U.S. Treasury Auction Yields During Boom, Bust, and Quantitative Easing: Role for Fed and Foreign Purchasers

Catherine L. Mann* & Oren Klachkin#

*Rosenberg Professor of Global Finance, International Business School, Brandeis University Visiting Scholar, Federal Reserve Bank of Boston #Masters '11, International Business School, Brandeis University; IHS Global Insight

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Abstract

Since 2007, three actors have been particularly important in U.S. Treasury auctions: The U.S. government, issuing \$8.4 trillion in U.S. Treasury securities in 2010 alone; foreign official entities, purchasing \$398 billion in U.S. Treasury securities in 2010 alone; and finally the Federal Reserve, which intervened in the U.S. Treasury market by purchasing \$900 billion U.S. Treasury securities during 2009 and 2010. Using our unique data set of every U.S. Treasury auction from May 2003 to year-end 2011, we find first, that the yield at auction compared to the previous-day's matched-maturity instrument varies significantly across the maturity of the instrument, as well as the time period of boom and bust. Similarly, the bid-cover ratios are importantly related to the auction yield and to macroeconomic environment. Third, we find that indirect bidders, a proxy for foreign official entities, although not allocated the largest shares at the auctions, were the relatively more important group in determining the auction yield on long-term U.S. Treasury securities. Finally, we find that all of these relationships change significantly when the Federal Reserve entered the Treasury market.

JEL: E43,E58, F34,F49 Key words: Federal Reserve, quantitative easing, foreign official, Dutch auction, US Treasury securities

I. Introduction

With some \$14 trillion of U.S. debt outstanding in 2011, the sustainability of new issuance has taken the spotlight. Analysts are examining the auctions of U.S. Treasury securities for a realtime snapshot of the demand for U.S. sovereign debt. Three actors have been particularly important the past few years: The US government, issuing \$8.4 trillion in US Treasury securities in 2010 alone; foreign official entities, purchasing \$398 billion in US Treasury securities in 2010 alone¹; and finally the Federal Reserve, which has intervened in the US Treasury market purchasing \$300 billion US Treasury securities as part of its Large Scale Asset Purchase (LSAP) program in 2009 and \$600 billion launched in November 2010 as part of the second round of its LSAP program, or what became commonly known as Quantitative Easing II (QE2).

Have the purchases by foreign official entities and the Federal Reserve affected the yield at the US Treasury auctions? Has the macroeconomic environment of boom, bust, turbulence and direct central bank intervention affected the U.S Treasury market? Using our dataset on every U.S. Treasury auction from May 2003 to year-end 2011, we find first, that the yield at auction compared to the previous-day's matched-maturity instrument varies significantly across the maturity of the instrument, as well as the time period of boom and bust. Similarly, the relationship between the bid-cover ratio and the auction yield is related to the macroeconomic environment. Third, we find that indirect bidders, a proxy for foreign official entities, were not allocated the largest share of any auction, but were the relatively more important group in determining the yield at the auctions of long-term U.S. Treasury securities. Finally, we find that all of these relationships change significantly when the Federal Reserve entered the Treasury market.

We proceed as follows. First we quickly describe the U.S. Treasury auction process. Then we review recent literature on factors influencing U.S. Treasury market yields. Section IV reviews basic data on U.S. Treasury auctions. We then examine the auction-by-auction data, which reveals a systematic difference in the yield at auction compared to its matched-maturity yield the previous day. Section VI examines the relationship between the auction yield and the three actors in the auction (primary dealers, direct bidders, and indirect bidders), controlling for various other aspects of each auction.

II. An Overview of the U.S. Treasury Auction Process

The auction process for U.S. Treasury securities follows a formal and rigid structure. The Treasury Department first releases data on its auctions through a number of announcements and disclosures. Prior to an auction, a press release is distributed by the Treasury Department stating the maturity, type, and amount of Treasury security to be sold. The announcement also details the quantity of Treasuries the Federal Reserve has maturing on the issuance date; to keep

¹ BEA, Table 5, line B2 accessed Oct 12, 2011

constant the face value of securities held in the Federal Reserve's System Open Market Account, the central bank will purchase at least some of the securities at that auction. Furthermore they release all details regarding the amount investors are scheduled to purchase via the TreasuryDirect system. Thereafter, the bidding process opens for the remaining securities available for purchase at the auction.

The Treasury Department employs a uniform price (sometimes termed a modified Dutch) auction to sell its offerings. Bids submitted are delineated as either competitive or noncompetitive; competitive bids are placed according to the minimum yield the bidder is willing to accept for a quantity of securities while noncompetitive bids merely bid on the quantity with the yield received determined by the competitive bids. To determine the appropriate yield, and therefore price, of the security, competitive bids and their respective yields are organized and accepted by increasing yield until the offering amount is reached.²

There are three bidder groups: primary dealers, direct bidders, and indirect bidders. The title of primary dealer is used to describe the twenty banks and securities broker-dealers that trade directly with the Federal Reserve and act as market makers for Treasury securities and must bid on U.S. Treasury securities when Treasury securities are auctioned.³

Direct bidders represent those bidders that have a direct trading relationship with the U.S. Treasury and are bidding for 'their own house accounts'. A direct bidder can be a domestic U.S. money manager, bank or broker-dealers not ordained as a primary dealer, or domestic mutual fund managers. However, unlike primary dealers, direct bidders are not required to bid on Treasury securities.

Lastly, the indirect bidder represents those bidders that do not bid via the previous two channels mentioned above; rather 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'.⁴ 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 class is a valid proxy for foreign and official bidders. ⁵ Hence, 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.⁶

² Competitive bids vastly out-weigh non-competitive bids: for example, at the October 14, 2010 auction competitive bids were \$32 billion and non-competitive bids were \$12 million

³ 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.

⁴ Quoted from Public Debt News, footnotes.

⁵ <u>http://www.newyorkfed.org/research/current_issues/ci13-1.pdf</u>

⁶ According to Reuters, 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.

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 some stylized examples.⁷ The first important metric of any auction is the bid-cover ratio. This is the ratio of the amount bid 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.⁸ 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 quantity. The 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 7 and 8 are included in the bid-cover statistic, but do not affect the auction high yield. We can imagine all sorts of bids by bidder class—bp,\$ combinations—that yield the same bid-cover ratio, but a different high yield.



bid-cover = 1.54 (\$200 bid by 8 bidders/\$130 issue amount) high yield = 180bp

http://www.reuters.com/article/2012/05/21/us-usa-treasuries-china-idUSBRE84K11720120521. It has also been noted that China had, 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.

⁷ The details on the specific characteristics of the bids at any auction, and which specific institutions get the allocation from the auction are not publicly available.

⁸ 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.

bidders 1 - 5 get allocated the amount that they bid, at the high yield bidder 6 gets only \$20 of their bid of \$50 bidders 7 and 8 get none of the issue

III. Literature Review

Ours is the first paper to bring together both the time period of very active foreign purchases of U.S. Treasuries and the time period of the Federal Reserve intervention to purchase Treasury securities as part of the LSAP programs. To put our work in context, this section reviews the previous research that addresses one or the other of these factors on the demand side of the US Treasury market.

First, with regard to the role for foreign demand to affect the yield on U.S. assets, including Treasuries, the literature often reaches different conclusions as to the importance of foreign demand. 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 at the time the authors completed their study. 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 on the yields of these maturities; therefore they conclude that foreign purchases did not affect the yields on U.S. Treasuries are relevant to explaining U.S. Treasury yields using econometric models that span these two previous works. They find that relaxing the econometric assumptions in Warnock and Warnock yields results that support the findings of Rudebusch et al and visa-versa.⁹ Therefore, Beltran et al conclude that the existing literature is not a reliable guide as to whether foreign official purchases affect U.S. interest rates.

Bernanke et al. (2011) investigate the effects of capital inflows to the United States on long-term U.S. interest rates. The authors find that international capital flows (albeit not specifically those by foreign official entities) indeed 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 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). The former paper ultimately employs a DSGE model, and concludes that foreign demand for UST does not impact yields. Sierra, examining the 1995-2008 period, and using an extensive set of instruments, concludes that official and private foreign purchases have opposite effects on UST yields—the official purchasers act to 'reduce' available supply (to the remaining private actors) and thus reduce the yield, whereas the private actors are the residual demanders. On balance, however, Sierra finds little role for foreign actors to reduce 10-year yields on U.S. Treasuries over the period of examination.

⁹ 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.

Taking a different tack, Krishnamurthy and Vissing-Jorgensen (2010) find that investors value the liquidity and safety attributes of Treasuries, although they do not focus on foreign entities. The authors reach this conclusion by determining that a one standard deviation reduction in Treasury supply lowers Treasury yields by 79 basis points relative to corporate bonds. An important implication of this paper is that it provides empirical evidence that Treasuries carry both a safety and liquidity attribute. Therefore, some investors might purchase Treasury securities not for their associated return, but for their safety characteristics and regardless of indicators of risk, or the point in the business cycle at which their economies stand.

Second, with regard to the question of the impact of the various Federal Reserve programs to purchase assets (the LSAPs), the literature delivers more systematic conclusions—these programs have influenced yields. Doh (2004), Gagnon et al (2010), and Neely (2010) using aggregate data suggest that these various programs did reduce interest rates. Although, Stroebel and Taylor (2009) conclude that the purchase of mortgage backed securities (MBS), in particular, did not have much impact on interest rates. In the most detailed examination, D'Amica and King (2010) used CUSIP data to find that the LSAP program reduced interest rates on the instruments (individual CUSIPs) that were purchased.

We bring together the strands of the literature on the relationships between U.S. Treasury (henceforth UST) yields to both Federal Reserve programs and purchases by foreign official entities. We use highly disaggregated data –specifically auction-by-auction data—and consider purchases by bidder class, with specific interest in the indirect bidders as proxy for foreign official purchasers.

IV. Methodology and an Overview of Treasury Data

Our method is grounded in models of imperfect asset substitution, portfolio balance, and preferred habitat. The models allow for quantity supplied (or reduced as in the Federal Reserve LSAP) or demanded (e.g. by foreign entities) to impact price—that is, actors need not be atomistic in the marketplace. The portfolio balance model has a long history in foreign exchange markets, and has been used to assess the impact of foreign exchange intervention in the markets, with differing degrees of success. The portfolio balance model and imperfect asset substitution models were considered early in the life of the Euro for whether the type and amount of foreign asset purchases impacted the Euro's value. The preferred habitat model is the foundation of D'Amico and King's work—their focus is on the shock reduction in supply of UST via LSAP program, whereas we parameterize direct and indirect bidder purchases as a shock increase in demand for UST.

In using these models as a platform for assessing the relationship between bidder demand for UST and resulting UST high yield at auction, we conclude that how much each bidder class gets at auction appears to matter for the auction yield. Given that the supply of UST offered at auction is known to the bidders, but who will bid and the characteristics of their bids is not, we conclude that the demand side identifies the revealed price (that is, high yield on the instrument) at the auction. Our method follows most similarly that of D'Amico and King, although, in their case, it

is the unknown reduction in supply of UST coming as a consequence of the LSAP that identifies the model.

For our data, we construct a unique panel dataset of various metrics of every U.S. Treasury auction from May 2003 until year-end 2010. These metrics included the high yield awarded to winning bid, the bid-cover ratio, the auction share awarded to primary dealers, the auction share awarded to direct bidders, the auction share awarded to indirect bidders, the absolute US dollar amount of US Treasury securities up for sale, and the maturity of the security being sold at auction. We also collected data on the secondary-market yields of comparable securities 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.¹⁰

As a backdrop to our analysis, we first review some basic indicators of recent U.S. Treasury auctions over our time period of 2003-2010, including the behavior of yields at similar-maturity auctions, the bid-to-cover ratio, and the shares of the bidder classes at selected auctions.

First, over the time period of our analysis 2003-2010, the yield curve has shifted down substantially (Figure below). This, of course, has been the objective of both standard open market operations as well as the direct UST intervention by the Federal Reserve. It is also possible, however, that this shifting down of the yield curve simply reflects the market's perception of the state of the U.S. economy.



¹⁰ The H.15 data are reported as 'market yield, constant maturity, quoted on investment basis'.

Second, the bid-to-cover ratio¹¹ has increased over this period (Figure below). The bid-cover ratios increased most dramatically for auctions of short-term UST (e.g. Bills, with maturity of less than one year) in 2009 and 2010. For medium-term maturity Bonds (2, 3, and 5 year) the increase in bid-cover is most apparent in 2010. The 30-year Bond was re-introduced in 2007, and the bid-cover increased, albeit much less dramatically, for auctions in 2009 and 2010.

Using the short-term UST, investors found safe and liquid instruments, to both replace dysfunctional other short-term markets and to park reserve funds. The smaller increase in the bid-to-cover ratios for longer-term maturities is worthy of another paper, as it may point to lower liquidity in the market for those maturities, and investors' reticence to hold the longer-term UST securities on the grounds that future U.S. government borrowing implies higher future interest rates (making today's longer-term, relatively lower coupon investments unprofitable), or potential future inflation (also making the holding of low coupon, longer-dated securities unwise).



¹¹ The bid-cover ratio is the value of bids placed to the value of bids accepted (which is the amount on offer) which often is considered a proxy for demand.

Although the auction data do not reveal the amount of bid by each bidder class, only the amount awarded, some insight into the demand for various length maturities is revealed by other sources of data, specifically the Fiscal Year 2011Q4 Report from the Office of Debt Management at the U.S. Treasury. The Figure below shows the share of the auction awarded to primary dealers and foreign bidders (other bidders can be viewed as the residual share).



First, is it clear that primary dealers are awarded the lion's share in all periods. However, the primary dealers' shares fell during the periods of greatest turmoil (2008, 2009). For bills, the foreign share did not change, implying the other domestic buyers (households, investment funds, other broker-dealers) took the share that primary dealers did not—which is consistent with the flight to liquidity by those investors.

For the foreign buyers (both private and official), their shares awarded at auction also changed over the period, especially for the short-term bonds early in the disrupted period (2008, 2009). For long-term bonds, the foreign buyers have been awarded higher shares from 2009 through auctions in 2011. If the shares awarded in 2006-2007 were 'normal', it would appear that foreign buyers are now larger awardees, shifting their portfolios toward the longer end of the maturity spectrum. 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. On balance, however, foreign buyers are allocated only about 10% (bills) to about 25% (bonds) of any auction.

This shift towards the longer-end can be corroborated by examining the Report on Foreign Portfolio Holdings of US Securities (US Treasury, Federal Reserve Bank of New York, and Federal Reserve Board of Governors) Table 14b. Considering just foreign official holders of US securities, from FY2004 to FY2010, the maturity structure has shifted significantly away from securities about to mature.

Maturity Structure of Foreign Official Holdings of U.S. Long-term Debt Securities (share, remaining years to maturity)

	FY2004	FY2006	FY2008	FY2010
one year or less	19.6	18.9	16.9	10.7
1 to 6 years	60.3	57.5	59.5	66.6
6 to 30 years	20.1	23.6	23.6	22.7

calculated from Table 14b, Report on Foreign Porfolio Holdings of U.S. Securities FY: as of June 30 of that year

While our auction-specific data do not include information as to the nationality of the indirect bidders, some insights can be obtained, albeit with less granularity in the time dimension, from the Treasury International Capital (TIC) system data. (Figure below). As is well known, China is the largest holder of U.S. Treasury securities, with an end of year (2010) stock at \$1.2 trillion of short- and long-term Treasuries, resulting from dramatic annual purchases between 2005 to 2010. Japan and the United Kingdom are the second and third largest holders of Treasuries at \$882 billion and \$272 billion, respectively. As the United Kingdom acts as a conduit for demand by financial institutions (including as conduits for official entities), the U.K. stock of U.S. Treasuries tends to be more volatile and should not be considered as representative of a final demand for the securities.



The flow purchases of short- and long-term Treasuries by China, Japan, and U.K. offer more details on these countries' (and intermediaries) investor behavior, especially as the 2008 global financial crisis worsened. (Figures below). First, the purchase of short-term U.S. Treasuries was largely stagnant before the onset of the 2008 financial crisis, whereas the purchase of long-term U.S. Treasuries remained robust, averaging about \$44 billion per quarter from Q1 2005 to Q2 2008. As the crisis takes a turn for the worse in September 2008 with the bankruptcy of Lehman Brothers, these particular foreign investors fled to the safety of long-term U.S. Treasuries. Net purchases of short-term Securities averaged -\$60 billion from Q3 2008 to Q1 2009, while net purchases of long-term U.S. Treasuries averaged \$55 billion during those three quarters, arguably the most tumultuous time for financial markets. As the worst of the financial crisis passed, demand by these three countries for U.S. Treasuries remains strong.



■Quarterly U.K. Net Purchases ■Quarterly Japanese Net Purchases ■Quarterly Chinese Net Purchases



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V: Information in the Auction Yield

We turn now to a more detailed analysis of our auction-by-auction dataset. A question that other research has addressed in various contexts is 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), in the course of their investigation of the liquidity phenomenon. They find that the on/off the run bid-ask daily differentials are narrowest immediately following an auction of the matched maturity instrument. They do not, however, consider how any of the bond prices relate to the auction price itself, as the auction data are not in their dataset.

Hou, Yan, Zhang (2011) do investigate the relationship between the seasoned bond yield and the auction yield. They show that in a several day window prior to and after a UST auction, that the yield of the matched security is some 2 to 6 basic points below the auction yield, narrowing to zero on the auction day. They point out that if the Treasury could have borrowed either before the auction or after it, the cost of borrowing would have been lower than at the auction itself.

Other researchers examine whether these differentials vary during times of financial turbulence. For example, research by Furfine and Remolona (2002)-- the main objective of which is to examine trading in successive on-the-run securities around the time of 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. They did not however, examine the relationship between the newly on-the-run and the auction yield itself. Jegadeesh (1993), who was investigating the alleged market manipulation by Salomon Bros, found a systematic difference between the auction yield and the maturity-matched instrument in the secondary market of about 4 basis points.

So, we start our analysis by determining whether there is any systematic difference between the auction yield on a security of maturity *j* auctioned on date *t*, and the yield on the maturity-matched security in the secondary market on the day prior to the auction (t-1).¹²

We calculate this "auction spread" (AS) for security of maturity j issued at auction day t as the difference between the auction yield for that security less the previous-day's secondary market-traded yield for security of that maturity j (from the Federal Reserve H.15 data series).

AS *j*, t = Market Yield *j*,t-*l* – Auction Yield *j*,t;

¹²Our work differs from Hou, Fan, Zhang in a number of ways. In particular, they are interested in the aggregated differential over all auctions of a particular maturity whereas we are interested in how the differential changes over time for a maturity as well as across maturities.

We have about 1700 observations coming from the auctions over the time period 2003-2011. Our maturities include short-term auctions (4-week, 3-month, 6-month bills) totaling 1177 auctions, and 634 auctions of longer-dated securities (2-year, 3-year, 5-year, 10-year, and 30-year bonds).

An examination of the auction spread *j*,*t* over the time period of study (2003-2011) by maturity of security reveals some interesting results. (Figures below for Short-term securities and Long-term securities.)



First, the AS for short-term Bills appears to have business-cycle properties related to the performance of the US equity markets. Whereas the AS did appear to be in the neighborhood of previous findings (plus or minus 5 basis points in 2003 and 2005), as the equity boom took off, the AS on short-term UST instruments is increasingly negative. A negative auction spread implies that the interest rate that is awarded at the auction is higher than that on the matched maturity instrument available in the market on the previous day, suggesting there is less demand

for Treasuries at auction than for Treasuries in the secondary market for the same maturity. ¹³ This makes sense in that during the 2003-2007 period, the economy exhibited robust growth and equity markets rallied making investors reticent to accept the relatively low, fixed returns associated with U.S. Treasuries. Moreover, liquidity was not a problem so holding deep-market UST was not a needed component of capital allocation. By the height of the boom, as the Dow was reaching for 14000, the difference between Bill yields at auction and in the market on the day previous to the auction for securities of matched maturity was at its largest, about 25 basis points.

Although the Dow reached successive highs between July and October 2007, the negative AS started to narrow as early as the April 2007 auctions and started to show positive AS in the some auctions in June 2007. Instability in financial markets during Fall 2007 and through the Spring of Bear Stearns is reflected in more positive AS on average, but there is substantial variability in the AS depending on the auction. As the 2008 financial crisis deepened and was exacerbated by the failure of Lehman Brothers in September, the auction spread on U.S. Treasury Bills collapsed to zero as investors fled to the safety of U.S. Treasuries.

For UST Bonds, the Auction Spread behaves rather differently. First, AS is about the 5 basis points, as found in the earlier analysis for the U.S. Treasuries with maturities from two to five years before, during and after the 2008 financial crisis and onset of the LSAP, and QE programs. Although, the positive AS, especially for 5-year maturity instruments, does widen around the period of Bear Sterns and Lehman. For Bonds with maturities of 10-years and 30-years, the AS is generally higher and remains higher than the ST auction spread through the period of direct Federal Reserve purchases (after March 2009). Also, there is volatility in the AS (positive and negative) during the final stages of the boom (2007), bust (2008), and onset of QE (2009).

¹³ This is consistent with the findings of Hou, Fan, Zhang. But we find that the spread has business-cycle properties, whereas they average all the auctions of a particular maturity and so mask any such time dynamics.



A positive auction spread means that investors exhibit relatively stronger demand for these UST securities at auction than for Treasuries of equal maturity being traded in the secondary market the previous day.¹⁴ Unlike the Bill auction spread, there is no apparent relationship to the equity market, in that the AS for LT securities is not systematically and increasingly negative during the boom. Thus, the longer-term maturities, unlike the ST Bills appear to have more overall demand by investors wanting to add more of this type of instrument to their investment portfolios.

Our question is, do different bidder classes have any systematic impact on the auction high yield? On the face of it, the answer should be no. "The color of money shouldn't matter" (using the colors in the example above on the Dutch auction). If preferences of the three bidder classes (and by extension, the individual bidders within each class) are heterogeneous, say with bid characteristics of (bp,\$) normally distributed around the auction high-yield, then bidder class should not matter to determine high-yield. However, we could imagine that one class of bidders (say indirect) have a relatively greater preference for the liquidity and safety of the UST and therefore will skew their bids to the right (willing to accept a lower yield), which, at the margin i would reduce the auction high-yield. Are these bidders as a group large, in the sense that they receive a large allocation of the auction? We showed above that the indirect bidders did not receive the largest allocation of the auctions. But, they could be important at the margin. This question takes us to the next section on regression and interpretation.

¹⁴ This liquidity, safe-haven demand for the US risk-free asset is consistent with Krishnamurthy and Vissing-Jorgensen (2010).

VI. Regression Results and Interpretation

We turn now to our main objective, which is to evaluate the relationship between the auction yield and the bidder class, with particular interest in the indirect bidders. We use an econometric method similar to D'Amico and King in that our measure of auction outcome is the left hand side variable, and there are measures of auction demand in our case (reduction of supply in the case of D'Amico and King) and auction controls on the right hand side.

Our specification relates the auction high yield to the absolute purchases of the three bidder classes at that specific auction, controlling for bid-cover, the pervious auction spread for the matched instrument, and maturity fixed effects. We use the lag of the AS for the maturity j under the supposition that the difference between the market yield on the day before the previous auction for maturities of type j and the yield awarded at that previous auction will inform bidders as they enter the auction at date t for securities of type j.

$$\begin{split} i_{t,j} &= a_{0,j} + a_1 BidCover_{t,j} + a_2 PrevIssue_{t-1,j} + a_3 AbsPurPD_{t,j} + a_4 AbsPurIndirects_{t,j} \\ &+ a_5 AbsPurDirects_{t,j} + \varepsilon \end{split}$$

 $i_{t,j}$: Auction yield at time t of U.S. Treasury security with maturity j

PrevIssue_{t-1,j}: the auction spread of maturity j from the previous auction (t-1) of maturity j

BidCover_{t,i}: the bid-cover ratio of the auction time t and maturity j

*AbsPurPD*_{t,j}: the dollar amount of Treasuries awarded to primary dealers at auction t of maturity j

*AbsPurIndirects*_{tj}: the dollar amount of Treasuries awarded to indirect bidders at auction t of maturity j

*AbsPurDirects*_{*tj*}: the dollar amount of Treasuries awarded to indirect bidders at auction t of maturity j

Several time periods and pools on maturities were run. The first regression considered the entire data set –all maturities all time periods, using dollar value allocated to each bidder class along with fixed effects by maturity type. Then, regressions for the full sample period were run separately for Bills and Bonds; the coefficients on Bills and Bonds differ statistically, and these results are presented below.

Then, we consider several different sub-periods of time chosen based on events. One sub-period break is defined by the first stock market tumble of the financial crisis (June 2007). A second

sub-period break is March 2009, when the Federal Reserve began direct purchases of long-term UST. ¹⁵ Tables below report the coefficients for the various sub-periods and for Bills and Bonds. Coefficients in red are not significant.

Our priors for signs are:

Bid-cover: Negative.

To the extent that a higher bid-cover indicates relatively greater demand for UST instruments, this sign should be negative. However, 'excess' bids mighte be presented with interest rates well above the auction high-yield. For example, consider a bi-modal distribution of bidders, one class that wants the bonds so badly its bids offer very low yields, and these get the full allocation, and another bidder class that really doesn't want the bonds, but is required to bid at the auction, so submits bids that demand very high yields. In this case, the bid-cover could be positively correlated with the auction high yield.

Previous Auction Spread: no obvious prior.

Suppose the previous auction spread is negative: the auction high yield is greater than the previous-day's market yield for the instrument at the previous auction for that maturity instrument. If yields mean revert, this information may induce bidders to 'bid low', bringing down the auction high yield at the present auction. On the other hand, if yields have momentum, the previous auction information could induce bidders to 'bid high' on the expectation that the auction high-yield is moving in the direction of the high-yield in the previous auction.

Amount bid by bidder class: negative

Controlling for the overall demand at the auction (bid-cover), and the allocations to the other bidder classes, then allocations received by a specific bidder classes should be negatively related to the high-yield.

¹⁵ Full set of regression results available on request.

	Auctions Before June 2007		Auctions After June 2007			
	All Maturities	Bills	Bonds	All Maturities	Bills	Bonds
bid cover	0.6234	0.5478	0.3915	-0.7471	-0.7171	-0.5523
prev-issu(t-1)	-14.0967	-14.5251	0.348	-0.0108	0.0947	0.0748
indirect	0.1843	0.4311	-0.2481	-0.1289	-0.1769	-0.0408
direct	0.2019	0.2827	-0.145	-0.10912	-0.1509	-0.1096
pd	0.0343	0.0195	-0.1328	-0.102	-0.1067	-0.1332
nob	755	613	142	955	717	238
R2	0.3729	0.512	0.4	0.6722	0.6851	0.7853

First consider the boom/post-boom break of June 2007.

<u>Bid-cover</u> has the unexpected positive sign in the boom for both maturities, reverting to the more expected negative in the post boom period.

<u>Previous auction spread</u> is the dominant driver of the ST auction high yield in the boom period, and becomes insignificant in the post boom period. Therefore, incorporating the previous AS in a forecast of the current auction yield could improve the forecast of the current auction yield. The previous AS is not significant in any of the Bond regressions, perhaps because these auctions are less frequent than Bill auctions, so there is more intervening macroeconomic information between auctions.

Bidder allocation:

Signs on bidder allocations are unexpectedly positive in the boom period for the ST instruments, further emphasizing the lack of desire for these ST instruments during a boom phase. For the post-boom period, the signs revert to as expected. The allocation to indirect bidders has a relatively larger role in determining the auction high yield.

For LT instrument pre and post boom, the bidder allocations signs are as expected. For the boom phase, the indirect bidders were the relatively more important bidders in the sense that the estimated relationship between auction allocation and auction high yield is the largest of the three bidder classes. The bids by this bidder class drove the high-yield down even though this class did not get the largest allocation. This suggests that the indirect bidders bids had disproportionately low interest rates offered in their bid. In the post-boom period, this behavior has apparently changed, or the behavior of the other bidder classes also changed.

	Auctions Before March 2009			Auctions After March 2009		
	All Maturities	Bills	Bonds	All Maturities	Bills	Bonds
bid cover	0.1136	0.0596	0.216	-0.0678	-0.0617	-0.4053
prev-issu(t-1)	-2.6713	-2.8708	0.9464	-0.0641	0.3993	-0.0751
indirect	-0.1087	-0.0906	-0.1959	0.0164	0.001316	0.06011
direct	-0.0577	0.04596	-0.1261	0.025	0.00896	0.05315
pd	-0.087	-0.0834	-0.164	0.0019	-0.0022	0.0358
nob	1097	885	211	613	445	169
R2	0.1905	0.1889	0.4887	0.0862	0.3919	0.3555

Now consider the break point based on Federal Reserve intervention:	March 2009. ¹	16
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<u>Bid-cover</u> is insignificant in the pre-QE period, and is a small negative during Fed intervention period. In comparing the two samples (June 2007 and March 2009 break), the bid-cover coefficient is much smaller during QE. Presumably, one of the objectives of QE is to set expectations, so perhaps the private bidders have a better idea of what the auction high-yield is going to be. Based on bid-cover ratios (as shown in previous charts) it is not the case that bidders stay away from the auctions—in fact bid-cover rises during this period.

<u>Previous auction spread</u> is significant for the ST auction high yield in the pre-QE period, but the coefficient is much smaller than in the boom period (prior to March 2009). In the Fedintervention period it becomes positive and significant. The smaller coefficient in the pre-March 2009 vs pre-June 2007 suggests that the information content of the previous auction spread to the current auction fell significantly. With regard to the small but significant positive coefficient in the QE period for ST instruments, QE was in the LT spectrum, but the language of the FOMC pointed to consistently low Federal Funds rate. Bidders may have cued on this language.

Bidder allocation:

Signs on bidder allocations are as expected sign during the pre-QE period. For all instruments, the coefficient on the indirect bidder allocation is the largest. For LT instruments, the coefficient is significantly larger than those for direct bidder and primary dealers in both boom and pre-QE periods.

¹⁶ The sample sizes start to be small, particularly for LT bonds to investigate the period between June 2007 and March 2009. The next version of the paper will consider this time period, at least for the ST bonds where there are 272 auctions.

During the QE period, the coefficients are smaller and positive. Since these same coefficients are small and negative in the period after June 2007, this suggests significant change in the behavioral relationships between June 2007 and March 2009.

The Figure below shows the coefficients by bidder class for Bond auctions for the boom period (pre-June 2007) and the pre-QE period, and then for the second part of the sample, for each of the bidder classes.



As already noted, indirect bidders – the proxy for foreign official buyers of UST securities have the largest coefficient before the financial crisis starts in June 2007. The negative coefficient is as expected: increased purchases by indirect bidders are negatively associated with the high yield awarded at the auction. But, recall that these bidders are awarded only about 25 percent of the auction. Therefore, their marginal dollar of a bid appears to be 'worth more' to bring down the auction high-yield than a dollar worth of bid by other bidder classes, particularly the primary dealers. This is consistent with bid that had much lower interest rates, as well collectively small size. These bidders must have really wanted the security to be willing to bid so low. (Although they also would recognize that the auction high-yield would surely be above their bid.)

The second observation is that the expected negative relationship between bidders and the auction yield disappears after QE starts. Increased purchases by bidders is associated with an increase in auction yields, not a decrease. This significant change in the behavior of the relationship between bidders and yields suggests that the Federal Reserve intervention into the UST market, specifically in the Bond market, altered the relationship between bidders and yields. This altered relationship appears across all bidder classes.

VII: Conclusion

This paper uses a unique auction-by-auction data set to study the relationship between bidder class and the yield at auction of UST over the time period 2003 to end 2011. We are particularly interested in the role for the indirect bidder, as that group is often a proxy for the demand by foreign official entities. Backed by the full faith and credit of the United States government, global investment flows into U.S. Treasuries have risen dramatically in recent years as global investors seek to invest their money for little risk, albeit also little return. As outstanding government debt has risen tremendously in recent years, the U.S. Treasury has come to increasingly rely on the appetite of foreigners, particularly official entities, for U.S. debt securities to finance both the current account deficit and fiscal budget deficit.

The regression results calculated for the time period of this study provide empirical evidence that foreign demand for U.S. Treasury securities sold at auction has a statistically significant relationship to the yield awarded at each respective Treasury auction. Moreover, we find that that relationship is larger than for these indirect bidders compared to the other bidder classes for Bonds, at least before the onset of direct intervention into the UST market by the Federal Reserve in March 2009. We find evidence that this intervention by the Federal Reserve has significantly altered the relationship between all bidders and yields at auction.

We also observe a systematic behavior of the auction yield to the difference between the auction yield and the previous day's matched-maturity yield. We find that this auction spread became increasingly negative (auction yield less than previous day's matched maturity yield) during the boom times, but narrowed and collapsed to zero in the Fed-intervention period. Our results suggest that bidders could use this information on the previous auction's spread to forecast auction yields in Bills auctions, but not Bond auctions. At least, anyway, before QE, at which point this forecastable component of the Bills auction is no longer present.

The purchase of U.S. Treasuries by the Federal Reserve as part of its quantitative easing policy may have obfuscated the demand by not only foreigners, but primary dealers and direct bidders as well. Our results suggest that the role for foreign bidders has been particularly important in the Bond markets. An important question is whether the foreign bidders will re-enter the Treasury market with the same importance when the Federal Reserve exits.

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