not known to any bidder, such as bid-cover ratio is generally significant with higher bid-cover negatively correlated with the auction high-yield, and Indirect Bidders apparently submitted 'low' bids in Bond auctions in the QE-period. On balance, implementing the policy of quantitative easing in the secondary market and through forward guidance have affected the auction market for U.S. Treasury securities.

We proceed as follows. Section II reviews recent literature on determinants of yields on US Treasury securities in secondary markets, and the much more limited literature on U.S. Treasury

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[1] During 2012, the Federal Reserve implemented the Extended Maturity Program, in which it sold shorter-term maturities Treasuries (0 to 3 years) for longer-term maturity Treasuries (6 to 30 year) while keeping the total dollar value the same. At the end of 2012, the Federal Reserve initiated so-called QE3, by resuming the purchase of long-term US Treasuries from the market at the pace of $45 billion per month.

[2] Marketable US debt held by the public, (US Treasury, *Monthly Statement of the Public Debt of the United States, December 31, 2012*, table 1). Nominal GDP, revised July 31, 2012, Bureau of Economic Analysis, *National Income and Product Accounts,* table 1. Figures for foreign holdings (table 1) and foreign official holdings (tables 10, 11) from U.S. Treasury, *Foreign Portfolio Holdings of U.S. Securities June 2012*, April 30, 2013. Federal Reserve holdings, Table H.4.1.

auctions. Section III describes the U.S. Treasury auction process and presents our auction dataset. Section IV reports on the relationships between the auction high-yields and both market and auction-specific factors before and after QE began.

II. Literature Context

This paper contributes to the literature on U.S. Treasury market in three ways. First, it fits into the literature on whether Federal Reserve QE-purchases in the secondary market affects U.S. Treasury yields, but we examine the auction high-yield before vs. after the onset of Federal Reserve intervention into the secondary market. Second, it fits into the literature on foreign demand for U.S. assets and interest rates, but we use highly disaggregated auction data and Indirect bidders as a proxy for foreign demand, rather than secondary-market aggregates and cross-border net flows. Third, it contributes to the literature on U.S. Treasury auctions, particularly considering what the bidders know before the auction, as well as auction-specific innovations on auction day.

Do Federal Reserve asset purchase programs affect interest rate?

This literature yields a systematic conclusion that the Federal Reserve asset purchase programs have influenced interest rates in the secondary market. Doh (2004), Gagnon et al (2010), and Neely (2010) using aggregate data, suggest that these various programs generally did reduce interest rates. However, Stroebel and Taylor (2009) conclude that the purchase of mortgage-backed securities, in particular, did not have much impact on interest rates. In the most detailed examination, D'Amica and King (2010) use CUSIP data to find that the Federal Reserve's purchase of U.S. Treasury securities reduced interest rates on the instruments (individual CUSIPs) that were purchased. Similar to D'Amica and King, we used a dataset with individual securities, but we consider the auction high-yield, not the secondary market yield.

Does foreign demand for U.S. assets, including U.S. Treasuries, affect interest rates?

The literature often reaches different conclusions as to the importance of foreign demand for U.S. asset for U.S. interest rates. None of this literature uses data on individual securities. Warnock & Warnock (2005), using aggregate data and the 10-year U.S. Treasury interest rate, conclude that, absent a year of foreign capital inflows, the yield on 10-year Treasuries would have been 150 basis points higher. On the other hand, Rudebusch et al. (2006), also using aggregate data in an attempt to explain the conundrum of low long-term U.S. interest rates, find that purchases of long-term Treasuries by foreign central banks between 2004-2005 had little explanatory power.[3] Bernanke et. al. (2011) find that international capital flows played an important role in lowering Treasury yields and returns on other U.S. assets, namely mortgages, in the years leading up to the 2008 financial crisis. Beltran et. al. (2011) model foreign private and

[3] Warnock and Warnock assume that foreign official inflows are exogenous, an assumption that Beltran et al reject. Rudebusch et al use trending data, which, upon examination by Beltran et al is shown to yield spurious correlations.

official purchases as endogenous, and examine the risk premium on Treasury securities as the metric of impact of foreign demand, an approach first considered by Sierra (2010), but find no impact of foreign demand. Unlike the aggregate data and second market interest rates as used in these papers, we use auction-specific data, and consider the role for foreign demand at the auction using the Indirect bidder as a proxy for the foreign bidder.

What determines U.S. Treasury auction high-yields?

Research in various contexts has examined the relationship between matched maturity instruments of different vintages. This on-the-run/off-the-run literature is well reviewed by Pasquariello and Vega (2009), and concludes that bid-ask daily differentials of on-the-run and off-the-run instruments are narrowest immediately following an auction of the matched maturity instrument. Other researchers examine whether these differentials vary during times of financial turbulence. For example, research by Furfine and Remolona (2002), on the time around the Russian debt crisis in 1998, found that although the trading activity in already-issued securities varied around auction days, prices adjusted immediately between the newly on-the-run and the newly off-the-run security.

Few papers address the relationship between the auction high-yield and the information set of previously issued securities of the same maturity. Jegadeesh (1993) found a systematic 4 basis point difference between the auction yield and the maturity-matched instrument in the secondary market. Similarly, Hou, Fan, and Zhang (2011) show that, in a several day window prior to and after an auction, the yield of the matched-maturity security is some 2 to 6 basic points below the auction yield, narrowing to zero on the auction day. These authors do not examine the time-series properties of this differential, nor whether it has explanatory power for future auctions of a similar maturity instrument, which we do examine.

II. Overview of U.S. Treasury Auction Process, Methodology, and Auction Dataset

Our method is grounded in models of imperfect asset substitution, portfolio balance, and preferred habitat. These models allow for quantities to impact price—that is, actors need not be atomistic in the marketplace and need not have identical preferences for asset types. The preferred habitat model is the foundation of D'Amico and King's work—their focus is on the shock reduction in supply of U.S. Treasury securities in the secondary market associated with Federal Reserve purchase. In our model of the US Treasury auctions, bidders of different types represent shock increases in demand for UST. Given that the supply of UST offered at auction is known to the bidders, but who will bid and the characteristics (amount, yield) of their bids is not, we conclude that the demand side prices the high-yield at the auction.

For our data, we construct a unique panel dataset of various metrics of every U.S. Treasury auction from May 2003 until year-end 2012. Data include the maturity of the security being sold at auction, the auction high-yield, the bid-cover ratio, the amount awarded to the three bidder

types (Primary Dealers, Direct bidders, Indirect bidders).[4] We also collected data on the secondary-market yields of comparable securities (matched by maturity) for the day before the auction. Auction data were obtained from the Bloomberg Profession Service while all secondary market yields were obtained from the Federal Reserve's H.15 database.[5]

Why should bidder amount and bidder type be relevant? The auction process for U.S. Treasury securities follows a formal and rigid structure. Bidders know in advance the maturity, type, and amount of Treasury security to be sold at the auction, which is undertaken using a uniform price auction (sometimes termed a modified Dutch auction). Bids are placed according to the minimum yield the bidder is willing to accept for the quantity of securities in the bid. To determine the auction high-yield for the security, bid amounts with their respective yields are organized and accepted by increasing yield until the offering amount is reached.[6]

Bidders are classified into three types: primary dealers, direct bidders, and indirect bidders. Primary Dealers trade directly with the Federal Reserve and act as market makers for Treasury securities and must bid when Treasury securities are auctioned.[7] Direct bidders have a direct trading relationship with the U.S. Treasury and are bidding for 'their own house accounts', but they are not required to bid at the auction. Indirect bidders are 'customers placing competitive bids through a direct submitter, including Foreign and International Monetary Authorities placing bids through the Federal Reserve Bank of New York.' Metrics associated with Indirect bidders' demand for Treasuries are often used to gauge the willingness of foreign and official entities to buy U.S. Treasury securities. [8]

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[4] An alternative data set presents auction allocations by different investor types. But, those data are available after the auction only with a lag, whereas the bid-cover, and bidder types and allocations are available immediately following the auctions. These immediately available data are used by financial markets to evaluate strength of demand at the auction for US Treasury securities.

[5] The H.15 data are reported as 'market yield, constant maturity, quoted on investment basis'.

[6] For more details of US Treasury auctions, such as purchases by System Open Market Account, TreasuryDirect, and non-competitive bids see Mann and Klachkin, "U.S. Treasury Auction Yields Before and During Quantitative Easing: Market Factors vs. Auction-Specific Factors," (2013) Brandeis Economics Department, Working Paper.

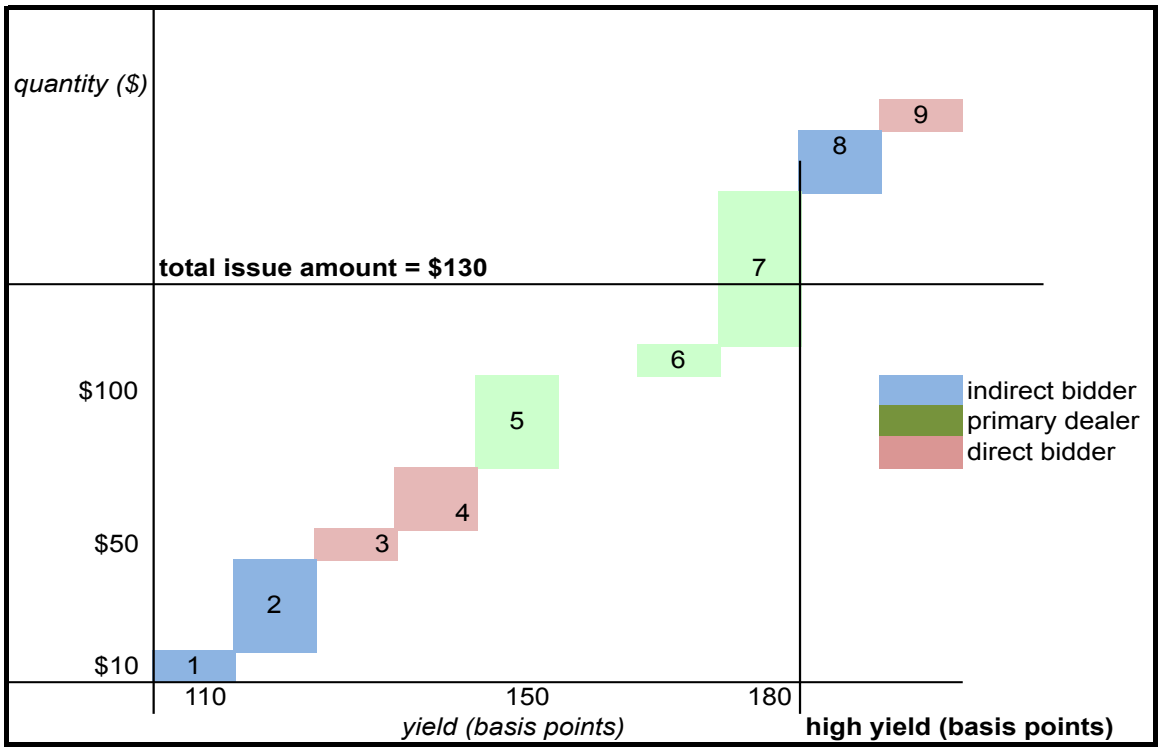
[7] The specific institutions that are direct bidders can change over time. The current list can be found at: http://www.newyorkfed.org/markets/pridealers_current.html accessed May 25, 2012.

[8] Although foreign official entities can place bids with Primary Dealers, research by Michael Fleming at the Federal Reserve Bank of New York shows that the Indirect bidder has been a valid proxy for foreign and official bidders http://www.newyorkfed.org/research/current_issues/ci13-1.pdf. As of June 2011, China's official purchasing representative has unique and direct access to the auction process and may, therefore, no longer be classified in the 'indirect' bidder class. Also, China has, in the past, divided up its bids to various primary dealer to bid on its behalf so as to mask the specific magnitude of their bids. Rule changes in 2009 altered this behavior. Finally, during 2012, the mapping between indirect and foreign bidders appeared to weaken. Based on investor-allocation data (which is made public with a delay from the auction date), the foreign share of investors has fallen where as the hedge fund share of investors has risen. Both could be classified as indirect bidders.

Because the auction process and metrics are an important foundation for exogeneity of some of our variables in the empirical estimation, it is worthwhile discussing a stylized example.[9] The first important metric of any auction is the bid-cover ratio. This is the ratio of the total amount bid by all bidders relative to the sum of the amounts allocated to the various bidders. The bid-cover ratio is often used as a metric of overall demand for the issue.[10] Is the bid-cover ratio exogenous to the auction high-yield? Yes, at least weakly exogenous since the bid-cover ratio is the aggregation of individual bidders' reservation yield and amount. The auction high-yield is determined by the set of bids that are covered, but the bid-cover ratio includes, as well, all the bidders whose reservation yield is 'too high' (e.g. above the auction high-yield). In the example below, bidders 8 and 9 are included in the bid-cover statistic, but do not affect the auction high-yield because their bids were above the high-yield. All sorts of bids (basis points, $amount) could generate the same high-yield, but yield a different bid-cover ratio.

[9] The details on the specific characteristics of the individual bids at any auction, and which specific institutions get the allocation from the auction are not publicly available.

[10] An auction where the bid-cover ratio is below 1 would be termed a 'failure' since the amount bid for is less than the amount offered. There is no such auction failure in our sample.



bid-cover = 1.46 ($190 bid by 9 bidders/$130 issue amount)
high yield = 180bp

bidders 1 - 6 get allocated the amount that they bid, at the high yield
bidder 7 gets only $20 of their bid of $50
bidders 8 and 9 get none of the issue

Does bidder type matter? If all bidder types had the same preferences for obtaining some of the issue at auction, the bids would be distributed evenly over the range of low to high bids: Some Direct bidders would bid high and some low, some Primary Dealers would bid high, and some low, and so on. Bidder type and auction high-yield would be uncorrelated.

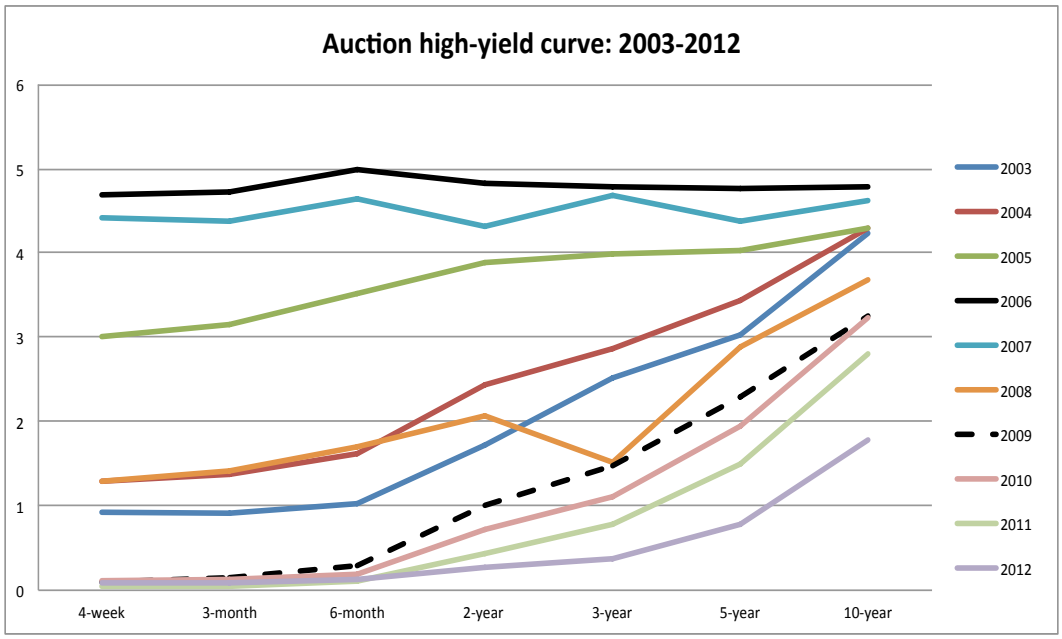
However, in the example above, this assumption is not true—in this example, the Indirect bidders (bidders 1, 2) systematically offer to buy the issue at the lowest basis points. These bidders are assured of being allocated some of the issue. They will receive a higher yield than what they submitted (because this is a uniform price auction). But, because of their preferences to be assured of being allocated the security at auction, they put downward pressure on the auction high-yield. So, bidder type could be important in determining the auction high-yield.

Information in the market offers the opportunity for strategic bidding. Suppose that Primary Dealers, who must bid at the auction, do not want any of this auction issue. The secondary market gives the Primary Dealers information about what the likely high-yield will be. They

could therefore bid on the 'high' side; hoping to be allocated relatively little of the auction. Their bids could put upward pressure on the high-yield compared to what it otherwise might be in an environment of homogeneous and non-strategic bidding. Again, bidder type could matter if the bidders differ systematically by type.

As a backdrop to our analysis, we first review some basic indicators of recent U.S. Treasury auctions over our time period of 2003-2012, including the behavior of the yield curve and the bid-to-cover ratio, as derived from the auction-specific data, as well as the allocations of the auction issue to the bidder types.

Taking these auction-specific data, and aggregating each maturity over the year shows the evolution of the auction high-yield over the time period of our analysis, 2003-2012 (Figure below). This auction-derived yield curve has shifted down substantially, which, of course was the objective of both standard open market operations (early in the period) as well as the intervention by the Federal Reserve into the secondary markets (after 2009). This shifting down of the yield curve also reflects the market's perception of the state of the U.S. economy. The anchoring of the short-term rates at zero reflects the Federal Reserve's forward guidance on the short-term policy rate.



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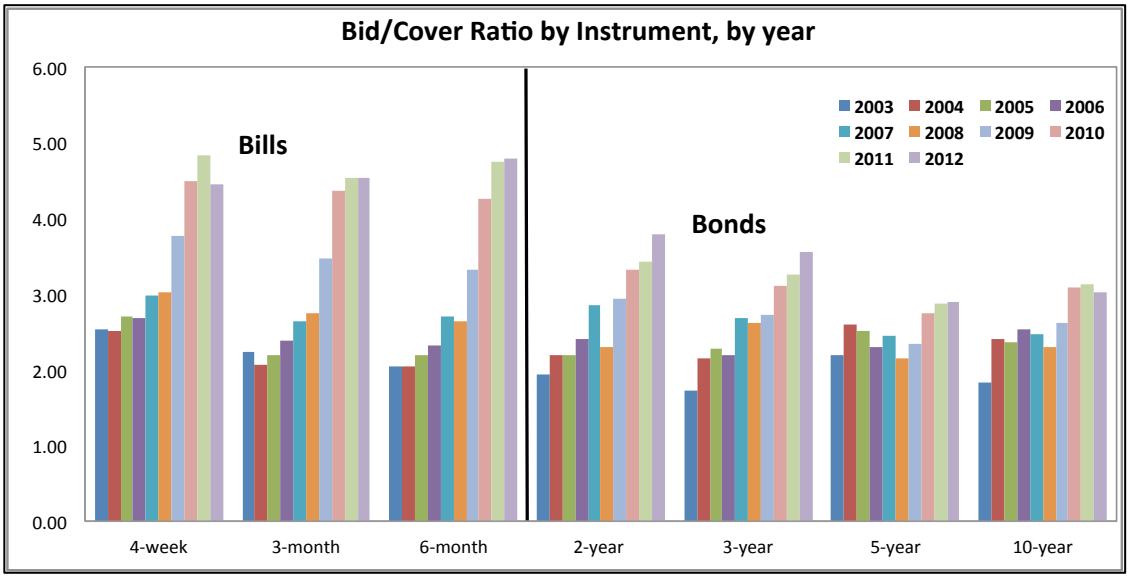
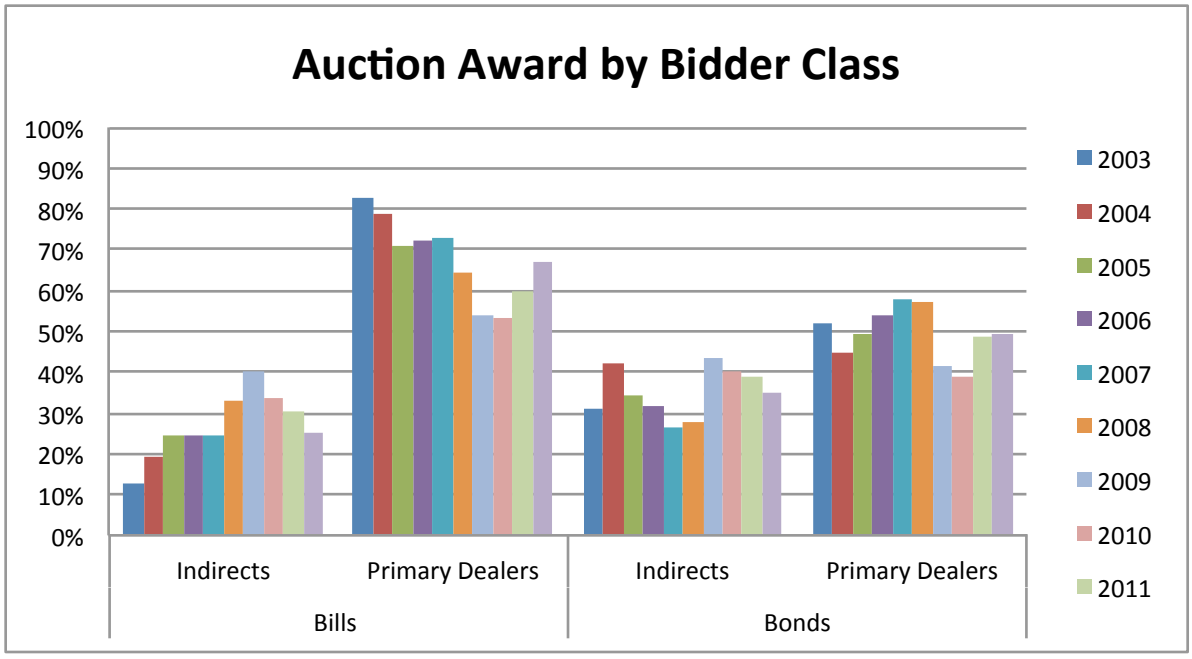
The bid-to-cover ratio (calculated from the auction-specific data as the average of all the auctions during the year for the specific maturity) has increased over this period, most notably for auctions during 2009 to 2011 (Figure below). The bid-cover ratios increased most dramatically for auctions of short-term UST (Bills, with maturity of less than one year) in 2009 and 2010. For medium-term maturity Bonds (2, 3 year) the increase in bid-cover is also apparent. Bid-cover for auctions at longer maturity Bonds (5, 10 years) flattened out after 2010, perhaps revealing

investors' reticence to hold the longer-term UST securities on the grounds that future U.S. government borrowing implies either higher future interest rates (making today's longer-term, relatively lower coupon investments unprofitable), or potential future inflation (also making the increase in holding of low coupon, longer-dated securities unwise), or a combination of both.[11]



The auction data do not reveal the amount of bid by each bidder type, but rather the amount awarded. Nevertheless, using the auction-specific data, we can view the pattern of allocations over time. The Figure below shows the share of the auction awarded to Primary dealers and Indirect bidders (Direct bidders are the residual share.)

[11] Data for 30-year Bonds are included in our regression estimation, but are not presented here since these Bonds were not issued at auction for some of the years during the 2003 to 2012 sample period.



Primary Dealers are awarded the lion's share, particularly at Bills auctions, but their share fell during the periods of greatest turmoil (2009). The share awarded Indirect bidders rose at the short-end maturities during the turmoil, but has stayed high at the longer-end maturities in recent years. If the shares awarded in 2006-2007 were 'normal', it would appear that Indirect bidders are now larger awardees, shifting their portfolios toward the longer end of the maturity spectrum relative to their bids in 2006-2007. It may also be the case that the re-introduction of the 30-year instrument was taken-up particularly by the foreign official investors, thus lengthening the maturity of their portfolios.[12]

IV. Regression Model and Analysis

We turn now to our main objective, which is to model the auction high-yield. Our objective is to consider the relative importance of information available to bidders going into the auction as compared to information revealed by the auction. We also want to address whether statistical relationships change for auctions before versus after the beginning of the extraordinary Federal Reserve purchases in the secondary market for U.S. Treasuries in March 2009.

Our econometric method is similar to D'Amico and King with the auction high-yield on the left hand side. Three types of factors may be relevant for the auction bidder: (1) General financial market conditions going into the auction, which include Fed-funds rate, return to alternative

[12] Auction data do not reveal nationality of bidders.

investments (S&P), market risk (VIX); (2) Auction-specific information that could be gleaned from previous auctions of the specific maturity on offer; (3) Information revealed by the auction process, including bid-cover and amount allocated to each of the three bidder types. The general formulation is:

$$\begin{aligned} \boldsymbol{i}_{t,j,} = a_{0,j} + a_1 \ \boldsymbol{FedFunds}_{t-1} + a_2 \boldsymbol{S\&P}_{t-1} + a_3 \boldsymbol{VIX}_{t-1} + a_4 \boldsymbol{BidCover}_{t,j} \\ + a_5 \boldsymbol{Abs\$PD}_{t,j} + a_6 \boldsymbol{Abs\$Indirects}_{t,j} + a_7 \boldsymbol{Abs\$Directs}_{t,j} \\ + a_8 \boldsymbol{PrevAuctionDif}_{tj-1,j} + \{a_9 \boldsymbol{PrevDayMktYield}_{t-1,j}\} + \boldsymbol{e} \end{aligned}$$

Dependent variable:

- $\boldsymbol{i}_{t,j}$: Auction high-yield for auction on day $\boldsymbol{t}$ of U.S. Treasury security with maturity $\boldsymbol{j}$

t ranges from May-2003 to December 2012, a total of 1926 auctions. There are j maturities including 4-week, 3-month, 6-month Bills and 2, 3, 5, 10, 30-year Bonds.

Independent variables in the Information set prior to the auction

Financial market conditions

These general financial market conditions are in the information set of the bidders as they come to the auction, and are common to all securities.

- $\boldsymbol{FedFunds}_{t-1}$: The Fed-funds rate anchors all the auction high-yields.

A higher Fed-funds rate should be positively associated with the auction high-yield.

- $\boldsymbol{S\&P}_{t-1}$: The S&P index is a proxy for investment alternatives.

A higher S&P should be negatively associated with the auction high-yield.

- $\boldsymbol{VIX}_{t-1}$: VIX is a measure of risk.

Risk and auction high-yield are likely negatively correlated, with higher risk inducing investors, at the margin, to bid more aggressively for the Treasury securities.

Auction-specific data in the information set of the bidders

Previous research pointed to a systematic difference between the auction high-yield and interest rate in the secondary market on the matched-maturity security the day before the action.

- $\boldsymbol{PrevAuctionDif}_{tj-1,j}$: The difference between the auction high-yield $\boldsymbol{i}_{t,j}$ and the previous-days matched-maturity security j *from the previous auction of maturity j*, which is dated tj-1 to differentiate the timing from the running calendar days. That is, the number of days before the auction dated time t depends on the frequency and time-table of the auction of maturity j.

The two Figures (Bills and Bonds) in the Appendix suggest that this variable is not random, and therefore may contain information that could be exploited by auction participants.[13]

Innovations on auction day.

- $\boldsymbol{BidCover_{t,j}}$: Total dollar bid relative to the issue at auction dated t of security of maturity j.

A higher bid-cover ratio should generally be negatively associated with the auction high-yield.

- $\boldsymbol{Abs\$PD_{t,j}}$: $\boldsymbol{Abs\$Indirects_{t,j}}$ $\boldsymbol{Abs\$Directs_{t,j}}$: Dollar amount of securities of maturity j awarded to Primary Dealers, Indirect bidders, and Direct bidders at auction dated t.

For these three allocation variables, the expected sign and even significance is unclear. If bidders are homogeneous and bids are distributed normal around the auction high-yield, then the amount allocated to any specific bidder type should be uncorrelated with the auction high-yield, and further, would be insignificant once controlling for bid-cover. However, as discussed in the example if bidder types differ systematically, then the amount awarded to one vs. another bidder type could matter for the auction high-yield.

Finally:

- $a_{0,j}$; maturity fixed effects

Efficient market test

For robustness, we also consider an efficient market specification whereby all information available to the investor prior to the auction is embodied in the interest rate on the matched maturity instrument prevailing in the market the day before the auction

- $\boldsymbol{PrevDayMktYield_{t-1,j}}$: The previous-day's secondary market yield for maturity j.

If the auction market is efficient in the classical sense, then this coefficient should be 1, all variables dated *t-1* should be insignificant in the regression, although the auction-day innovations could still be statistically significant.

Estimation

Using our dataset on every U.S. Treasury auction from May 2003 to year-end 2012, we investigate factors underpinning the high yield at the auctions. We are interested in (1) The importance of auction yields as driven by prevailing market conditions known in advance of the auction, (2) The importance of auction-specific information known before the auction, (3) The importance of information revealed by the auction, and (4) Do these relationships change before

[13] Estimating the factors underlying the behavior of this variable, as the left-hand side, is put aside for another paper. The point of including this variable in the estimation of the auction high-yield is that the auction-specific information embodied in this variable is known by all bidders going into the auction for maturity j.

versus after March 2009, when the Fed began its extraordinary monetary policy of intervention into the secondary-market for U.S. Treasury securities?

Table 1 shows results for the full sample (all auctions) as well as decomposition of auctions into Bills and Bonds, and before and during QE. Estimated coefficients are for market variables known in advance (that is, in the information set of the bidders)—Fed Funds, S&P, VIX. Also in the information set of the bidders is the auction-specific information known in advance – the difference between the auction high-yield and previous day market yield the last time an auction of that particular maturity took place (PrevAuctionDif). Finally, auction-specific information revealed by the auction (bid-cover and allocations to each bidder type).[14]

All dates: All Auctions vs Bills and Bonds Auctions

Considering all dates in the sample and all maturities, the market variables known in advance are significant and the expected sign. The auction-specific variable known in advance is nearly significant at the 10% level. Information revealed at the auction had the expected sign for bid-cover, and bidder allocations to the Indirect and Direct bidders appear to shade-up the high-yield.

However, examination of the estimated coefficients on the Bills vs. Bonds for the full calendar period indicates that the all dates-all maturities pool is not statistically supported. All the market variables known in advance of the auctions are significantly different. The information revealed at the auction also has different coefficients. Thus, we proceed to analyze the Bills and Bond auctions separately and consider the two periods before and during QE.

Before vs. During QE: Bills vs. Bonds

Financial Market Conditions in the information set of all bidders

First, all the market variables are significant and of the correct sign, except for the Fed Funds rate during the QE period for Bond auctions. The high-yield at Bills auctions are more highly correlated with FedFunds rate, which makes sense given the shorter maturity of the Bills. Higher S&P is negatively correlated with auction-yield yield, with a greater negative correlation in the Bond auction high-yield. Higher volatility as measured by VIX is negatively correlated with both auctions, implying flight to Treasuries in a risky environment; the negative correlation is more notable for Bonds in the QE period.

Auction-specific variables in the information set of all bidders

The information contained in the previous auction – how the high-yield at the auction varied relative to the market-yield the previous day for the matched-maturity instrument at the last time that maturity was auctioned– is significant and positive for Bills in both periods. This suggests that auction-specific information that is known in advance (from the previous auction of that

[14] Preliminary regressions revealed statistical differences in the Bills auctions vs. the Bond auctions. Table presents only the auctions estimated separately for these two broad maturity groups.

security) can be used to forecast the auction high-yield for Bills. Thus, the auction bids for Bills could be strategic.

For Bonds, the information contained in the previous auction of the matched maturity instrument does not add to the information set of the bidders. These auctions are less frequent, and therefore any information in the previous auctions would be overtaken by information in the overall financial conditions variables.

Auction-specific information revealed at the auction

For Bills, but not for Bonds, the bid-cover ratio is negatively correlated with the auction high-yield. Higher bid-cover ratios push down the high-yield at Bills auctions. The bid-cover ratio is more strongly correlated in the QE period, suggestive of the role for forward guidance anchoring the short-end of the yield curve at zero and the use of short-term Bills for collateral.

Considering the hypothesis of whether bidder type matters, the results are mixed. For Bills, in the pre-QE period, generally the signs are positive, but only significant for Direct bidders. Direct bidders do not have to bid at the auction. But, knowing the information from the previous auction, and bidding strategically, Direct bidders could potentially shade the auction high-yield up from where it might have been based on homogenous and atomistic bids. In the QE period, only the allocations to Primary Dealers and Indirect bidders are significant, and their coefficients are nearly identical, which could suggest strategic bidding by these two groups.

Considering the Bond auctions, bid-cover is not significant. Before QE, higher allocations to Primary Dealers and Indirect bidders are negatively associated with high-yields at the auction. During QE, none of the auction-specific variables are significant. Notice as well the dramatic decline in the explanatory power of the regression as measured by R2. Thus, it appears that the Federal Reserve policy intervention into the secondary market for Bonds affected the auction market for Bonds not only through the market variables, but also by changing bidding behavior.

Table 1	All dates	All dates	Before QE May 2003-March 2009	QE April 2009-December 2012	All dates	Before QE May 2003-March 2009	QE April 2009-December 2012
	All auctions	**Bill Auctions**			**Bonds Auctions**		
In the information set before auction							
Market variables							
Fed Funds	0.8603	0.9533	1.003	0.7963	0.5269	0.4287	-1.5575
	0.01079	0.007539	0.01149	0.0413	0.02582	0.03721	0.7592
S&P	-0.001115	-0.001045	-0.001628	-0.0001413	-0.002354	-0.001528	-0.004075
	0.000103	0.0000726	0.000123	0.0000204	0.000243	0.0003635	0.0003431
VIX	-0.01635	-0.01479	-0.01622	-0.001401	-0.02531	-0.01784	-0.05629
	0.001351	0.0009406	0.001613	0.0003283	0.003347	0.00401	0.006356
Auction-specific variables							
PrevAuctionDif	*-0.20133*	0.07562	0.1614	0.1815	0.065529	0.6786	*-0.1948*
	0.0127	0.06324	0.07916	0.08143	0.43376	0.6156	*0.4966*
Not in the information set before auction							
Auction-specific shocks							
Bid-Cover	-0.1076	0.0007151	-0.07222	-0.2054	-0.2585	0.132	0.05912
	0.01661	0.011716	0.03153	0.003735	0.06944	0.1121	0.121
Abs$PD	-0.04016	0.010509	*0.007099*	0.0020365	-0.05977	-0.06252	0.02169
	0.002873	0.001957	*0.003698*	0.0005096	0.008619	0.0161	0.01933
Abs$Indirect	0.01332	-0.0002416	*0.008679*	0.001962	-0.01133	-0.059	0.02211
	0.003179	-0.002294	*0.004875*	0.0005673	0.007483	0.01777	0.01263
Abs$Direct	0.01993	0.02019	0.04313	*0.002749*	-0.04497	-0.03741	0.0328
	0.005634	0.006507	0.1575	*0.001381*	0.009623	0.02205	0.01749
maturity fixed effects in each regression							
Standard errors shown below; Shaded cells are not significant. Italic are nearly significant at 10%							
NOB	1926	1486	886	600	440	211	229
R2	0.7895	0.978	0.9606	0.4688	0.7283	0.7493	0.0059

Efficient Market Test

Table 2 is a robustness check that considers whether the auction market is efficient in the sense that all information relevant to the auction is embodied in the previous-day's market yield for the matched-maturity instrument, and whether the auction high-yield is associated with any auction-specific behavior.

This robustness check reveals, generally, that both maturities and time periods come close to the classical efficient market: The coefficient on the previous-day's market yield for the matched instrument is close to 1: Before QE begins, for both Bills and Bonds, the previous-days market yield for the matched maturity has a coefficient of about 0.98. During QE, however, the Bills coefficient falls to 0.91 and the Bonds coefficient rises to 1.0. Thus the market appears to be less efficient during QE for Bills.

With respect to the role for auction-specific shocks, for Bonds, the bid-cover ratio is significant and negative both before and during QE: more bidding is associated with a lower high-yield in both periods. For bidder allocation, Indirect Bidders in both periods are negative, and significant in period including QE, which is modestly suggestive that the Indrect Bidders bid 'low' at the auctions for Bonds.

For Bills before QE, none of the auction-specific shocks are significant, suggesting that bidders are homogeneous. During QE, bid-cover is negatively associated with the Bills high yield, so bidding is robust which, on balance is associated with a lower high-yield at the auction. All the bidder allocations are significant and positive sign, with larger coefficients for the Primary Dealers and Indirect Bidders. Together with the drop in the coefficient on previous days market yield suggests the bidders kept challenging the Federal Reserve's forward guidance of maintaining the policy rate at 0-25 basis points.

Table 2	all dates all auctions	all dates	Before QE May 2003-March 2009	QE April 2009-Dec.2012	all dates	Before QE May 2003-March 2009	QE April 2009-Dec. 2012
		Bills Auctions			Bond Auctions		
In the information set before auction ***Auction-specific***							
PrevDayMarketYield	0.9821	0.9812	0.9822	0.9123	0.9929	0.9898	1.00543
	0.002737	**0.003199**	0.004254	0.01348	0.00351	0.005777	0.006851
Not in the information set before auction							
Auction-specific shocks							
Bid-Cover	0.004472	0.003936	0.03326	-0.007972	-0.039	-0.03434	-0.05237
	0.004361	0.00548	0.01624	0.001469	0.006563	0.01214	0.01315
Abs$PD	0.002028	-0.09027	*0.005324*	0.0006938	0.00102	*0.000582*	*-0.004184*
	0.0008261	0.02773	*0.002051*	0.0002074	0.0009407	*0.001722*	*0.002414*
Abs$Indirect	*0.001842*	0.004028	0.007845	0.0006358	0.0000139	*-0.001244*	-0.00385
	0.0009461	0.00127	0.002602	0.0002672	0.0007091	*0.001898*	0.00163
Abs$Direct	0.0006635	-0.000898	*0.01868*	0.002306	0.0020489	*0.003717*	*-0.003208*
	0.0017611	0.003825	*0.009764*	0.0006146	0.001023	*0.002314*	*0.002215*
NOB	1926	1486	886	600	440	211	229
R2	0.9936	0.9925	0.9846	0.9459	0.9987	0.9972	0.9982
maturity fixed effects in each regression Standard errors shown below; Shaded cells are not significant. Italic are nearly significant at 10%							

VI: Conclusion

This paper uses a unique auction-by-auction data set to examine factors underpinning the auction high-yield for U.S. Treasury auctions over the time period 2003 to end 2012. We find that prevailing market conditions known in advance of the auction, such as the fed-funds rate, the value of alternative investments (S&P), and market volatility (VIX) are all significant for the auction high-yield. A lower Fed-funds is associated with a lower high-yield at auction, particularly for Bills. A higher return on alternative investments (S&P) and more risk (VIX) are associated with a lower yields at auction. Information embodied in the previous auction of a specific maturity is correlated with the auction high-yield for Bills, implying that the high yield at Bills auctions can be forecast based on information from the previous auction of the specific maturity Bill, not just from generally available market factors.

Robustness analysis shows that all lagged information—both market and auction-specific—are embodied in the previous-day's market yield on the matched maturity instrument. In this sense,

the Treasury auction market is efficient—the best predictor of an auction high-yield is the market yield on the matched instrument the previous day. The coefficient is not 1.0 however, particularly for Bills following the start of QE, leaving open the possibility for strategic auction behavior.

We also considered the role for auction-day information, such as bid-cover ratio and allocations by bidder type to influence the auction high-yield. Such auction-day information on bid-cover is generally significant and expected sign: A higher bid-cover ratio is negatively correlated with the auction high-yield, particularly in the efficient-market specification. With regard to bidder allocations, there is modest indication that Indirect bidders (a frequently used proxy for foreign official bidders) bid 'low' in Bond auctions, perhaps to be assured of obtaining the securities.

Finally, does the auction market behave differently during the period 2003 through March 2009 versus after 2009 when the Fed is implementing quantitative easing? Market structural factors (FedFunds, S&P, VIX) are differentially correlated with the auction high-yield before and after onset of QE. Bid-cover appears to convey different information comparing the two time periods, and between Bills and Bonds. On balance, the policy of quantitative easing implemented in the secondary market appears to have influenced the structure of the auction market for U.S. Treasury securities.

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Appendix Charts