

This one's optimistic

Broad improvements in Treasury market liquidity trends in 2024

- Treasury trading volumes in 2024 have averaged \$817bn daily, a 30% increase from 2023. Turnover has risen modestly but remains low, stabilizing after a decade-long decline. The 3- to 5-year sector has seen the highest volumes, followed by T-bills. Long-end volumes in the 20+ year sector are nearly triple those in the 10- to 20-year sector
- Market depth, has improved since early 2022 but remains 50% below its decade-long average. Depth is highly sensitive to volatility, which has declined from decade-long highs but remains above pre-COVID levels. Improvement is uneven across the curve, with the front end lagging
- Price impact, has declined from its pandemic-era peak and is now close to average levels observed since 2016, indicating a smaller footprint for each trade. The share of depth provided by more high frequency traders has been stable around 75% in the 10-year sector for the last three years. However, their share in the long end has been more variable, influenced by events like the UK LDI deleveraging and Treasury auction size increases
- The RMSE of our par curve has risen to 2-year highs, and increased dispersion has traditionally indicated deteriorating liquidity in off-the-run Treasuries and potential for deleveraging. A deeper dive shows increased dispersion is mainly evident at the front end. We think the recent rise in dispersion is overstated and largely reflects the outsized influence of a number of illiquid and deeply off the run bonds which were issued more than 20 years ago
- Combining various liquidity measures, the market functioning index shows that Treasury market liquidity is close to average levels observed over the last three years. The front end is the main exception
- Primary dealer inventories have risen above pandemic peaks, nearly 2 standard deviations above the 5-year average. Inventories as a share of total marketable debt remain below pre-GFC levels
- TIPS daily trading volumes have averaged \$18.5bn YTD, close to averages observed in recent years, with daily turnover of the market excluding Fed holdings remaining just above 1%. TIPS volumes as a share of overall Treasury volumes have declined from their post-COVID peak but remain elevated on a historical basis...
- ...TRACE data reveal that TIPS trading volumes remain highly cyclical, with volumes rising on month-end, CPI release days, and auction days
- Overall, Treasury market liquidity has improved in 2024, with rising market depth, falling price impact, and moderate dispersion. Despite rising dealer inventories, market functioning remains relatively healthy, though weaker than pre-pandemic conditions. Elevated dealer balance sheets are a development to watch, given their impact during the pandemic

Fixed Income Strategy

Jay Barry ^{AC}

(1-212) 834-4951
john.f.barry@jpmorgan.com

Phoebe White ^{AC}

(1-212) 834-3092
phoebe.a.white@jpmorgan.com

Afonso Borges

(1-212) 834-4349
afonso.borges@jpmorgan.com

Liam L Wash

(1-212) 834-5230
liam.wash@jpmchase.com
J.P. Morgan Securities LLC

See page 12 for analyst certification and important disclosures.

This one's optimistic

Treasury market liquidity and functioning has been back at the forefront of conversations over the last week or so: the unwind of carry trades and signs that Treasury curve dispersion was rising led market participants to question whether the Treasury market was at the incipient stages of another round of dysfunction. Thus far, the deleveraging that occurred across various markets has not led to a broader deterioration in bond market liquidity. Nonetheless, we think it's an opportune time to take an in-depth look at Treasury market liquidity and functioning. In the coming pages, we will dissect the overall state of affairs in Treasury market liquidity, from trading volumes, turnover and market depth, down to trading conditions in off-the-run Treasuries.

Overall, we find that broad measures of liquidity have been on an improving trend through 2024, supported by declining delivered volatility amid one of the longer Fed-on-hold periods in modern history. We also find that dispersion in off-the-run Treasuries has increased, but some of the recent concerns have been exaggerated by the presence of very small and highly illiquid bonds issued in the late-1990s. We also find little evidence of increased liquidity preference. However, it is notable that dealer positions, while still low compared to pre-GFC trends, have made new highs recently, approaching a share of total marketable debt outstanding that persisted just prior to the outbreak of the COVID-19 pandemic.

Trading volumes surge, but turnover stabilizes at low level

Figure 1: Trading volumes have increased 30% YTD from 2023, but turnover remains stuck at historically low levels...

Average daily Treasury trading volumes (lhs, \$bn) versus daily Treasury market turnover (rhs, %); monthly data



Source: Federal Reserve Bank of New York, US Treasury

Figure 2: ..and most volumes are occurring in the intermediate sector

Average daily Treasury trading volumes by sector, YTD; \$bn

Type	Avg daily volumes	Share of total
T-bills	176	20.0%
FRNs	3	0.3%
0-2y	129	14.6%
2-3y	85	9.7%
3-5y	186	21.1%
5-7y	60	6.8%
7-10y	130	14.8%
10-20y	26	2.9%
20y+	68	7.7%
<5y TIPS	11	1.2%
5-10y TIPS	6	0.6%
>10y TIPS	1	0.2%
Total	881	100%

Source: FINRA TRACE

From a high-level perspective, there has been a healthy increase in Treasury trading in 2024, as daily volumes have averaged \$817bn YTD a 30% increase from 2023 (**Figure 1**). This increase has outstripped the growth of the Treasury market, and turnover has risen modestly, but has merely stabilized at low levels after a decade of a declining trend. Along the curve, volumes have been generally focused in intermediates: by share

the largest volumes YTD have been in the 3- to 5-year sector (**Figure 2**), with T-bills seeing the second largest share of volumes on a notional basis. Within the details, it's notable that volumes in the 3- to 5-year sector far outpace those in surrounding tenors, while at the long end, volumes in the 20+ year sector are nearly tripled those in the 10- to 20-year sector. To an extent this makes sense, as there is a two-year gap in the 2034-2036 sector where no securities exist, and even then, many of the bonds outstanding are original-issue 30-years from the GFC period with relative small free float, which trade less actively than less deeply off-the-runs at the very long end. **Overall, though turnover is low, this is not a new dynamic, and it's been more stable in recent years.**

Depth and price impact point to improving liquidity conditions

Increased volumes indicate better liquidity conditions, but we have a bigger suite of liquidity measures which offer deeper insight into Treasury market functioning. Many of the other metrics we follow all indicate liquidity is stable to improving: market depth, our preferred measure of Treasury market liquidity, has been steadily improving since hitting its lows in early-2022 (**Figure 3**). To be fair, market depth remains about 50% below its decade-long average, as Treasury market liquidity remains highly sensitive to uncertainty. **Figure 4** shows total Treasury market depth regressed on the daily delivered volatility of our US Government Bond Index (GBI-US), and we see that depth decreases as volatility increases and vice versa. Though delivered volatility has declined this year from decade-long highs, it **remains considerably above pre-COVID levels**: uncertainty has declined as the Fed has held rates steady for the last 11 months, but the path for easing has been pushed back, and the Treasury market has experienced a wide 90bp range in 10-year yields YTD. **Looking ahead, the empirical vol/rate directionality imply that volatility should decline further as yields decline, which would support a further increase in market depth as the Fed begins easing.** However, this is predicated on a Fed which eases because the disinflationary process resumes, not because an exogenous shock to the labor market forces aggressive easing.

Figure 3: Market depth has steadily improved from its nadir in mid-2022, but remains well below decade-long averages...

Duration-weighted Treasury market depth*, 1-month moving average; \$mn 10-year Treasury equivalents



Source: BrokerTec, J.P. Morgan

* The sum of the three bids and offers by queue position, averaged between 8:30 and 10:30am daily. This is the sum of 2-, 5-, 10-, and 30-year depth in 10-year equivalents

Figure 4: ...as volatility remains elevated compared to the pre-pandemic period

Duration-weighted Treasury market depth*; 3-month moving average, regressed on 3-month standard deviation of daily changes in US-GBI yield (bp/day), regression over the last decade; \$mn 10-year Treasury equivalents



Source: Source: J.P. Morgan, BrokerTec

* The sum of the three bids and offers by queue position, averaged between 8:30 and 10:30am daily. This is the sum of 2-, 5-, 10-, and 30-year depth in 10-year equivalents

Along the curve the improvement has not been uniform: at the front end, market depth remains below averages observed over the last 5 years, while in longer tenors, depth is sitting in the upper 20-35% of ranges observed over the period (**Figure 5**). **This makes**

sense given that the front end continues to experience significantly higher volatility now than it did during the pandemic; thus front-end depth is very unlikely to retrace back toward those highs any time soon.

Figure 5: The front end has lagged the broad improvement in liquidity conditions

Treasury market depth by tenor, latest readings with 5-year statistics; \$mn unless otherwise indicated

Sector	Latest	5-year min	5-year max	5-year avg.	Percentile
2y	98	16	857	227	45%
3y	45	10	630	152	46%
5y	97	19	367	136	40%
10y	126	16	266	123	56%
20y	15	5	25	13	65%
30y	19	4	35	15	78%

Source: BrokerTec, J.P. Morgan

* The sum of the three bids and offers by queue position, averaged between 8:30 and 10:30am daily.

Below the surface, more advanced measures indicate healthy liquidity conditions as well. Figure 6 displays the evolution of price impact, which measures the average move for a \$100mn notional trade in 10-year Treasuries. This metric spiked to over 1.4/32nds on average, during the onset of the COVID-19 pandemic, but then normalized thanks to the Fed's unprecedented actions. However, unsurprisingly, price impact rose as volatility increased sharply during the Fed's breakneck 2022-2023 tightening campaign. However, this measure has retraced over the last year or so, supported by a Fed on hold, and is sitting close to average levels observed since we first began capturing this series in 2016.

Figure 6: Price impact has declined, indicating a smaller footprint for each trade in the Treasury market...

10-year Treasury price impact*, 1-month moving average; 32nds

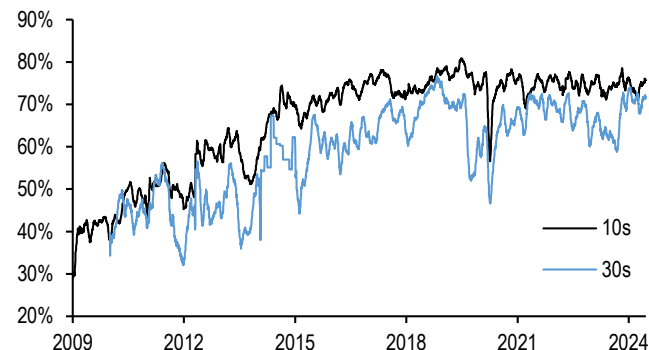


Source: J.P. Morgan, BrokerTec

* The average move in order book mid-price against a \$100mn flow in traded notional. See [Drivers of price impact and the role of hidden liquidity](#), 1/13/17 for more details.

Figure 7: ...and the fast flow share of liquidity provision remains stable at high levels, despite high volatility

Fraction of 10-year Treasury market depth provided by high-frequency activity*, 1-month moving average; %



Source: J.P. Morgan, BrokerTec

* Defined as passive limit orders that are reacting within 0.1 second to another event in the CLOB

Microstructure data also indicate more stable liquidity provision: Figure 7 shows the share of market depth provided by high frequency traders has remained relatively stable in the 10-year sector, averaging 75% over the last 3 years. However, the share of liquidity provision from higher-frequency traders at the long end has been more variable, rising in the post-pandemic period, but declining in 2022-2023. Recall, late-2022 was defined by the UK LDI deleveraging, which seemed to impact long-dated Treasuries, and the summer of 2023 was punctuated by the Treasury's open-ended series of long-duration auction size increases; thus, the decline in automated liquidity

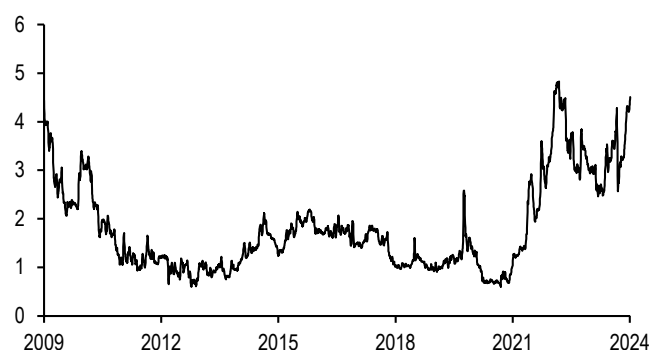
provision could have been prompted by the policy uncertainty and volatility surrounding those events. **It's notable that now the share of depth being provided by high-frequency participants at the long end is nearly on par with the share provided in the 10-year sector, and this has been a relatively rare occurrence, seen only for a brief period in 2018 and in early-2021.**

Dispersion rising, but mainly a function of curve construction

In recent weeks, market participants and the media have noted that a rise in Treasury yield curve dispersion point to deteriorating liquidity and risks of deleveraging. **Indeed, the RMSE of our Treasury par curve has been on a rising trend and is now at levels last seen during the early days of QT2 and the LDI-related delevering in the fall of 2022 (Figure 8).** In the past, rising RMSE has been associated with liquidation of more financing intensive off-the-runs, as occurred during fall 2022 and before that, during the onset of the COVID-19 pandemic in March 2020. **Rising RMSE could be a proverbial canary in the coal mine for a more serious deterioration in liquidity conditions, but we believe the recent rise in dispersion is overstated, and a relic of curve construction, rather than a harbinger of potential financial calamity.** Indeed, **Figure 9** shows the largest moves in RMSE have been isolated to the two front-end buckets, which are now both at 5-year highs, while RMSE in other tenors are generally above their 5-year averages, but not dislocated by any stretch.

Figure 8: The dispersion to our fitted curve has risen to two-year high...

Root mean square error of J.P. Morgan Treasury par curve, one-week moving average; bp



Source: J.P. Morgan

Figure 9: ...mainly driven by the front end...

RMSE of J.P. Morgan Treasury par curve by sector with 6-month changes and 5-year statistics

Maturity	Last	6m chg	5y min	5y max	5y avg	%
0-2y	30.9	10.9	0.8	317.9	12.5	94%
2-3y	7.7	6.5	0.3	7.7	1.5	100%
3-5y	3.1	0.6	0.3	4.0	1.6	92%
5-7y	2.3	-0.5	0.3	4.3	1.9	56%
7-10y	5.7	-0.4	0.5	7.2	2.7	94%
10-20y	2.2	-2.8	0.8	11.7	3.9	25%
20-30y	1.0	-0.7	0.6	6.3	1.9	13%

Source: J.P. Morgan

Drilling down, this high RMSE largely stems from original-issue 30-year bonds issued in the late 1990s. Recall these bonds were issued during the days of small budget deficits and even surpluses, with free floats (amount issued less SOMA ownership and bonds held in stripped form) of \$5bn or less, and are substantially smaller than other off-the-runs in this sector (**Figure 10**). As the figure shows, most of these small, illiquid issues are all trading very *rich* relative to our fitted curve, disproportionately impacting RMSE measures at the front end. **Thus, while dispersion is likely increasing somewhat, it's being overstated by these tiny, illiquid deeply off-the-run bonds which were auctioned more than 20-years ago, and trade very infrequently.**

Figure 10: ...driven by deeply off-the-run original-issue 30-year bonds issued in the late-1990s, all of which have small free floats and trade extremely rich relative to the curve

Treasury securities with less than \$8bn in free float*; units as indicated

CUSIP	Free float (\$bn)	Issue Date	Maturity Date	Orig. issue (years)	Yield error (bp)
912810FA1	2.1	8/15/1997	8/15/2027	30	-5.2
912810EZ7	2.2	2/18/1997	2/15/2027	30	-20.5
912810EV6	2.3	8/15/1995	8/15/2025	30	-32.8
912810ET1	2.3	2/15/1995	2/15/2025	30	-66.5
912810ES3	2.5	8/15/1994	11/15/2024	30	-74.9
912810EX2	2.9	8/15/1996	8/15/2026	30	-17.1
912810FJ2	3.2	8/16/1999	8/15/2029	30	-4.0
912810EY0	3.2	11/15/1996	11/15/2026	30	-40.2
912810FG8	4.0	2/16/1999	2/15/2029	30	-9.9
912810FE3	4.1	8/17/1998	8/15/2028	30	-11.9
912810PT9	4.8	2/15/2007	2/15/2037	30	-2.3
912810EW4	5.6	2/15/1996	2/15/2026	30	-23.2
912810FM5	5.6	2/15/2000	5/15/2030	30	-1.2
912810PU6	6.0	8/15/2007	5/15/2037	30	-2.3
912810PW2	6.1	2/15/2008	2/15/2038	30	-2.8
912810FB9	6.4	11/17/1997	11/15/2027	30	-5.4
912810FT0	6.6	2/15/2006	2/15/2036	30	-4.2
912810FF0	7.1	11/16/1998	11/15/2028	30	-5.1
912810PX0	7.2	8/15/2008	5/15/2038	30	-2.7
912810FP8	7.4	2/15/2001	2/15/2031	30	-10.6

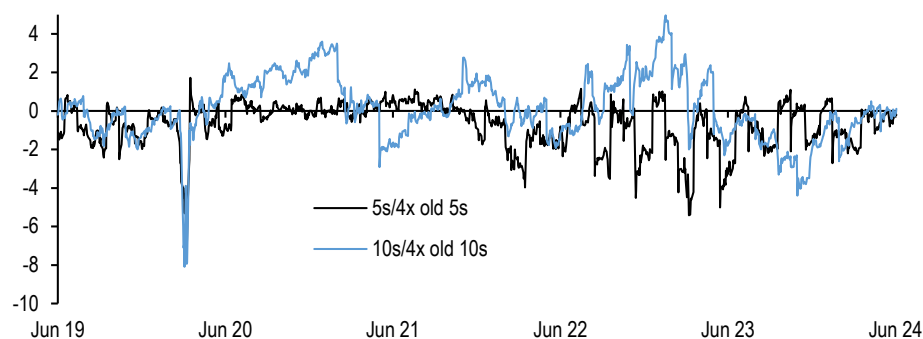
Source: J.P. Morgan, US Treasury

*Amount outstanding less the sum of SOMA holdings and the stripped amount

Away from dispersion, comparing matched-maturity SOFR spreads for on-the-run Treasuries with their near off-the-run counterparts give us insight on liquidity preference (**Figure 11**). Prior to the Fed's interventions in March 2020, on-the-runs in the 5- and 10-year sectors traded 5-7bp rich relative to their near off-the-run counterparts on a matched-maturity SOFR spread basis. 5s traded with some liquidity premium during the 2022-2023 tightening cycle as demand to borrow collateral drove consistent repo specialness. However, it's notable that on-the-run 5- and 10-year notes now display no liquidity premium relative to off-the-runs issued 4- to 12 months ago. **Overall, given near off-the-runs are trading relatively in line with on-the-runs, this doesn't give us a sense that off-the-run liquidity conditions have deteriorated materially.**

Figure 11: There are no signs of liquidity preference in on-the-run/off-the-run spreads

5s/quadruple old 5s and 10s/quadruple old 10s spreads matched-maturity SOFR spread curves; bp



Source: J.P. Morgan

Market functioning sitting at post-pandemic averages

In sum, with market depth rising, price impact falling, and dispersion increasing moderately, these data points suggest that Treasury market liquidity has been on an improving trend in 2024. Each of the data series above are individually helpful in identifying liquidity trends, but we can combine these measures to provide a more holistic view of Treasury market liquidity conditions by tenor. **Figure 12** displays current levels as well as 3-year z-scores for each of these factors, broken out by sector of the curve. We also average these z-scores into a “market functioning index” for each tenor, in order to illustrate the relative health of the Treasury market by maturity. **The table shows that in aggregate, market functioning is very close to average levels observed over the last 3 years in most tenors.**

Figure 12: Market functioning in most sectors is in line with post-pandemic averages, with the exception of the front end, which is being compromised by elevated RMSE

Current levels and 3-year z-scores for Treasury market depth*, price impact**, and Treasury curve RMSE***, by sector of the curve, with Treasury market functioning index†; units as indicated

Market depth	Current (\$mn)	3y z-score	Price impact (32nds)	Current	3y z-score	RMSE (bp)	Current	3y z-score	Market functioning
2y	102	-0.1	2y	0.00	0.9	2y	7.7	-4.5	-1.3
5y	87	-0.1	5y	0.23	1.6	5y	3.1	-1.1	0.1
10y	129	0.9	10y	0.73	0.5	10y	5.7	-1.3	0.0
30y	19	1.2	30y	0.77	0.3	30y	1.0	1.1	0.9

Source: J.P. Morgan, BrokerTec

* Market depth is the sum of the three bids and offers by queue position, averaged between 8:30 and 10:30am daily

**Defined as passive limit orders that are reacting within 0.1 second to another event in the CLOB

*** Root Mean Square Error of J.P. Morgan para fitted Treasury curve. We use Fed purchase buckets: 2y = 0-2y, 5y = 3-5y, 10y = 7-10y, 30y = 20-30y

† We multiply the price impact and RMSE z-scores by -1 so positive z-score means better Treasury market functioning

The main exception we can observe is at the front end, where historically high dispersion is dragging down the market functioning index in the 0-2-year sector. As discussed above, we think this is more a factor of curve construction than a sign of compromised market functioning. **As a result, we can conclude that in aggregate, Treasury market functioning is sitting at relatively average levels compared to the last 3 years, although is clearly much weaker than conditions that persisted prior to the pandemic.**

Primary dealer near record levels, but less alarming after accounting for growth of the Treasury market

Amid relatively healthy market functioning, primary dealer inventories have been rising, and for the last 2-3 months have been sitting above the highest levels observed during the pandemic, and nearly 2 standard deviations above the trailing 5-year average (Figure 13). Recall that high dealer inventories were an impediment to market functioning during 2020. Across the curve it's notable that most of the increase has come in the intermediate sector of the nominal curve, and in TIPS, while inventory at the front end and long end is sitting pretty close to average levels observed over the last 5 years.

Figure 13: Dealer inventories in Treasuries are at record levels...

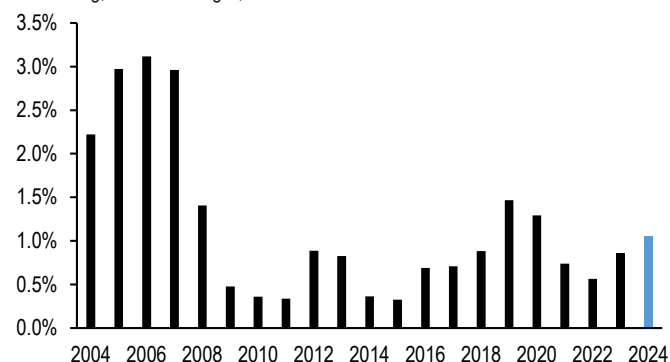
Primary dealer inventory in Treasuries, current levels, YTD changes with 5-year statistics; \$bn unless otherwise indicated

Maturity	Last	YTD chg	5y avg	5y min	5y max	5y z-score
T-bills	75	23	51	-4	119	0.9
<2y	33	16	35	-17	97	-0.1
2-3y	16	12	5	-14	18	1.9
3-6y	69	18	29	-2	69	2.6
6-7y	25	11	12	-4	29	2.0
7-11y	23	4	3	-10	27	2.7
>11y	50	5	44	0	62	0.8
11-21y	21	2				
>21y	29	3				
TIPS	24	8	13	1	25	2.2
FRNS	10	6	8	-1	52	0.4
Total	325	101	201	76	325	2.2

Source: Federal Reserve Bank of New York

Figure 14: ..and have risen as a share of the Treasury market, but remain well below pre-GFC shares

Primary dealer inventory in Treasuries as a share of total marketable Treasury debt outstanding, annual average*, %



Source: Federal Reserve Bank of New York, US Treasury
*2024 through 6/5/24

While inventories have exceeded the peak during the pandemic, given the growth of the Treasury market over the last 4 years, inventories as a share of total marketable Treasury debt remains below the 2019-2020 local peak: YTD primary dealer inventory in Treasuries accounts for approximately 1.1% of total marketable debt outstanding (Figure 14). This share has risen sequentially over the last 2 years, and is approaching the peak in 2019-2020, but is well below pre-GFC levels. While banks do not appear to be leverage constrained right now, this is a development worth watching, because elevated dealer balance sheets heading into the pandemic gave dealers little room to add inventory amid the wholesale deleveraging that occurred in March 2020.

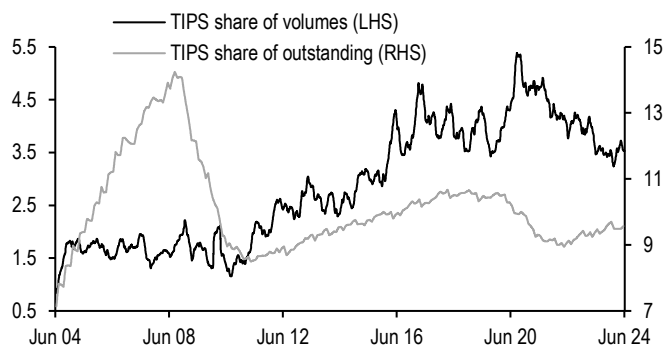
TIPS liquidity remains robust

Daily trading volumes of TIPS have averaged \$18.5bn YTD, close to averages observed in recent years, with volumes close to evenly split between on-the-run and off-the-runs. On a relative basis, TIPS volumes as a share of coupon Treasury volumes have fallen in recent years, averaging roughly 3.5% YTD, down from a peak above 5% in mid 2020. It's not surprising to see this share decline in recent years, as the demand for inflation protection has fallen, but it's worth recognizing that this share remains near pre-pandemic levels, even as the TIPS share of the coupon Treasury market remains below levels that prevailed in 2019 (Figure 15). Daily turnover remains depressed near 2023 levels, and below average levels observed prior to the pandemic, but once adjusting for

the higher share of the market held by the Fed, turnover has remained fairly stable just above 1% (**Figure 16**). The share of the TIPS market held by SOMA peaked at 27% prior to the start of QT, and has fallen to a still historically elevated 23% share. While a high share of the market held by the Fed has reduced the tradable float of the TIPS market and contributed to declining turnover, it's notable that the share of the market held by foreign official investors has fallen markedly over the last 5 years, from approximately 31% to 16% as of June 2023 (see [TIPS Strategy](#), 5/3/24), increasing the tradeable float, on the margin.

Figure 15: TIPS volumes as a share of coupon Treasury volumes has fallen in recent years, averaging roughly 3.5% YTD

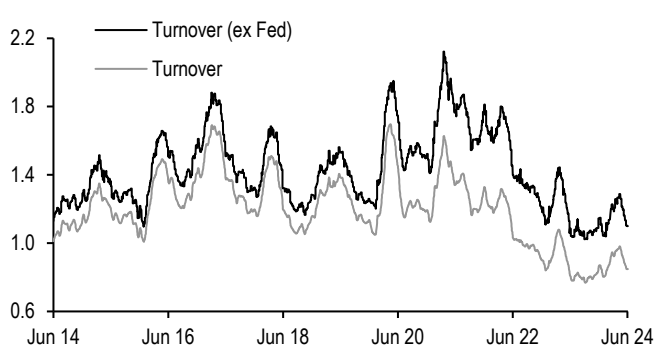
TIPS average daily trading volumes relative to total Treasury (ex-bill) volumes (LHS) and TIPS outstanding relative to total Treasury (ex-bill) market (RHS); % both axes



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

Figure 16: Daily turnover of the TIPS market (excluding Fed holdings) remains just above 1% on average

Daily TIPS market turnover, including and excluding Fed holdings; %



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

Digging a level deeper, we recognize that while volumes on average have remained robust, trading volumes in the TIPS market are highly cyclical. Utilizing daily volumes data from TRACE since February 2023, we observe that TIPS trading volumes tend to more than double on month-end dates, and this rise in volumes is much more pronounced in TIPS relative to nominal Treasuries (**Figure 17**). This makes sense intuitively given the significant share of the TIPS market held by inflation-focused funds, mutual funds and ETFs (see [The inflation fund landscape: Reviewing trends in flows, composition, and positioning](#), 5/28/24). More specifically, we find that month-end trading volumes in the TIPS market tend to be highly correlated with the size of the monthly extension in the Bloomberg US Treasury Inflation-linked Bond Index (see [TIPS Strategy](#), 2/2/24). We also observe a significant rise in front-end TIPS trading volumes on CPI release days, and, like nominal Treasuries, trading volumes tend to rise on auction days in the sector being offered. This is particularly true at the long end, where the auction can be used as a liquidity event: on average, trading volumes in the 10- to 30-year sector are nearly triple on the day of a 30-year TIPS auction compared with all other days, driven by a jump in on-the-run 30-year TIPS volumes.

Figure 17: TIPS trading volumes are more cyclical than nominals, with volumes jumping on month-end. Front-end volumes also rise materially on CPI release days

Ratio of daily trading volume by sector for each event versus average daily trading volume*

	Nominals								TIPS			
	(0,2y]	(2,3y]	(3,5y]	(5,7y]	(7,10y]	(10,20y]	(20,30y]	Total	(0,5y]	(5,10y]	(10,30y]	Total
Month end	1.8	1.7	1.4	1.9	1.4	1.5	1.5	1.6	2.2	2.9	3.2	2.5
Auction	1.4	1.8	1.3	1.8	1.8	1.6	1.4	1.6	1.5	2.2	2.8	2.2
CPI	1.1	1.4	1.1	1.0	1.3	1.0	1.2	1.2	1.7	1.0	0.8	1.4
Fed	1.2	1.1	1.2	1.0	1.1	1.0	1.0	1.1	2.2	1.7	1.1	1.9

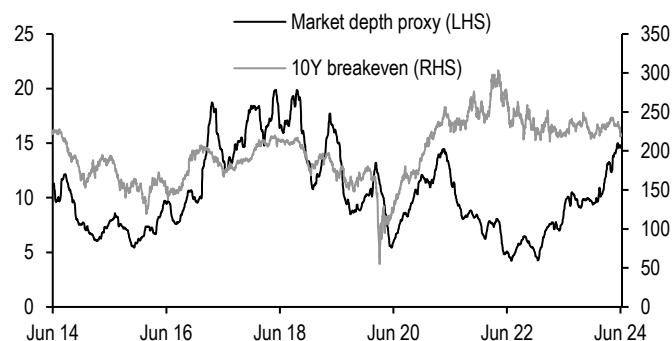
Source: TRACE, J.P. Morgan

* For auctions, event dates vary by sector. We compare volumes in the sector being offered on auction day to volumes on all other days. Total reflects the average ratio across sectors. Data since February 13, 2023

Turning to market behavior and pricing, it appears that liquidity remains robust, by a variety of measures. Our TIPS market depth proxy, calculated as average TIPS trading volumes relative to realized volatility in 10-year breakevens, has been on the rise over the last couple of years, after declining in the aftermath of the pandemic (**Figure 18**). Notably, this is largely a reflection of breakeven volatility declining, even while TIPS trading volumes have remained relatively elevated. Lastly, against a backdrop in which liquidity remains healthy by a variety of measures, we observe that 5Y and 10Y IOTAs, a proxy for the liquidity premium embedded in cash breakevens, have narrowed over the past year (**Figure 19**). At the long-end, 30Y IOTAs remain near the wide end of their 5-year range. The richening of cash breakevens on this basis in the front to intermediate part of the curve is notable against the backdrop of ongoing Fed QT, although unsurprisingly, IOTAs remain considerably wider than levels observed during the QE period. Looking ahead, if macro volatility remains subdued, we expect liquidity in the TIPS markets to remain supported. However, we are cognizant that an unexpected flight to quality could drive renewed preference for nominal Treasuries, implying a wider liquidity premium in TIPS breakevens, as we saw in certain pockets of the market last week (see [TIPS Strategy](#), 6/14/24).

Figure 18: Our TIPS market depth proxy has been on the rise recently...

TIPS market depth proxy* (lhs; unitless) versus 10-year TIPS breakevens (rhs; bp)

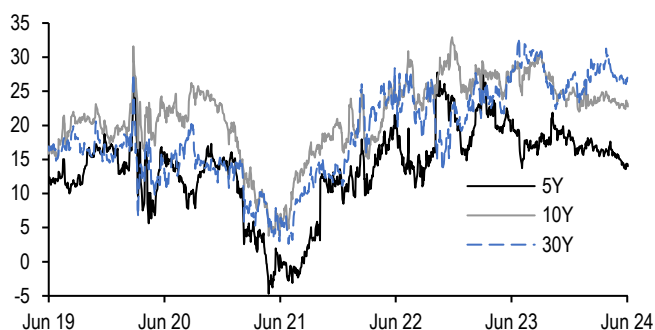


Source: Federal Reserve Bank of New York, J.P. Morgan

* Depth proxy is one-month moving average of dealer transactions in TIPS divided by one-week average of the magnitude of daily changes in 10-year TIPS breakevens

Figure 19: ...and IOTAs have narrowed over the past year, primarily in the 5- and 10-year sectors, despite ongoing QT

IOTA (from Z-spread to SOFR differential) for 5-, 10-, and 30-year TIPS; bp



Source: J.P. Morgan

Conclusions: liquidity conditions stable and improving, with a watchful eye on dealer inventories and liquidity preference

Overall, a host of Treasury market metrics indicate stable to improving liquidity conditions: trading volumes are rising, and turnover has stabilized at low levels. Meanwhile, market depth in nominals and TIPS has been on a rising trend, price impact has continued to decline, and the HFT share of depth provision has been stable as well. Meanwhile, dispersion has been on the rise, but we attribute much of this move to a select few deeply off-the-run bonds from the late-1990s and early-2000s, and moves look muted when excluding these CUSIPs. In contrast though, dealer inventories have been on the rise, and as a share of total Treasury debt outstanding, inventories are approaching levels reached in late-2019/early-2020. Overall, if volatility continues to decline, we think this bodes well for Treasury market liquidity conditions, but we do not expect a return to pre-pandemic levels. Of course, any exogenous shock would be a negative for liquidity conditions.

Analyst Certification: The Research Analyst(s) denoted by an “AC” on the cover of this report certifies (or, where multiple Research Analysts are primarily responsible for this report, the Research Analyst denoted by an “AC” on the cover or within the document individually certifies, with respect to each security or issuer that the Research Analyst covers in this research) that: (1) all of the views expressed in this report accurately reflect the Research Analyst’s personal views about any and all of the subject securities or issuers; and (2) no part of any of the Research Analyst’s compensation was, is, or will be directly or indirectly related to the specific recommendations or views expressed by the Research Analyst(s) in this report. For all Korea-based Research Analysts listed on the front cover, if applicable, they also certify, as per KOFIA requirements, that the Research Analyst’s analysis was made in good faith and that the views reflect the Research Analyst’s own opinion, without undue influence or intervention.

All authors named within this report are Research Analysts who produce independent research unless otherwise specified. In Europe, Sector Specialists (Sales and Trading) may be shown on this report as contacts but are not authors of the report or part of the Research Department.

Important Disclosures

Company-Specific Disclosures: Important disclosures, including price charts and credit opinion history tables, are available for compendium reports and all J.P. Morgan–covered companies, and certain non-covered companies, by visiting <https://www.jpmm.com/research/disclosures>, calling 1-800-477-0406, or e-mailing research.disclosure.inquiries@jpmorgan.com with your request.

A history of J.P. Morgan investment recommendations disseminated during the preceding 12 months can be accessed on the Research & Commentary page of <http://www.jpmorganmarkets.com> where you can also search by analyst name, sector or financial instrument.

Analysts' Compensation: The research analysts responsible for the preparation of this report receive compensation based upon various factors, including the quality and accuracy of research, client feedback, competitive factors, and overall firm revenues.

Other Disclosures

J.P. Morgan is a marketing name for investment banking businesses of JPMorgan Chase & Co. and its subsidiaries and affiliates worldwide.

UK MIFID FICC research unbundling exemption: UK clients should refer to [UK MIFID Research Unbundling exemption](#) for details of J.P. Morgan’s implementation of the FICC research exemption and guidance on relevant FICC research categorisation.

Any long form nomenclature for references to China; Hong Kong; Taiwan; and Macau within this research material are Mainland China; Hong Kong SAR (China); Taiwan (China); and Macau SAR (China).

J.P. Morgan Research may, from time to time, write on issuers or securities targeted by economic or financial sanctions imposed or administered by the governmental authorities of the U.S., EU, UK or other relevant jurisdictions (Sanctioned Securities). Nothing in this report is intended to be read or construed as encouraging, facilitating, promoting or otherwise approving investment or dealing in such Sanctioned Securities. Clients should be aware of their own legal and compliance obligations when making investment decisions.

Any digital or crypto assets discussed in this research report are subject to a rapidly changing regulatory landscape. For relevant regulatory advisories on crypto assets, including bitcoin and ether, please see <https://www.jpmorgan.com/disclosures/cryptoasset-disclosure>.

The author(s) of this research report may not be licensed to carry on regulated activities in your jurisdiction and, if not licensed, do not hold themselves out as being able to do so.

Exchange-Traded Funds (ETFs): J.P. Morgan Securities LLC (“JPMS”) acts as authorized participant for substantially all U.S.-listed ETFs. To the extent that any ETFs are mentioned in this report, JPMS may earn commissions and transaction-based compensation in connection with the distribution of those ETF shares and may earn fees for performing other trade-related services, such as securities lending to short sellers of the ETF shares. JPMS may also perform services for the ETFs themselves, including acting as a broker or dealer to the ETFs. In addition, affiliates of JPMS may perform services for the ETFs, including trust, custodial, administration, lending, index calculation and/or maintenance and other services.

Options and Futures related research: If the information contained herein regards options- or futures-related research, such information is available only to persons who have received the proper options or futures risk disclosure documents. Please contact your J.P. Morgan Representative or visit <https://www.theocc.com/components/docs/riskstoc.pdf> for a copy of the Option Clearing Corporation's Characteristics and Risks of Standardized Options or http://www.finra.org/sites/default/files/Security_Futures_Risk_Disclosure_Statement_2018.pdf for a copy of the Security Futures Risk Disclosure Statement.

Changes to Interbank Offered Rates (IBORs) and other benchmark rates: Certain interest rate benchmarks are, or may in the future become, subject to ongoing international, national and other regulatory guidance, reform and proposals for reform. For more information, please consult: https://www.jpmorgan.com/global/disclosures/interbank_offered_rates

Private Bank Clients: Where you are receiving research as a client of the private banking businesses offered by JPMorgan Chase & Co. and its subsidiaries (“J.P. Morgan Private Bank”), research is provided to you by J.P. Morgan Private Bank and not by any other division of J.P. Morgan,

including, but not limited to, the J.P. Morgan Corporate and Investment Bank and its Global Research division.

Legal entity responsible for the production and distribution of research: The legal entity identified below the name of the Reg AC Research Analyst who authored this material is the legal entity responsible for the production of this research. Where multiple Reg AC Research Analysts authored this material with different legal entities identified below their names, these legal entities are jointly responsible for the production of this research. Research Analysts from various J.P. Morgan affiliates may have contributed to the production of this material but may not be licensed to carry out regulated activities in your jurisdiction (and do not hold themselves out as being able to do so). Unless otherwise stated below, this material has been distributed by the legal entity responsible for production. If you have any queries, please contact the relevant Research Analyst in your jurisdiction or the entity in your jurisdiction that has distributed this research material.

Legal Entities Disclosures and Country-/Region-Specific Disclosures:

Argentina: JPMorgan Chase Bank N.A Sucursal Buenos Aires is regulated by Banco Central de la República Argentina ("BCRA"- Central Bank of Argentina) and Comisión Nacional de Valores ("CNV"- Argentinian Securities Commission - ALYC y AN Integral N°51). **Australia:** J.P. Morgan Securities Australia Limited ("JPMSAL") (ABN 61 003 245 234/AFS Licence No: 238066) is regulated by the Australian Securities and Investments Commission and is a Market Participant of ASX Limited, a Clearing and Settlement Participant of ASX Clear Pty Limited and a Clearing Participant of ASX Clear (Futures) Pty Limited. This material is issued and distributed in Australia by or on behalf of JPMSAL only to "wholesale clients" (as defined in section 761G of the Corporations Act 2001). A list of all financial products covered can be found by visiting <https://www.jpmm.com/research/disclosures>. J.P. Morgan seeks to cover companies of relevance to the domestic and international investor base across all Global Industry Classification Standard (GICS) sectors, as well as across a range of market capitalisation sizes. If applicable, in the course of conducting public side due diligence on the subject company(ies), the Research Analyst team may at times perform such diligence through corporate engagements such as site visits, discussions with company representatives, management presentations, etc. Research issued by JPMSAL has been prepared in accordance with J.P. Morgan Australia's Research Independence Policy which can be found at the following link: [J.P. Morgan Australia - Research Independence Policy](#). **Brazil:** Banco J.P. Morgan S.A. is regulated by the Comissão de Valores Mobiliários (CVM) and by the Central Bank of Brazil. Ombudsman J.P. Morgan: 0800-7700847 / 0800-7700810 (For Hearing Impaired) / ouvidoria.jp.morgan@jpmorgan.com. **Canada:** J.P. Morgan Securities Canada Inc. is a registered investment dealer, regulated by the Canadian Investment Regulatory Organization and the Ontario Securities Commission and is the participating member on Canadian exchanges. This material is distributed in Canada by or on behalf of J.P.Morgan Securities Canada Inc. **Chile:** Inversiones J.P. Morgan Limitada is an unregulated entity incorporated in Chile. **China:** J.P. Morgan Securities (China) Company Limited has been approved by CSRC to conduct the securities investment consultancy business. **Dubai International Financial Centre (DIFC):** JPMorgan Chase Bank, N.A., Dubai Branch is regulated by the Dubai Financial Services Authority (DFSA) and its registered address is Dubai International Financial Centre - The Gate, West Wing, Level 3 and 9 PO Box 506551, Dubai, UAE. This material has been distributed by JP Morgan Chase Bank, N.A., Dubai Branch to persons regarded as professional clients or market counterparties as defined under the DFSA rules. **European Economic Area (EEA):** Unless specified to the contrary, research is distributed in the EEA by J.P. Morgan SE ("JPM SE"), which is authorised as a credit institution by the Federal Financial Supervisory Authority (Bundesanstalt für Finanzdienstleistungsaufsicht, BaFin) and jointly supervised by the BaFin, the German Central Bank (Deutsche Bundesbank) and the European Central Bank (ECB). JPM SE is a company headquartered in Frankfurt with registered address at TaunusTurm, Taunustor 1, Frankfurt am Main, 60310, Germany. The material has been distributed in the EEA to persons regarded as professional investors (or equivalent) pursuant to Art. 4 para. 1 no. 10 and Annex II of MiFID II and its respective implementation in their home jurisdictions ("EEA professional investors"). This material must not be acted on or relied on by persons who are not EEA professional investors. Any investment or investment activity to which this material relates is only available to EEA relevant persons and will be engaged in only with EEA relevant persons. **Hong Kong:** J.P. Morgan Securities (Asia Pacific) Limited (CE number AAJ321) is regulated by the Hong Kong Monetary Authority and the Securities and Futures Commission in Hong Kong, and J.P. Morgan Broking (Hong Kong) Limited (CE number AAB027) is regulated by the Securities and Futures Commission in Hong Kong. JP Morgan Chase Bank, N.A., Hong Kong Branch (CE Number AAL996) is regulated by the Hong Kong Monetary Authority and the Securities and Futures Commission, is organized under the laws of the United States with limited liability. Where the distribution of this material is a regulated activity in Hong Kong, the material is distributed in Hong Kong by or through J.P. Morgan Securities (Asia Pacific) Limited and/or J.P. Morgan Broking (Hong Kong) Limited. **India:** J.P. Morgan India Private Limited (Corporate Identity Number - U67120MH1992FTC068724), having its registered office at J.P. Morgan Tower, Off. C.S.T. Road, Kalina, Santacruz - East, Mumbai - 400098, is registered with the Securities and Exchange Board of India (SEBI) as a 'Research Analyst' having registration number INH000001873. J.P. Morgan India Private Limited is also registered with SEBI as a member of the National Stock Exchange of India Limited and the Bombay Stock Exchange Limited (SEBI Registration Number - INZ000239730) and as a Merchant Banker (SEBI Registration Number - MB/INM000002970). Telephone: 91-22-6157 3000, Facsimile: 91-22-6157 3990 and Website: <http://www.jpmipl.com>. JPMorgan Chase Bank, N.A. - Mumbai Branch is licensed by the Reserve Bank of India (RBI) (Licence No. 53/ Licence No. BY.4/94; SEBI - IN/CUS/014/ CDSL : IN-DP-CDSL-444-2008/ IN-DP-NSDL-285-2008/ INBI00000984/ INE231311239) as a Scheduled Commercial Bank in India, which is its primary license allowing it to carry on Banking business in India and other activities, which a Bank branch in India are permitted to undertake. For non-local research material, this material is not distributed in India by J.P. Morgan India Private Limited. Compliance Officer: Spurthi Gadamsetty; spurthi.gadamsetty@jpmchase.com; +912261573225. Grievance Officer: Ramprasadh K, jpmipl.research.feedback@jpmorgan.com; +912261573000.

Investment in securities market are subject to market risks. Read all the related documents carefully before investing. Registration granted by SEBI and certification from NISM in no way guarantee performance of the intermediary or provide any assurance of returns to investors.

Indonesia: PT J.P. Morgan Sekuritas Indonesia is a member of the Indonesia Stock Exchange and is registered and supervised by the Otoritas Jasa Keuangan (OJK). **Korea:** J.P. Morgan Securities (Far East) Limited, Seoul Branch, is a member of the Korea Exchange (KRX). JPMorgan

Chase Bank, N.A., Seoul Branch, is licensed as a branch office of foreign bank (JPMorgan Chase Bank, N.A.) in Korea. Both entities are regulated by the Financial Services Commission (FSC) and the Financial Supervisory Service (FSS). For non-macro research material, the material is distributed in Korea by or through J.P. Morgan Securities (Far East) Limited, Seoul Branch. **Japan:** JPMorgan Securities Japan Co., Ltd. and JPMorgan Chase Bank, N.A., Tokyo Branch are regulated by the Financial Services Agency in Japan. **Malaysia:** This material is issued and distributed in Malaysia by JPMorgan Securities (Malaysia) Sdn Bhd (18146-X), which is a Participating Organization of Bursa Malaysia Berhad and holds a Capital Markets Services License issued by the Securities Commission in Malaysia. **Mexico:** J.P. Morgan Casa de Bolsa, S.A. de C.V. and J.P. Morgan Grupo Financiero are members of the Mexican Stock Exchange and are authorized to act as a broker dealer by the National Banking and Securities Exchange Commission. **New Zealand:** This material is issued and distributed by JPMSAL in New Zealand only to "wholesale clients" (as defined in the Financial Markets Conduct Act 2013). JPMSAL is registered as a Financial Service Provider under the Financial Service providers (Registration and Dispute Resolution) Act of 2008. **Philippines:** J.P. Morgan Securities Philippines Inc. is a Trading Participant of the Philippine Stock Exchange and a member of the Securities Clearing Corporation of the Philippines and the Securities Investor Protection Fund. It is regulated by the Securities and Exchange Commission. **Singapore:** This material is issued and distributed in Singapore by or through J.P. Morgan Securities Singapore Private Limited (JPMS) [MCI (P) 030/08/2023 and Co. Reg. No.: 199405335R], which is a member of the Singapore Exchange Securities Trading Limited, and/or JPMorgan Chase Bank, N.A., Singapore branch (JPMCB Singapore), both of which are regulated by the Monetary Authority of Singapore. This material is issued and distributed in Singapore only to accredited investors, expert investors and institutional investors, as defined in Section 4A of the Securities and Futures Act, Cap. 289 (SFA). This material is not intended to be issued or distributed to any retail investors or any other investors that do not fall into the classes of "accredited investors," "expert investors" or "institutional investors," as defined under Section 4A of the SFA. Recipients of this material in Singapore are to contact JPMS or JPMCB Singapore in respect of any matters arising from, or in connection with, the material. **South Africa:** J.P. Morgan Equities South Africa Proprietary Limited and JPMorgan Chase Bank, N.A., Johannesburg Branch are members of the Johannesburg Securities Exchange and are regulated by the Financial Services Conduct Authority (FSCA). **Taiwan:** J.P. Morgan Securities (Taiwan) Limited is a participant of the Taiwan Stock Exchange (company-type) and regulated by the Taiwan Securities and Futures Bureau. Material relating to equity securities is issued and distributed in Taiwan by J.P. Morgan Securities (Taiwan) Limited, subject to the license scope and the applicable laws and the regulations in Taiwan. According to Paragraph 2, Article 7-1 of Operational Regulations Governing Securities Firms Recommending Trades in Securities to Customers (as amended or supplemented) and/or other applicable laws or regulations, please note that the recipient of this material is not permitted to engage in any activities in connection with the material that may give rise to conflicts of interests, unless otherwise disclosed in the "Important Disclosures" in this material. **Thailand:** This material is issued and distributed in Thailand by JPMorgan Securities (Thailand) Ltd., which is a member of the Stock Exchange of Thailand and is regulated by the Ministry of Finance and the Securities and Exchange Commission, and its registered address is 3rd Floor, 20 North Sathorn Road, Silom, Bangrak, Bangkok 10500. **UK:** Unless specified to the contrary, research is distributed in the UK by J.P. Morgan Securities plc ("JPMS plc") which is a member of the London Stock Exchange and is authorised by the Prudential Regulation Authority and regulated by the Financial Conduct Authority and the Prudential Regulation Authority. JPMS plc is registered in England & Wales No. 2711006, Registered Office 25 Bank Street, London, E14 5JP. This material is directed in the UK only to: (a) persons having professional experience in matters relating to investments falling within article 19(5) of the Financial Services and Markets Act 2000 (Financial Promotion) (Order) 2005 ("the FPO"); (b) persons outlined in article 49 of the FPO (high net worth companies, unincorporated associations or partnerships, the trustees of high value trusts, etc.); or (c) any persons to whom this communication may otherwise lawfully be made; all such persons being referred to as "UK relevant persons". This material must not be acted on or relied on by persons who are not UK relevant persons. Any investment or investment activity to which this material relates is only available to UK relevant persons and will be engaged in only with UK relevant persons. Research issued by JPMS plc has been prepared in accordance with JPMS plc's policy for prevention and avoidance of conflicts of interest related to the production of Research which can be found at the following link: [J.P. Morgan EMEA - Research Independence Policy](#). U.S.: J.P. Morgan Securities LLC ("JPMS") is a member of the NYSE, FINRA, SIPC, and the NFA. JPMorgan Chase Bank, N.A. is a member of the FDIC. Material published by non-U.S. affiliates is distributed in the U.S. by JPMS who accepts responsibility for its content.

General: Additional information is available upon request. The information in this material has been obtained from sources believed to be reliable. While all reasonable care has been taken to ensure that the facts stated in this material are accurate and that the forecasts, opinions and expectations contained herein are fair and reasonable, JPMorgan Chase & Co. or its affiliates and/or subsidiaries (collectively J.P. Morgan) make no representations or warranties whatsoever to the completeness or accuracy of the material provided, except with respect to any disclosures relative to J.P. Morgan and the Research Analyst's involvement with the issuer that is the subject of the material. Accordingly, no reliance should be placed on the accuracy, fairness or completeness of the information contained in this material. There may be certain discrepancies with data and/or limited content in this material as a result of calculations, adjustments, translations to different languages, and/or local regulatory restrictions, as applicable. These discrepancies should not impact the overall investment analysis, views and/or recommendations of the subject company(ies) that may be discussed in the material. J.P. Morgan accepts no liability whatsoever for any loss arising from any use of this material or its contents, and neither J.P. Morgan nor any of its respective directors, officers or employees, shall be in any way responsible for the contents hereof, apart from the liabilities and responsibilities that may be imposed on them by the relevant regulatory authority in the jurisdiction in question, or the regulatory regime thereunder. Opinions, forecasts or projections contained in this material represent J.P. Morgan's current opinions or judgment as of the date of the material only and are therefore subject to change without notice. Periodic updates may be provided on companies/industries based on company-specific developments or announcements, market conditions or any other publicly available information. There can be no assurance that future results or events will be consistent with any such opinions, forecasts or projections, which represent only one possible outcome. Furthermore, such opinions, forecasts or projections are subject to certain risks, uncertainties and assumptions that have not been verified, and future actual results or events could differ materially. The value of, or income from, any investments referred to in this material may fluctuate and/or be affected by changes in exchange rates. All pricing is indicative as of the close of market for the securities discussed, unless otherwise stated. Past performance is not indicative of future results. Accordingly, investors may

21 June 2024

receive back less than originally invested. This material is not intended as an offer or solicitation for the purchase or sale of any financial instrument. The opinions and recommendations herein do not take into account individual client circumstances, objectives, or needs and are not intended as recommendations of particular securities, financial instruments or strategies to particular clients. This material may include views on structured securities, options, futures and other derivatives. These are complex instruments, may involve a high degree of risk and may be appropriate investments only for sophisticated investors who are capable of understanding and assuming the risks involved. The recipients of this material must make their own independent decisions regarding any securities or financial instruments mentioned herein and should seek advice from such independent financial, legal, tax or other adviser as they deem necessary. J.P. Morgan may trade as a principal on the basis of the Research Analysts' views and research, and it may also engage in transactions for its own account or for its clients' accounts in a manner inconsistent with the views taken in this material, and J.P. Morgan is under no obligation to ensure that such other communication is brought to the attention of any recipient of this material. Others within J.P. Morgan, including Strategists, Sales staff and other Research Analysts, may take views that are inconsistent with those taken in this material. Employees of J.P. Morgan not involved in the preparation of this material may have investments in the securities (or derivatives of such securities) mentioned in this material and may trade them in ways different from those discussed in this material. This material is not an advertisement for or marketing of any issuer, its products or services, or its securities in any jurisdiction.

Confidentiality and Security Notice: This transmission may contain information that is privileged, confidential, legally privileged, and/or exempt from disclosure under applicable law. If you are not the intended recipient, you are hereby notified that any disclosure, copying, distribution, or use of the information contained herein (including any reliance thereon) is STRICTLY PROHIBITED. Although this transmission and any attachments are believed to be free of any virus or other defect that might affect any computer system into which it is received and opened, it is the responsibility of the recipient to ensure that it is virus free and no responsibility is accepted by JPMorgan Chase & Co., its subsidiaries and affiliates, as applicable, for any loss or damage arising in any way from its use. If you received this transmission in error, please immediately contact the sender and destroy the material in its entirety, whether in electronic or hard copy format. This message is subject to electronic monitoring: <https://www.jpmorgan.com/disclosures/email>

MSCI: Certain information herein ("Information") is reproduced by permission of MSCI Inc., its affiliates and information providers ("MSCI") ©2024. No reproduction or dissemination of the Information is permitted without an appropriate license. MSCI MAKES NO EXPRESS OR IMPLIED WARRANTIES (INCLUDING MERCHANTABILITY OR FITNESS) AS TO THE INFORMATION AND DISCLAIMS ALL LIABILITY TO THE EXTENT PERMITTED BY LAW. No Information constitutes investment advice, except for any applicable Information from MSCI ESG Research. Subject also to [msci.com/disclaimer](https://www.msci.com/disclaimer)

Sustainalytics: Certain information, data, analyses and opinions contained herein are reproduced by permission of Sustainalytics and: (1) includes the proprietary information of Sustainalytics; (2) may not be copied or redistributed except as specifically authorized; (3) do not constitute investment advice nor an endorsement of any product or project; (4) are provided solely for informational purposes; and (5) are not warranted to be complete, accurate or timely. Sustainalytics is not responsible for any trading decisions, damages or other losses related to it or its use. The use of the data is subject to conditions available at <https://www.sustainalytics.com/legal-disclaimers>. ©2024 Sustainalytics. All Rights Reserved.

"Other Disclosures" last revised April 06, 2024.

Copyright 2024 JPMorgan Chase & Co. All rights reserved. This material or any portion hereof may not be reprinted, sold or redistributed without the written consent of J.P. Morgan. It is strictly prohibited to use or share without prior written consent from J.P. Morgan any research material received from J.P. Morgan or an authorized third-party ("J.P. Morgan Data") in any third-party artificial intelligence ("AI") systems or models when such J.P. Morgan Data is accessible by a third-party. It is permissible to use J.P. Morgan Data for internal business purposes only in an AI system or model that protects the confidentiality of J.P. Morgan Data so as to prevent any and all access to or use of such J.P. Morgan Data by any third-party.

Completed 20 Jun 2024 07:38 PM EDT

Disseminated 21 Jun 2024 06:15 AM EDT