Interest Rate Derivatives Seminar Series

Benchmark reform: | September 2020

Josh Younger
(212) 270-1323
joshua.d.younger@jpmorgan.com
J.P. Morgan Securities LLC

Henry St John[AC]
(212) 834-5669
henry.stjohn@jpmorgan.com
J.P. Morgan Securities LLC

Colin Paiva
(212) 834-2037
colin.w.paiva@jpmorgan.com
J.P. Morgan Securities LLC

Agenda

J.P.Morgan

What was Libor then?

- LIBOR = London Interbank Offered Rate
- Invented in the late 1960s to benchmark floating interest rates on a large syndicated bank loan to the Shah of Iran
- In subsequent years Libor was standardized via polling of a panel of large international banks
- Calculated as a trimmed mean of submissions
- “The rate at which an individual Contributor Panel bank could borrow funds, were it to do so by asking for and then accepting inter-bank offers in reasonable market size, just prior to 11.00 London time”

In just U.S. markets, Libor is embedded in nearly $200tn notional, dominated by the derivatives market

Notional balance (current and future assuming passive evolution); $bn

Category	Subcategory	Notional ($bn) Current	End 2021
OTC Derivatives	IRS	$81,000	$53,460
	FRAs	$34,000	$34,000
	Options	$12,000	$7,800
	Xccy swaps	$18,000	$15,840
Exchange Traded Derivatives	Futures	$34,000	$33,660
	Options	$11,000	$10,890
Business loans	Syndicated	$1,500	$1,245
	Non-syndicat	$800	$688
	CRE/commer	$1,100	$913
Consumer loans	Retail mtges	$1,200	$684
	Other	$100	$0
Bonds	FRNs	$1,800	$1,512
Securitizations	MBS & CMOs	$1,000	$570
	CLOs	$400	$104
	ABS	$200	$110
	CDOs	$200	$96
Total		**$198,300**	**$161,572**

Note: Taken from the ARRC Second Report.
Source: J.P. Morgan, ARRC, NYFRB, BIS, Bloomberg, CME, DTCC, FRB

Banks can tap a range of short-term markets to fund themselves

BANK LIABILITIES	BANK ASSETS
Retail deposits	Reserves
Institutional deposits	Treasuries, Agency MBS
Repo	Corps & munis
Short-term debt	Real estate loans (resi, CRE)
Long-term debt	C&I loans
FX forwards	Consumer loans

More expensive

Wider spreads

Unsecured

Secured

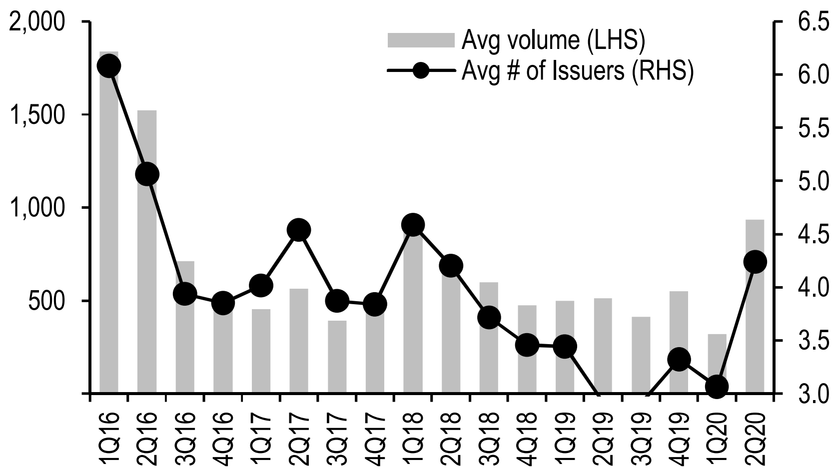
J.P.Morgan

Source: J.P. Morgan

Shifts in market structure have fundamentally changed the nature of Libor submissions…

Though not particularly active as of last year, issuance by panel banks in short-term unsecured bank funding markets has slowed further…

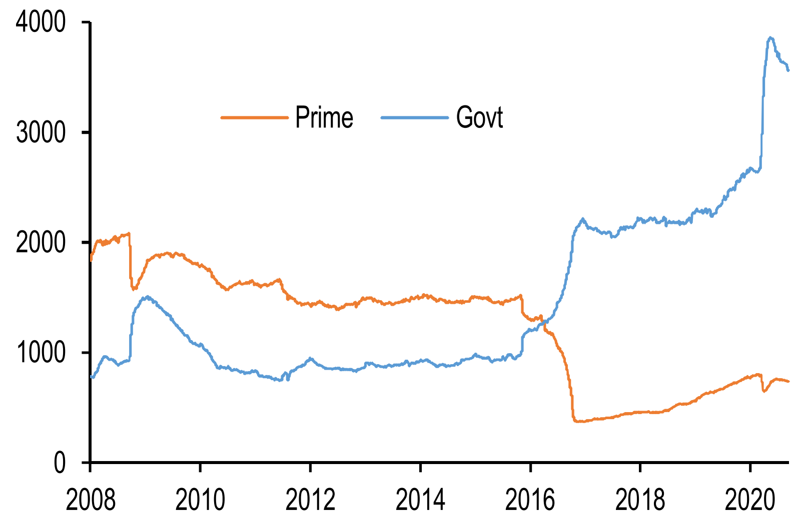
Average daily gross trading volume (LHS; $mn) and active issuers by count (RHS) grouped by quarter since Jan 2016



Source: J.P. Morgan, DTCC

… reflecting a combination of regulatory incentives and shifts in allocations of cash at the front end in the wake of money market fund reform

AUM of prime and government money market funds; $bn



Source: J.P. Morgan, iMoneyNet

J.P.Morgan

... and at this point in most maturities, it's mostly tied to other markets...

Libor remains tied to CP/CD rates, but with panel banks less active in this market, the relative impact of moves in other market-based funding indicators has increased

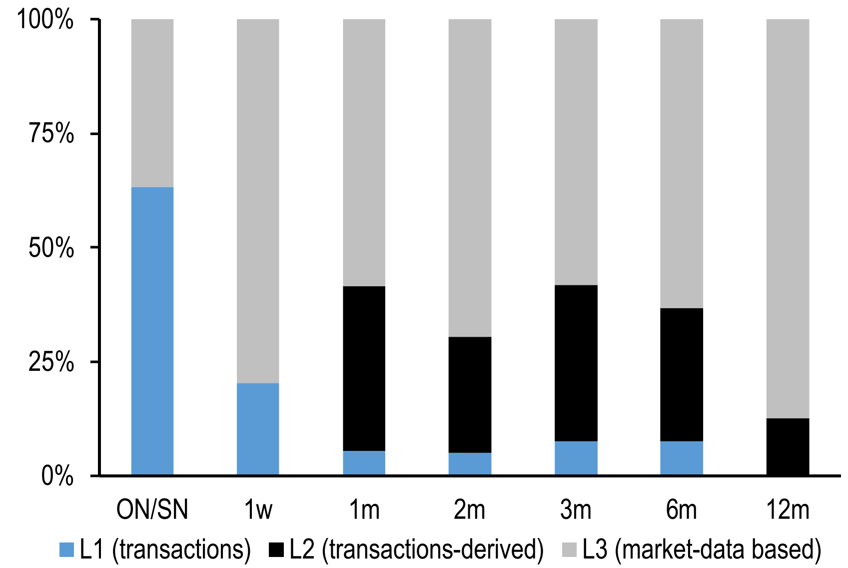
Summary of the Libor submission waterfall from relevant ICE guidelines*

Waterfall	Description	Eligible transactions
Level 1	Transactions	Unsecured deposits New issue CP and CD fixed rates
Level 2	Transactions-derived	Historical level 1 transaction 3d lookback for 1-3M, 5d for 6M & 10d for 12M
Level 3	Market-data based	FRAs/swaps, FRNs, FX fwds, OIS, repo Third party transactions/broker quotes Macro factor, e.g. policy rate changes

Source: J.P. Morgan, ICE
* For details see discussion in Short-Term Fixed Income 2017 Outlook (A. Roever et al., 11/23/16) Roadmap for ICE Libor (published 3/18/16), and Summary of ICE Libor Evolution (published 1/25/17)

Most Libor submissions are not directly transaction-based and rely on some degree of expert judgment

Percentage of submission types for USD Libor panel in Q4 2019



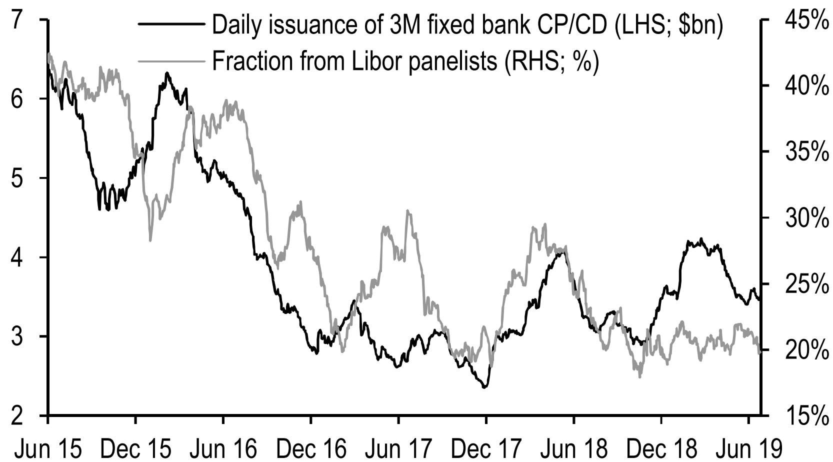
Source: J.P. Morgan, IBA 2019 Q4 Report on Volumes

J.P.Morgan

… and fixings appear decoupled from credit markets more broadly

Banks have relied less and less on unsecured wholesale funding, particularly Libor panelists

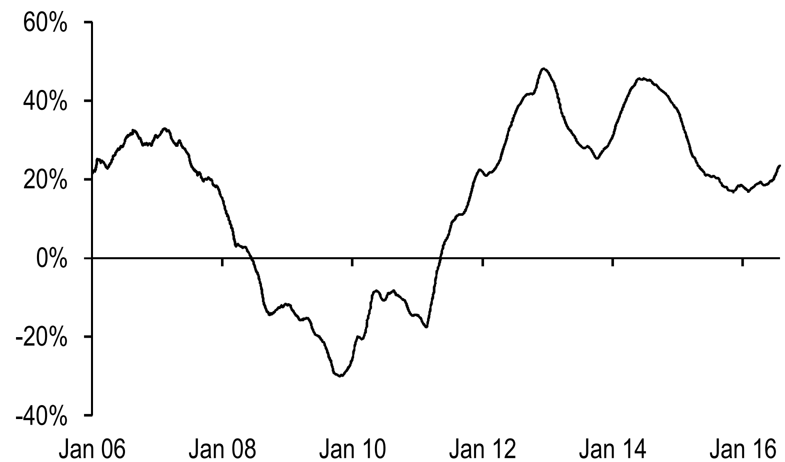
3-month moving average of daily issuance in 3-month fixed-rate bank CP and CDs (LHS; $bn) and fraction of that from Libor panelists (RHS; %)



Source: J.P. Morgan, DTCC

The rank order of Libor submissions is not particularly well correlated with the CDS spreads of panelists, and has in fact been negative at times

Rolling 1-year average correlation between the rank order of Libor submissions and the same for 1-year CDS spreads for panel banks; %



Source: J.P. Morgan, ICE, BBA

J.P.Morgan

Agenda

J.P.Morgan

Timeline of Libor reform

2008… …2012 2013 2014 2015 2016 2017

- 4/08 – WSJ publishes article on possible LIBOR manipulation
- 9/12 – The Wheatley Review of LIBOR is published
- 7/13 – IOSCO publishes “Principles of Financial Benchmarks”
- 2/14 – BBA transfers LIBOR administration to ICE
- 7/14 – FSB publishes report on reforming major interest rate benchmarks
- 10/14 – ICE publishes a position paper on the Evolution of ICE LIBOR
- 11/14 – Alternative Reference Rates Committee is formed
- 3/16 – ICE releases a Roadmap for ICE LIBOR
- 6/17 – ARRC selects SOFR as the recommended alternative benchmark
- 7/17 – FCA announces its intention to phase out LIBOR by end of 2021

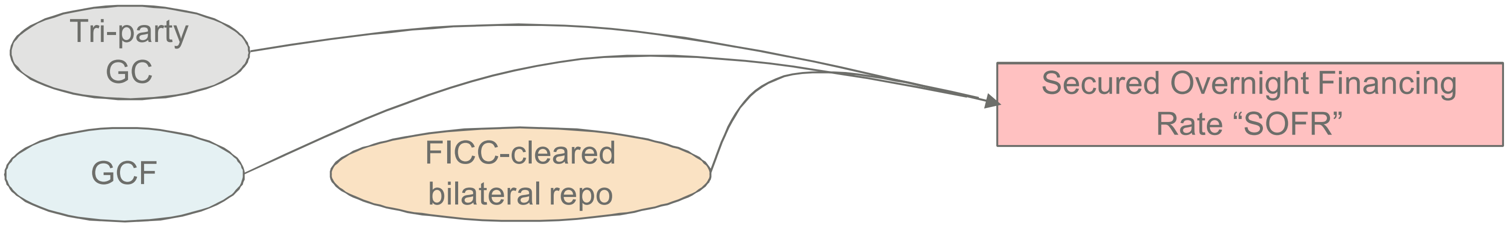
Key upcoming developments…

Date	Description
16th October 2020	Big Bang transition for cleared swap discounting
4Q 2020	ISDA fallback protocols formalized/ratified
4Q 2020 - 4Q 2021	ISDA announcement date for future cessation
4Q 2020	ARRC consultation into SOFR term rate
1st January 2022	Libor cessation, fallbacks effective

Source: J.P. Morgan

J.P.Morgan

What is SOFR?



Tri-Party General Collateral Rate (TGCR)

- GC repo transactions secured by US Treasuries
- Identity of counterparties is known at time of trade
- Transaction level tri-party data collected from the Bank of New York Mellon (BNYM)

Broad General Collateral Rate (BGCR)

- TGCR + GCF repo

GCF:
- Offered by the Fixed income Clearing Corporation (FICC)
- Only accessible to FICC – eligible institutions
- Trades negotiated through interdealer brokers on a blind basis
- FICC is the legal counterparty to both sides of the trade – anonymity of the CPs is maintained

Secured Overnight Financing Rate (SOFR)

- BGCR + FICC-cleared bilateral repo

FICC-cleared (DVP) repo:
- Counterparties choose specific securities (rather than a pool of acceptable collateral)
- Can be used to temporarily acquire specific securities
- Captures securities trading "special", but removes transactions below the 25th percentile

Source: J.P. Morgan

SOFR is published daily by the New York Fed

- SOFR is published daily to the New York Fed's website
- The previous day's print is made available at approximately 8:00 a.m. EST
- Also available are the 1st, 25th, 75th and 99th percentiles for SOFR, as well as total daily volume

DATE	RATE (PERCENT)	PERCENTILES				VOLUME (US$ BILLIONS)
		1ST (PERCENT)	25TH (PERCENT)	75TH (PERCENT)	99TH (PERCENT)	
09/14	0.09	0.06	0.07	0.12	0.18	881
09/11	0.09	0.06	0.07	0.12	0.18	900
09/10	0.09	0.06	0.07	0.13	0.19	924
09/09	0.09	0.06	0.07	0.12	0.18	937
09/08	0.09	0.06	0.07	0.13	0.19	957
09/07	Holiday, no data.					
09/04	0.09	0.06	0.07	0.13	0.18	935
09/03	0.10	0.06	0.06	0.12	0.17	955
09/02	0.09	0.05	0.06	0.12	0.17	947
09/01	0.09	0.05	0.06	0.12	0.17	969
08/31	0.09	0.06	0.07	0.13	0.19	934
08/28	0.07	0.04	0.05	0.10	0.16	881

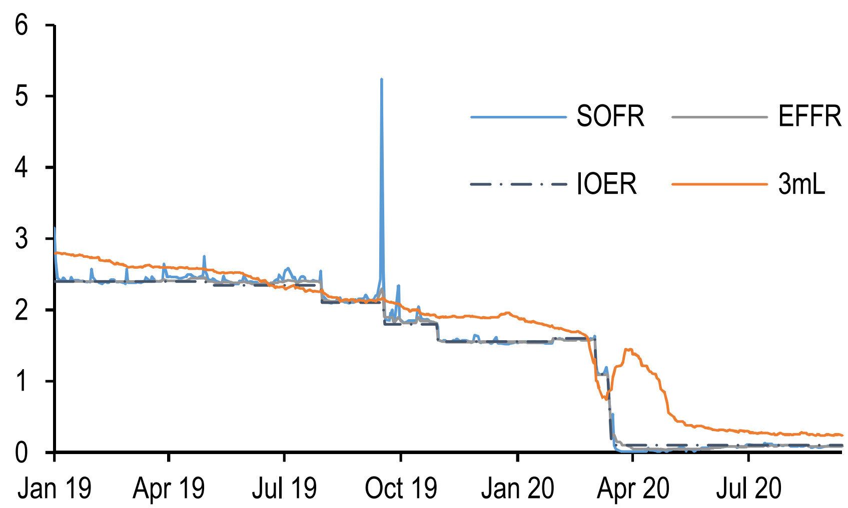
J.P.Morgan

Source: J.P. Morgan, FRBNY

Replacing Libor: Introducing the Secured Overnight Financing Rate Index (SOFR)

Recently, SOFR has traded at the lower end of the policy rate corridor, but over the long run is mostly in line with Fed funds effective…

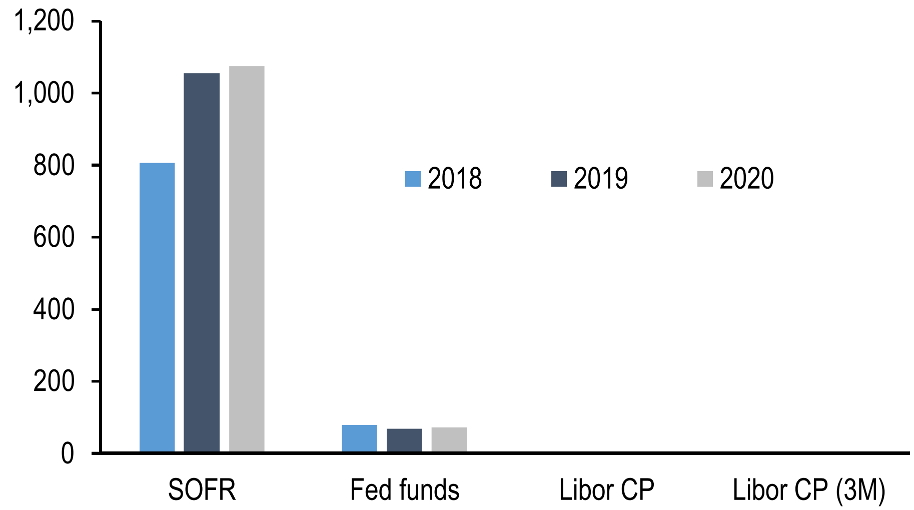
3-month Libor, IOER, Fed funds effective and SOFR*; bp



Source: J.P. Morgan, FRBNY

… and is based on a much larger universe of transactions than Fed funds and especially bank CP markets

Average daily trading volume by year* for transactions underlying SOFR, Fed funds effective, and fixed-rate CP/CD issuance by Libor panel banks



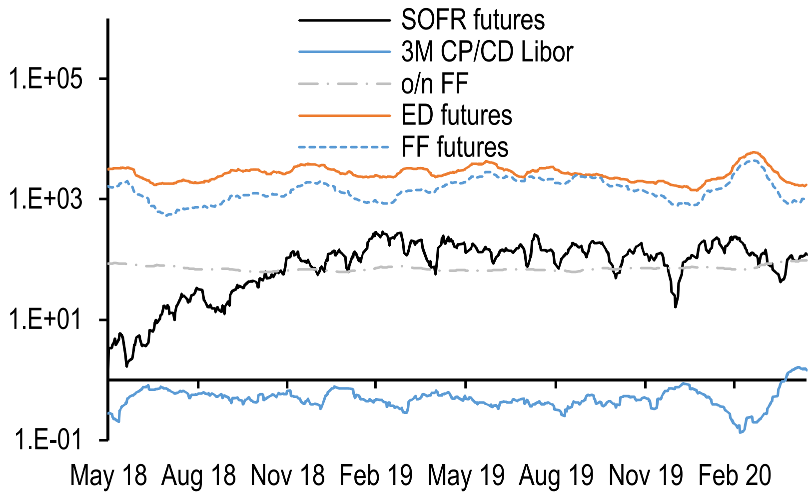
Source: J.P. Morgan, FRBNY, DTCC

J.P.Morgan

Trading activity in exchange-traded SOFR derivatives has not meaningfully increased in a while, but unlike OTC swaps has not declined materially either

SOFR futures volume has rebounded off its March lows, as volumes have moderated in Eurodollar and Fed fund futures

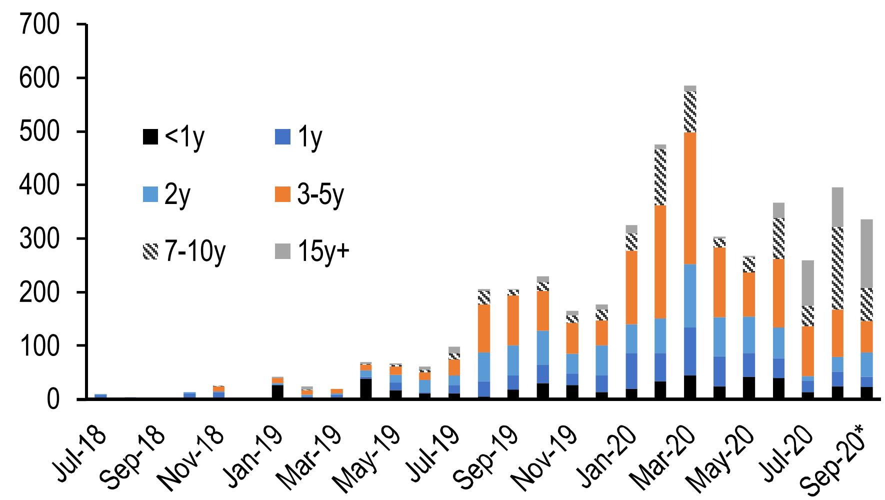
Daily transaction volume in 3M CP/CD among Libor panel banks, SOFR futures*, overnight Fed funds, and Fed Funds and Eurodollar futures; $bn in powers of 10



* Consistent with their matched DV01s to ED and FF futures, we assume $1mn and $5mn for quarterly and monthly CME SOFR futures, respectively; contract size for ICE SOFR futures is $12mn.
Source: CME, ICE, NY FRB, J.P. Morgan

Volumes in the SOFR OTC market remain weak following the volatility in March

Monthly notional traded in SOFR OTC derivatives by original maturity (LHS; count) and breakdown of trade type (inset; %)



Source: J.P. Morgan, Bloomberg SDR

J.P.Morgan

Agenda

J.P.Morgan

Key challenges

- Transition to SOFR discounting on cleared swaps (October 16^{th})
- Discounting on uncleared derivatives
- Transition of cash market to SOFR instruments
- Fallbacks for derivatives and cash products
- Term SOFR?

J.P.Morgan

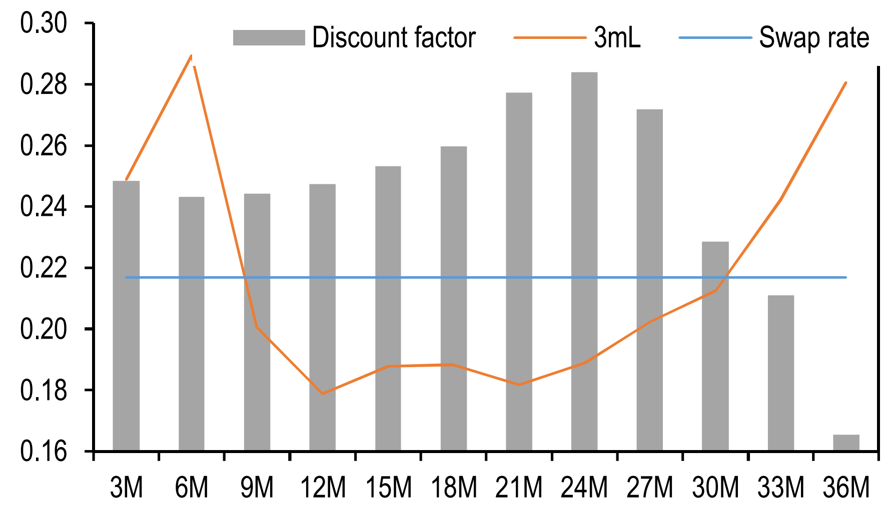
Transition of discounting on cleared swaps

What is discounting risk?

- Discounting risk arises from differences in the reference rate for computing cash flows and discount factors on the pricing of a swap or other derivative
- Cleared USD swaps are (currently) discounted off the Fed funds effective (EFFR) OIS curve
- Bilateral swaps without a CSA are discounted to Libor, those that are discounted vs FF-OIS
- OTC swaptions tend to be uncleared, but deliver into cleared swaps
- As of October 16th, 2020, the major clearing houses are switching discounting from FF-OIS to SOFR-OIS

For a swap not at par, shifts in the discount factor will carry PV implications

Forward 3mL rates (LHS; %), 3Y swap rate (LHS; %) and discount factors (RHS; unitless)



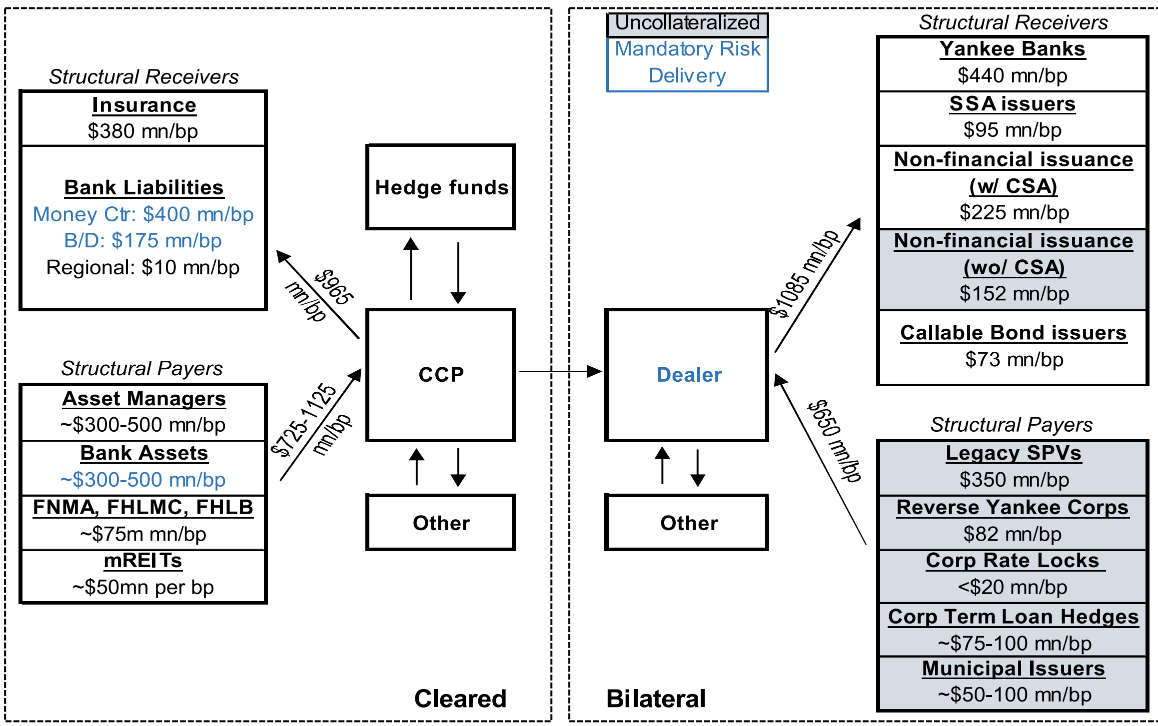
Source: J.P. Morgan

J.P.Morgan

The topography of discounting risk

A schematic of the swaps market for both cleared and bilateral positions

Arrows indicate pay-fixed direction, duration estimates* from a variety of sources; $mn



* All swaps assume par coupons as of trade date. Insurance positions from NAIC disclosure of line-item derivatives (retrieved from SNL Financial 2Q19 disclosure [the most recent data] with manual overlays to indicate direction, dollar duration, and moneyness assuming no significant re-couponing or changes to positions since that time). Bank issuance data from JULI constituents, and SSAs from public issuance data assuming all fixed deals are swapped. Asset managers assumes 5-10% of the ~$10tn notional of debt securities owned by mutual funds and households as of 1Q 2020 (Fed Z.1 data) is duration hedged with swaps at a 7-year WAM. All U.S. banks are assumed to clear, while Yankee issuance is assumed to be mostly packaged with cross-currency hedges in a bilateral format. FHLBs from recent estimates and FNMA/FHLMC recent retained portfolio balance (~$144bn) with duration equal to the J.P. Morgan Agency MBS Index. Bank asset swappers assumes ~50% of debt securities (ex-MBS) that mature/re-price more than 5-years forward are swapped at a ~5-year hedge duration. REITs from AGNC and NLY 1W 2020 disclosure (found in Investor Presentations) for swap hedges, scaled up to the overall universe. Non-financial corporates also from JULI constituents assuming swapping rates based on comparing SDR to issuance data and CSA/non-CSA assigned based on J.P. Morgan estimates. Within that category Yankee issuance is assumed to be swapped back to home currency via a bilateral fixed/float swap with embedded cross-currency cashflows. Within Reverse Yankee issuance corps are assumed to be swapped back to USD fixed and financials to USD float. Formosa issuance assumes par callable swap strike rates as of the announcement date using Bloomberg lockout and maturity information as available, and accounts for calls of outstanding debt as well as new issuance. Rate locks assume 3% of the forward calendar is hedged for notional, using recent majority composition to estimate PVBP for calculating dollar duration. Bank term loan hedges from Fed data as of Q1 2020, including lending by depository institutions with <1% default risk, 50% hedge ratio and 5-year maturity. Municipal hedges assume 25% of the current stock of VRDNs (~$125bn) are swapped to fixed. Legacy SPVs from Intex data on CDOs and other structured products with embedded swap hedges.

J.P.Morgan

Source: J.P. Morgan, FRB, DTCC, Bloomberg, FHLMC, FNMA, FHLB Office of Finance, AGNC, NLY, SNL Financial, NAIC, Intex

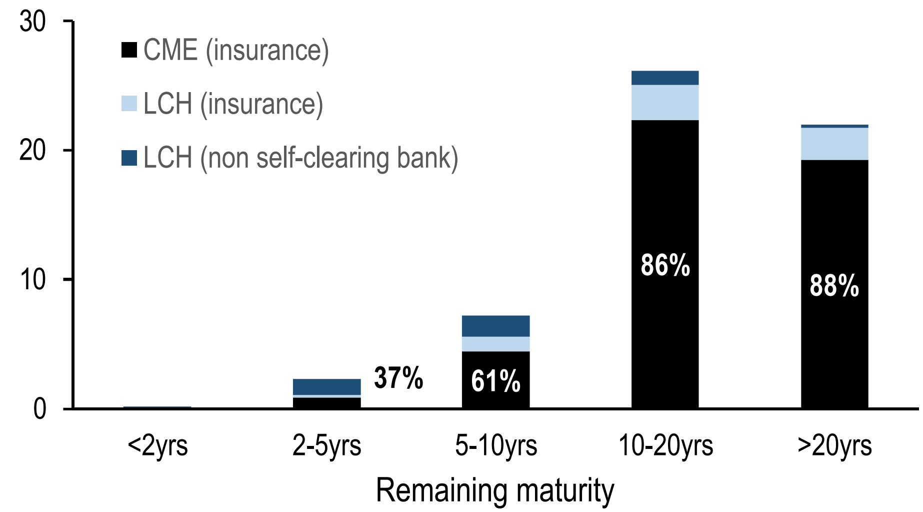
The Big Bang process…

How does the discounting switch work?

- A SOFR curve is constructed and used to compute the change in present value on swaps evaluated versus the old and new curves
- All participants get a transfer to compensate for this change
- SOFR/FF basis swaps are delivered to compensate accounts for the change in their discounting risk
- Non-dealers have the opportunity to opt out of these swaps
- An auction process is carried out among dealers to allocate the residual “opted-out” risk
- CME & LCH plans differ in some details of this process

The likely opt-out risk comes mostly via the insurance community, skewed to the long end and towards CME

Discounting risk by remaining maturity bucket and clearinghouse among potential opt-out counterparties; $mn per bp



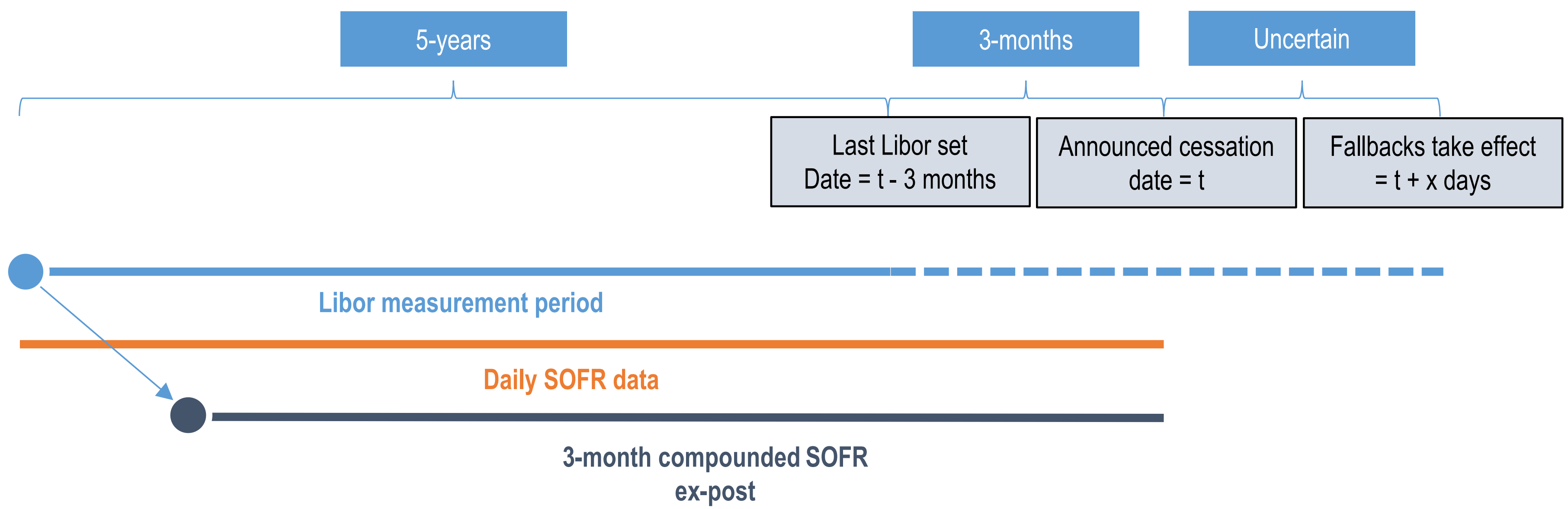
Note: We assume all bank issuance hedgers are on LCH.
Source: J.P. Morgan, NAIC, SNL

J.P.Morgan

The recently published Bloomberg Rulebook governs the calculation of ISDA fallback spreads, which are set as of an FCA announcement that Libor will be non-representative but only affect cash flows when that designation is effective

The choice of cessation date, or a pre-cessation event, pins down the 5-year window for the fallback spread calculation

Schematic of ISDA fallback methodology for 3-month Libor



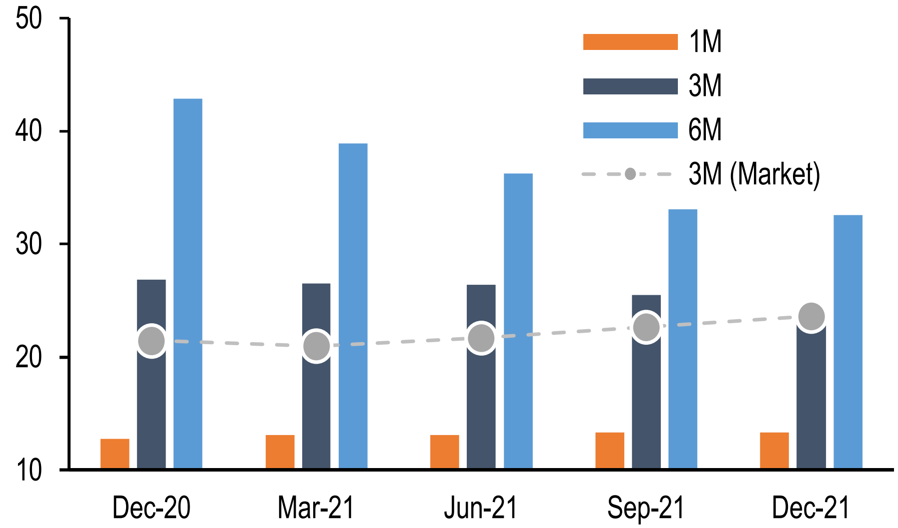
Source: J.P. Morgan

J.P.Morgan

Given the placement of MMF reform in the lookback window, an earlier setting of fallback spreads means wider swaps pricing

Winding back the likely cessation date for Libor leads to higher Libor/SOFR fallbacks…

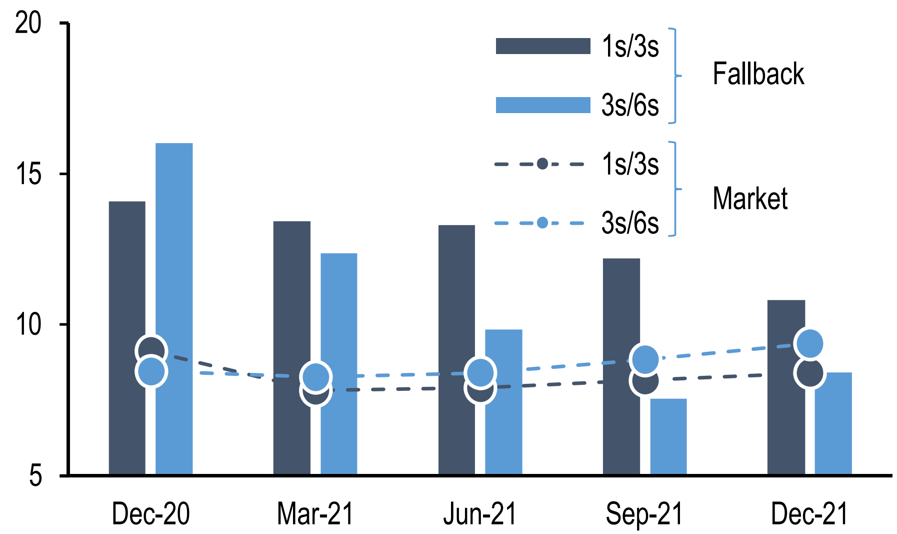
Libor/SOFR ISDA fallback spreads by cessation date and Libor/SOFR market level; bps



Note: Market levels reflect 1-year swaps forward starting as of the date shown along the x-axis.
Source: J.P. Morgan

… increasing as a function of tenor, which implies wider 1s/3s and 3s/6s

Implied 1s/3s and 3s/6s basis from ISDA fallbacks by cessation date and market levels; bps



Note: Market levels reflect 1-year tenor basis swaps forward starting as of the date shown along the x-axis. Source: J.P. Morgan

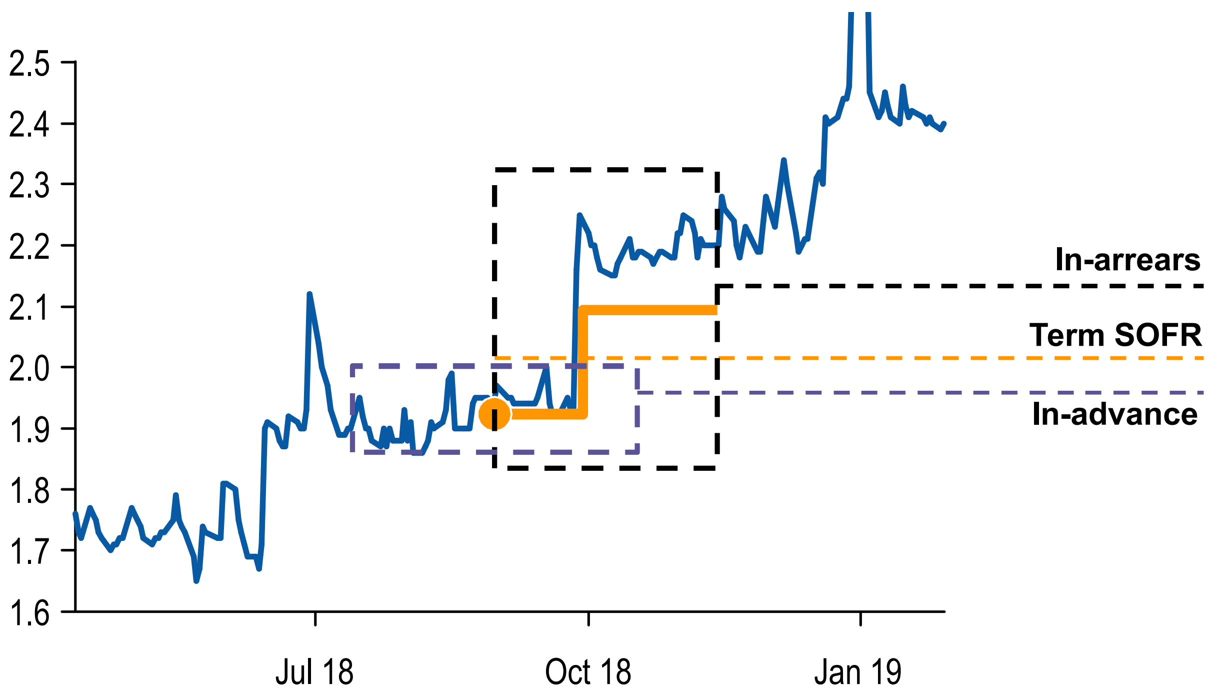
J.P.Morgan

Term SOFR

- Since an early round of proposals in 2019, news flow on term SOFR has been slow…
- The initial proposal provided by the FRBNY was to use monthly and quarterly SOFR futures to infer forward-looking term rates, i.e., an expectation of compounded overnight SOFR sets over a given period
- More recently, the ARRC released an RFP "*seeking a potential administrator to publish forward-looking SOFR term rates*" – without necessarily committing to a guarantee that a term rate would ultimately be recommended or not
- There are also some private sector proposals for an alternative term rate that includes a credit component, these include:
  - The **Bank Yield Index**: Administered by ICE and based off both primary CP/CD funding as well as short-dated secondary market transactions; looks at transactions across short-dated tenors and then fits a curve
  - **AXI (Across-the-curve credit spread index):** Uses primary and secondary market TRACE data to fit a single short-term point that captures credit spreads
  - **Ameribor:** Transaction volume weighted average rate of overnight unsecured loans from a larger community of borrowers

J.P.Morgan

Different coupon conventions



in arrears:

- average of observed overnight rates
- most accurately reflects funding rates over interest period
- coupons unknown until just before payment

term SOFR:

- inferred from SOFR futures pricing (forward-looking)
- reflects anticipated funding rates over interest period (market's best guess)
- coupons known at the start of interest period, well in advance

in advance:

- average of observed overnight rates *well ahead* of coupon date (e.g., 45 days)
- reflects previously seen overnight rates, which can diverge from future settings
- coupons known in advance, by construction

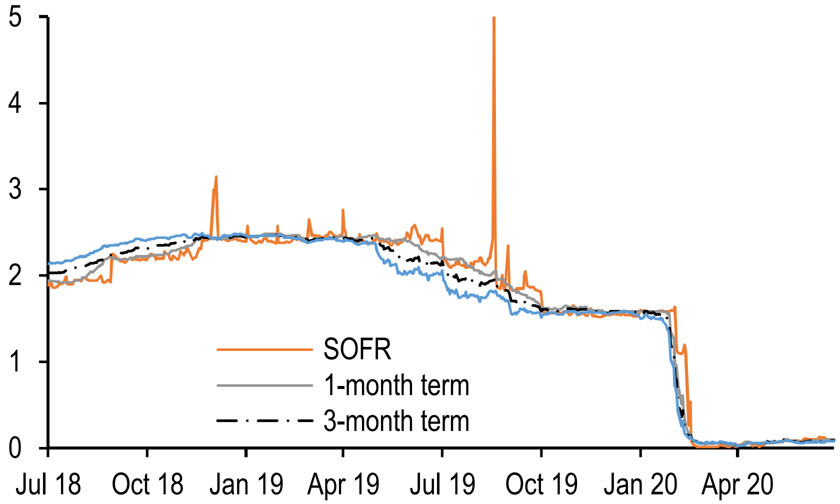
J.P.Morgan

Source: J.P. Morgan, FRBNY

Term SOFR is well behaved, both versus overnight rates and term Libor…

While overnight SOFR itself has featured large month- and quarter-end turns, consistent with dynamics in the broader repo market of late, the proposed term rates prove far less volatile…

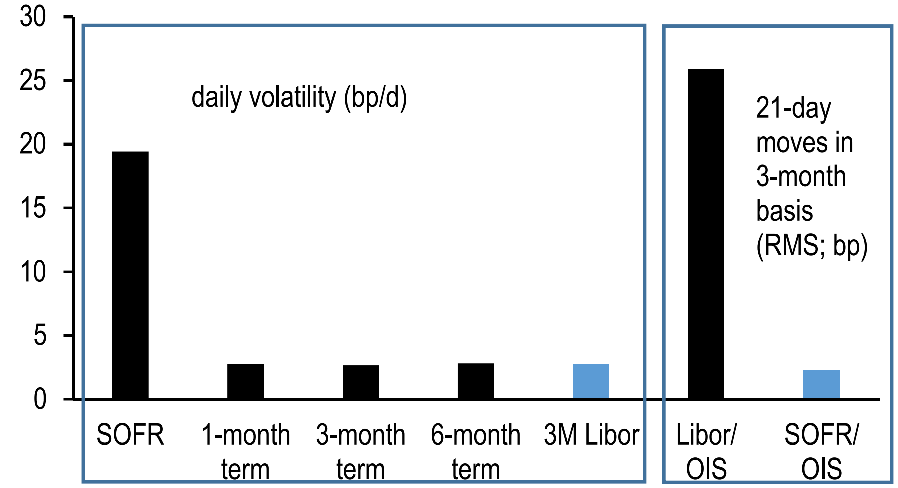
Forward-looking term 1M, 3M and 6M SOFR computed via SOFR futures*, compared to daily SOFR; %



*Computed using 1M and 3M CME SOFR futures; see Inferring term rates from SOFR futures prices, E. Heitfield and Y. Park, 2/5/19 for details
Source: J.P. Morgan, NY FRB

… and over longer periods, 3M SOFR/OIS is far better behaved than Libor/OIS

Daily volatility in SOFR, the Fed's proposed term SOFR from futures*, and in 3-month Libor (LHS; bp/day); root-mean-square of month-on-month moves in 3M SOFR/OIS† and Libor/OIS



* Computed using 1M and 3M CME SOFR futures; see Inferring term rates from SOFR futures prices, E. Heitfield and Y. Park, 2/5/19 for details
† 3M SOFR/OIS is a comparison of term 3M SOFR* versus a spot 1M Fed funds OIS
Source: J.P. Morgan, NY FRB

J.P.Morgan

Agenda

J.P.Morgan

Disclosures

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 their analysis was made in good faith and that the views reflect their own opinion, without undue influence or intervention.

All authors named within this report are research analysts unless otherwise specified. In Europe, Sector Specialists 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 by visiting https://www.jpmm.com/research/disclosures, calling 1-800-477-0406, or e-mailing research.disclosure.inquiries@jpmorgan.com with your request. J.P. Morgan's Strategy, Technical, and Quantitative Research teams may screen companies not covered by J.P. Morgan. For important disclosures for these companies, please call 1-800-477-0406 or e-mail research.disclosure.inquiries@jpmorgan.com.

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.

Any data discrepancies in this report could be the result of different calculations and/or adjustments.

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

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 research division.

Legal entity responsible for the production of research: The legal entity identified below the name of the Reg AC research analyst who authored this report is the legal entity responsible for the production of this research. Where multiple Reg AC research analysts authored this report with different legal entities identified below their names, these legal entities are jointly responsible for the production of this research.

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, Clearing and Settlement Participant of ASX Limited and CHI-X. 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 Comissao de Valores Mobiliarios (CVM) and by the Central Bank of Brazil. Ombudsman J.P. Morgan: 0800-7700847 / ouvidoria.jp.morgan@jpmorgan.com. **Canada**: J.P. Morgan Securities Canada Inc. is a registered investment dealer, regulated by the Investment Industry Regulatory Organization of Canada 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. **China:** J.P. Morgan Securities (China) Company Limited has been approved by CSRC to conduct the securities investment consultancy business. **Dubai**: 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 to persons regarded as professional clients or market counterparties as defined under the DFSA rules. **Germany**: This material is distributed in Germany by J.P. Morgan Securities plc, Frankfurt Branch, which is regulated by the Bundesanstalt für Finanzdienstleistungsaufsich and also by J.P. Morgan AG ("JPM AG"), which is a member of the Frankfurt Stock Exchange, is authorised by the European Central Bank ("ECB") and is regulated by the Federal Financial Supervisory Authority (BaFin), JPM AG is a company incorporated in the Federal Republic of Germany with a registered office at Taunustor 1, 60310 Frankfurt am Main, the Federal Republic of Germany. **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 is organized under the laws of the United States with limited liability. **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: www.jpmipl.com. For non-local research material, this material is not distributed in India by J.P. Morgan India Private Limited. **Indonesia**: PT J.P. Morgan Sekuritas Indonesia is a member of the Indonesia Stock Exchange and is regulated by the OJK a.k.a. BAPEPAM LK. **Korea**: This material is issued and distributed in Korea by or through J.P. Morgan Securities (Far East) Limited, Seoul Branch, which is a member of the Korea Exchange (KRX) and is regulated by the Financial Services Commission (FSC) and the Financial Supervisory Service (FSS). **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 Advisers Act 2008). JPMSAL is registered as a Financial Service Provider under the Financial Service providers (Registration and Dispute Resolution) Act of 2008. **Pakistan**: J. P. Morgan Pakistan Broking (Pvt.) Ltd is a member of the Karachi Stock Exchange

and regulated by the Securities and Exchange Commission of Pakistan. **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. **Russia**: CB J.P. Morgan Bank International LLC is regulated by the Central Bank of Russia. **Singapore**: This material is issued and distributed in Singapore by or through J.P. Morgan Securities Singapore Private Limited (JPMSS) [MCI (P) 018/04/2020 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) [MCI (P) 070/09/2019], 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 JPMSS or JPMCB Singapore in respect of any matters arising from, or in connection with, the material. As at the date of this material, JPMSS is a designated market maker for certain structured warrants listed on the Singapore Exchange where the underlying securities may be the securities discussed in this material. Arising from its role as a designated market maker for such structured warrants, JPMSS may conduct hedging activities in respect of such underlying securities and hold or have an interest in such underlying securities as a result. The updated list of structured warrants for which JPMSS acts as designated market maker may be found on the website of the Singapore Exchange Limited: http://www.sgx.com. **South Africa**: J.P. Morgan Equities South Africa Proprietary Limited is a member of the Johannesburg Securities Exchange and is regulated by the Financial Services Board. **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 and European Economic Area (EEA)**: J.P. Morgan Securities plc ("JPMS plc") 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. Registered in England & Wales No. 2711006. Registered Office 25 Bank Street, London, E14 5JP. Unless specified to the contrary, material is distributed in the UK and the EEA by JPMS plc. 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 "relevant persons". This material must not be acted on or relied on by persons who are not relevant persons. Any investment or investment activity to which this material relates is only available to relevant persons and will be engaged in only with 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. Any data discrepancies in this material could be the result of different calculations and/or adjustments. 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

Disclosures

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 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. 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.

"Other Disclosures" last revised September 12, 2020.