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North America Fixed Income Strategy
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The Hitchhiker's Guide to the Treasury Market

An in-depth overview of the US Government securities market

- The US Treasury market remains the largest and deepest fixed income market in the world: as of June 2016 outstanding marketable debt totaled $13.4tn, representing approximately one-third of the US fixed income market
- We provide an in-depth look at the Treasury market, focusing on the Treasury debt auction process, the types of securities issued by Treasury, the drivers of Treasury yields, as well as relative-value trading strategies in the Treasury market. We also discuss recent developments in market structure and liquidity
- The repo market plays a pivotal role in maintaining liquidity in the US fixed income markets, particularly Treasuries. We provide an overview of the market, discuss recent developments, and explain specialness and fails
- Treasury's debt management strategy aims to finance the federal government at the lowest cost to the taxpayer over time. To that end, one element of Treasury's financing strategy is to be a "regular and predictable" borrower, maintaining relatively stable auction sizes and bringing new issues to market with a set frequency. We review the supply announcement process, how to value when-issued securities, and auction mechanics
- We review Treasury bills, FRNs, TIPS, and STRIPS, discuss who trades these varied Treasury products, and explore their idiosyncratic drivers
- We delve into a valuation framework for Treasury yields across the curve. The stance of monetary policy has been the primary driver of Treasury yields over the longer term, but we discuss other factors which are influential on front-end, intermediate, and long-end Treasuries
- We discuss Treasury relative value—the process of determining richness or cheapness along the curve, net of fundamental drivers. We use the level of rates and the slope of the curve to identify macro relative value, and use our par-fitted curve to discern value in individual Treasury securities
- We review recent developments in Treasury market structure and liquidity. Turnover has slowed in recent years as trading volumes have not kept pace with the growth of the market over the same period. Changing demand dynamics have contributed to this, as the share of the Treasury market owned by foreign official institutions and the Fed has risen over the past decade. Market depth has rebounded from historically-weak levels but has become more sensitive to delivered volatility and is less resilient than in the past

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Introduction

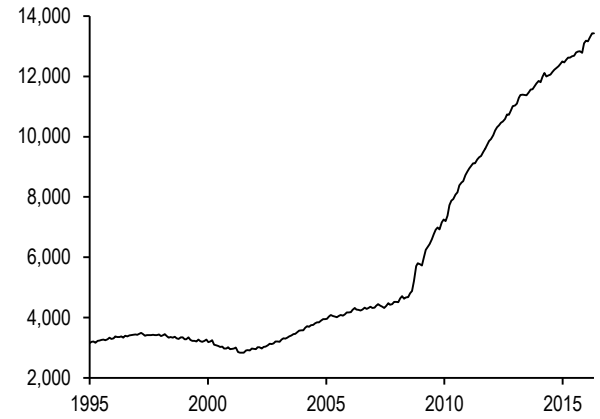
"*A national debt, if it is not excessive, will be to us a national blessing*," Alexander Hamilton, 1789

The US Treasury market remains the largest and deepest fixed income market in the world: as of June 2016 outstanding marketable debt totaled $13.4tn, representing approximately one-third of the US fixed income market. The Treasury Department auctions marketable debt in order to fund federal deficit spending, and the market uses Treasuries as a benchmark for pricing and hedging spread asset classes, given the large size, deep liquidity, and risk-free nature of this market. In recent years the Treasury market has also played a prominent role in the Federal Reserve's implementation of monetary policy: through large-scale asset purchases (LSAPs, also known as quantitative easing), the Fed more than tripled its Treasury holdings in an effort to add further monetary stimulus when the Federal funds rate was floored at 0%. The stock of outstanding Treasury debt has more than tripled over the past decade, as sharp increases in federal budget deficits during the Great Recession and the ensuing years drove Treasury's increased borrowing needs (**Exhibit 1**). However, this growth has slowed in recent years as the federal budget deficit has declined from a peak of $1.4tn in FY09 to $438bn in FY15.

The Treasury Department auctions five types of marketable securities: bills, notes, bonds, inflation-protected securities (TIPS), and Floating Rate Notes (FRNs). Treasury bills are securities with maturities ranging from a few days to 52 weeks, sold at a discount to their face value. **Notes** are securities that are issued with maturities of 2, 3, 5, 7, and 10 years and pay interest semiannually. **Bonds** mature in 30 years and also pay interest semiannually. **TIPS** provide investors with inflation protection, as principal is adjusted based on changes in the Consumer Price Index, pay interest semiannually, and are issued with maturities of 5, 10, and 30 years. **FRNs** pay interest that fluctuates based on discount rates for 13-week Treasury bills, are issued for a term of 2 years, and pay interest quarterly. We explore each product in more detail later in this publication.

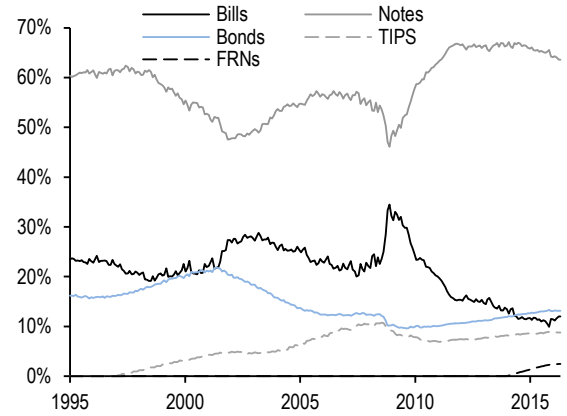
Exhibit 2 shows that Treasury notes account for nearly two-thirds of the Treasury market, while bonds, bills, and TIPS represent much smaller shares. FRNs, which were introduced in 2014, account for just 2% of the total Treasury market. Further, the exhibit shows how this composition has evolved over time. One notable trend has been in bills, which rose from a 21% share of outstanding debt in late-2007 to a 34% share a year later, as Treasury had to rapidly increase issuance to meet funding needs during the financial crisis. Since then, bills have fallen sharply as a share of total Treasury debt outstanding and now represent just 12% of the Treasury market.

Exhibit 1: The Treasury market has more than tripled in size over the last decade
Total outstanding marketable Treasury debt; $bn



Source: US Treasury

Exhibit 2: The share of T-bills outstanding has declined to historically low levels as TIPS and notes have grown
Treasury products as share of total outstanding marketable Treasury debt; %



Source: US Treasury

Treasury's primary debt management tenets are to be a regular and predictable borrower and to finance the federal government at the least expected cost over time. Treasury attempts to be transparent to the public in its debt management strategy and utilizes the quarterly refunding process as a way of communicating with market participants. The quarterly refunding announcement is traditionally made on the first

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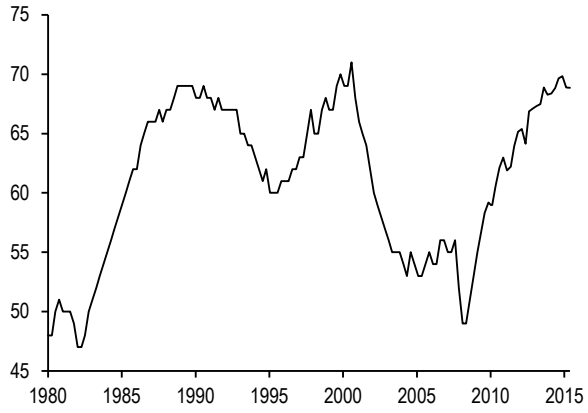
Exhibit 3: The WAM of Treasury's debt is near its longest level of the past 35 years

Weighted average maturity of marketable US Treasury debt; months



Source: US Treasury

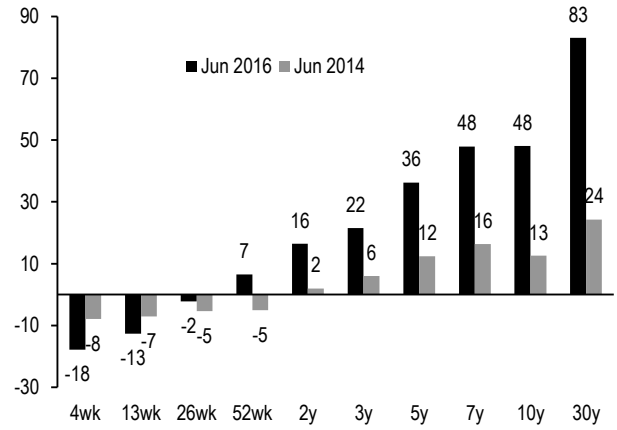
Wednesday of February, May, August, and November (or occasionally the last Wednesday of the prior month), and the mid-month Treasury auctions are held the following week. However, the process begins weeks prior, when the Treasury surveys the primary dealer community on pertinent topics in the Treasury market.[1] Treasury also meets with the Treasury Borrowing Advisory Committee (TBAC) in the days leading up to the refunding announcement. The TBAC is comprised of senior representatives from dealers, asset managers, and hedge funds, and presents recommendations on debt management issues to Treasury.[2]

For the first few years of the post-crisis era, Treasury's debt management strategy focused on increasing the weighted average maturity (WAM) of its debt in order to reduce rollover risk. As a function of this effort, the WAM of Treasury's debt has extended by 20 months over the last 7 years and now stands at the high end of its historical range (**Exhibit 3**). More recently, however, Treasury's funding goals have shifted to account for a number of other important considerations.

First, as term premia on average have been significantly lower at the front end of the curve, funding shorter would help Treasury minimize interest costs and save taxpayers money. **Exhibit 4** shows matched-maturity Overnight Index Swap (OIS) spreads for on-the-run Treasuries. To the extent that OIS rates represent future expectations for the Fed funds rate, Treasury/OIS spreads can be thought

Exhibit 4: With longer-dated Treasuries cheapening sharply versus OIS, making coupon cuts and increasing T-bill issuance will reduce Treasury's expected funding cost over time

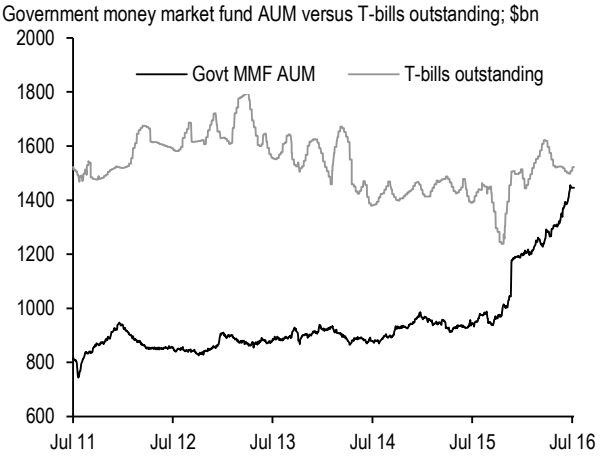
Matched-maturity Treasury/OIS spreads for on-the-run Treasuries, June 2016 average versus June 2014 average; bp



Source: J.P. Morgan

Exhibit 5: Government MMF AUM has increased more quickly than the size of the T-bill market, and there is room for more increases in supply over the balance of 2016

Government money market fund AUM versus T-bills outstanding; $bn



Source: US Treasury, iMoneyNet

of as the premium or discount to the risk-free rate at which the Treasury Department issues bonds. T-bills continue to trade rich relative to OIS, and this stands in stark contrast to the long end, where Treasuries have cheapened further and now trade more than 50bp cheap to OIS. We have argued that this cheapening is likely due to structural factors, including regulatory-driven balance sheet constraints (see Interest Rate Derivatives, *US Fixed Income Markets 2016 Outlook*, 11/25/15). All else equal, this suggests that Treasury should increase issuance at the front end, where it enjoys a premium relative to the long end of the curve.

[1] https://www.treasury.gov/resource-center/data-chart-center/quarterly-refunding/Pages/overview.aspx
[2] https://www.treasury.gov/resource-center/data-chart-center/quarterly-refunding/Pages/who-is-tbac.aspx

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Second, the decline in the share of T-bills noted earlier has occurred at the same time that demand has increased structurally from government money market funds (MMFs) as a result of the SEC's MMF reform finalized in July 2014 (see "SEC adopts MMF reform rules," Alex Roever, 7/24/14). **Exhibit 5** shows that Government MMF AUM has risen sharply since mid-2015, as a number of Prime funds have converted to Government status, and have grown faster than the T-bills market. Treasury announced at the November 2015 refunding that "demand for Treasury bills is high and is expected to continue to grow. Therefore, Treasury believes that it is prudent to increase the level of Treasury bills outstanding over the coming quarters. "As Treasury has previously indicated, the increase in bill issuance will help achieve our objective of lowest cost of funding over time and will also enhance market functioning and liquidity."[3]

Turning more broadly to demand for Treasuries, who are the largest participants in the market, and how has investor base evolved over time? **Exhibit 6** shows the ownership of Treasury securities, broken down by investor class at year-end 2015, compared with 2005 and 2010. Combined, **foreign investors and the Fed own nearly two-thirds of the Treasury market**, a 6.4%-pt increase from the end of 2010. This change in ownership has implications for Treasury trading dynamics: using Federal Reserve data on custody holdings of Treasuries, central banks represent at least 50% of total foreign ownership and largely utilize Treasuries for reserve management rather than active trading. Moreover, while the Fed can lend out holdings from its SOMA portfolio, it does not actively trade them, suggesting that the percentage of the Treasury market available for trading has fallen over the last five years. While daily Treasury trading volumes grew rapidly in the first decade of this century, peaking at $570bn/day in 2007, volumes leveled off in the period immediately after the financial crisis and have been on a declining trend since then, averaging $505bn to date in 2016 (**Exhibit 7**).

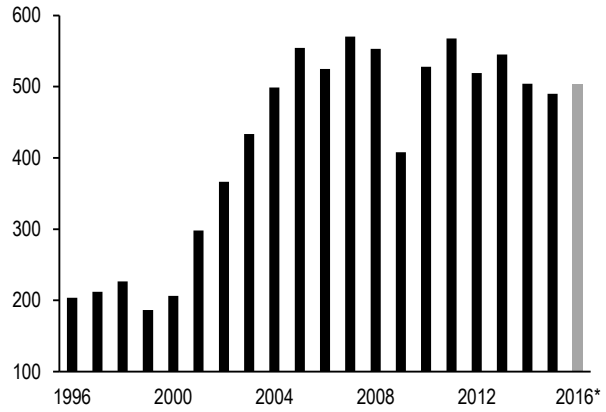
Over the following pages, we provide an in-depth look at the Treasury market, focusing on the Treasury repo market, the auction process, the types of securities issued by Treasury, the drivers of yields, as well as relative value trading strategies in the Treasury market. Lastly, we discuss recent developments in market structure and liquidity.

Exhibit 6: The Treasury market is increasingly owned by investors who trade these securities less actively...
Ownership of Treasury securities (excluding savings bonds) by investor type; %

Institution type	2005	2010	2015
Foreign	44%	48%	46%
Federal Reserve	17%	10%	19%
Household	6%	9%	8%
Money managers	4%	3%	5%
State and local govt	10%	8%	5%
Banking institutions	3%	3%	4%
Pension	8%	6%	4%
Money market funds	2%	5%	4%
Insurance companies	5%	3%	2%
Others*	1%	1%	1%
ETFs	0%	1%	1%
Broker dealers	-1%	2%	0%
Corporate	2%	1%	0%

* Includes GSEs, issuers of ABS, and holding companies
Source: Federal Reserve Z.1

Exhibit 7: …and after increasing sharply in the first decade of this century, trading volumes have leveled off
Average daily US Treasury market trading volumes, 1996-2016*; $bn



* Through 6/30/16
Source: Federal Reserve Bank of New York

Repurchase agreements

Treasury repo market overview

A repurchase agreement, or repo, is essentially a collateralized loan. One counterparty posts collateral in the form of some financial asset in order to borrow cash for a brief period of time from a cash-lending counterparty. At the end of the transaction, the borrower returns the cash to the lender plus interest and receives back the collateral posted at the beginning of the transaction. The repo market plays a pivotal role in maintaining liquidity in the US fixed income markets,

[3] https://www.treasury.gov/press-center/press-releases/Pages/jl0249.aspx

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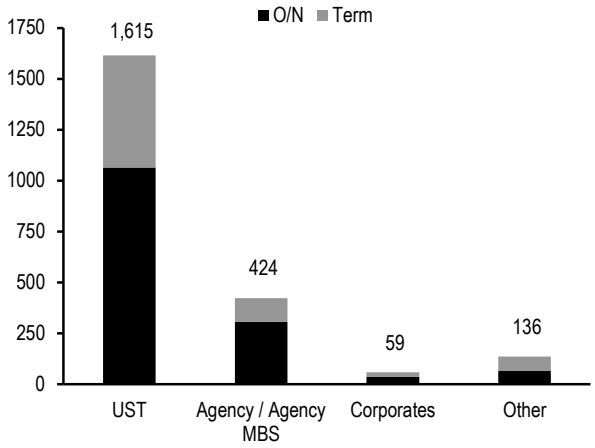
particularly the Treasury market: it allow dealers to finance long positions and source securities for setting shorts in order to perform their function as market-maker. Currently, repo secured by US Treasury collateral amounts to $1.6tn and comprises almost 75% of the total repo market (**Exhibit 8**). Treasury repos usually have very short maturities—nearly 70% mature overnight, and 80% mature within 30 days.

For end-users, repos allow cash borrowers to leverage their portfolios in order to obtain higher returns and lenders to invest excess cash into a relatively low-risk asset. The primary cash investors in the repo market are hedge funds, asset managers, securities lenders, and money market funds. The primary cash borrowers are securities dealers, prime brokerage clients, hedge funds, and the Federal Reserve via its overnight reverse repo (ON RRP) program.

Structurally, the repo market can be broken down into two primary segments: the bilateral repo market and the tri-party repo market (**Exhibit 9**). In the bilateral repo market, transactions are done directly between cash borrowers and lenders, and typically involve very specific collateral. In the tri-party repo market, one of two designated clearing banks (The Bank of New York Mellon or J.P. Morgan) will facilitate the collateral selection, custody and settlement between borrower and lender. In aggregate, we estimate the total size of the repo market to be roughly $2.2tn[4] ($1.5tn tri-party + $0.7tn bilateral).

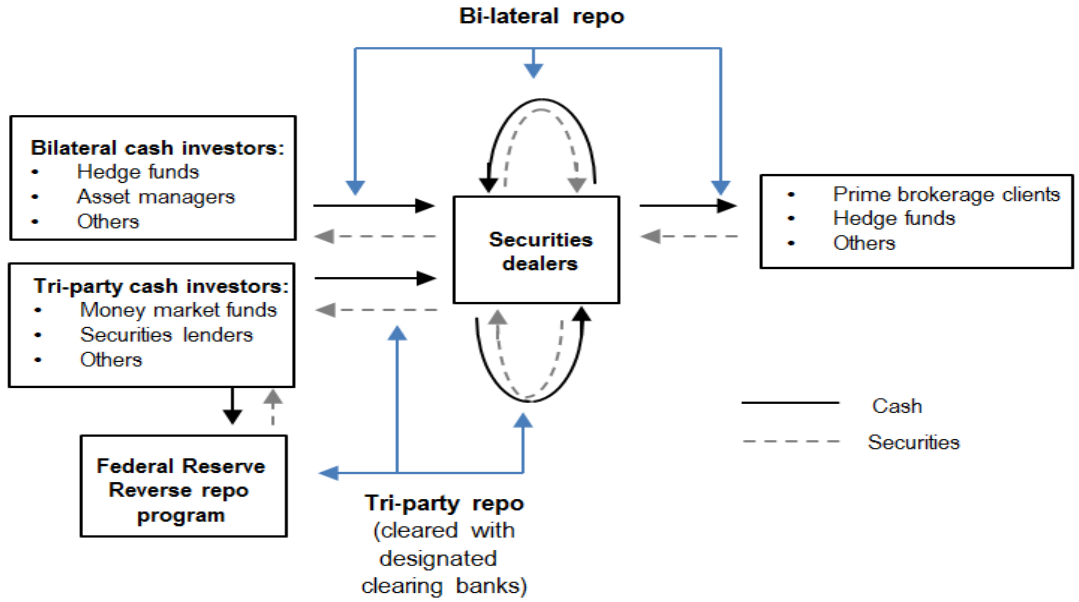
Exhibit 8: Almost 75% of all repo transactions are collateralized by US Treasury securities
Collateral and maturity breakout of repo market; $bn



Source: Federal Reserve Bank of New York

Outstanding balances of both Treasury repo and the broader repo market have fallen since the financial crisis (**Exhibit 10**). These declines are due in large part to post-crisis regulatory developments. Leverage and capital rules have made the repo business less profitable for many large banks, pressuring them to reduce their footprint in the market and consequently causing overall outstandings to fall over the past several years. However, with the rule-making process for most

Exhibit 9: The repo market is comprised of the bilateral and tri-party repo markets
Structural diagram of the repo market



Source: J.P. Morgan, Federal Reserve Bank of New York

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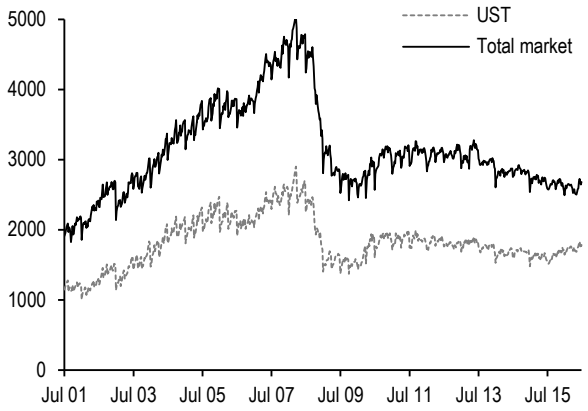
regulations complete and most banks already in compliance with the rules, we suspect that most large reductions by repo dealers have already been made and that repo supply may have reached a set point for the time being.

The effects of higher balance-sheet costs and reduced repo financing activities are also evidenced by the trends in repo market pricing. The most heavily watched rate in the repo market is the overnight Treasury general collateral (GC) rate. Overnight Treasury GC represents the rate for repo transactions in which the collateral can vary across a range of specified liquid Treasury securities, rather than one specific issue. As such, the GC rate is driven by the supply and demand for cash rather than the supply and demand for specific assets. Technically, there are two published overnight Treasury GC rates. The first is produced by the DTCC and represents a trade-weighted average of dealer-to-dealer or "GCF" repo—i.e., the rate at which dealers are willing to extend financing to each other. The second is produced by BNY Mellon and represents a trade-weighted average of dealer-to-non-dealer repo—i.e., where non-dealer end-users can invest cash. Importantly, dealer-to-dealer GCF transactions receive certain regulatory netting benefits, which have translated to increased usage, especially around key reporting dates such as quarter-ends. While these rates are highly correlated, there has been a growing gap between the two (**Exhibit 11**).

In addition to GC repo, there are also large sub-markets for repo collateralized by specific Treasury issues. Speculation and dealer hedging are two factors that drive demand for certain bonds. As such, repo rates for specific issues differ from GC rates in that they are dependent on the supply and demand of a given security. In fact, when specific collateral is in high demand, its repo rate may trade below the GC rate and even negative. When this occurs, the specific issue is considered to be "trading special." The lower a specific issue trades below GC, the more "special" it is.

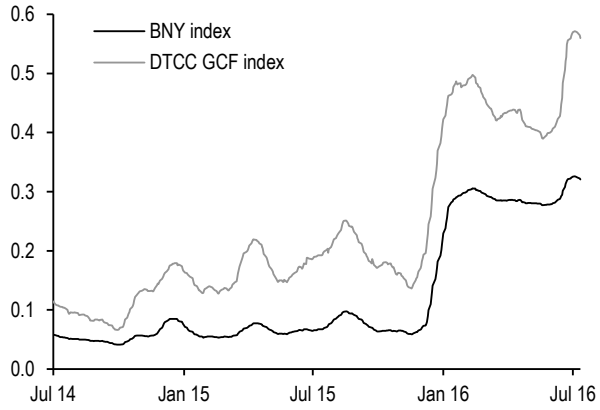
Several factors influence a given security's "specialness" relative to the GC rate. On the supply side, Treasury plays an important role. Based on its fiscal needs, Treasury can elect to increase/decrease auction sizes of any Treasury security. Decreases in the stock of a certain security would pressure its repo rate lower and vice versa. Furthermore, regulatory challenges facing dealers can reduce lendable repo supply in some securities as dealers seek to reduce inventories and optimize balance sheet. On the demand side, market sentiment plays a major role. After a large short base is built up around a certain point of the curve, market participants will bid more competitively for specific securities needed to cover their short positions when the market turns.

Exhibit 10: Broadly speaking, repo balances have declined since the financial crisis
Repo and securities lending outstanding balances*; $bn



* The Fed did not begin separating repo and securities lending within primary dealer report until 2013
Source: Federal Reserve primary dealer report

Exhibit 11: There has been a growing gap between dealer-to-dealer and dealer-to-non-dealer GC rates
BNY Treasury GC index vs DTCC Treasury GCF index, 1-month moving average; %



Source: Bank of New York Mellon, DTCC

In a scenario like the above where demand for a specific scarce security is high, it is not uncommon for repo transactions collateralized by the security to "fail" en masse. Consequently, a security's level of specialness and the number of failed contracts in the issue exhibit a strong correlation during periods of immense demand (**Exhibit 12**). A failed repo occurs when one party of the transaction fails to deliver the collateral specified in the repo's contract in time to settle the trade. There are several negative implications of repo trades failing. Mainly, collateral involved in a failed trade may have already been pledged in a subsequent trade which would cause that trade to fail as well, creating a cascade effect.

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As a means to prevent fails from occurring and to promote order within the repo market, the FICC now charges counterparties who fail to deliver collateral a penalty of 3% minus the target Fed funds rate.[5]

Supply process

Treasury's debt management strategy aims to finance the federal government at the lowest cost to the taxpayer over time. To that end, one element of Treasury's financing strategy is to be a "regular and predictable" borrower, maintaining relatively stable auction sizes and bringing new issues to market with a set frequency. More specifically, the timing of Treasury issuance on an intra-month basis depends on the tenor of the issue being offered:

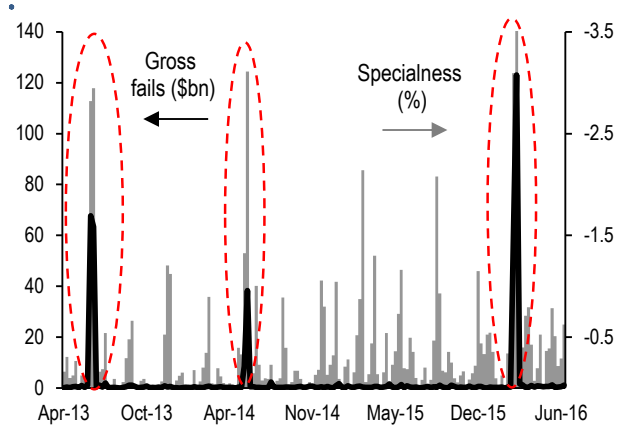
- T-bills are generally auctioned on a weekly basis, with the exception of the 52-week bill (once every four weeks). For 13- and 26-week bills, the auction typically falls on a Monday, while 4- and 52-week bills are auctioned on Tuesday.
- Nominal fixed-rate Treasury auctions are held over two separate weeks. Three-, 10-, and 30-year Treasuries are auctioned mid-month for settlement on the 15th (or the following business day), while 2-, 5-, and 7-year auctions are held at the end of the month for settle on the last day of the month (or the following business day).
- One TIPS offering is auctioned in the week between the mid-month and end-of-month nominal auctions and settle on the last business day of the month.
- The 2-year FRN is auctioned at the end of the month, alongside the 2-, 5-, and 7-year nominal auctions. New-issue FRNs settle on the last day of the month, while reopenings settle on the last Friday of the month.

Exhibit 13 shows the 2016 new-issue auction calendar for longer-term Treasury debt. New-issue 2-, 3-, 5-, and 7-year notes are auctioned monthly, while new 10- and 30-year nominals, as well as the 2-year FRN, are issued quarterly and subsequently reopened twice. New 5- and 30-year TIPS are auctioned on an annual basis, and new 10-year TIPS are auctioned semi-annually.

[5] See https://www.newyorkfed.org/medialibrary/microsites/tmpg/files/Fails-Charge-Trading-Practice-2016-07-13.pdf for background on the fails charge.

Exhibit 12: When demand is high, specialness and failed repo contracts of specific issues exhibit a high correlation

Gross fails vs specialness of on-the-run 10-year Treasury; $bn, %, inverted axis



Source: Federal Reserve, J.P. Morgan

Exhibit 13: Treasury auctions debt across the maturity spectrum in a "regular and predictable manner"

Monthly realized and projected gross coupon issuance schedule in 2016, reopenings shaded in grey; $bn

	2s	3s	5s	7s	10s	30s	5y TIPS	10y TIPS	30y TIPS	2y FRN	Total
Jan 16	26	24	35	29	21	13		15		15	178
Feb 16	26	24	34	28	23	15			7	13	170
Mar 16	26	24	34	28	20	12		11		13	168
Apr 16	26	24	34	28	20	12	16			15	175
May 16	26	24	34	28	23	15		11		13	174
Jun 16	26	24	34	28	20	12			5	13	162
Jul 16	26	24	34	28	20	12		13		15	172
Aug 16	26	24	34	28	23	15	14			13	177
Sep 16	26	24	34	28	20	12		11		13	168
Oct 16	26	24	34	28	20	12			5	15	164
Nov 16	26	24	34	28	23	15		11		13	174
Dec 16	26	24	34	28	20	12	14			13	171
Total	312	288	409	337	253	157	44	72	17	164	2053
CY15	312	288	420	348	264	168	50	82	23	164	2119
Diff.	0	0	-11	-11	-11	-11	-6	-10	-6	0	-66

Source: J.P. Morgan

The announcement and when-issued trading

The Treasury issuance process typically begins with the supply announcement. For most Treasury securities, this announcement is made in the week prior to the auction for most securities. The auction announcement specifies the size of the offering, CUSIP, issuance and maturity dates, and the type of security to be sold.

At the time of announcement, the security to be auctioned begins trading on a "when-issued" (WI) basis.

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Because the coupon on the security is not known during this period, the WI security trades on a yield basis, for settlement on the issue date of the new security. WI trading offers several benefits for the Treasury market. For auction participants, the WI trading period allows for greater price discovery ahead of the actual auction process. For dealers in particular, flows in the WI also allow them to better gauge demand for the upcoming auction. Finally, WI trading helps build liquidity in the new issue.

Because of differences in maturity, coupon, and interest accrual periods, the WIs are valued as a spread to the existing on-the-run issue, known as the WI roll. Buying the WI roll effectively means an investor will sell the current issue for regular settlement to buy the WI for settlement on the issue date. At a high level, roll valuations are driven by four distinct factors (**Exhibit 14**):

- **Carry/Financing cost**: an investor buying the WI will not accrue interest or pay financing costs until the new issue settles, whereas the investor will give up the carry on the on-the-run over the same period.[6] As a result, the carry for the existing on-the-run for the period between announcement and settlement is added to the yield, in order to compensate investors for not earning coupon income during the pre-settlement period.
- **Curve**: in upward sloping or inverted yield curve environments, the WI yield will differ from the current issue due to the duration difference between the WI security and the existing on-the-run. Changes in the expected coupon of the new issue will also impact the issue's duration and thus curve valuations.
- **Liquidity premium**: on-the-run securities are the most actively traded and liquid Treasury securities, and as a result tend to enjoy a liquidity premium relative to off-the-run securities.
- **Bad day adjustment**: for nominal Treasuries whose maturity date falls on a non-business day, investors will receive the principal and last coupon payment on the next business day (1-3 days after the stated maturity). Because of the delay, bonds with non-business day maturity dates tend to trade with a higher yield. Moreover, this tends to be more impactful for valuations in shorter tenors, as the delay represents a larger fraction of the total life of the security. All else equal, if the new-issue maturity falls on a non-business day, fair value of the roll is more positive, and if the current issue maturity falls on a non-business day, the fair value of the roll is less positive.

Exhibit 14: The WI roll is driven by a combination of carry, curve, liquidity premium, and bad day settlement adjustments

Fair value projections for WI 3-year Treasury roll; units as indicated

Current 3-year note	0.875%	Jun 15, 2019
Yield of current	0.680%	
Expected Amount	$24.0bn	
WI 3-year Maturity		Jul 15, 2019
WI Settle Date		Jul 15, 2016
Term Repo (%)*	-0.05	
Financing Cost (bp)	0.6	
Curve/liquidity (bp)	1.0	
Bad Days (current)	2	
Bad Days (WI)	0	
Bad Day Adjustment (bp)	-0.1	
Estimated Roll (bp)	**1.50**	
Expected Range (bp)	1.25 to 1.75	

* Term repo through the settlement date
Source: US Treasury, J.P. Morgan

Treasury auction mechanics

On the day of the auction, participants submit bids in either one of two formats: noncompetitive and competitive. Noncompetitive bids are guaranteed to be filled but give bidders no control over pricing—bidders receive their allotment at whatever level the auction clears. Noncompetitive bidders are generally retail in nature, and the share of noncompetitive bids represents a very small portion of the total auction offering.

Competitive bids at auction are conducted in a single-price, or Dutch, auction format. Bidders specify both the quantity to purchase as well as desired yield (to the nearest 0.1bp). The lowest-yielding bids are filled until the auction is completely sold, but all bidders are awarded the highest-yielding bid that is filled. **Exhibit 15** highlights this process. In the example, aggregate bids at a yield of 1.597% or lower exhaust the $34bn competitive offering size. As such, the auction clearing level is 1.597%, with all competitive bids lower in yield filled in full. At the clearing level, bids are partially filled on a prorated basis such that the total accepted bids equal the size of the offering.

At times, the Fed may also purchase Treasuries at auction. The Fed's System Open Market Account (SOMA) owns more than $2.4tn in Treasuries, and under the existing reinvestment policy, the Fed will reinvest the

[6] Financing costs are based on term repo rates through the settlement date.

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principal proceeds at auction as these holdings mature. Similar to non-competitive bidders, the SOMA is awarded securities at the same price for all competitive bidders. However, securities sold to the Fed are "added on" to the public offering amount; thus the amount sold to the public remains unchanged, and the additional amount sold to the Fed effectively upsizes the total outstanding of these securities.[7]

For new-issue Treasuries, the coupon is set at the nearest eighth of a percentage point, rounded down, ensuring that the security price is offered at or below par. However, in the event that the auction clears at a yield near zero or at a negative yield, the coupon is floored at 0.125%, and the bond will be issued at a premium. For scheduled reopenings, the spread or coupon is already known at the time of the auction and is thus independent of the reopening auction clearing level. Importantly, as rates fluctuate over time, it is possible that a new-issue security carries the same coupon and maturity date as a pre-existing issue that has rolled down the curve with the passing of time. In this scenario, the auction results in an unscheduled reopening of the older security, instead of trading independently with its own CUSIP.

Who participates at auctions?

Participants at auction fall under two broad categories: primary dealers and end users. Given the sheer amount of debt it must raise on a monthly basis to meet financing needs, Treasury relies on a system of banks and securities broker-dealers, known as primary dealers, in order to help facilitate the auction process.[8] In addition to their responsibilities as trading counterparties for the New York Fed in its open market operations, primary dealers are required to bid for a certain amount of the supply being auctioned. These bids may be placed for the dealers' own books, or on behalf of clients looking to participate in the auction.

Given their role in the supply process, primary dealer participation tends to fluctuate with Treasury financing needs, rising as issuance picks up, and falling as borrowing needs wane. Dealer takedown of Treasury is also inversely related to the strength of end-user demand, falling as investor appetite for Treasuries rises, and vice versa. As **Exhibit 16** shows, dealer participation across the curve increased immediately following the crisis, as Treasury ramped up issuance to fund larger budget deficits. However, dealer takedown has been declining over the past 3-4 years, largely driven by greater demand from end users. To a lesser extent, dealer participation post-crisis has also been adversely impacted by a combination of lower dealer risk appetite as well as growing costs of capital to hold Treasury inventory (see "Market structure and liquidity" below).

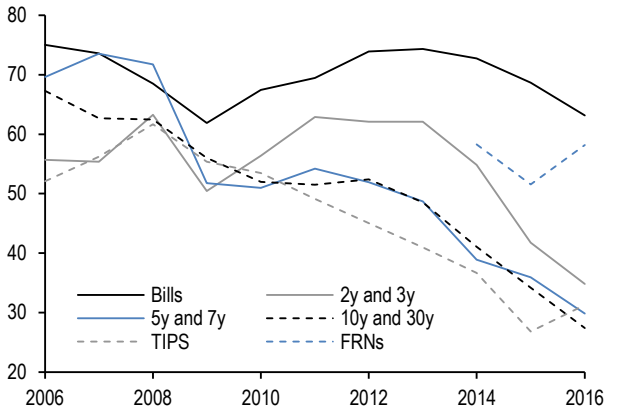
Exhibit 15: Example auction bidding structure for a $34bn offering*

Auction bid (%)	Total size ($bn)	Cumulative bids	Filled?
1.590	2.0	2.0	Yes
1.591	3.0	5.0	Yes
1.592	5.0	10.0	Yes
1.593	9.0	19.0	Yes
1.594	6.0	25.0	Yes
1.595	5.0	30.0	Yes
1.596	3.0	33.0	Yes
1.597	3.0	36.0	Partial
1.598	4.0	41.0	No
1.599	2.0	43.0	No
1.600	3.0	46.0	No
Bids accepted ($bn)			34.0
Bids tendered ($bn)			46.0
Bid-to-cover			1.35
Tenders allotted at high			33.3%

* Example assumes no noncompetitive bids
Source: J.P. Morgan

Exhibit 16: The dealers' share of auction allotments has declined in recent years, driven in part by reduced funding needs, increased end-user demand, and lower dealer risk appetite

Dealer* participation at auction by product type, annual average**; %



* Includes primary dealers, other commercial bank dealer departments, and other non-bank dealers and brokers
** 2016 figure reflect January through June data
Source: US Treasury

[7] See *US Treasury Market Daily*, 1/4/16
[8] See https://www.newyorkfed.org/markets/primarydealers.html for a list of primary dealers and background information on their relationships with the Federal Reserve and Treasury.

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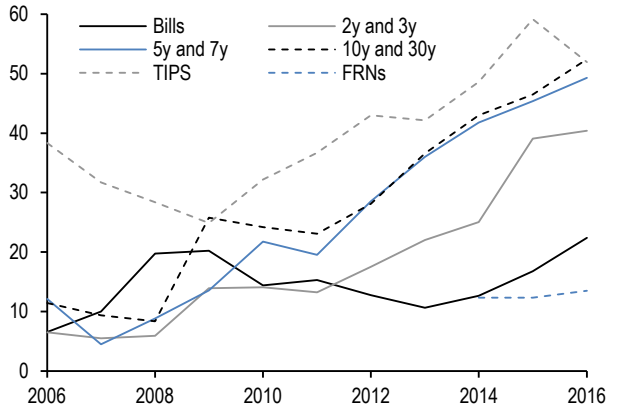
Amongst end users, investment managers are generally the largest source of demand at auction, particularly in coupon Treasuries (**Exhibit 17**). Notably, sponsorship from investment managers has trended higher in the post-crisis years, driven by a combination of the growth of Treasuries as a share of the investable fixed income universe, as well as the growth in assets under management.

International investors also comprise a large share of Treasury auction allotments. For the official sector, demand is driven primarily by the pace of FX reserve accumulation but can also be influenced by risk appetite. **Exhibit 18** shows the trend in foreign sponsorship of Treasuries across the curve: foreign demand for the front end and intermediate sector peaked in 2009, likely driven by a flight-to-quality bid for Treasuries during the financial crisis. International investors have also been regular participants at long-end and TIPS auctions: foreign participation at auction has steadily trended higher over the last decade.

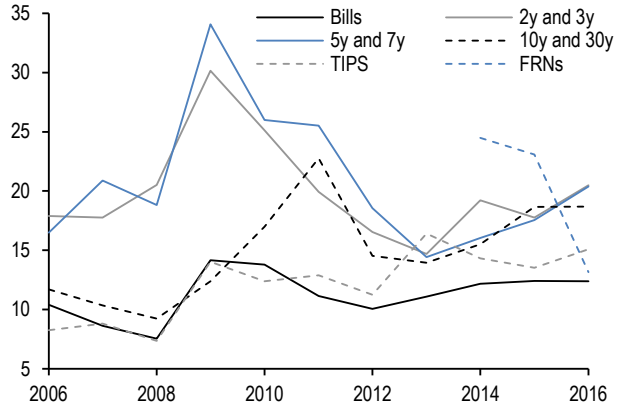
Away from these major investor classes, who else participates in Treasury auctions? Treasury's detailed auction allotment data shows that commercial banks, pension and retirement funds, and individuals also purchase Treasuries through the auction process.[9] However, for the most part these investor classes comprise a very small portion of primary demand.

Exhibit 17: Investment manager demand has trended higher as assets under management have grown
Investment manager participation at auction by product type, annual average*; %



* 2016 figure reflect January through June data
Source: US Treasury

Exhibit 18: Foreign participation at auction declined earlier this decade but has increased in recent years
Foreign investor participation at auction by product type, annual average*; %



* 2016 figure reflect January through June data
Source: US Treasury

Product overview

1. Notes and bonds

As discussed earlier, notes and bonds make up the lion's share of the Treasury market: as of mid-2016, they accounted for 77% of the outstanding marketable debt (Exhibit 2). Notes and bonds also account for more than 80% of the share of trading volumes in Treasuries: **Exhibit 19** shows the distribution across various sectors, and show that in notional terms, intermediates comprise the largest share of daily trading volumes across the curve, led by the 3- to 6-year and 7- to 11-year sectors. This makes sense, as the duration of many investment grade bond indices are close to 6 years. While notes and bonds represent that majority of trading and stock in the Treasury market, we detail all other products here, and then discuss our valuation framework for nominal Treasuries below (see "Key drivers of yields" below).

2. Treasury bills

Treasury bills are different from other Treasuries in that they are not coupon-bearing instruments: they are sold at a discount to their par amount and pay interest at maturity. The interest paid is equivalent to the par value minus the purchase price of the T-bill. The Treasury Department auctions T-bills in four main maturities: 4-week, 13-week, 26-week, and 52-week: 13-, 26-, and 52-week bills are announced on Thursday for auction the following week, while 4-week bills are announced on Monday for auction on Tuesday (**Exhibit 20**). In addition, Treasury also auctions Cash Management Bills (CMB) in various tenors, in order to help manage its cash flows when the traditional suite of bills does not adequately meet these needs.

[9] https://www.treasury.gov/resource-center/data-chart-center/Pages/investor_class_auction.aspx

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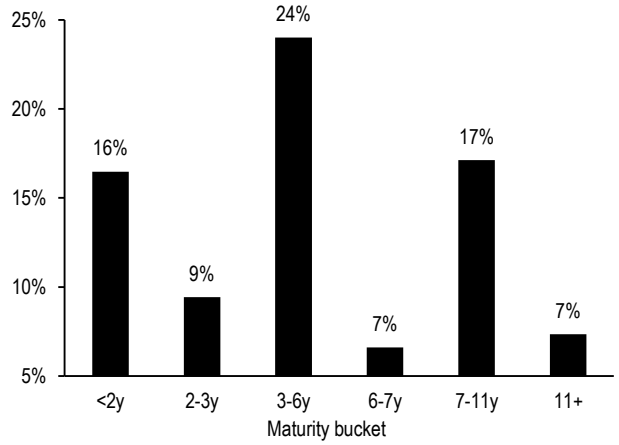
Exhibit 19: Treasury notes and bonds account for more than 80% of trading in Treasury securities, with the bulk focused in intermediates

Average daily trading volumes in Treasury coupon securities by sector as a share of total Treasury trading volumes, 2016 average; %



Source: Federal Reserve Bank of New York

Treasury primarily uses T-bills as a cash management tool. Seasonally, the smallest primary deficits come in months when Treasury receives corporate tax receipts (March, June, September, and December), estimated individual tax payments (June, September, and January), and individual income tax receipts (April), while primary deficits are larger in all other months. Conversely, T-bill issuance tends to mirror this pattern, with net issuance highest in months in which the federal government runs the largest primary deficits (**Exhibit 21**). What creates this need? Treasury's issuance calendar in notes, bonds, TIPS, and FRNs varies only slightly from month to month, in an effort to remain a reliable and predictable borrower, and it is easier to increase or decrease bill issuance on a weekly or monthly basis to smooth out the seasonality of the federal government's cash flows.

Who trades Treasury bills? **Exhibit 22** shows that foreign investors and money market funds are the dominant players in the market, together owning more than 60% of the stock of outstanding T-bills. The Fed, which owned more than 20% of the T-bill market a decade ago, now holds no Treasury bills in the SOMA portfolio. During the throes of the financial crisis, the Fed ran down its short-term holdings in order to ramp up its liquidity facilities, and then only focused on buying longer-term Treasuries during its large-scale asset purchase programs.

3. Treasury FRNs

Treasury formally introduced 2-year FRNs at the November 2013 quarterly refunding announcement, the first new product that Treasury brought to market in 17 years, and FRNs were first auctioned in January 2014.[10] We published an extensive note on the structure of Treasury FRNs in 2013 before they were first brought to market (see "Treasury FRN Primer," 11/13/13). These securities are daily-reset floaters, indexed to the High

Exhibit 20: Most T-bills are auctioned weekly, though 1-year bills are auctioned every four weeks

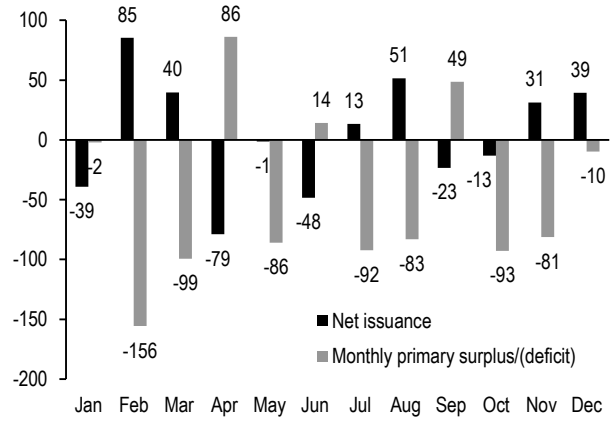
Treasury bills auction schedule

Term	Auction Frequency	Announcement	Auction
4-week	Weekly	Monday	Tuesday
13-week	Weekly	Thursday	Monday
26-week	Weekly	Thursday	Monday
52-week	Every four weeks	Thursday	Tuesday

Source: US Treasury

Exhibit 21: Seasonally, the federal government tends to run larger deficits in months where tax receipts are low and T-bills fill the net issuance gap during these months

Monthly primary surplus/ (deficit)* and monthly Treasury bill net issuance; average of FY06-FY15; $bn



* Primary surplus/ (deficit) is revenues less expenditures, excluding interest payments
Source: US Treasury

Exhibit 22: Foreign investors and MMFs own nearly two-thirds of the Treasury bill market

Treasury bill ownership by investor type; %

Investor type	2005	2010	2015
Foreign	22%	40%	48%
Insurance Co.	3%	1%	2%
MMFs	6%	13%	15%
Mutual Funds	N/A	2%	2%
Federal Reserve	21%	1%	0%
Others	48%	43%	32%
Total	**100%**	**100%**	**100%**

Source: Federal Reserve

[10] While only 2-year FRNs are currently offered, Treasury could issue any maturity between one and ten years, based on its 2013 final rule.

Rate from the most recent 13-week Treasury bill auction (applied with a 1-day lag), and interest is paid quarterly.[11] Each day's interest accrual is calculated based on the reference rate plus a spread and is subject to a 0% floor. The 13-week bill auction occurs weekly on Mondays, or the first business day of the week, so although the accrual rate resets each business day, the reference rate changes only once per week. The spread is determined in the initial FRN auction and is the number of basis points necessary to set the initial auction price close to par. It can be positive, zero, or negative and is rounded to the nearest tenth of a basis point. Once determined, the spread will not change over the life of the security—the spread on reopened FRNs will be the spread determined in the first auction of that security.

Additionally, there is a 2-day lockout period prior to the auction settlement date and quarterly interest dates: a 13-week bill auction that becomes effective during this period is ignored until after the issue date or interest date, and the rate in effect will instead reference the previous 13-week bill auction.

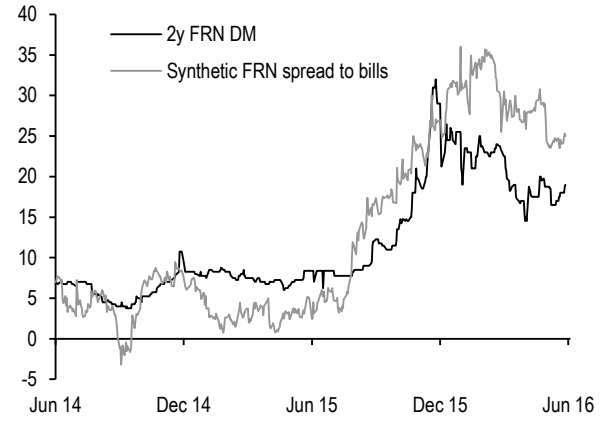
Treasury auctions new FRNs quarterly, with two monthly reopening between new auctions—currently in the sizes of $15bn and $13bn, respectively. Original issue offerings settle on the last calendar day of a month (or the first business day thereafter), while reopenings settle on the last Friday of a month (or the first business day thereafter). The auction process and mechanics are similar to other government securities, with Treasury announcing the offering on the Thursday prior to the auction, allowing for a WI trading period, and FRNs are auctioned in a single price format (see Treasury auction process: mechanics and participants). In contrast though, competitive bids are submitted in terms of a desired discount margin relative to the reference rate, rather than yield.

Relative pricing

How should we think about the relative pricing of Treasury FRNs? We can think about recreating the same cash flow stream in two different ways. **First**, an investor could buy 13-week bills and roll them every week for the next two years, thereby earning the same as the FRN index rate. However, in this case, the investor would pay bid-offer to stay current in bills each week, suggesting that the FRN DM would theoretically need to trade in negative territory to make an investor indifferent between the two options. **Second**, an investor could buy similar maturity fixed-rate Treasuries, swap to floating, and enter into a Libor/T-bills basis swap.

Exhibit 23: Treasury FRNs traded near swapped fixed-rate Treasury notes until the end of 2015 and have since richened

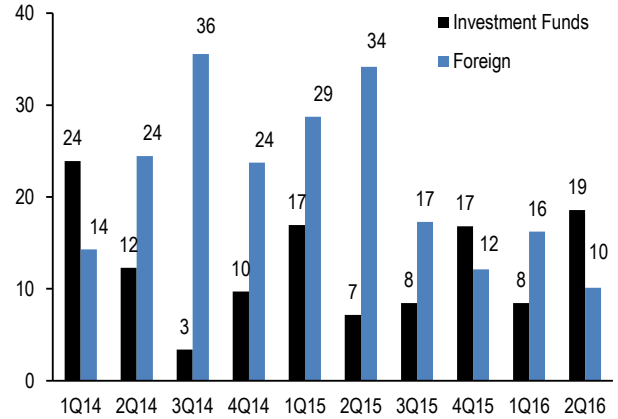
2-year FRN discount margin (DM) and synthetic FRN spread to bills;* bp



* 2-year Treasury yield – 2-year swap rate + 2-year libor/T-bills basis
Source: J.P. Morgan

Exhibit 24: Foreign demand for FRNs at auction has fallen from recent highs

2-year Treasury FRN auction allotments to foreign investors and investment funds; %



Source: US Treasury, J.P. Morgan

Exhibit 23 shows 2-year FRN DMs compared with the spread to T-bills for the synthetic FRN. A few observations are worth noting. In the first year and a half of trading, FRNs traded in a narrow range, with a DM of about 4-10bp over bills. Moreover, the FRN DM largely tracked the synthetic FRN, albeit at a modest discount. In late 2015, both the FRN DM and synthetic spread widened significantly, suggesting that both 2-year FRNs and 2-year fixed-rate notes cheapened materially relative to bills. Lastly, since the end of last year, while 2-year

[11] The High Rate is the stop-out rate at which the bill auction prices, converted to a simple-interest money market yield using an actual/360 basis. See term sheet here: https://www.treasurydirect.gov/instit/statreg/auctreg/FRNTermSheet.pdf.

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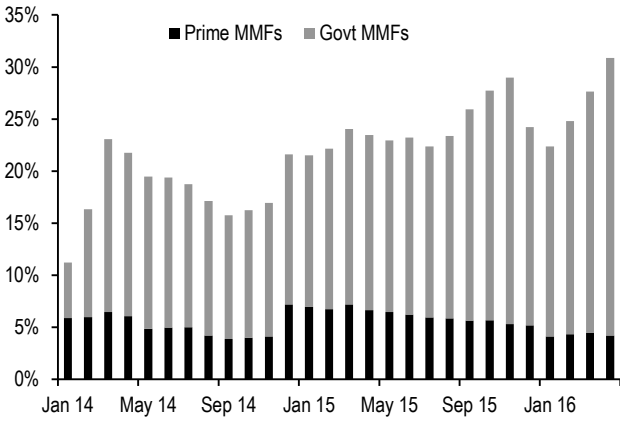
Exhibit 25: MMFs' ownership share of Treasury FRNs has steadily increased since the product's inception
MMF holdings of total Treasury FRN market; %



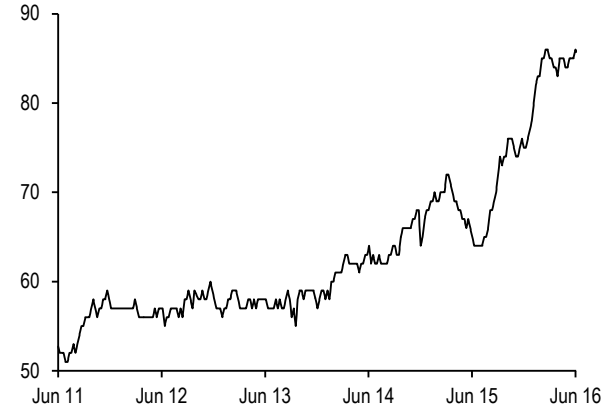
Source: Crane data

fixed-rate notes remained cheap, FRNs have richened, with the DM currently trading near 18bp.

The cheapening in both securities through late 2015 were likely driven by the same key factors: the accelerated FX reserve liquidation by the foreign official community primarily, as well as heightened balance-sheet costs, exacerbated by month-end G-SIB measurement dates from July to September (see "Dogs and cats living together," Joshua Younger, 11/5/15). Foreign official institutions tend to focus their Treasury holdings in the short to intermediate sector, and therefore reduced foreign demand was felt at the front end as well as in FRNs. **Exhibit 24** shows that primary demand from foreign investors for FRNs fell nearly 20%-pts from 2Q15 to 4Q15, leaving balance-sheet constrained dealers to take down more of the supply. More recently, foreign investor participation has stabilized somewhat.

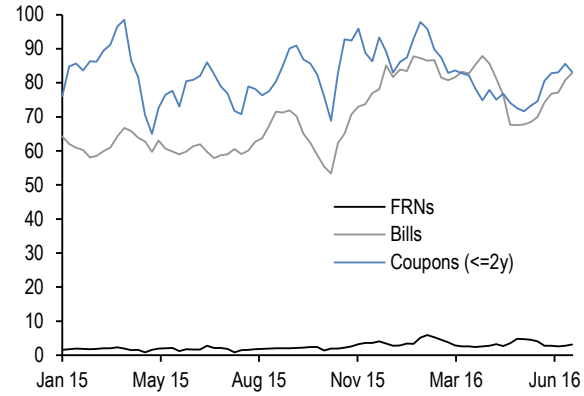
More generally, the composition of investor demand is an important difference between bills, FRNs and fixed-rate notes. MMFs have historically been among the largest buyers of Treasury bills and short-dated Treasury coupons. Since the introduction of FRNs, they have become significant holders of the product—they now own 31% of outstanding Treasury FRNs, up from 24% at year-end 2015 (**Exhibit 25**). However, their ability to own 2-year FRNs is limited: under the SEC's 2a-7 rule, MMFs are subject to a 120-day weighted average life (WAL) limit and cannot hold securities with a maturity greater than 397 days. While the maturity of 2-year FRNs under this rule is considered to be just 1 day, reflecting the daily reset period, its "life" reflects the full 2-year maturity.

Exhibit 26: The WAL of Treasury-only MMFs is at historic highs, constraining their ability to buy FRNs
Weighted Average Life for Treasury MMFs; days



Source: iMoneyNet

Exhibit 27: Trading volume of FRNs is a fraction of that of T-bills and short-maturity coupons
Average daily primary dealer transactions in FRNs, T-bills, and notes with maturities of 2 years or less; $bn



Source: Federal Reserve Bank of New York

As FRNs cheapened significantly relative to bills into the end of last year, MMFs shifted their holdings. **Exhibit 26** shows that the WAL of Treasury-only MMFs is near historic highs, extending to 86 days from 65 days over the past year. Since MMFs represent a significant part of the investor base for short-duration Treasuries and need to be compensated for extending their WAL, this likely contributes to FRNs' persistent discount to bills that we have observed.

Lastly, relative pricing also reflects differences in the liquidity of each product. The average daily trading volume of FRNs is roughly 3% of the volume of short-maturity fixed rate notes and roughly 4% of the volume of bills (**Exhibit 27**). Therefore it is perhaps unsurprising that the pricing of FRNs has been highly correlated with the relative cheapening of fixed-rate

notes. Over the past 2 years, FRN DMs have exhibited an 85% correlation with the level of 2-year Treasury/OIS spreads. For every 10bp 2-year notes cheapen relative to OIS, FRN DMs tend to widen by 6bp. Note that the low relative liquidity of FRNs also likely contributes to the persistent discount relative to bills, as well as the discount to fixed-rate notes that persisted prior to mid-2015.

With only a short history of trading data, we have a limited ability to draw broader conclusions about how this product trades under various conditions. However, given the differences in liquidity and demand profiles discussed, we continue to expect FRNs to trade cheap relative to bills but rich relative to similar maturity fixed-rate notes over the near term.

4. TIPS[12]

How do TIPS work?

Treasury Inflation-Protected Securities (TIPS) are structured to provide inflation-protected cash flows to investors. This is achieved by indexing the principal of a TIPS security to the US headline CPI non-seasonally adjusted series (CPURNSA Index on Bloomberg) published by the Bureau of Labor Statistics (BLS). Thus, the principal of a TIPS increases with inflation and decreases with deflation, with the semiannual coupons calculated as a fixed percentage of this inflation-adjusted principal.

Since CPI for a given month is released about two weeks after the end of that month, **TIPS principals are indexed to CPI with a 3-month lag**. For example, the principal on June 1 is based on March CPI, and the principal on July 1 is based on April CPI. On any day between June 1 and July 1, the reference CPI value is calculated by linearly interpolating between the March and April CPI values.

At maturity, holders of TIPS are paid the adjusted principal or the original principal (par), whichever is greater. Effectively, this means that TIPS have an embedded floor on the principal amount. **Exhibit 28** shows the cash flows of a hypothetical 5-year TIPS based on the given CPI scenario. Note that the principal decreases over year 2 because of realized deflation, so the coupon paid at the end of year 2 is smaller than the coupon from year 1.

Exhibit 28: Hypothetical cash flows of a 5-year TIPS security

Hypothetical cash payments of a 5-year TIPS issued at par with a 2% real coupon based on given CPI index reference values

Year	CPI index	YoY inflation	Inflation-adjusted principal	Coupon (2% real)
0	201.8		100	
1	210.0	4.08%	104.08	2.08
2	207.0	-1.45%	102.58	2.05
3	213.0	2.90%	105.55	2.11
4	218.0	2.35%	108.03	2.16
5	223.0	2.29%	110.51	2.21

Note: For simplicity purposes, we have assumed annual coupon payments, whereas actual TIPS pay semiannual coupons.
Source: J.P. Morgan

How do TIPS trade?

TIPS are quoted on a **real price/real yield basis**, and they trade on a T+1 settlement basis like nominal Treasuries. Real yields are derived in the same way as fixed-coupon nominal Treasuries, using the "real" cash flows (real price, real coupons, and par at maturity) to calculate a real IRR.

When executing a cash transaction in TIPS, the real dirty price of the bond needs to be adjusted by a daily indexation factor (a multiplier that accounts for the cumulative inflation since the issue date). This indexation factor is the ratio between today's reference CPI value and the value on the day the bond was originally issued.[13]

What is the TIPS "breakeven?"

Although TIPS trade on a real yield basis, market participants more often look at the implied **inflation breakeven, or the average annual inflation needed over the life of the TIPS in order for it to provide the same return as a nominal Treasury with the same maturity**. We approximate this breakeven rate as the similar-maturity Treasury yield minus the TIPS real yield, typically quoted in basis points. **Exhibit 29** illustrates the breakeven curve.

A position in the breakeven spread is established by buying (selling) TIPS and selling (buying) a DV01-matched amount of Treasuries. Usually a 1:1 risk ratio is used, but other ratios can be used if the investor believes TIPS will be more/less volatile than Treasuries or if the investor wants to express a certain duration view in the

[12] For a more in-depth introduction to TIPS, please see "An Introduction to TIPS and US CPI Derivatives," Kimberly Harano, 4/8/15.

[13] A list of daily TIPS index ratios can be found on Treasury's website: http://www.treasurydirect.gov/instit/annceresult/tipscpi/tipscpi.htm

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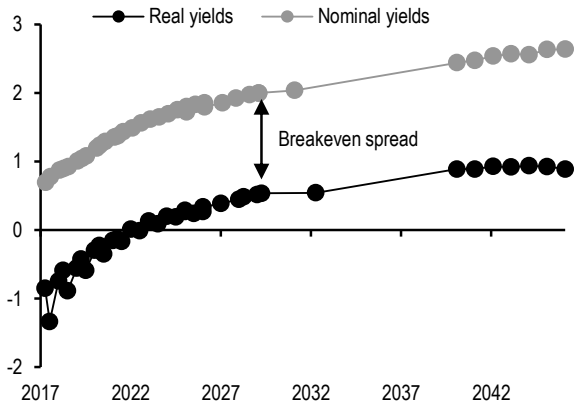
Exhibit 29: The breakeven is the spread between a TIPS real yield and a similar-maturity Treasury yield
TIPS real yield curve and yield curve of similar-maturity nominal Treasuries; %



Source: J.P. Morgan

breakeven trade. In addition to trading breakevens themselves, investors can also take views on the breakeven curve or on the breakeven spread differential between two or more bonds (by trading "switches").

Market participants, as well as the Federal Reserve, use TIPS breakevens as a market-based measure of inflation expectations. In particular, investors and the Federal Reserve regularly monitor the 5yx5y forward breakeven measure derived from par Treasury rates, though in recent years, the Fed has also relied on survey-based measures of inflation expectations, such as the University of Michigan survey (**Exhibit 30**).

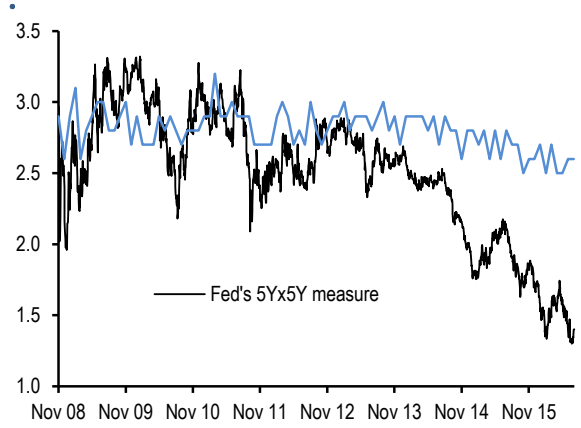
How liquid are TIPS?

Although the TIPS market has been around for almost twenty years and is about $1.2 trillion in size, TIPS remain far less liquid than their nominal counterparts. Over recent years, daily trading volume with primary dealers has increased, averaging about $16bn/day in 2016, which equates to about 1.3% turnover each day (**Exhibit 31**). In contrast, daily trading volume in nominal Treasuries has been around $510bn/day, or about 4.3% daily turnover.

Seasonality in CPI and TIPS relative value

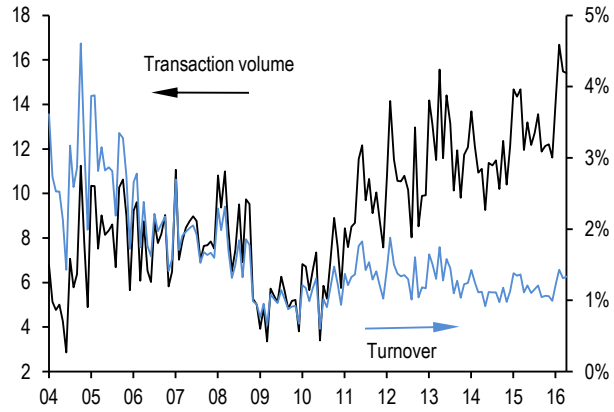
Since TIPS are indexed to non-seasonally adjusted CPI, seasonal variations in headline inflation impact the pricing of TIPS that mature in different months of the year. As **Exhibit 32** shows, CPI seasonals tend to be very positive for TIPS in the first few months of the year, moderate in the middle of the year, and turn very negative in the last quarter of the year. Because of the lag in the indexation process, this means that July TIPS mature after several months of positive seasonals, while

Exhibit 30: Survey-based measures of longer-term inflation expectations have been more stable than market-based measures
Federal Reserve measure of the 5yx5y breakeven inflation rate versus University of Michigan survey: median price expectations over 5-10 years; %



Source: University of Michigan/Thomson Reuters, Federal Reserve

Exhibit 31: TIPS are not as liquid as Treasuries
4-week average of primary dealers' daily transaction volume in TIPS versus daily turnover*;
$bn/day %



* Daily transaction volume divided by TIPS outstanding
Source: US Treasury, Federal Reserve Bank of New York

January and April TIPS mature when CPI seasonals are negative. **As a result, July TIPS trade rich relative to January and April TIPS with similar maturities**. This effect is more pronounced in shorter-maturity TIPS: for example, a 0.82%-pt April-versus-July CPI differential is worth 41bp for Apr-18 and Jul-18 TIPS, but it is only worth 21bp for Apr-20 and Jul-20 TIPS (**Exhibit 33**).

Value of the inflation floor in TIPS

When expected future inflation is well above zero, the embedded floor on TIPS principal (floored at par at maturity) is usually worth very little because the option is far out-of-the-money. As **Exhibit 34** shows, the estimated values of the embedded floors currently range

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between 0-4bp of yield. These floors tend to decline in value as issues age and their index ratios rise above 1.0 (par) due to accrued inflation. The floors in recently-issued 5-year TIPS tend to be worth the most because their implied forward index ratios tend to be closest to 1.0.

However, when expected future inflation is close to zero, the inflation floor on newly-issued TIPS can become quite valuable, as we saw during the financial crisis. For most of 2008 Apr-13 TIPS (a newly issued 5-year TIPS with an index ratio close to 1.0) and Jul-13 TIPS (an old 10-year TIPS with an index ratio around 1.15) were trading basically on top of each other (**Exhibit 35**). However, when the financial crisis intensified and inflation swaps began to price in zero inflation/deflation over the next 5 years, the embedded floor on Apr-13 TIPS became in-the-money, and Apr-13 TIPS richened substantially relative to Jul-13 TIPS. As inflation swaps rebounded, however, the Apr-13 TIPS floor became less valuable, and this differential narrowed.

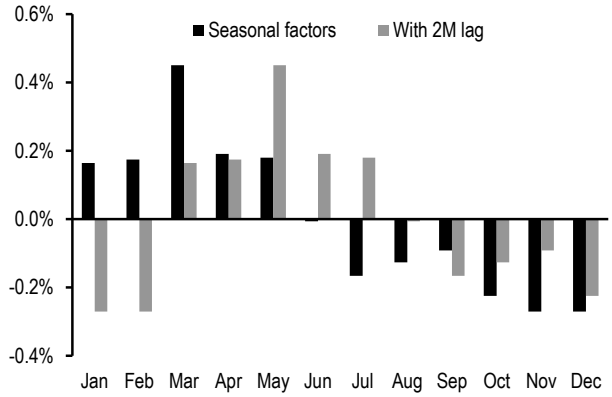
Who trades TIPS?

Other than the auction demand data, there are very little data available on the major holders of TIPS, because most data sources (such as the Fed's Z.1 Financial Accounts of the U.S. or the Treasury International Capital System) do not separate TIPS from nominal Treasuries. Based on auction data and anecdotal evidence, however, we can draw a few conclusions regarding the major investors in TIPS.

In auctions, **real money** accounts have become the dominant buyer of TIPS. TIPS are *not* included in commonly-followed benchmark aggregate indices, but some core bond funds using these indices may still

Exhibit 32: Seasonality in headline CPI...

Difference between non-seasonally adjusted and seasonally-adjusted monthly changes in headline CPI averaged by calendar month over 2006-2015, and with 2-month lag; %



Source: Bureau of Labor Statistics, J.P. Morgan

Exhibit 33: ...causes July TIPS to trade rich to April and January TIPS

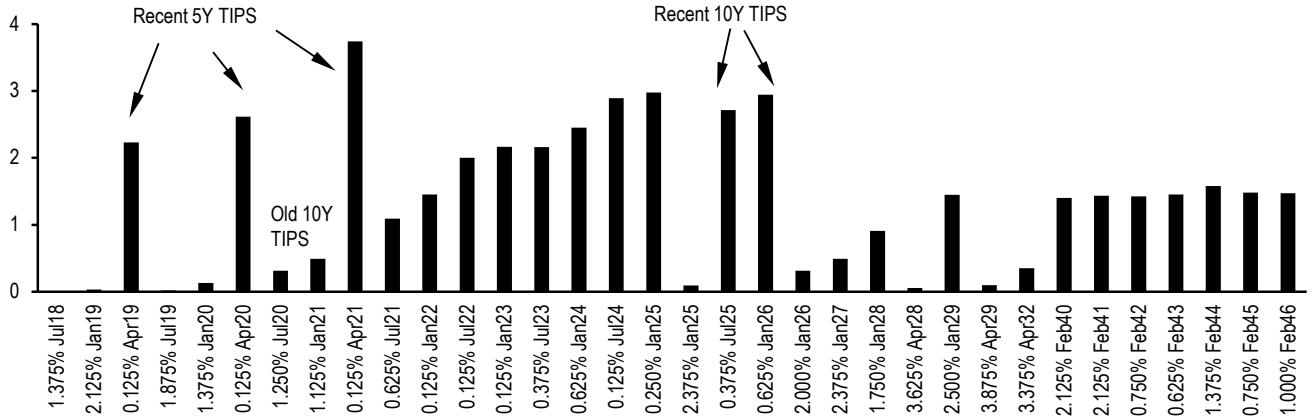
Estimated value of the seasonality difference* in return terms for TIPS of different maturity months and yield impact for TIPS of different maturity years (units as indicated)

	Jan/Apr	Jan/Jul	Apr/Jul
Price impact (%)	0.16%	-0.66%	-0.82%
Yield impact, by maturity year (bp of impact)			
2018	8.8	-35.3	-40.7
2020	4.2	-17.4	-20.6
2022		-11.3	
2024		-8.5	
2029	1.4		

* Based on the values in Exhibit 32

Exhibit 34: The value of the embedded floor tends to be highest for recently-issued 5-year TIPS

Estimated value of the embedded inflation floor in TIPS; bp of yield



Source: J.P. Morgan

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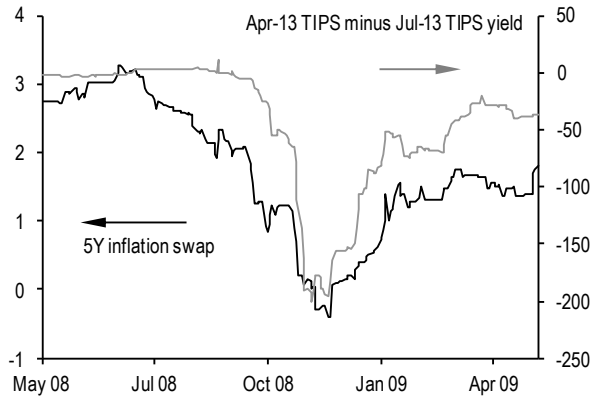
choose to make strategic allocations to TIPS. In addition, some investment managers may have dedicated TIPS or inflation-protected funds and may buy (sell) TIPS when these funds see inflows (outflows), and in order to match the profile of their benchmark index. As **Exhibit 36** shows, assets under management for inflation-protected bond funds grew steadily after the financial crisis, but then declined sharply during the "taper tantrum" and have been moving sideways since then.

In addition to buying TIPS outright, these accounts may also take views on the shape of the real yield curve or the spread between two or more bonds (switch trades and butterfly trades). Some real money investors may also be able to sell Treasury futures against their TIPS holdings (creating a synthetic breakeven position) or trade commodity futures against TIPS.

Although **foreign investors** buy a smaller portion of TIPS at auction, anecdotal evidence suggests that central banks and sovereign wealth funds are major players in the market. Unlike real money accounts, foreign central banks are mostly buy-and-hold, longer-term investors. They may or may not manage their TIPS holdings against a benchmark index. Some foreign accounts may also trade breakevens or sell Treasury futures to create synthetic breakeven positions, but primarily, they are outright buyers.

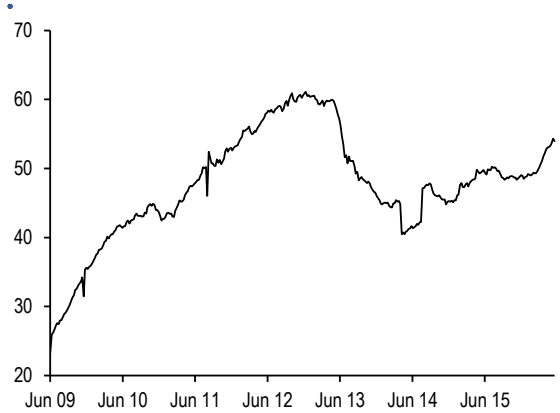
Hedge funds are also large players in the TIPS market. They may use TIPS to express a view on real yields, the real curve, bond spreads, TIPS breakevens, and the breakeven curve. They may also opportunistically buy/sell TIPS to earn carry. Hedge funds are also very active in the very front end of the curve (<1Y to maturity). Real money accounts benchmarked to TIPS indices tend to sell their front-end TIPS as soon as they roll out of the index, and hedge funds tend to buy this paper when it cheapens.

Exhibit 35: When expected inflation falls to zero, as it did during the financial crisis, the embedded floor in newly-issued TIPS can become very valuable
5-year inflation swap rate versus (Apr-13 TIPS yield) minus (Jul-13 TIPS yield); % bp



Source: J.P. Morgan

Exhibit 36: Inflation-protected mutual funds grew steadily after the crisis but saw outflows during the "taper tantrum"
Total net assets for inflation-protected mutual funds; $bn



Source: Morningstar, Inc.

Our model for TIPS breakevens

We can think of TIPS breakevens of consisting of three components: inflation expectations, inflation risk premium, and liquidity/credit risk premia. In principle, economic releases, news, or market variables that affect any of these three components are likely to drive TIPS breakevens.

In practice, we find that breakevens can be well explained by three main explanatory variables : 1) the average year-over-year percent change in headline CPI, lagged by one month, 2) the six-month percent change in our trade-weighted USD index, and 3) high grade corporate spreads (as a proxy for risk appetite). For 5-year breakevens, which have a greater sensitivity to energy prices, we use one additional variable—the 3-month percent change in Brent oil futures prices. The statistics for our fair value model using these variables are shown in **Exhibit 37**.

The signs of the betas in the model make intuitive sense. First, inflation expectations tend to rise as realized inflation increases, and vice versa. Currently, we find that longer-term breakevens are slightly more sensitive to the 2-year trend in inflation than 5-year breakevens are. This is probably due to the increased sensitivity of front-end breakevens to energy prices, as evidenced by the

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Exhibit 37: In our fair value model for breakevens, we use realized headline CPI, our trade-weighted dollar index, high grade spreads, and oil (for 5-year breakevens only) as the explanatory variables

Statistics for 1-month forward breakevens* (bp) regressed against the 2-year moving average of year-over-year headline CPI (nsa), lagged 1 month (bp), the 6-month percent change in the J.P. Morgan nominal broad trade-weighted dollar index (%), JULI (our high grade credit index) portfolio spread to Treasuries (bp), and the 3-month percent change in rolling front Brent oil futures contract prices (%) for 5-year breakevens only; model uses daily data over the past two years

	Avg YoY CPI (bp)		Chg in trade-wtd USD (%)		High grade spd (bp)		Chg in Brent oil (%)		Intercept	R-sq	Std error
	Beta	T-stat	Beta	T-stat	Beta	T-stat	Beta	T-stat	(bp)		(bp)
5Y	0.33	7.3	-0.97	-5.6	-0.36	-7.1	0.29	8.4	176	77%	10.4
10Y	0.35	13.8	-1.13	-7.9	-0.44	-15.4			211	85%	8.6
30Y	0.37	14.9	-1.35	-9.9	-0.34	-12.4			208	84%	8.2

* We use 1-month forward breakevens to mitigate the effects of near-term carry
Source: Bureau of Labor Statistics, J.P. Morgan

positive beta between 5-year breakevens and changes in oil prices.

We also find that breakevens tend to narrow as the dollar appreciates. Interestingly, this sensitivity tends to increase further out the curve, perhaps because the long end is impacted by foreign central bank QE, which also influences the dollar. Finally, we find that breakevens tend to narrow when risky assets underperform (credit spreads widen), with the 10-year sector being most sensitive to changes in risk appetite. Although the strong correlation between corporate credit and breakevens may be somewhat surprising given the difference in credit quality, we think the correlation has been driven by liquidity considerations—i.e., both asset classes have been impacted in similar ways by reduced liquidity and market-making activity.

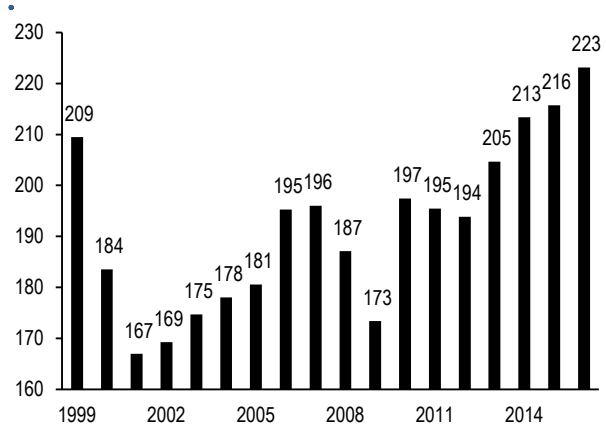
We use this model to evaluate whether breakevens look narrow or wide, and we also use it to set our breakeven forecasts.

5. STRIPS

Unlike the previously mentioned product offerings, **Treasury STRIPS**, or Separate Trading of Registered Interest and Principal of Securities, are not issued or sold to investors directly. Instead, STRIPS are zero-coupon securities constructed from the separation of the coupon and principal payments of an existing coupon-bearing Treasury security. Treasury introduced the STRIPS program in 1985, though the separation of Treasury bond cash flows was popularized for its tax advantages well before the official introduction of the program, and the size of the STRIPS market now stands at more than $223bn, or roughly 1.7% of the total Treasury market (**Exhibit 38**). Data on the STRIPS market and stripping activity is provided on a monthly basis, as part of Treasury's Monthly Statement of the Public Debt (MSPD).

Exhibit 38: The STRIPS market stands at $223bn as of June 2016

P-STRIPS outstanding; $bn



Source: US Treasury

When Treasury bonds are stripped of their coupon payments, they produce **Principal STRIPS** (P-STRIPS), as well as a series of **Coupon STRIPS** (C-STRIPS). The number of C-STRIPS generated from the stripping of a Treasury bond depends on its final maturity: for example, a 10-year note can be stripped into one P-STRIPS and 20 C-STRIPS, each trading with a different CUSIP. Notably, C-STRIPS with the same maturity date but generated from different whole bonds are fungible (and as a corollary trade with the same CUSIP), whereas same-maturity P-STRIPS are not.

Sources of demand

Stripping bonds results in P-STRIPS that have a longer duration than the whole bonds themselves. As such, longer-maturity STRIPS are popular instruments for investors who have longer-duration liabilities, like insurance companies and pension funds. Moreover, because STRIPS trade at a discount to par, owning the same dollar amount of STRIPS instead of their whole bonds effectively allows for a levered duration position. As a result of this demand, stripping activity tends to be concentrated in the long end of the curve.

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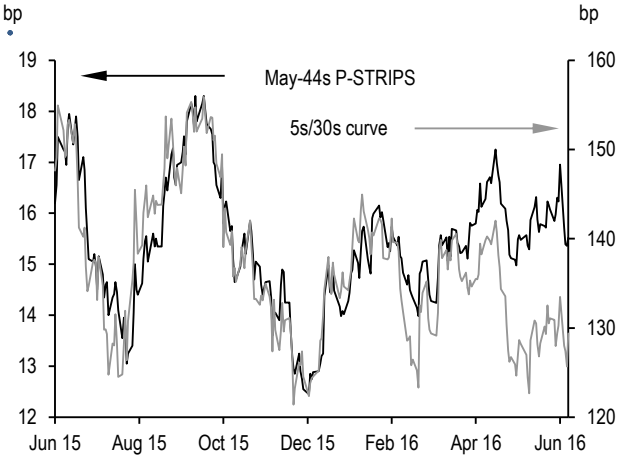
Exhibit 39: The spread between P-STRIPS and their corresponding whole bonds is driven by the shape of the long end of the curve…

May-44s P-STRIPS/3.375% May-44s spread versus 5s/30s Treasury benchmark curve;



Source: J.P. Morgan

To a lesser extent, stripping activity also occurs at the front end of the Treasury curve, as short-dated STRIPS are often used as a cash management tool (given their singular cash flow payout), particularly for defeasance purposes. For instance, a bond issuer may use some of the issuance proceeds to purchase STRIPS in order to match the size and timing of the bond's cash flow payments.

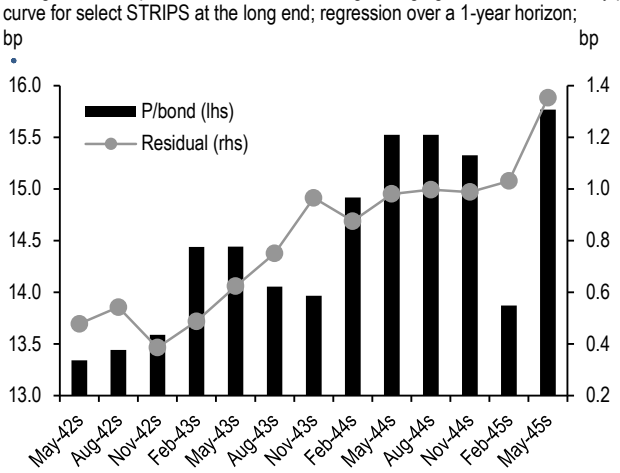
STRIPS relative value

P-STRIPS can at times offer relative value opportunities versus whole bonds. Because the P-STRIPS is a longer duration instrument than a similar-maturity whole bond, trading P-STRIPS against the whole bond can be thought of as an alternative way to position for changes in curve shape. For instance, the spread between the May-44s P-STRIPS and the 3.375% May-44s is highly correlated to moves in the 5s/30s Treasury curve (**Exhibit 39**). This relationship can also be used to identify sources of relative value across P/bond spreads. **Exhibit 40** shows outright P/bond spreads and residuals after regressing against the 5s/30s Treasury par curve for a handful of STRIPS at the long end: a positive residual suggests that the P-STRIPS is trading cheap to the whole bond, after adjusting for the broader Treasury curve, and vice versa.

Additionally, there are differences in valuations between similar-maturity C-STRIPS and P-STRIPS, known as the C/P spread. Because most stripping activity tends to occur at the long end (as discussed earlier), the lion's share of P-STRIPS outstanding is generally concentrated at the long end of the curve (**Exhibit 41**). At the same

Exhibit 40: …and the residual from regressing P/bond spreads on the slope of the curve is a useful tool for identifying sources of relative value

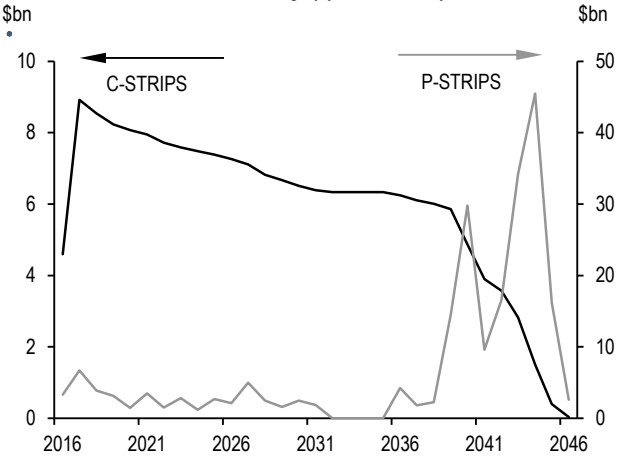
Outright P/bond spreads and residual after regressing against 5s/30s Treasury par curve for select STRIPS at the long end; regression over a 1-year horizon;



Source: J.P. Morgan

Exhibit 41: P-STRIPS and C-STRIPS supply tends to be concentrated in the long end and short end, respectively

C-STRIPS and P-STRIPS outstanding by year of maturity, as of 6/30/16;



Source: US Treasury

time, the process of stripping a long-duration bond creates an annuity of C-STRIPS, resulting in greater C-STRIPS supply in the belly of the curve, where there are fewer natural buyers. Given the differences in stripping supply and demand in various sectors of the curve, greater net stripping activity tends to widen C/P spreads and vice versa, particularly in the intermediate sector (**Exhibit 42**).

Key drivers of yields

What are the primary drivers of Treasury yields? Over the long term, the level of yields is most influenced by

the stance of monetary policy: **Exhibit 43** shows that 10-year Treasury yields have tracked the real Fed funds rate quite closely over the past 20 years, and this factor explains roughly 76% of 10-year yield variation over this period. Along the curve, real policy rates are clearly more influential on shorter-maturity Treasuries: by comparison, the real Fed funds rate explains 92% and 63% of the variation in 2-year and 30-year yields, respectively, over the same period. Since future adjustments to the Fed funds rates are dictated by developments in inflation and unemployment, long-end yields incorporate a more medium-term outlook on macroeconomic variables.

Furthermore, while the real Fed funds rate has driven a significant portion of yield moves over a longer history, it has been less influential in recent years, as the policy rate has been stuck near zero and the Fed has engaged in unconventional forms of policy accommodation. In addition, structural changes to supply and demand in the Treasury market are often important drivers of medium-term changes in yields. Over shorter horizons, swings in demand for Treasuries from speculative investors can have a significant impact on yield levels—for example, pushing yields lower if investors in aggregate reach for securities as a source of carry or sending yields higher if speculative investors build substantial short positions. As an aside, we monitor various metrics on a daily basis to inform tactical trading strategies (see grey box).

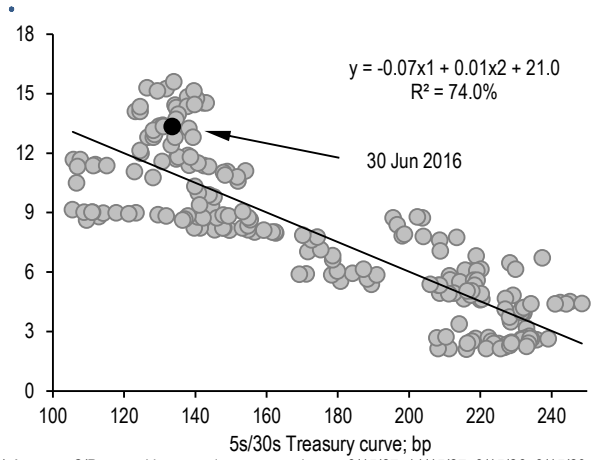
We develop valuation frameworks of Treasuries at various maturity points, as well as the shape of the yield curve, using regression analysis based on various empirical fundamental and technical factors. These models help drive our expectations for the future path of yields, based on the outlook for the underlying factors, and also inform our views around whether Treasuries appear rich or cheap relative to their drivers at a point in time. Over time, we monitor how well the factors are explaining yield changes, and periodically modify the frameworks. We review each of our current fair value models in turn over the following sections.

Front-end Treasury fair value model

As discussed earlier, over a long period of time, the real Fed funds rate has accounted for over 90% of the variation in front-end yields, but with policy rates near zero since December 2008, this factor has had more limited impact on the front end in more recent years. While the real policy rate has been relatively stable, policy rate expectations have been more volatile, and 2-year Treasury yields are driven, **first** and most fundamentally, by expected future changes in the Fed

Exhibit 42: C/P spreads have been driven by the size of the P-STRIPS market and the slope of the curve

Coupon minus Principal STRIPS yield spread in the 2027-2031* sector regressed on the 5s/30s Treasury curve (bp) and P-STRIPS outstanding ($bn); weekly regression from 6/30/2012-6/30/2016; bp

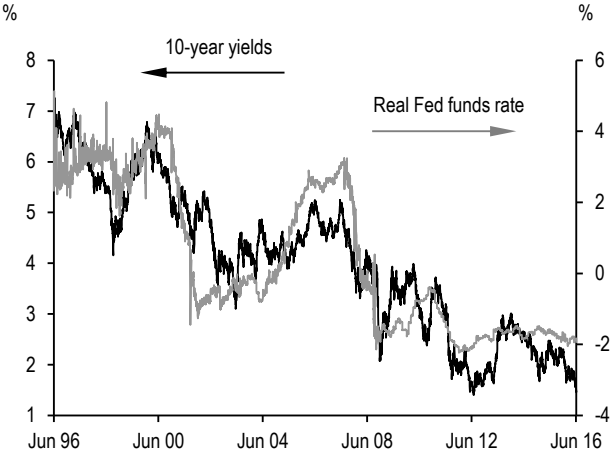


* Average C/P spread between issues maturing on 8/15/27, 11/15/27, 8/15/28, 8/15/29, 5/15/30, and 2/15/31

Source: US Treasury, J.P. Morgan

Exhibit 43: Monetary policy is the primary driver of Treasury yields over the long term

10-year Treasury yields and the real Fed funds rate*;



* Fed funds effective rate less oya core CPI

Source: J.P. Morgan

funds rate, as estimated by 1y3m Overnight Index Swap (OIS) rates (**Exhibit 44**).[14] **Second**, since August 2011, the Fed has given the markets additional information about the future path of policy rates through the use of explicit forward guidance, so we include this factor in

[14] We prefer to use OIS markets over other derivatives in estimating policy expectations as OIS are customizable and more liquidly traded beyond 1 year. For a full discussion on these considerations, see "Interest Rate Derivatives and Monetary Policy Expectations," Richard Crump, et al. Liberty Street Economics, December 5, 2014. Note that the 1y3m rate refers to a swap 1-year forward with a 3-month term.

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Exhibit 44: Our framework shows 2-year Treasury yields are driven by current and expected Fed monetary policy, speculative positions, and changes in FX reserves…

2-year Treasury yield model;* units as indicated

Variable	Current value	Coefficient	T-statistic
Intercept		56.6	43.1
1y3m OIS, bp	42.1	0.533	50.4
Excess reserves, $bn	2361.9	-0.0085	-20.1
2y change in global FX reserves, $bn	-700.1	-0.0063	-31.0
Policy guidance, months	0.0	-0.361	-15.4
Spec positions in TU, 000s of contracts	13.9	-0.036	-20.5
R-squared; %	95.7%		
Standard Error; bp	4.4		

* Regression from 6/30/11 to 6/30/16
Source: Bloomberg, CFTC, Federal Reserve, J.P. Morgan, US Treasury

our model. Locally, this factor is less influential now as the Fed has transitioned from on hold to a more active regime, but we expect this to remain a key part of the FOMC's monetary policy toolkit over time. **Third**, as a byproduct of the Fed's quantitative easing programs excess reserve balances have grown from $9bn pre-crisis to a peak of $2.8tn in late 2014. This excess liquidity has also worked to depress front-end yields.

In addition to these fundamental drivers, we include two technical variables. To account for investor positioning, we add speculative holdings of 2-year Treasury futures, based on data from the CFTC. Lastly, we control for changes in FX reserves, since large swings can have significant effects on front-end Treasury valuations. Global FX reserve assets nearly tripled over the past decade to a peak of roughly $12.1tn in August 2014 before capital outflows from EM and a sharp appreciation in the dollar led to a reversal of this trend. At a high level, reserve managers typically buy foreign assets to offset the currency effects of large private capital inflows and liquidate reserves in the case of capital outflows to prevent currency depreciation. The US dollar remains the global reserve currency of choice, representing 64% of allocated FX reserves in 4Q15, and this share has been relatively stable over the past 15 years. Further, of the USD-denominated reserves, we estimate roughly 60% are invested in Treasuries, likely concentrated in the front end of the curve. Thus, we include 2-year change in global FX reserves as the **fifth** variable in our fair value model (see Treasuries, *US Fixed Income Markets Weekly*, 1/29/16).

Taken together, these five factors explain 95% of 2-year Treasury yield variability over the past 5 years: yields tend to rise as Fed funds expectations rise, as excess reserves decline, and as Fed forward policy guidance wanes. Yields also tend to rise as global FX reserve

Estimating investor positions in Treasuries

Given the importance of position technicals in the fixed income market, we track a number of positioning metrics, which are updated regularly in the Appendix of our *US Treasury Market Daily* publication and include the following:

J.P. Morgan Treasury Client Survey: This survey is conducted on the first business day of the week. Clients are asked if they are currently short, neutral, or long duration relative to their benchmark. If the client does not have a benchmark, the outright duration position is indicated. For the overall survey, 40-60 clients are surveyed, with an approximate breakdown of 60% real money, 25% spec accounts, and 15% central bank/sovereign wealth funds (U.S. Treasury Client Survey).

CFTC non-commercial positions: Released on the Friday of each week with a breakdown of Treasury and Eurodollar futures positions as of the previous Tuesday, CFTC's Commitments of Traders report divides reportable traders into "commercial" and "noncommercial" categories. The latter category generally represents positions of speculative traders (available here).

CTA exposure to 10-year Treasuries: This estimate is the partial beta of CTA excess returns over cash (based on the HFRXSDV Index from Bloomberg) with respect to the J.P. Morgan US GBI 7-10Y bond index. The model estimates CTA exposures by regressing CTA excess returns on excess returns of a number of variables over a 1-month horizon: JPM 7-10Y US GBI, JPM Global Bond Index ex-US, S&P 500 index, JPM cash index, Goldman Sachs Commodities Index (see Treasuries, *US Fixed Income Markets Weekly*, 6/20/14).

Active Core Bond Fund Managers' exposure to 10-year Treasuries: This is the partial beta of US active core bond fund excess returns with respect to 10-year US Treasury yields. Core bond funds typically provide investors with a broad exposure to the US IG bond market. We track daily excess returns of the 15 largest (by AUM) core bond funds relative to a benchmark and compute the asset value-weighted average. This is then regressed on a number of variables over a 3-month horizon: 10Y Treasury yields, 5s/30s Treasury curve, 5Y CDX.IG spread, MBS Libor OAS, and 3Mx10Y swaption volatility (see "Estimating active core bond fund positioning," 5/23/14).

Macro Hedge Fund exposure to 10-year Treasuries: This is a partial beta of macro hedge fund excess returns (based on the HFRXM Index from Bloomberg) with respect to the J.P. Morgan US GBI 7-10Y bond index. We estimate macro hedge fund exposures by regressing excess returns over cash on the following factors over a 6-week horizon: JPM 7-10Y US GBI, JPM Global Bond Index ex-US, S&P 500 index, JPM cash index, Goldman Sachs Commodities Index, MSCI World ex-US (see *US Treasury Market Daily*, 7/14/15).

Tracking these metrics on 1-year z-score basis gives us an idea of whether aggregate positions are crowded and likely to reverse over the near term (see Treasuries, *US Fixed Income Markets Weekly*, 4/1/16).

liquidation accelerates and as speculative long positions in 2-year futures decline.

10-year Treasury fair value model

Some of the explanatory variables in our 10-year fair value model are similar to those used for 2-year yields: we again control for market-implied Fed funds expectations (1y3m OIS rates), Fed rate forward guidance, and speculative investor positioning—this time using a 3-year z-score of positions across Eurodollar and Treasury futures—for many of the same reasons discussed above. Further out the curve however, the macroeconomic outlook has a greater influence on yields since future short-term rates will depend on the medium-term path of inflation and unemployment: we account for this using 5-year forward 5-year inflation expectations derived from the inflation swap rate market and the year-ahead consensus real GDP forecast from Blue Chip Economics.

Additionally, various academic studies have shown that integrated international financial markets have contributed to a greater correlation of yields across countries and importantly, that the variance in long-term US bond yields can be explained at least partially by developments in global financial conditions.[15] Thus, we include a factor for global monetary policy expectations and see that average 1y3m OIS rates for G7 countries (ex-US), on a GDP-weighted basis, have been a statistically significant driver of 10-year Treasury yields since 2007. The model shows that every 100bp of expected rate cuts in the average G7 policy rate (ex-US) lowers the fair value of 10-year yields by roughly 37bp, holding all other factors constant (**Exhibit 45**).

Overall, this model explains more than 94% of the variability in 10-year yields since 2007 (**Exhibit 46**). It shows that yields tend to rise as medium-term inflation and growth expectations rise, as near-term Fed funds expectations rise, and as global policy rate expectations rise, while they tend to fall Fed forward policy guidance is pushed out. Yields also tend to fall as speculative positions in Eurodollar and Treasury futures rise.

10s/30s curve fair value model

Lastly, what drives the shape of the long end of the yield curve? We find that there are four key factors. **First**, the long end tends to flatten along with increases in medium-term Fed funds expectations (as measured by 2y3m OIS rates), as a path of tighter policy lowers longer-term expectations for inflation and growth. This single factor is by far the most significant driver of the 10s/30s curve. **Second**, the nominal yield curve incorporates not only the expected future path of short-term real yields but also the term structure of inflation expectations, where the yield curve tends to flatten along with declines in 5yx5y inflation swap rates. **Third**, we control for aggregate cross-asset gross duration supply: every $100bn of supply (in 10-year equivalents) tends to steepen the yield curve by 9bp, all else equal. **Lastly**, the shape of the long end is significantly impacted by variable-annuity duration hedging flows (in $bn of 20-year swap equivalents): large declines in equities and Treasury yields overall tend to produce a massive duration

Exhibit 45: …while 10-year yields are driven by inflation and growth expectations, global monetary policy expectations, and investor positions

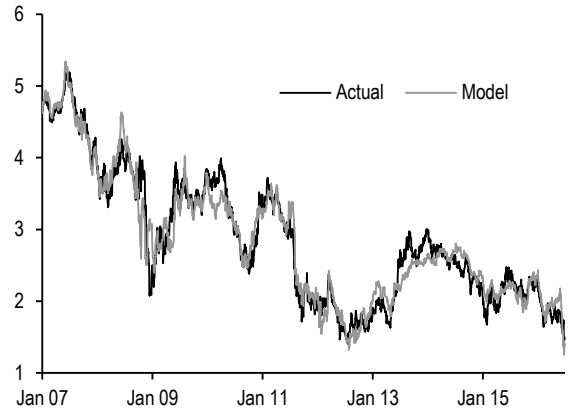
10-year Treasury yield model;* units as indicated

	Current value	Coefficient	T-statistic
Intercept		-0.26	-5.6
5yx5y Inflation swap rate; %	1.853	0.764	43.7
1y-ahead Growth Forecast; %	2.30	0.184	25.2
1y3m OIS rate; %	0.42	0.22787	22.8
Fed Rate Fwd Guidance; months	0	-0.019	-37.2
G7 ex-US Avg 1y3m OIS rate; %	-0.32	0.366	29.7
CFTC positions; 3-yr z-score	1.06	-0.159	-34.8
R-squared; %	94.5%		
Standard Error; bp	21.5		

* Regression from 1/2/07 to6/30/16
Source: Bloomberg, CFTC, Federal Reserve, J.P. Morgan, US Treasury

Exhibit 46: Our current 10-year fair value model explains 95% of the yield variability since 2007 and suggests 10-year Treasuries are only modestly rich

10-year Treasury yields versus model implied fair value*; %



* Fair value model for 10-year yields derived from a regression since 1/1/07. See Exhibit 45 for model details.
Source: J.P. Morgan, CFTC, Blue Chip Economics, Bloomberg

[15] See e.g., Kamin, Steven B., "Financial Globalization and Monetary Policy." June 30, 2010. FRB International Finance Discussion Paper No. 1002.

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Exhibit 47: The 10s/30s curve is driven by Fed and inflation expectations, insurance hedging needs, and duration supply

10s/30s Treasury curve model*; units as indicated

	Current Value	Coeff	T-stat
Intercept		143.93	11.5
2y3m OIS; %	0.56	-34.51	-56.0
5yx5y inflation swap rates; %	1.85	6.29	3.2
VA hedging index**; $bn 20y equiv.	286.9	-0.22	-8.6
Total duration supply; $bn 10y equiv.	289.0	0.05	4.8
R-squared	88.4%		
Standard Error; bp	4.60		

* Regression from 6/30/13 to 6/30/16
** VA hedging index is an estimate of variable annuity duration hedging needs
Source: J.P. Morgan

shortfall in insurance companies' portfolios, leading these entities to buy Treasuries or receive in swaps (see "Interest Rate Risk in Variable Annuities," Srini Ramaswamy & Terry Belton, 9/28/11). Our model suggests that a $10bn increase in VA duration would flatten the 10s/30s curve by roughly 1.4bp. Together, these four factors explain 90% of variability in the 10s/30s curve over the past three years (**Exhibit 47**).

Relative Value

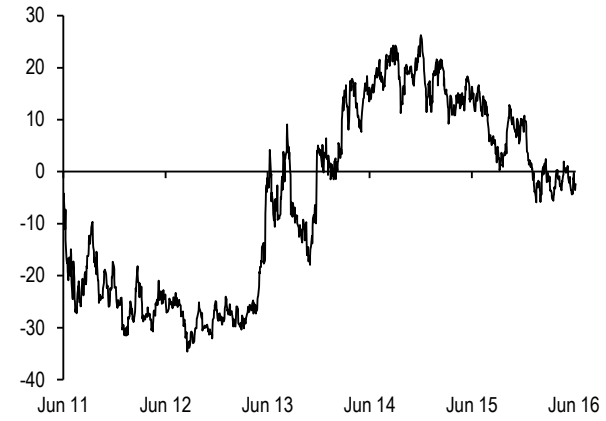
Much of our discussion thus far has been focused on valuation frameworks for Treasury yields and the shape of the yield curve. To take it one step further beyond outright value, we consider relative value, or the richness or cheapness of assets after adjusting for their underlying drivers. Macro relative value involves broad curve relative value, or discerning the relative richness or cheapness of a sector along the Treasury curve, while micro relative value applies to security selection in Treasury securities.

Macro relative value

As the name implies, macro relative value is the practice of discerning value for a given sector of the Treasury curve, after adjusting for its fundamental drivers. In the simplest sense, we like using Treasury butterflies to isolate the value of a specific sector. **Exhibit 48** displays the 2s/5s/10s Treasury butterfly, and shows 5-year Treasuries have outperformed the 50:50 weighted combination of 2- and 10-year Treasuries by 25bp over the past 18 months, and are now trading near their richest levels of the past 3 years. On the surface this suggests some richness of the 5-year sector, but ignores the drivers of this spread. **Exhibit 49** shows this same butterfly regressed on the level of rates and the shape of the curve. In this case we regress the butterfly on the body of the

Exhibit 48: Treasury butterflies are useful in isolating value in specific sectors along the Treasury curve…

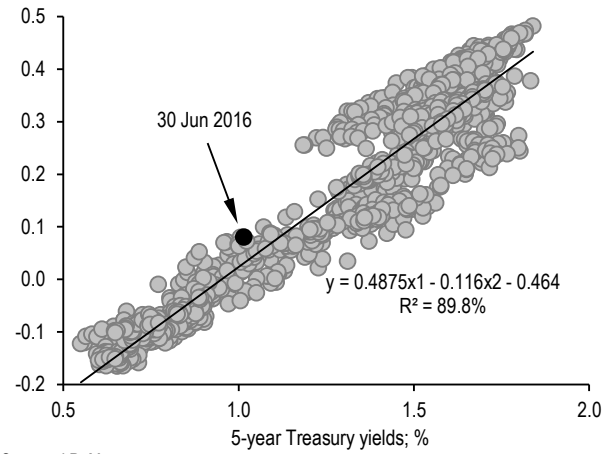
2s/5s/10s Treasury butterfly; bp



Source: J.P. Morgan

Exhibit 49: …but need to be adjusted by the drivers

2s/5s/10s Treasury butterfly regressed on 5-year Treasury yields and 2s/10s Treasury curve, regression over the last 5 years; %



Source: J.P. Morgan

butterfly (5-year yields) and the slope of the wings (2s/10s curve). The regression shows these factors explain more than 89% of the variation in this butterfly over the past 5 years, with the butterfly richening 4.9bp for every 10bp decline in 5-year yields, and richening 1.2bp for every 10bp steepening of the 2s/10s curve. Finally, adjusting for these drivers, this shows the 5-year sector appeared modestly cheap relative to the wings.

More generally, we can apply this level- and curve-neutral analysis across the curve: **Exhibit 50** displays regression statistics for a number of Treasury benchmark butterflies. The table shows the level of rates and slope of the curve explain much of the variation in these butterflies, and the explanatory value is relatively higher for wide butterflies than more narrow spreads. Therefore, we think this is a robust measure for

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Exhibit 50: The level of rates and the slope of the curve are the primary two drivers of most wide Treasury butterflies

Regression statistics for various Treasury butterflies regressed on the level of rates of the body of the butterfly and the slope of the curve of the wings of the butterfly, regression from June 2011-June 2016; units as indicated

Butterfly	R-squared	Level beta	Level t-stat	Curve beta	Curve t-stat
2s/3s/5s	70%	0.176	47.1	-0.170	-46.4
2s/5s/10s	90%	0.488	104.6	-0.116	-28.8
2s/5s/30s	92%	0.641	108.3	-0.222	-52.4
2s/7s/10s	94%	0.421	105.7	0.049	13.2
3s/5s/10s	93%	0.291	118.1	-0.159	-66.3
3s/5s/30s	96%	0.398	108.1	-0.251	-95.3
3s/7s/10s	95%	0.283	130.1	0.057	25.4
3s/7s/30s	92%	0.449	118.5	-0.127	-43.9
5s/10s/30s	78%	0.162	57.7	0.052	21.9

Source: J.P. Morgan

evaluating Treasury value. We offer a "US Treasury Butterfly Report" as part of our daily *US Cash Interest Rate Product Analytics Package*, available on the US Rates Strategy page on J.P. Morgan Markets.

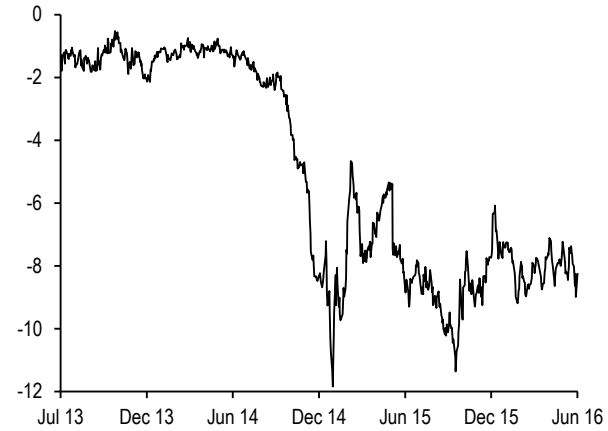
Micro relative value

While macro relative value is focused on a sector-by-sector analysis of the Treasury curve, micro relative value is centered on estimating the value of specific Treasury securities. A yield curve is needed to effectively estimate the richness or cheapness of these securities, and we use our par-fitted Treasury curve as the basis for evaluation. The most basic output is the yield error—the difference between market observed yield on a particular Treasury security and the yield derived from our par fitted curve for the same security. A positive yield error implies the bond appears cheap relative to the curve, while a negative yield error implies the bond is rich.

Exhibit 51 shows the yield error for the 4.5% Feb-2036s, the first 30-year bond that was auctioned after the Treasury reintroduced the security in 2006. The exhibit shows that the bond traded modestly rich relative to our fitted curve for much of 2013 and 2014, before richening sharply toward year-end 2014, and the bond now trades more than 7bp rich relative to our fitted curve. This richening was largely driven by dynamics in the US ("classic bond") contract, and the roll from the USH5 into the USM5. With the 5.375% Feb-31s rolling out of the US basket, and a 5-year gap in bond issuance, the Feb-36s became the cheapest-to-deliver into the US contract. This CTD shift was a duration extension of more than 4 years, and technicals suggest this bond will remain the CTD for a number of years to come. As a result, the Feb-36s are likely to retain this premium for a

Exhibit 51: The 4.5% Feb-36s richened substantially in late 2014 before they became CTD into the US contract and have remained rich since then…

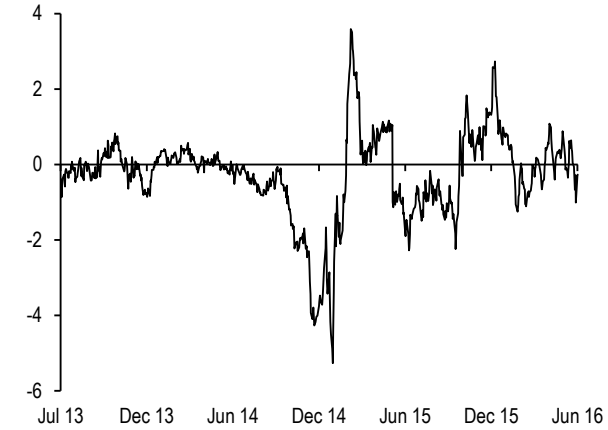
Yield error for 4.5% Feb-2036s; bp



Source: J.P. Morgan

Exhibit 52: …but after adjusting for this persistent dynamic, the Feb-36s no longer appear rich

Rich/cheap measure* for 4.5% Feb-2036s; bp



* Rich/cheap measure is spot yield error minus 3-month moving average of yield error
Source: J.P. Morgan

significant period as well. As such, looking at the yield error for this bond is somewhat misleading.

Instead, we favor normalizing yield errors, adjusting for any idiosyncratic richness or cheapness, and prefer using our rich/cheap measure, which is the spot yield error for a given bond less the three-month moving average of the yield error. **Exhibit 52** shows the rich/cheap measure for the Feb-36s, and again shows the outsized richening of the issue in the time before the CTD switch occurred. However, it also shows that this bond actually appears modestly cheap, after adjusting for this structural richness. Given that there are a number of issues that will go through periods of protracted richness or cheapness relative to our fitted curve, due to various idiosyncratic factors, we prefer to use this normalized

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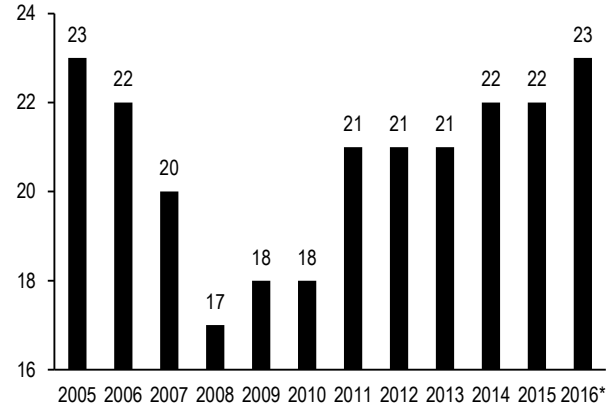
Exhibit 53: The number of primary dealers has retraced to pre-crisis levels…

Number of Treasury primary dealers at year-end*



* 2016 figure as of 7/7/16
Source: Federal Reserve

measure for evaluating relative value for individual Treasury securities. Our "Treasury Carry, Roll, and Relative Value Report," which shows yield errors and rich/cheap measures for all outstanding coupon Treasuries, can also be found in the daily *US Cash Interest Rate Product Analytics Package*, available on the US Rates Strategy page on J.P. Morgan Markets.

Market structure and liquidity

As we discussed earlier in the section on Treasury auction dynamics and participation, the role of the primary dealer community has changed in recent years. Consolidation before and during the financial crisis dropped the number of primary dealers from 23 in 2005 to just 17 in 2008, but the number of dealers has now returned to pre-crisis levels (**Exhibit 53**). However, market share has become increasingly concentrated: data from the New York Fed show the top quintile of primary dealers held a 52% market share in Treasuries at the end of 2015, up from 44% in 2006 (**Exhibit 54**). Moreover, risk appetite among the primary dealer community has declined significantly. Dealer positions across Treasuries, Agency debt, MBS, and corporates are currently close to their lowest levels in 15 years and are roughly one-third of the pre-crisis peak (**Exhibit 55**).

Certainly, regulatory developments, including the US Supplementary Leverage Ratio (SLR), first proposed in 2013, and the US G-SIB surcharge, first proposed in the fall of 2014, have leaned heavily on the principal trading model. The consistent theme running through these regulatory developments is the high cost of taking and

Exhibit 54: …but market share has become increasingly concentrated among the top quintile of dealers

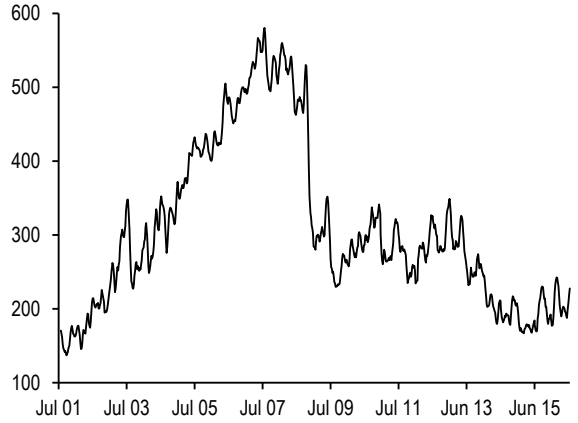
Market share* for first and second quintile of primary dealers for various asset classes over 1Q16, 3Q14, and 3Q06;** %

	1Q16			3Q14			3Q06		
	1st quint	2nd quint	Sum	1st quint	2nd quint	Sum	1st quint	2nd quint	Sum
Treasuries	**55%**	25%	81%	**49%**	27%	76%	**44%**	30%	75%
Agencies	**74%**	17%	91%	**57%**	30%	87%	**54%**	33%	87%
MBS	**73%**	21%	94%	**78%**	17%	95%	**54%**	31%	86%
Credit	**67%**	25%	93%	**71%**	23%	94%	**73%**	25%	98%
TIPS	**58%**	30%	88%	**58%**	27%	85%	**68%**	23%	92%

* Calculated as the average of market share values for each of the individual sub-sectors, weighted by daily average transaction volume for the sub-sector
** FRBNY provides this data on a historical basis only through 3Q06. Only the latest quarterly release is available on its website here.
Source: Federal Reserve Bank of New York, J.P. Morgan

Exhibit 55: Primary dealer positions in fixed income have declined to their lowest levels in 15 years

Aggregate magnitude of primary dealer positions across Treasuries, Agencies, MBS and corporates; 4-week moving average; $bn



Source: Federal Reserve Bank of New York

holding positions (assets) and financing these positions (liabilities) on bank balance sheets. Under the Supplementary Leverage Ratio rule, advanced approaches firms[16] have to hold a minimum 3% leverage capital against their positions, regardless of their riskiness, while the 8 US G-SIBs are subject to a higher requirement. As a result, this has led to reduced holdings of even the safest assets. As of 3Q15, roughly 70% of CCAR banks, weighted by Treasury holdings, are constrained by leverage ratios in a stress scenario (see Interest Rate Derivatives, *US Fixed Income Markets 2016 Outlook*, 11/25/15). Accordingly, banks have become constrained not just by the composition of their balance sheets (i.e. risk-weighted assets), but also by the

[16] These include large, internationally-active banking organizations, with at least $250bn in total consolidated assets or at least $10bn in on-balance sheet foreign exposure.

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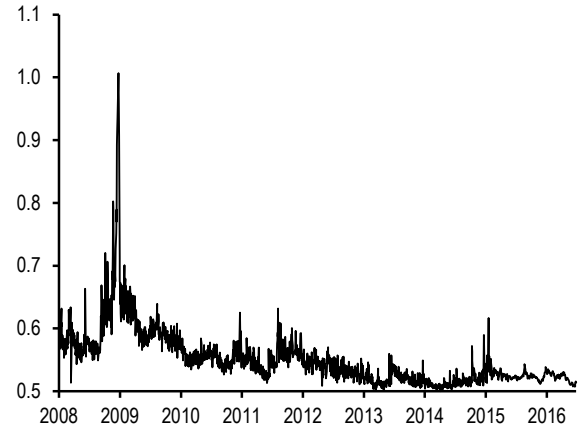
Exhibit 56: Bid/offer in the Treasury market has retraced to pre-crisis levels…

One-week moving average of bid/offer spreads in 10-year Treasuries; 32nds



Source: BrokerTec

sheer size. In addition to regulation, at least a portion of this reduced risk tolerance is self-inflicted in nature: the experience of the financial crisis has led dealers to pare back on the risk profile of their trading books, and risk management and control frameworks at banks have become more sophisticated in the post-crisis era, resulting in lower risk appetite.

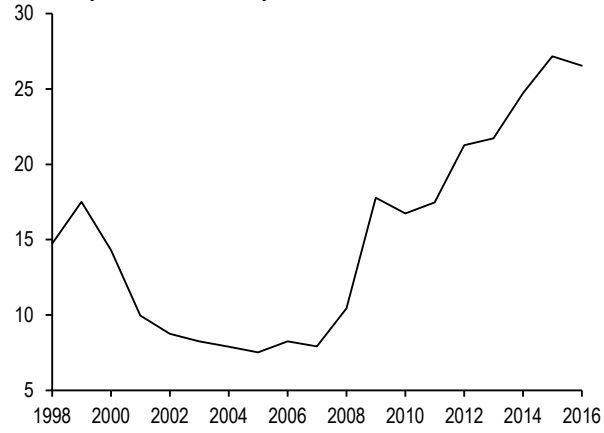
The declining footprint of traditional primary dealers has left room for other, new entrants into the Treasury market. The SEC, the Fed, Treasury, the New York Fed, and the CFTC released the *Joint Staff Report: The US Treasury Market on October 15, 2014* in October 2015 in an effort to explain the outsized volatility experienced in the flash crash nearly two years ago and pointed out that principal trading firms (PTFs), many of which engage in algorithmic and high-frequency trading strategies (HFT), account for more than half of the trading volumes on the major inter-dealer broker (IDB) electronic trading platforms.

Treasury market liquidity

On the surface, the Treasury market appears as liquid as it always has been: **Exhibit 56** shows the average bid/offer spread in 10-year Treasury notes since early 2008. The bid/offer spread doubled to 1/32nd during the depths of the financial crisis in late-2008, but has since retraced to historical norms. However, below the surface, the liquidity of the Treasury market has deteriorated somewhat. As we discussed in the introductory section of this piece, trading volumes have leveled off over the past decade, even though the Treasury market has more than tripled in size over the same period. As a result, turnover has slowed: **Exhibit 57** shows that it takes more than 26 days to fully turn

Exhibit 57: …but it takes longer for the Treasury market to turn over

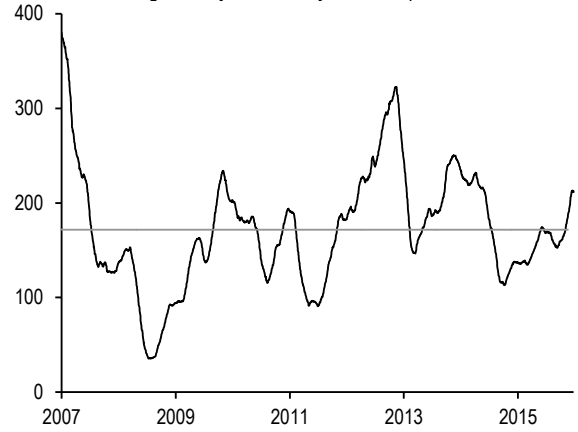
US Treasury market turnover*; days



* Total outstanding divided by average daily trading volumes
Source: Federal Reserve Bank of New York, US Treasury

Exhibit 58: After spending much of 2015 below average levels, Treasury market depth has rebounded in 2016…

Three-month average of 10-year Treasury market depth; $mn



Source: BrokerTec

over the Treasury market, from just 8 days in 2007, and 21 days as recently as 2012, as a result of the continued growth of the Treasury market and slower Treasury market turnover.

Certainly, changing demand dynamics have contributed to this: foreigners and the Fed account for nearly two-thirds of ownership in the Treasury market. Foreign official institutions became active sellers of Treasuries to stem the tide of currency depreciation from late-2014 until early 2016, but away from this, they do not actively turnover their portfolios.

Separately, commercial banks own just 4% of the Treasury market, but their ownership has increased by nearly 50% over the past three years. Treasuries are

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treated as Level 1 assets under the Liquidity Coverage Ratio (LCR), and commercial banks have used Treasuries to meet their high quality liquid asset (HQLA) needs as the LCR phase-in began in January 2015. Concurrent with this increase in Treasury demand, banks have also been moving more Treasuries out of Available for Sale (AFS) accounts and into Held to Maturity (HTM) accounts: Treasuries held in HTM by domestic banks rose to $84bn in 1Q16, from just $9bn at the end of 2012. By moving securities into HTM accounts, banks benefit from lower capital volatility as interest rates move, but it also becomes more difficult for institutions to sell these securities. Taken together, these three factors have contributed to slowing turnover.

While bid/offer spreads and turnover are measures of Treasury market liquidity, our preferred measure is market depth. We define market depth as the average of the sum of the top three bids and offers in on-the-run Treasuries, averaged between 8:30am and 10:30am Eastern time each day. We choose this time period because it traditionally represents the most liquid period of the US trading day. **Exhibit 58** shows the three-month average of 10-year market depth since the middle of 2007. Market depth declined severely during the financial crisis and has declined around other periods of stress, as well as around year-ends, but has averaged about $171mn for 10-year notes over this period. After a sustained period below average for much of 2015, Treasury market depth has rebounded in recent months and is now in line with longer-term averages.

This is evident across the Treasury curve: **Exhibit 59** shows market depth averages over the first half of 2016 for select on-the-run Treasuries, comparing them with ranges since 2007. Market depth has rebounded everywhere except the 2-year sector, where it remains nearly 50% below its post-crisis average. This is likely due to monetary policy: market depth was elevated at the front end from 2011-2014, as monetary accommodation via zero interest rate policy (ZIRP), forward guidance, and QE helped to keep front-end yields anchored at low levels. Structurally, we find that market depth is very much related to volatility. **Exhibit 60** shows the 3-month average of 10-year Treasury market depth regressed on the 3-month standard deviation of daily changes in 10-year Treasury yields. The exhibit shows that market depth tends to be robust during times of low delivered volatility, while it declines as delivered volatility rises, and this becomes particularly acute in times of outsized volatility.

We think these same structural changes discussed above that have reduced the footprint of primary dealers have

Exhibit 59: …and this is evident everywhere but the front end

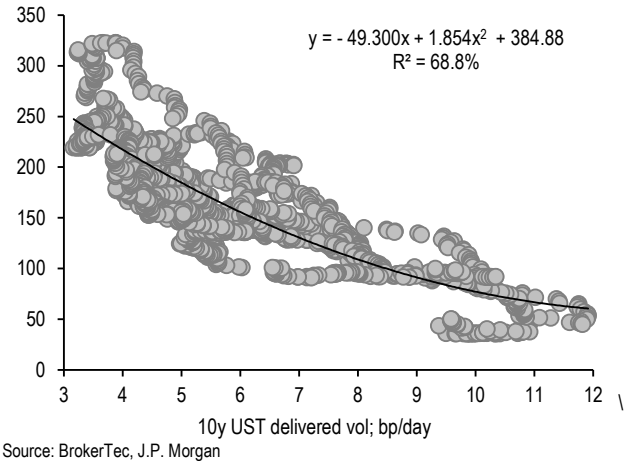
2016 YTD* average of market depth for on-the-run Treasuries, and various statistics for market depth since July 2007; $mn

Sector	YTD avg	Minimum	Maximum	Average	YTD vs. long-term avg
2-year	714	46	5076	1383	-48%
5-year	222	14	856	221	1%
10-year	186	9	413	170	9%
30-year	20	4	51	19	5%

* As of 6/30/16
Source: BrokerTec

Exhibit 60: Treasury market depth tends to be robust when delivered volatility is low, and vice versa…

Three-month moving average of 10-year Treasury market depth regressed on 3-month standard deviation of daily changes in 10-year Treasury yields, regression over the last 8 years; $mn



Source: BrokerTec, J.P. Morgan

allowed PTFs, which use algorithmic trading strategies, to take on a greater prominence in trading on-the-run Treasuries. This also has incentivized market makers to rely more heavily on similar strategies to minimize inventories. The rise of active queue management has made liquidity providers more likely to withdraw in times of heightened volatility. To be fair, market depth has always been somewhat pro-cyclical with delivered volatility; this makes sense, in that large intraday swings can make it more difficult to monetize the bid/ask spread. However, we have observed that active queue management has made liquidity conditions much more reactive in recent years. To quantify this, we model the variation in seasonally-adjusted liquidity conditions using a combination of the average daily trading range (measured between 7:30am and 5:00pm EST from an interdealer electronic trading platform) and risk aversion (adjusted using 5-year IG CDX). This shows the partial beta of market depth with respective to the intraday trading range has more than tripled over the past five years (**Exhibit 61**). This increased sensitivity means that

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market depth is much less resilient in times of heightened volatility than it was in past years.

Measuring off-the-run liquidity

In contrast to on-the-run securities, where bid/offer spreads, trading volumes, and market depth are readily available, very little liquidity data exist for off-the-run securities. In light of this, we can instead look at indirect metrics: **Exhibit 62** shows the Root Mean Squared Error (RMSE) of the Treasury curve relative to our par-fitted curve over the last 20 years, which is our measure of dispersion of yields along the Treasury curve. From a high-level perspective, RMSE has compressed substantially from the extreme levels seen during the financial crisis and currently is more in line with its longer-term average. However, yield curve dispersion has more than doubled over the last 3 years and is currently close to 5-year highs.

What has driven the pickup in Treasury curve dispersion? **First**, during periods of QE, the Fed preferred to purchase off-the-run securities that traded cheap to the broader curve, effectively becoming the largest relative value trader in the market. However, since QE3 ended in October 2014, the Fed's absence has led to a pickup in dispersion along the curve. **Second**, yield curve dislocations tend to increase as market liquidity (observed via market depth) declines. Though market depth has recovered from historically low levels in early 2015, it is less resilient than in the past, and tends to decline rapidly in periods of higher volatility. **Finally**, reduced risk appetite among the primary dealer community and greater leverage constraints have also contributed to increased dispersion along the Treasury curve.

As a result, low-margin, balance sheet-intensive businesses, such as repo finance, are becoming more expensive to manage. As mentioned in the repo section above, this increased cost has manifested itself recently in the widening spread between GCF repo (where dealers borrow from each other) and traditional tri-party repo. This spread can be thought of as bid/offer in the repo market: while dealers can still borrow from end users such as money market funds at relatively cheap levels, the marginal lenders are charging more to gross up their balance sheets and finance other dealers via the GCF market. The GCF/tri-party spread has become more volatile and has trended wider over the last two years (Exhibit 11 in "Repurchase agreements" section). To the extent that off-the-run Treasuries trade less frequently and with lower volume than on-the-runs, they are more financing-intensive, as dealers who provide liquidity to

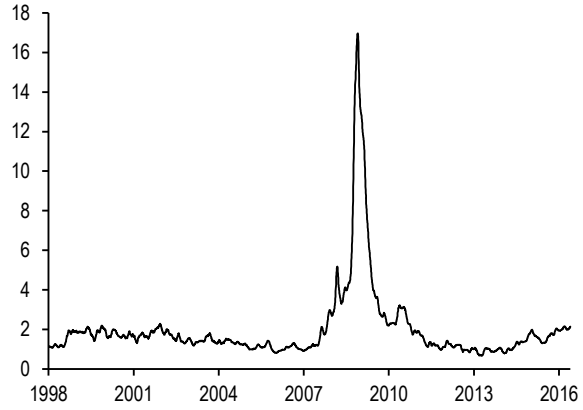
Exhibit 61: …and we find the sensitivity to volatility has tripled over the past 5 years

Partial beta of seasonally-adjusted market depth ($mn) with respect to monthly average of the daily trading range in 10-year Treasuries (bp), adjusted for 5-year IG CDX spread (bp)

Note: The intraday trading range is measured between 7:30am and 5:00pm EST from an interdealer electronic trading platform. Seasonal adjustment is calculated as the average % deviation from the mean for a given month, estimated over the past three years. Regression period is three years
Source: BrokerTec, J.P. Morgan

Exhibit 62: Treasury curve RMSE has compressed thanks to Fed QE, but has risen recently and is approaching multi-year highs

Off-the-run Treasury curve RMSE, 1-month moving average; bp



Source: J.P. Morgan

buyers and sellers need to hold the securities on their balance sheets at least temporarily. As a result, increased repo costs, observable via widening GCF/tri-party spreads, are also contributing to greater dislocations in off-the-run Treasury yields.

Putting the pieces together, we can model aggregate Treasury curve dispersion as a function of these four factors (**Exhibit 63**). **Yield curve dispersion tends to increase as dealer inventories fall, market depth declines, the Fed's balance sheet shrinks, and dealer financing becomes more expensive, and vice versa**.

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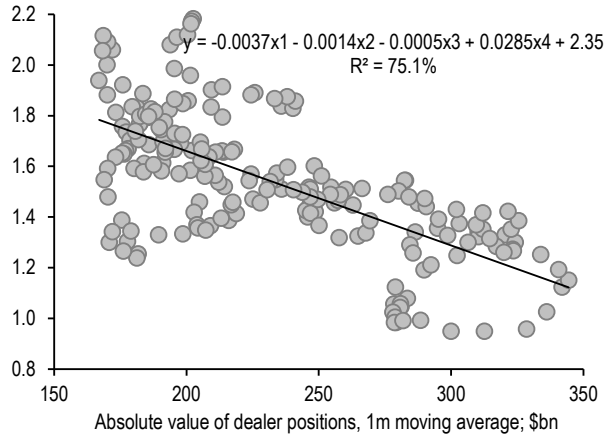
These factors explain roughly 75% of the variation in Treasury RMSE over the last four years, and each $100bn decline in dealer inventory (the most significant driver of dispersion) tends to increase Treasury curve dispersion by 0.3bp. What can we say about dispersion going forward? Despite near-term recession concerns, the odds of further QE are low, so the Fed likely will not play a role in normalizing off-the-run valuations. In addition, regulatory pressures and reduced risk appetite are unlikely to dissipate, and dealers are unlikely to ramp up their balance sheets materially from current levels. Finally, market depth has rebounded recently, but is much less resilient and tends to disappear more rapidly in times of heightened volatility. **Given this backdrop, it is likely that the increase in Treasury curve dispersion will persist, resulting in cheaper off-the-run valuations**.

Exhibit 63: Treasury curve dispersion tends to rise as dealer inventories fall, the Fed reduces its balance sheet, market depth declines, and dealer financing becomes more expensive

1-month moving average of Treasury RMSE regressed on the 1-month moving average of magnitude of dealer positions ($bn), 1-month moving average of 10-year Treasury market depth* ($mn), 6-month change in the Fed's balance sheet ($bn), and 1-month average of 1-month GCF/OIS spread (bp); weekly regression over the last four years; bp



* Market depth is the sum of the top three bids and offers by queue position, using the top 3 bids and offers in Treasury notes and bonds, averaged between 8:30 and 10:30am daily
Source: Federal Reserve Bank of NY, J.P. Morgan, Brokertec

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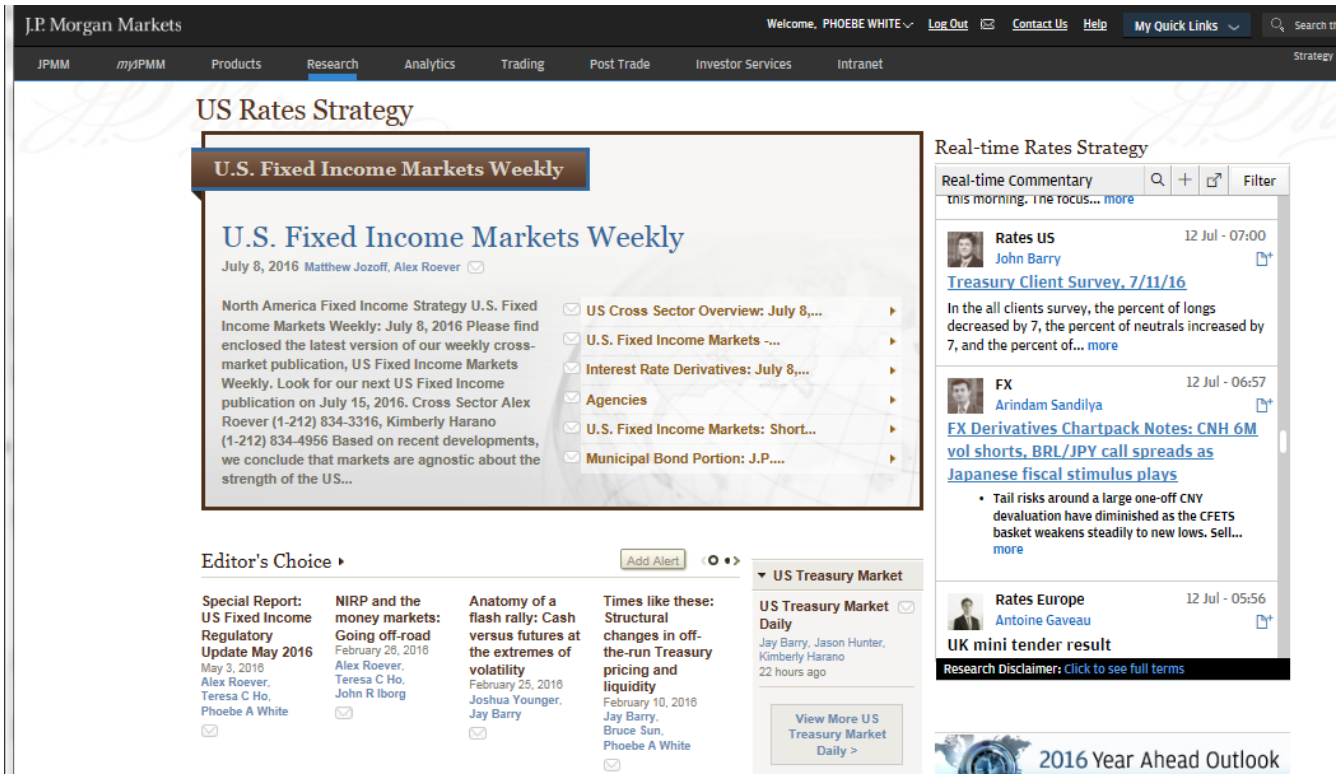

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