An introduction to TIPS and US CPI derivatives

2020 update

- The TIPS market remains the largest inflation-linked bond market in the world, with $1.49tn outstanding—larger than the UK and Euro area linker markets combined
- We provide an overview of the TIPS market, the mechanics of inflation-adjusted cash flows, including considerations around CPI seasonality and the embedded floor options, the drivers of inflation breakevens, and the sources of demand in the market. We also discuss inflation derivatives, including zero-coupon swaps, asset swaps, and options
- Gross issuance is likely to total $155bn in 2020, five times its 1997 levels. While TIPS have fallen as a share of the Treasury market in recent months, Treasury is likely remain committed to the TIPS program and maintain TIPS allocations as a moderate proportion of the debt stock
- TIPS breakevens reflect not only inflation expectations, but also inflation risk premium and liquidity premium components. We model the fair value of seasonally- and carry-adjusted breakevens based on nominal yields, changes in oil prices, high-grade credit spreads and our broad USD index
- Given the aggressive pace of Fed purchases throughout QE4, over $310bn TIPS (inflation-adjusted) were held in the SOMA portfolio as of August 2020, representing more than 20% of TIPS outstanding. Foreign investors owned 46% of the market as of June 2019, and inflation-focused mutual fund AUM has risen to nearly $200bn, or about 13% of the TIPS market
- In Europe, inflation derivatives are more liquid and more widely-traded than cash linkers, but in the US, the opposite is true, with TIPS more liquid than CPI derivatives. Trading volume in USD zero coupon inflation swaps in the interdealer market averaged roughly $550mn/day over the first half of 2020

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See page 20 for analyst certification and important disclosures.

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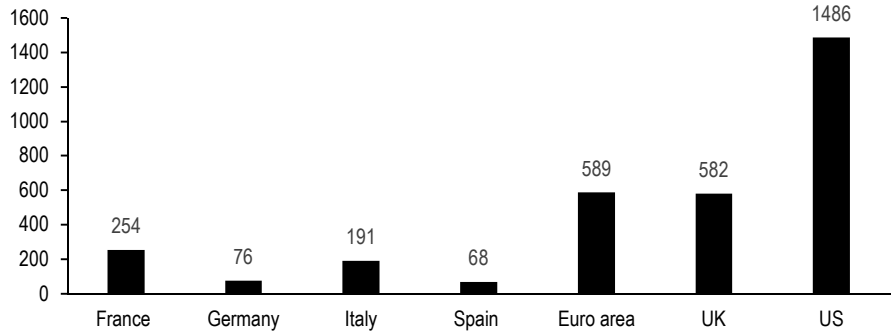
Introduction

Treasury began issuing Treasury Inflation-Protected Securities (TIPS) in January 1997, selling $31bn in that first year, and TIPS have grown to be the largest inflation-linked bond market in the world, with $1.49tn outstanding as of July 2020, including $0.14tn of inflation compensation (**Exhibit 1**). Over the following pages, we provide an overview of the TIPS market, the mechanics of inflation-adjusted cash flows, including considerations around CPI seasonality and the embedded floor options, the drivers of inflation breakevens, and the sources of demand in the market. We also discuss inflation derivatives, including zero-coupon swaps, asset swaps, and options.

Exhibit 1: The TIPS market is the largest linker market in the world
Amount of linker debt outstanding as of 7/31/2020; USD bn



* The uplifted notional outstanding for a given linker is the product of its notional outstanding by its indexation factor. Note: France include FCPIxT- and HICPxT-linked bonds, Italy excludes BTP Italia, and Euro area is the aggregate of France (FCPIxT and HICPxT), Germany (HICPxT), Italy (HICPxT) and Spain (HICPxT).

Source: US Treasury, national DMOs

For more information on global inflation markets, see *Inflation Linked Markets Guide*, F. Diamond, 4/15/17.

Treasury made major changes to the TIPS issuance calendar in 2004 and 2010 in order to improve liquidity in the market. In 2004, Treasury began issuing 20-year TIPS and more than doubled annual TIPS issuance. In 2010, Treasury replaced its 20-year TIPS offering with 30-year TIPS. Later that year, Treasury decided to add second reopenings for each of the new issues it offers, and it modified the auction calendar so that there is one TIPS auction each month. In 2019, Treasury added a second new-issue 5-year TIPS auction in October and cut the number of 30-year auctions each year from three to two. Under the current issuance calendar, Treasury auctions two new 10-year TIPS per year (January and July maturities) and two new 5-year issues (April and October maturities), and each are reopened twice. Treasury auctions one new 30-year issue per year (February maturity) followed by one reopening auction (**Exhibit 2**).

Gross issuance is likely to total $155bn in 2020, five times its 1997 levels, and matching the pace of issuance observed in 2013-2015 (**Exhibit 3**). TIPS have represented roughly a 9% share of all Treasuries outstanding over the last four years, but that share has fallen to 7.4% as of July 2020 as Treasury has ramped up nominal issuance to fund COVID-19 stimulus efforts, while leaving the TIPS auction calendar unchanged. The debt optimization model presented by the Treasury Borrowing Advisory Committee (TBAC) in 2018 showed that debt service costs for TIPS are generally lower than that of similar maturity nominal issuance and that TIPS offer diversification benefits for Treasury due to the negative correlation

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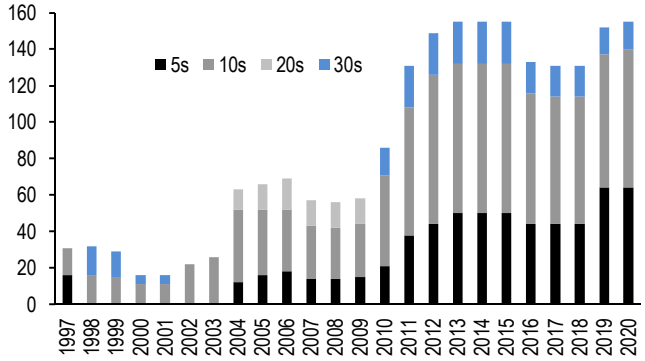
between CPI and US primary deficits. An extension of that model presented in August 2020 showed that while FRNs and bills can also reduce risk due to the negative correlation of short rates and primary deficits, TIPS may provide a greater reduction in rollover risk at the zero lower bound (ZLB). Thus, Treasury is likely remain committed to the TIPS program and maintain TIPS allocations as a moderate proportion of the debt stock.

Exhibit 2: Treasury conducts monthly auctions of TIPS
J.P. Morgan forecast for gross issuance of TIPS in 2020; reopening shaded in grey; $bn of real principal

	5Y	10Y	30Y	Subtotal
Jan 20		14		
Feb 20			8	
Mar 20		12		34
Apr 20	17			
May 20		12		
Jun 20	15			44
Jul 20		14		
Aug 20			7	
Sep 20		12		33
Oct 20	17			
Nov 20		12		
Dec 20	15			44
2020 TOTAL	**64**	**76**	**15**	**155**

Source: US Treasury, J.P. Morgan

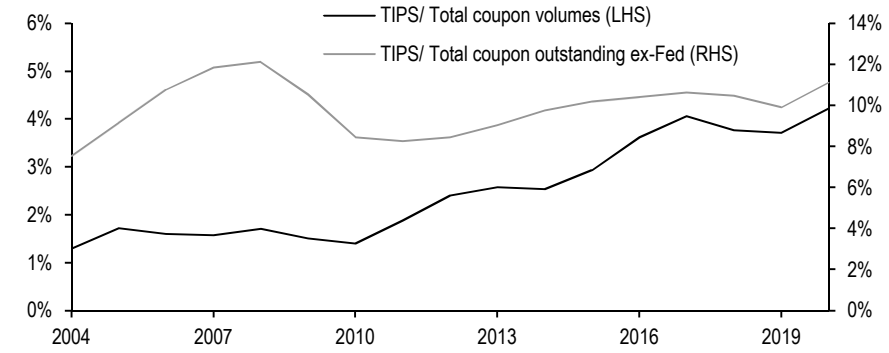
Exhibit 3: Gross issuance of TIPS has increased five-fold from its 1997 levels
Historical gross issuance of TIPS by maturity and J.P. Morgan forecast for 2020; $bn of real principal



Source: US Treasury, J.P. Morgan

Although the TIPS market has been around for more than twenty years and comprises a significant share of the Treasury market, TIPS remain far less liquid than their nominal counterparts. Over recent years, daily trading volumes with primary dealers has been about $17bn/day, rising to an average of $21bn/day in 2020 YTD, but still equating to about 1% turnover each day. In contrast, daily trading volumes in nominal coupon Treasuries has been around $470bn/day, or about 4-5% turnover, and TIPS have represented roughly 4% of total coupon volumes (**Exhibit 4**). A greater share of buy-and-hold investors likely contributes to the lower turnover (see "Who trades TIPS" below).

Exhibit 4: TIPS are not as liquid as nominal Treasuries
Average daily TIPS trading volumes as a fraction of total coupon Treasury volumes (LHS) and TIPS outstanding (ex-Fed) as a fraction of total coupon Treasuries outstanding (ex-Fed) (RHS); % both axes



Source: US Treasury, Federal Reserve Bank of New York

TIPS are typically auctioned on the third Thursday of the month at 1:00 p.m., with the announcement of the auction occurring on the previous Thursday at 11:00 a.m. The auction process works the same as all Treasury auctions: an investor may either submit a non-competitive or competitive bid for a TIPS auction, where competitive bids are subject to a Dutch auction process (see *The Hitchhikers Guide to the Treasury Market, redux* for more detail), and the coupon rate is floored at 0.125%. When real yields on TIPS are trading negative, as they are currently, this rule means that new-issue TIPS are auctioned at a premium (i.e., the initial price is greater than 100).

Overview of TIPS

TIPS are structured to provide inflation-protected cash flows to investors. Thus, an investor that purchases a TIPS outright locks in a *real* return that is not a function of future inflation. Inflation protection is achieved by indexing the principal of a TIPS to the US headline CPI non-seasonally adjusted series (CPURNSA Index on Bloomberg) published by the Bureau of Labor Statistics (BLS)—the principal of a TIPS increases with inflation and decreases with deflation. On each day, the inflation-adjusted principal is equal to par multiplied by the inflation index ratio, where the index ratio is calculated as the reference CPI on the trade settle date divided by the reference CPI on the first issue date (the base CPI value).

Since CPI for a given month is released about two weeks after the end of that month, **TIPS principals are indexed to CPI with a 3-month lag**. Specifically, the reference CPI on the first day of a calendar month is based on the CPI for the third preceding calendar month. For example, the principal on June 1 is based on the CPI reported for March, and the principal on July 1 is based on April CPI. On any day between June 1 and July 1, the reference CPI value is calculated by linearly interpolating between the March and April CPI values. All rounding is to 5 decimal places.

Semiannual coupon payments are calculated as a fixed percentage of the inflation-adjusted principal. **At maturity, holders of TIPS are paid the adjusted principal or the original principal (par), whichever is greater.** Effectively, this means that TIPS have an embedded floor on the principal amount.

TIPS are quoted on a **real price/real yield basis**, and they trade with T+1 settlement like nominal Treasuries. Real yields are derived in the same way as fixed-coupon nominal Treasuries, using the "real" cash flows (real price, real coupons, and par at maturity) to calculate a real Internal Rate of Return ("IRR"). When doing a cash transaction in TIPS, the real price of the bond (plus the real coupon accrued) is adjusted by the daily index ratio.

A list of daily TIPS index ratios can be found on Treasury's website and is available in our daily *TIPS Fitted Curve Relative Value Report* here. One can also find the index ratio for a particular bond using the Bloomberg YA screen.

Example: The current index ratio for the 0.125% Jan-30 TIPS, issued on January 15, 2020, for a transaction settling on August 15, 2020, is calculated as follows:

Reference CPI for August 15, 2020 = Interpolated value between Ref May 2020 (256.394) and Ref June 2020 (257.797) = 256.394 + 14 / 31 * (257.797 – 256.394) = 257.02761

Base CPI value = reference CPI for Jan. 15, 2020 = 257.28368

Index Ratio = reference CPI for August 15, 2020 / reference CPI for Jan.15, 2020

= 257.02761 / 257.28368

= 0.99900

In this case, because headline inflation was negative through early 2020, the principal on the Jan-30 TIPS in August 2020 is *lower* than it was at issue.

Carry is defined as the income accrued while holding a security minus the cost of funding the position. In other words, it measures the total return during a particular timeframe assuming that the IRR of the investment is unchanged (i.e. no capital gains or losses from changes in the IRR). In the case of conventional fixed-coupon bonds, this can be seen in simple terms as the coupon accrued minus the cost of funding the bond investment (i.e. its repo rate). Alternatively, one can express carry as the spot price of the bond minus its forward price.

We can also analyze carry for inflation-linked bonds in this manner. **The difference is that the dirty price of a linker includes the accrual of a real coupon plus the accrual of inflation for the given horizon.** Since the cash flows of inflation-linked bonds are indexed, this means that there is a positive carry effect during periods when (lagged) inflation indices increase and a negative carry effect when indices decrease. The actual carry is thus the real coupon accrued plus inflation accrual minus the cost of funding. Effectively, this means that forward prices of linkers depend on real yields, funding rates, and the evolution of inflation indices. The normal evolution of inflation indices is what makes carry in inflation linked bonds particularly interesting. The seasonal variation in inflation, discussed in more detail later in this note, makes carry on inflation-linked bonds very volatile, switching from positive to negative throughout the year. An example of a detailed carry calculation is provided in the Appendix.

Note that when calculating forwards we must know the value of the indexation factor at the horizon of choice, or use forecasts. Given the lag used in the inflation accrual calculation (3-month lag for most bonds) and the publication schedule (most inflation prints come out around the middle of the following month) it is always possible to know the actual value of the indices for the current month. Once a CPI print is released, one can calculate the forwards for the next calendar month. For example, the July 2020 CPI report was released on August 12, 2020. Up until that point, we only knew the CPI reference values through September 1, 2020 (based on the June 2020 CPI report). In other words, we could only calculate the carry for about 2 weeks with certainty. Once the July CPI report was released, however, we knew the CPI reference values through October 1, 2020, which means we could calculate carry for over 1 month with certainty.

The inflation breakeven

Since TIPS provide inflation-protected cashflows, we can calculate breakeven inflation rates across the term structure by comparing TIPS real yields with nominal Treasury yields. Breakeven inflation can simply be thought of as the average annual inflation needed over the life of the TIPS in order for it to provide the same return as a Treasury with the same maturity (i.e., the level of inflation that makes an investor indifferent between buying TIPS or Treasuries). We approximate this breakeven rate as the similar-maturity Treasury yield minus TIPS real yield (usually it is quoted in basis points).

The Fisher Equation expresses the relationship between nominal rates, real rates and inflation by mathematically decomposing nominal rates into real rates and inflation. The Fisher Equation is expressed as follows:

$$(1 + n) = (1 + i) \times (1 + r)$$

where: n = nominal rates
i = inflation rate
r = real rate

If we expand this out we can see that:

$$1 + n = 1 + i + r + ir$$

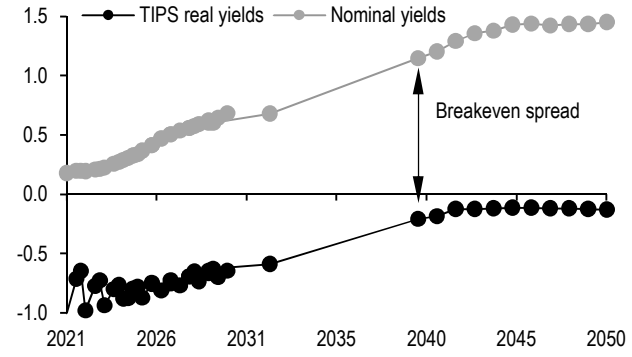
As ir is generally a very small term in this equation, the Fisher equation is often shown in its simplified approximate form:

$$n = i + r$$

In fact, in the bond sphere, breakeven inflation is calculated simply by subtracting the real yield from the nominal yield of a comparator bond.

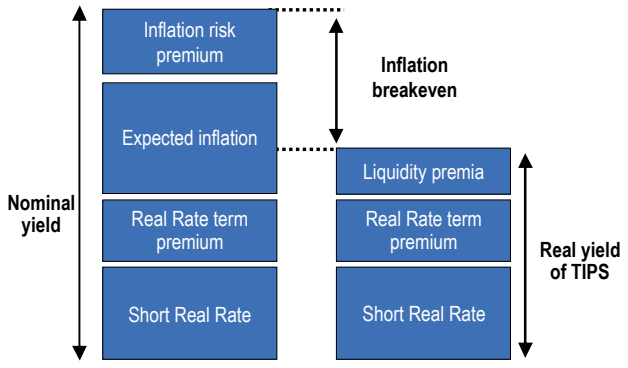
Exhibit 5 illustrates the breakeven curve. Note that because breakeven rates are *annualized* rates, the magnitude of front-end (<1Y to maturity) breakevens can be quite large. For example, a breakeven of 490bp for a TIPS with two months to maturity implies that the market is pricing 0.4% monthly gains in inflation over the next two months (on a lagged basis). Similarly, a breakeven of -350bp for a TIPS with two months to maturity implies the market is pricing in -0.3% monthly declines in inflation over the next two months (on a lagged basis): -3.5% = $(1\text{-}0.3\%)^{12}$ - 1.

Exhibit 5: The breakeven is the spread between a TIPS real yield and a similar-maturity Treasury yield…
TIPS real yield curve and yield curve of similar-maturity nominal Treasuries; %



Source: J.P. Morgan

Exhibit 6: …and this "breakeven" rate reflects more than just expected inflation
Breakdown of nominal and real TIPS yields



Source: J.P. Morgan

Nominal and real yields can be decomposed into various factors as shown in **Exhibit 6**. It is worth noting that **although inflation breakevens are a good measure of the market expectations of inflation, and are often used in modelling for such a purpose, there are other market-driven factors that determine breakeven rates**. Specifically, the inflation breakeven can be rewritten as expected inflation plus an inflation risk premium minus a liquidity premium, and each factor can vary across maturity points. Real TIPS yields reflect a liquidity premium (or illiquidity cost) to compensate investors for the relative illiquidity of inflation-linked bonds compared

to nominals. As we saw during the 2008 financial crisis and again in March 2020, this component can sometimes become a dominant driver of breakevens (see "Drivers of breakevens" below).

Still, market participants, as well as the Federal Reserve, use TIPS breakevens as a market-based measure of inflation expectations. In particular, investors and the Federal Reserve regularly monitor the 5Yx5Y forward breakeven measure derived from par Treasury rates. Compared to spot breakevens, the Fed views 5Yx5Y breakevens as less affected by cyclical factors such as energy prices and thus a better measure of how well the market thinks it is meeting its goal of longer-term price stability (see *Why we look at 5-year forward 5-year inflation*, K. Harano, 3/23/11). For more information on how to build an inflation curve for estimating forward inflation breakevens, see *Revising our TIPS fitted curve*, P. White, 8/15/19.

A breakeven position is established by buying (selling) TIPS and selling (buying) a DV01-matched amount of Treasuries. Usually a 1:1 risk ratio is used, but other ratios can be used if the investor believes TIPS will be more/less volatile than Treasuries. For example, investors who want to position for the outperformance of TIPS while limiting their duration exposure, may choose to weight the short nominal Treasury leg of a breakeven widener trade, based on a the empirical beta of real yields versus nominal yields. In addition to trading breakevens themselves, investors can also take views on the breakeven curve, or do breakeven switches.

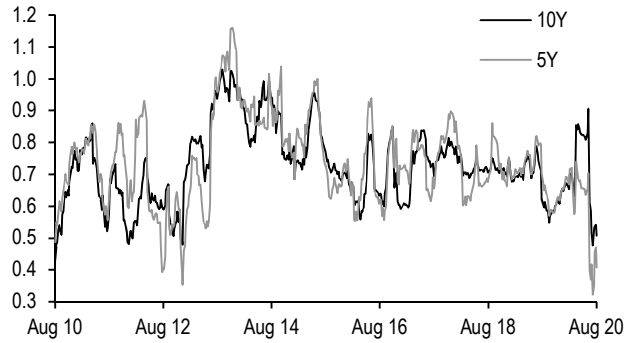
Drivers of TIPS and breakevens

Government bond markets and nominal yields: The dominant driver of real yields is nominal yields, with real yields tending to increase when nominal yields increase and vice-versa. Historically, the beta between TIPS yields and nominal yields has generally been below 1, meaning that TIPS yields rise less than nominal yields in a sell-off, and decline less in a rally (**Exhibit 7**). As a result, breakevens typically widen in a sell-off and narrow in a rally. This makes intuitive sense since stronger growth expectations are generally correlated with stronger inflation expectations and should propel nominal yields higher, while weaker growth and inflation expectations should push nominal yields lower.

While this directionality has been consistently observed over the life of the TIPS product, there have been periods where this relationship has broken down. The beta between real yields and nominal yields, especially in the 5-year sector, declined sharply in the 2011-2012 period when enhanced forward guidance was last introduced at the effective lower bound: 5-year nominal yields were little changed between August 2011 and the end of 2012, while real yields continued to drift lower. During the "taper tantrum" of 2013, real/nominal yield betas rose above 1, and breakevens actually *narrowed* in the sell-off, likely due to a sharp rise in liquidity premium as market depth declined. With the Fed now back at the lower bound and likely to introduce enhanced forward guidance in September 2020, nominal yield betas have again dropped across the curve, to near their lowest levels since late 2012.

Exhibit 7: The beta between TIPS yields and nominal yields is generally less than 1 and has recently fallen to near the lowest levels since 2012

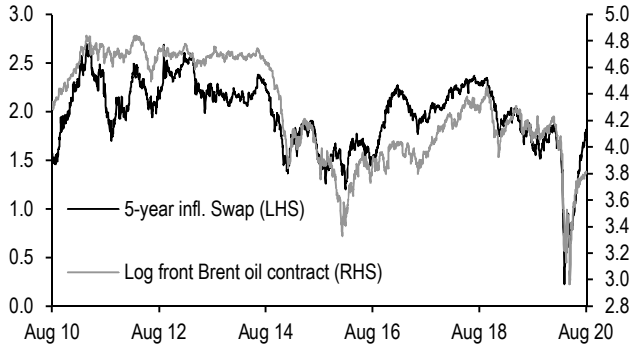
Rolling 3-month betas of daily changes in on-the-run TIPS yields regressed against daily changes in on-the-run Treasury yields



Source: J.P. Morgan

Exhibit 8: Front-end inflation expectations tend to be largely driven by energy prices

5-year US CPI inflation swap rate (LHS, %) versus log of rolling front Brent oil futures price* (RHS)



* We show the logarithm of the oil price so that the scale reflects percentage changes rather than $ changes, since the magnitude of the percentage change influences the inflation rate

Source: J.P. Morgan

Inflation prints and inflation expectations: The evolution of actual headline and core CPI inflation prints generally heavily influence expectations of future inflation. In addition, factors affecting expectations of future inflation are also important drivers of TIPS and breakevens. For example, TIPS investors closely follow macro drivers of core inflation like the unemployment rate, wage inflation, and the currency. While we find little empirical sensitivity of breakevens to unemployment rates and wage growth, breakevens tend to be negatively correlated with the J.P. Morgan nominal broad trade-weighted dollar index, as a stronger dollar should push import prices lower, on the margin, and vice versa.

Near-term inflation dynamics also determine the carry offered by TIPS, given their indexation mechanics. Energy prices tend to drive headline inflation and thus heavily influence front-end TIPS (**Exhibit 8**). When the month-on-month change in the CPI is large, so is the carry offered by TIPS, and vice versa. It is common for investors to hedge the energy exposure on a front-end TIPS or breakeven trade by selling oil or gas futures against it. We discuss energy hedging breakeven exposure in more detail in *De-energizing inflation breakevens*, P. White & A. Gaveau, 4/17/20.

Liquidity/credit risk: Technically, TIPS have the same sovereign credit risk as nominal Treasuries, since they are both obligations of the US federal government. However, in practice, TIPS often trade like risky assets, with breakevens widening (TIPS outperforming) on "risk-on" days, and breakevens narrowing (TIPS underperforming) on "risk-off" days. Breakevens have tracked investment-grade bond spreads relatively closely over recent years, especially during crisis periods. One explanation for this correlation is the fact that TIPS—like several risky asset sectors—are significantly less liquid than Treasuries, as we discussed at the start of this note. Often, flight-to-quality events are also flight-to-liquidity events, so if investor risk appetite declines—even if inflation expectations are unchanged—TIPS may underperform and breakevens may narrow.

Exhibit 9: In our TIPS breakeven fair value models, we regress 1-month forward, seasonally-adjusted breakevens on nominal yields, high grade credit spreads, changes in oil prices, and our trade-weighted USD index

Statistics for 1-month forward seasonally-adjusted breakevens (bp) regressed against closest-maturity on-the-run Treasury yields (bp), JULI (our high grade credit index) portfolio spread to Treasuries (bp), the 1-month percent change in rolling front Brent oil futures contract prices (%), and the J.P. Morgan nominal broad trade-weighted dollar index; model uses daily data over the past three years

	Tsy yields (bp)		High grade spd (bp)		Chg Brent oil (%)		Trade-wtd USD index		Intercept (bp)	R-sq	Std error (bp)
	Beta	T-stat	Beta	T-stat	Beta	T-stat	Beta	T-stat			
5Y	0.29	37.1	-0.38	-19.3	0.47	12.2	-0.60	-3.4	246	91%	11.9
10Y	0.28	46.3	-0.22	-15.9	0.24	9.0	-0.39	-3.0	199	92%	8.5
30Y	0.28	36.6	-0.07	-4.9	0.19	6.9	-0.76	-5.8	220	87%	8.4

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

Putting this together, we present our fair value models for breakevens in **Exhibit 9**: we regress 1-month forward, seasonally-adjusted breakevens on nominal yields, high grade credit spreads, changes in oil prices, and our trade-weighted USD index. (We discuss the seasonal adjustment process in the following section.) Our model implies breakevens tend to widen when nominal yields increase, high grade spreads tighten, oil prices rally, and the broad dollar declines. For all sectors, nominal yields appear to be the most significant driver. In addition, as one would expect, 5-year breakevens show the greatest sensitivity to oil prices, while 30-year breakevens show the least sensitivity. We use fair value models to discern richness/cheapness and help inform our outlook for breakevens.

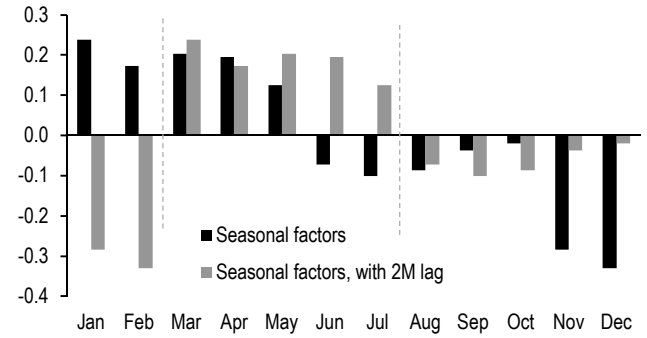
Seasonality in CPI and TIPS

Headline CPI inflation tends to be strong in the first few months of the year, moderate in the middle of the year, and soften in the last quarter of the year. This comes from various seasonal factors that drive each of the CPI components—for example, energy price inflation tends to firm into the peak of the summer travel season before moderating, while retail discounts around the holiday season in November and December tend push apparel prices lower, etc. The BLS uses statistical methods to derive these seasonal factors and seasonally-adjusted CPI is often a better indicator of underlying trends in inflation. However, TIPS are indexed to the unadjusted CPI, since seasonal adjustment factors are subject to revision for up to five years after their original release. Thus, it is unsurprising that TIPS prices reflect the expected changes in CPI that normally occur at the same time every year.

Recall TIPS securities mature in January, February, April, July, and October (Exhibit 2).

Consider the relative pricing of securities maturing in different maturity months. **Exhibit 10** shows the additive 2019 seasonal adjustment factors from BLS by month—i.e., the difference between the m/m % changes in unadjusted and adjusted headline CPI. As mentioned, these seasonals tend to be very positive in the first few months of the year and very negative in late in the year. Because of the lag in the indexation process, this means that July TIPS mature after several months of positive seasonals, while January and April TIPS mature after several months of negative seasonals. As a result, July TIPS trade rich relative to January and April TIPS with similar maturities. This effect is more pronounced in shorter-maturity TIPS: for example, a 0.55%-pt April-versus-July CPI differential is worth 20bp for Apr-23 and Jul-23 TIPS, but it is only worth 11bp for Apr-25 and Jul-25 TIPS (**Exhibit 11**).

Exhibit 10: Seasonality in headline CPI...
Difference between non-seasonally adjusted and seasonally-adjusted monthly changes in headline CPI based on 2019 BLS seasonal adjustment factors, and with 2-month lag; %



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

Exhibit 11: ...causes July TIPS to trade rich to April and January TIPS
Estimated value of the seasonality difference* in return terms for TIPS of different maturity months and yield impact for TIPS impacts of different maturity years (units as indicated)

	Jan/Apr	Jan/Jul	Apr/Jul	Apr/Oct
Price impact (%)	-0.15%	0.40%	0.55%	0.39%
Yield impact, by maturity year (bp of impact)				
2023	5.9	-14.9	-19.6	
2024	4.2	-10.8	-14.4	-10.0
2025	3.3	-8.5	-11.4	
2027		-6.0		
2029		-4.7		

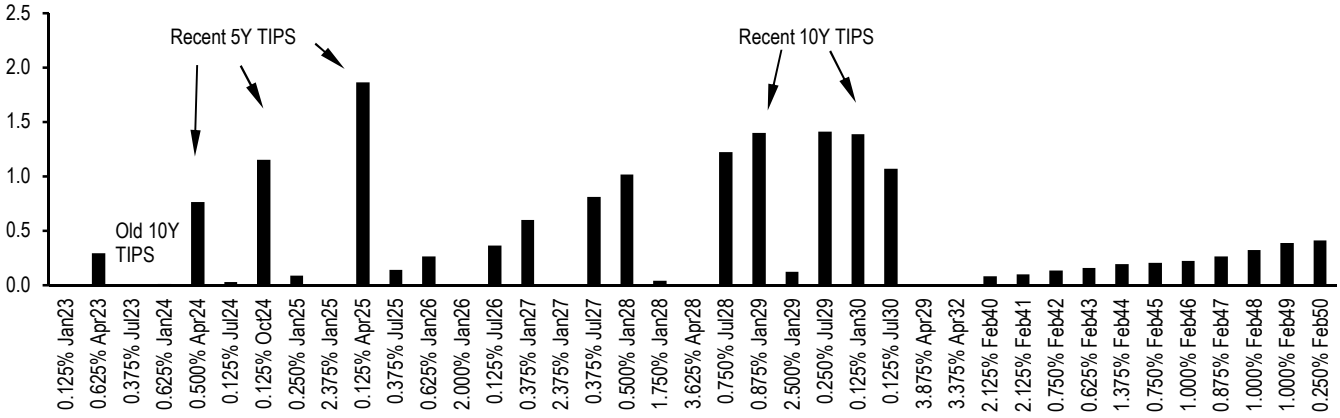
* Based on the values in Exhibit 10

Source: J.P. Morgan

Similarly, seasonality matters for the pricing of a given security at different times of the year. Consider a newly issued April-maturity 5-year TIPS: principal at maturity will be scaled based on CPI changes over five full years, so seasonality has no impact. As time passes from April through January, CPI (on a lagged basis) is seasonally positive. This suggests that if you purchase the security when it has 4.5 years to maturity, for example, seasonality is expected to pressure CPI lower over the final six months before maturity, so spot prices move lower (and yields higher) to reflect this. Conversely, from January to April, CPI is seasonally negative, so spot prices rise (yields fall). Since we can quantify these effects, we often find it useful to look at seasonally-adjusted TIPS yields and breakevens, in order to assess performance and valuations and approximate market-based measures of expectations for trend inflation (see *How do you measure, measure a year?*, 10/23/19).

Value of the inflation floor in TIPS

Exhibit 12: The value of the embedded floor tends to be highest for recently-issued 5-year TIPS
Estimated value of the embedded inflation floor in TIPS (based on our internal options pricing model); bp of yield



Source: J.P. Morgan

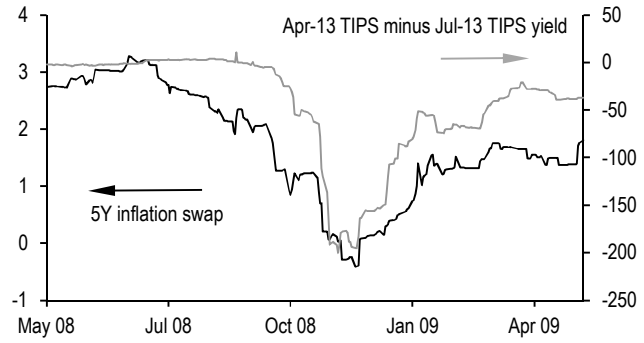
When expected future inflation is well above zero, the embedded floor on TIPS principal (floored at par at maturity) is usually worth very little, because the option is very far out-of-the-money. As **Exhibit 12** shows, the estimated values of the embedded floors currently range between 0-2bp of yield. These floors tend to decline in value as issues age and their index ratios rise above 1.0 (par) due to

accrued inflation. The floors in recently-issued 5-year TIPS tend to be worth the most because their implied forward index ratios tend to be closest to 1.0.

However, when expected future inflation is close to zero, the inflation floor on newly-issued TIPS can become quite valuable, as we saw during the financial crisis. As **Exhibit 13** shows, for most of 2008 Apr-13 TIPS (a newly issued 5-year TIPS with an index ratio close to 1.0) and Jul-13 TIPS (an old 10-year TIPS with an index ratio around 1.15) were trading basically on top of each other. However, when the financial crisis intensified and inflation swaps began to price in no inflation/deflation over the next 5 years, the embedded floor on Apr-13 TIPS became in-the-money, and this issue richened substantially relative to Jul-13 TIPS. As inflation swaps rebounded, however, the Apr-13 TIPS floor became less valuable, and this differential narrowed. In March 2020, inflation swap rates dropped sharply again as COVID-19 spread through the US: **Exhibit 14** shows that the floor value on hot-run Oct-24s TIPS rose, causing Oct-24s TIPS to outperform versus near off-the-runs with high index factors, such as the 2.375% Jan-25s, though the move was not nearly as severe as we observed in late 2008.

Exhibit 13: When expected inflation falls to zero, as it did during the financial crisis, the embedded floor in newly-issued TIPS can become very valuable

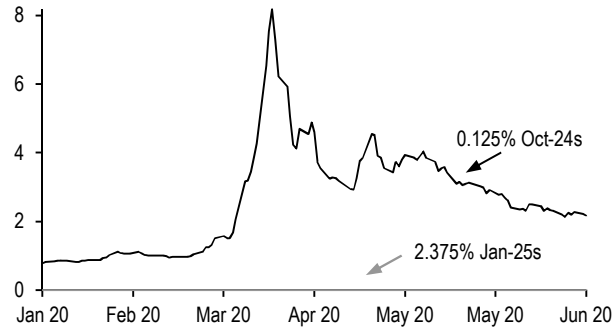
5-year inflation swap rate (%, LHS), versus Apr-13 TIPS yield minus Jul-13 TIPS yield (bp, RHS)



Source: J.P. Morgan

Exhibit 14: While embedded floor premiums on low-index TIPS also rose in March 2020, the moves were not as severe

Premium of floor embedded in 0.125% Oct-24 TIPS versus floor in 2.375% Jan-25 TIPS; bp of yield



Source: J.P. Morgan

Who trades TIPS?

In the early years of the TIPS program, dealers were the largest buyers of TIPS at auction, but in recent years, end-user demand for TIPS has steadily increased (**Exhibit 15**). Specifically, investment-manager demand for TIPS has risen since the financial crisis. TIPS are *not* included in commonly-followed benchmark aggregate indices, but some core bond funds using these indices may still choose to make strategic allocations to TIPS. In addition, some investment managers may have dedicated TIPS or inflation-protected funds and may buy (sell) TIPS when these funds see inflows (outflows), and in order to match the profile of their benchmark index. As **Exhibit 16** shows, assets under management for inflation-protected bond funds grew sharply after the financial crisis, declined during the "taper tantrum," and have been growing steadily again in recent years to $197bn as of July 2020. In addition to buying TIPS outright, these accounts may also take views on the shape of the real yield curve or the spread between two or more bonds (switch trades and butterfly trades). Some real money investors may also be able to sell Treasury futures against their TIPS holdings (creating a synthetic breakeven position).

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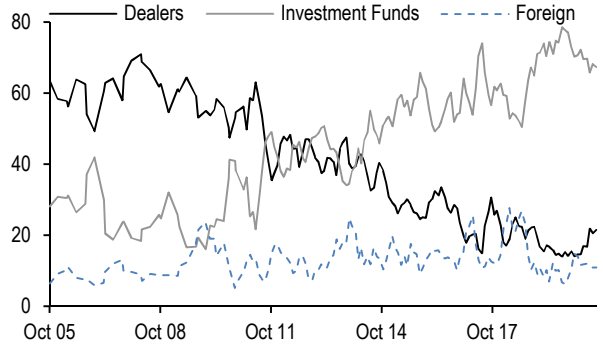
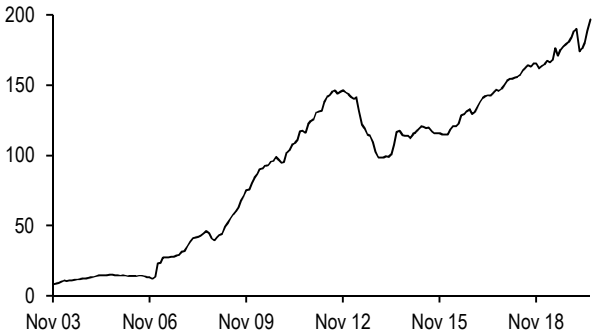
Exhibit 15: End-user demand for TIPS at auction has been increasing in recent years, driven by investment managers
Allocation to dealers, investment managers, and foreign investors, 3-month moving average across all TIPS auctions; %



Source: US Treasury

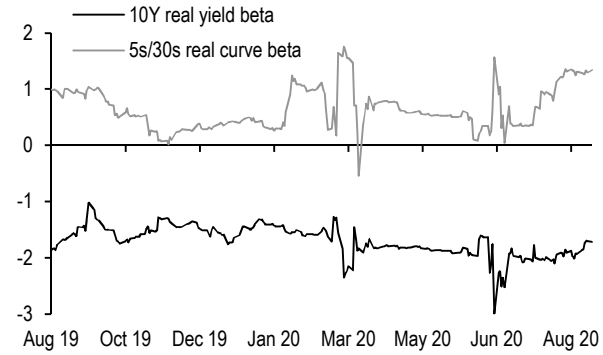
Exhibit 16: Inflation-protected mutual funds grew sharply after the crisis, saw outflows during the "taper tantrum," and have grown steadily again in recent years
Total net assets for inflation-protected domestic bond funds; $bn



Source: EPFR

To gauge the positioning of the active TIPS fund universe, we rely on a simple model that regresses the asset-value weighted average excess return of the 15 largest TIPS-focused funds relative to the J.P. Morgan TIPS Index (JUSTINE) on daily changes in various market factors, including real yields, breakevens, and the real yield curve, over a rolling 3-month regression horizon. A positive partial beta of excess returns with respect to real yields would suggest that these funds are long real duration exposure relative to the index, and vice versa. In the model, the duration beta remains the most statistically significant variable in explaining excess returns, and the model implies these funds are currently short duration relative to the benchmark and positioned for a steeper 5s/30s real yield curve (**Exhibit 17**).

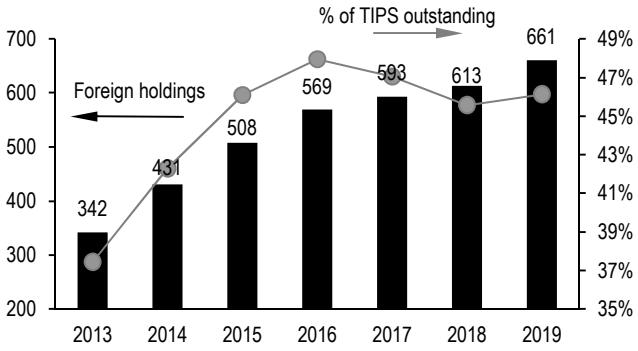
Exhibit 17: We use our TIPS fund index to assess positioning in TIPS, breakevens, and the real yield curve
Rolling 3-month partial betas with respect to 10-year real yields and the 5s/30s real yield curve*; unitless



* Daily excess return (%) of our TIPS fund index are regressed against daily changes in 10-year real yields, the 5s/30s real yield curve, and 10-year breakevens. Our TIPS fund index is comprised of the 15 largest (by assets under management) inflation-protected funds focused on the US.

Source: Bloomberg, J.P. Morgan

Exhibit 18: Foreign holdings of TIPS continued to increase through mid-2019, accounting for 46% of the market
Foreign holdings of TIPS (left axis; $bn) and as a percentage of TIPS outstanding (right axis; %) as of June of each year



Source: Treasury International Capital System, US Treasury, J.P. Morgan

Although **foreign investors** buy a smaller portion of TIPS at auction, anecdotal evidence suggests that central banks and sovereign wealth funds are major players in the market. Traditionally, foreign central banks are mostly buy-and-hold investors, and operate with longer investment horizon than other real money investors. They may or may not manage their TIPS holdings against a benchmark index. Foreign holdings of TIPS are available annually from the Treasury International Capital System (TIC), and these data show that foreign investors accounted for 46% of the market as of June 2019, with China representing the largest share (**Exhibit 18**). Notably, foreign investors have exhibited a preference for TIPS over nominal Treasuries in recent years, and this trend has been most evident among the official sector, holding an increasing share of the TIPS market, while their share of nominal Treasuries has declined nearly 10%-pts since 2012.

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

It is also worth noting that given the aggressive pace of Fed purchases throughout QE4, over $310bn TIPS (inflation-adjusted) were held in the **SOMA portfolio** as of August 2020, representing more than 20% of TIPS outstanding—the SOMA ownership share is roughly the same for the overall Treasury market given that the allocation of purchases to TIPS in QE4 has been in line with their share of the overall market.

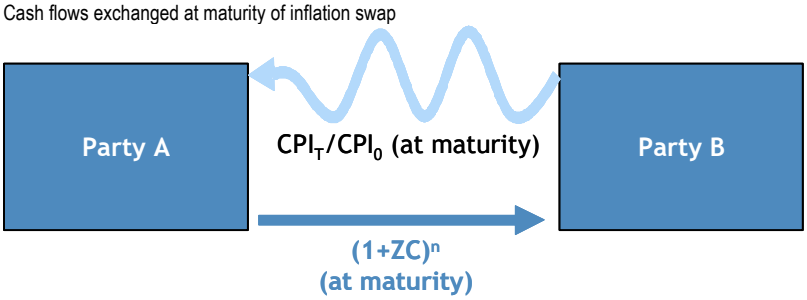
US CPI inflation swaps

In Europe, inflation derivatives are more liquid and more widely-traded than cash linkers, but **in the US, the opposite is true: the TIPS market is more liquid than US CPI derivatives**. Daily trading volumes in USD zero coupon inflation swaps in the interdealer market averaged only about $550mn over the first half of 2020, though a wide range of investor types participate in the market. As of August 2020, LCH reported $7.0tn notional of inflation swaps outstanding (in USD-equivalent), where USD swaps represented roughly 24% of that, while EUR and GBP swaps represented each represented roughly a 38% share.

Zero Coupon inflation swaps

Zero Coupon (ZC) inflation swaps are the most frequently traded US inflation derivative. The structure is very simple, with the only payments occurring at maturity (**Exhibit 19**). The party who receives inflation (pays fixed) in the swap will receive the accrued inflation over the life of the swap on the initial notional. In practice, the two payments at the maturity of the swap are netted off. Importantly, the payment at maturity is not path dependent, depending only on the final reference CPI compared to the base CPI, both of which are subject to the same 3-month lag as TIPS. Thus carry is largely irrelevant for zero-coupon swaps.

Exhibit 19: Zero coupon inflation swap cash flows
Cash flows exchanged at maturity of inflation swap



Source: J.P. Morgan

For zero-coupon swaps, breakeven inflation is the inflation that must be realized for the swap initiated at mid to realize zero value. This can be shown so that:

$BEI = [(CPI_f / CPI_0) ^ (1/n)] - 1$

where: CPI_f = CPI level upon maturity
CPI_0 = CPI level upon inception of the swap
n = tenor of the swap in years
BEI = Breakeven Inflation

Example: If the reference CPI index increased from 260 to 318 over 10 years, equivalent to an annual inflation rate of 2.034%, the payment on $10mn notional is equal to:

(318/260) * $10mn = $12.23mn

The counterparty will receive a compounded fixed rate, which was set at the inception of the swap and represents the expected breakeven inflation rate. Therefore, if the fixed rate in this case was 1.90%, the payment will be equal to:

$10mn * (1 + 1.90%) ^ 10 = $12.07mn

Therefore, the net payment in this example is that the inflation receiver will be paid $159,808 by the inflation payer upon maturity.

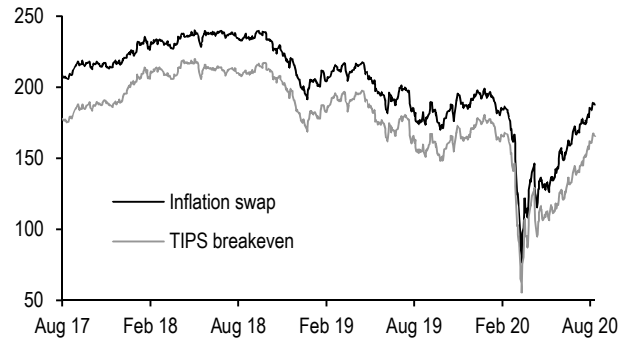
"Inflation basis"

The difference between the inflation swap rate and the on-the-run TIPS breakeven is called the **inflation basis**. As **Exhibit 20** shows, inflation swaps and TIPS breakevens tend to be very well-correlated, but the inflation swap rate tends to be higher than the corresponding TIPS breakeven rate. One explanation for this consistently-positive basis is that the inflation swap market is predominantly one-sided: most investors want to receive inflation/pay fixed, and there are no natural payers of inflation (other than the Treasury through TIPS). As a result, the fixed rate that investors must pay is biased higher. One could argue there is a credit component embedded in the swap rate as well: although the vast majority of inflation swaps are cleared, the counterparty is not the US government.

Investors can trade the basis directly, but basis trades are less common than outright inflation swap trades. In general, the basis tends to be mean-reverting over the medium term but very flow-driven over the short term (**Exhibit 21**). It's also

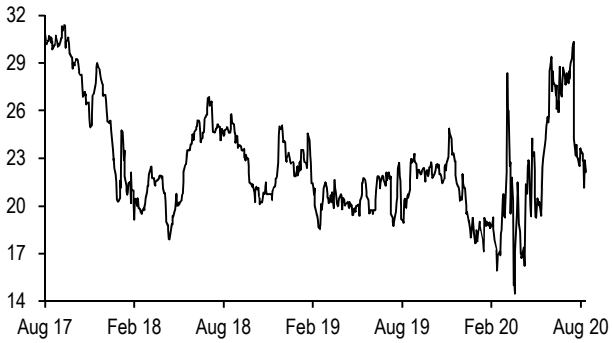
important to note that the shape of the curve will influence the basis, since the inflation swap has a constant maturity, while the maturity of the hot-run TIPS will be shorter. Moreover, since the zc inflation swap does not have an embedded floor, a richening or cheapening in the floor can also impact the basis. For these reasons, when gauging the relative performance of swaps versus breakevens, it is often useful to compare breakevens with matched-maturity swap rates, and adjust for the value of the floor on the TIPS. Historically, our basis models have tended to be unstable, with shorter-term correlations not tending to persist over longer horizons. That said, we would expect the basis to be at least partially explained by the cost and availability of balance sheet and overall TIPS market liquidity, and for the basis to trade directionally with nominal swap spreads. We also find that the basis tends to widen as term GC/OIS spreads widen. Lastly, we observe some seasonality in the basis, even when using matched-maturity inflation swap rates, with cash breakevens tending to outperform swaps when ex-ante carry is higher.

Exhibit 20: The difference between the inflation swap rate and the on-the-run TIPS breakeven is called the "inflation basis"…
10-year US CPI inflation swap rate and 10-year TIPS breakeven; bp



Source: J.P. Morgan

Exhibit 21: …which tends to be mean-reverting over the medium term
10-year inflation basis (10-year US CPI inflation swap rate minus 10-year TIPS breakeven); bp



Source: J.P. Morgan

Trading CPI fixings

Instead of expressing a medium-term view on inflation over the life of a TIPS or an inflation swap, investors can also take a view on an individual CPI fixing (i.e., the September 2020 CPI level). Generally, this market is liquid only a few months into the future.

If clients "buy" the fixing, they will make money if actual CPI exceeds the quoted level, and vice-versa if they sell the fixing. For example, if the risk in the trade is $10,000 per 0.1-point deviation, the quoted level is 259.2, and the actual is 259.4, the payout is (259.4-259.2)/0.1*(10,000) = $20,000.

Who trades inflation swaps?

Real money accounts generally receive inflation via swaps, either as an alternative to buying TIPS in an inflation-linked fund, or as an alpha-generation strategy in a core bond fund. They may also add a receive-inflation swap overlay to a muni or corporate bond position in order to create a synthetic inflation-protected asset. Occasionally, real money accounts may pay inflation in a swap as part of an alpha-generation strategy. Similarly, insurance companies generally receive inflation in order to hedge inflation-linked liabilities such as annuities. Occasionally they may buy TIPS on asset swap (which implicitly involves paying inflation) as an alternative to nominal Treasuries they otherwise need to buy. Hedge funds will trade both sides of the swap market (receiving or paying inflation) and will often try to trade the range.

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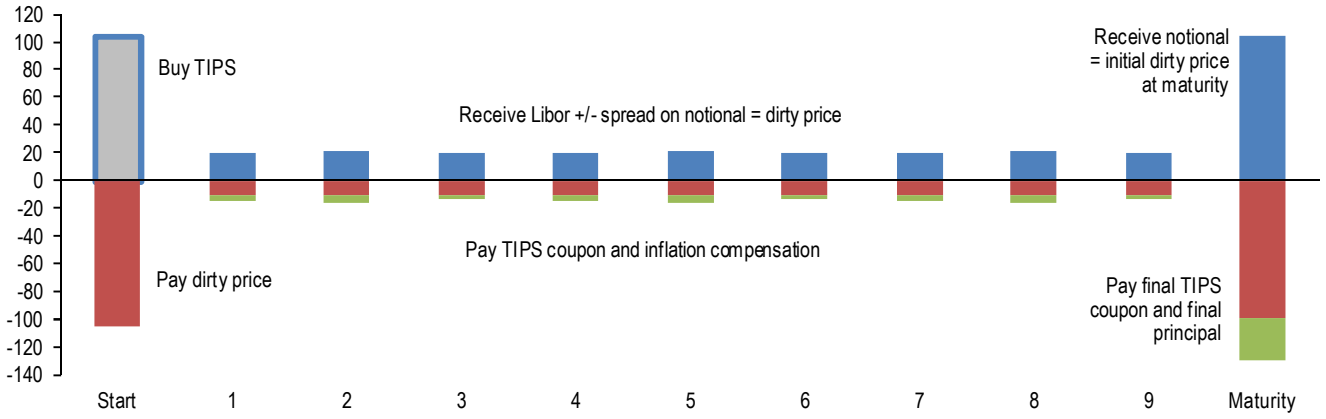
TIPS asset swaps

A traditional asset swap is a package that transforms a fixed-rate coupon bond into a floater that pays Libor +/- a spread, plus exchanges of initial and final cash flows. The nature of the initial and final payment (par or dirty price) depends on the nature of the asset swap; i.e., if it's a par/par asset swap (par) or a proceeds-based asset swap (dirty price). In the Euro area, linkers typically trade on a par/par asset swap basis, but in the US, **TIPS asset swaps are overwhelmingly proceeds asset swaps**, and this is assumed to be the convention.

Exhibit 22: A TIPS asset swap creates a synthetic floater...
Hypothetical illustration of cash flows for an investor buying TIPS on asset swap



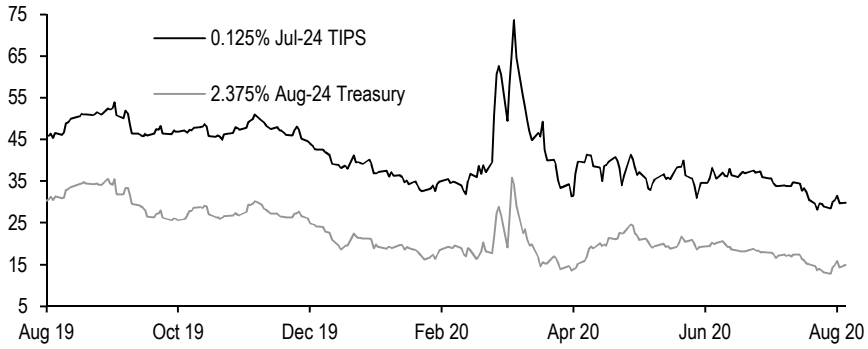
Source: J.P. Morgan

In a TIPS asset swap, the buyer first buys the bond at the current dirty price. Over the life of the TIPS, the investor pays all the TIPS cash flows to the dealer and receives Libor +/- a spread on a notional equal to the initial dirty price. At maturity, the investor pays the dealer the final TIPS principal and final coupon and receives a notional equivalent to the initial dirty price (**Exhibit 22**). Since inflation is usually positive, the final TIPS cash flow will most likely be greater than the initial dirty price, so the final cash flow exchange will likely net out to a *payment to the dealer*. As a result, investors may incur credit/funding charges on longer-dated trades with a dealer.

Note that asset swaps can be seen as a supply of inflation in derivatives/swaps form, as well as a supply of options/floors on the principal amount (given that in an asset swap the buyer gives the inflation-linked cash flows to the seller).

The relative cheapness of TIPS asset swaps versus conventional Treasuries have made them the target of investors looking for attractive pickup (**Exhibit 23**). Hedge funds, insurance companies, and bank treasuries trade TIPS on asset swap. Some real money accounts may also participate. These investors are effectively getting paid for providing liquidity to the market. Investors may also buy TIPS asset swaps in order to realize roll-down (since the spread curve is generally upward sloping). They may also buy TIPS asset swaps in order to position for tighter spreads (i.e. given a view that TIPS should richen). Alternatively, investors may add a nominal interest rate swap to the TIPS asset swap in order to transform the package from a Libor floater into a fixed-rate synthetic Treasury, with a pickup to nominal Treasuries. Doing so may allow some investors to use hedge accounting.

Exhibit 23: …which generally trades cheap to Treasury asset swaps
0.125% Jul-24 TIPS and 2.375% Aug-24 Treasury proceeds asset swap spreads; bp



Source: J.P. Morgan

The (TIPS asset swap) minus (Treasury asset swap) differential is generally directional with the inflation basis. This means that when TIPS richen relative to Treasuries on asset swap, breakevens tend to widen relative to inflation swaps. This differential tends to be driven primarily by flows in the short run, and often sharp moves become exacerbated before the basis reverts to the mean.

Inflation options: Caps & Floors

The market trades **floors and caps on US CPI inflation**. There are two types of caps/floors that trade in the inflation market: **Zero Coupon (ZC)** and **Year-over-Year (YoY)**. ZC caps/floors reference the cumulative inflation over a certain period, usually more than one year, while YoY caps/floors consist of a strip of independently-exercisable options which reference year-over-year inflation rates and have an annual, semiannual, or quarterly look. For example, consider a 10-year 0% YoY floor between 2020 and 2030. If realized inflation is +2% every year to 2026 with the exception of 2024-2025, when it is -5% (deflation), the payout is 5% for the owner of this floor. In the case of a 10-year 0% floor (ZC), however, the payout would be 0.

Zero coupon caps/floors trade in greater volume, especially floors with 0% strikes, since TIPS are a natural source of these floors. Year-over-year caps/floors trade less frequently, and premiums tend to be much higher because vol is much higher. The product was more popular in the early part of the last decade, with supply/demand coming from the structured note market and occasionally from corporate contracts linked to CPI, though trading of these types of notes slowed to a trickle over recent years. For both types of options, far out of the money strikes (0% and 4% for example) are more liquid than ATM strikes (1.5%-2.5%).

In general, the inflation option market is even less liquid than the inflation swap market, with virtually no inflation options traded in the interdealer market over the past three years, though volumes have started to pick up somewhat in recent months. Hedge funds and insurance companies are usually interested in buying options. Real money accounts are generally long TIPS in their portfolios, so they may sell inflation floors as a way to monetize the embedded optionality in TIPS and earn carry. They may also sell inflation caps as a covered call-like strategy.

Research and analytics

For J.P. Morgan's latest research and analytics reports on TIPS, please visit https://jpmm.com/#research.rates.inflation.

Appendix

Carry dynamics

One way of measuring carry is to take the **forward real yield minus the spot real yield**. If a linker is trading at a spot (clean) price P_s or spot real yield y_r we can calculate the carry of the linker using Equations 1-3 below. The carry in basis points would be $y_f - y_r$, the forward real yield minus the spot real yield.

Notation used in the formulae:

P_s = Real (clean) price of linker (quoted on market)

c_t = Real coupon of linker at discrete times

y_r = spot real yield of linker (quoted on market)

I_s = Index ratio on spot date

I_f= Index ratio on forward date

i_s = Real coupon accrued as of spot date

i_f= Real coupon accrued as of forward date

$repo_f$ = repo rate for a term ending at the forward date, annualized

days = # days between spot and forward date

P_f = Real (clean) forward price of linker

y_f = Forward real yield of linker

Equation 1

$$P_s = \sum_{t=s} \frac{c_t}{(1+y_r)^t} - i_s$$

Equation 2

$$P_f = \frac{I_s}{I_f} * (P_s + i_s) * (1 + repo_f * \frac{\#days}{360}) - i_f$$

Equation 3

$$P_f = \sum_{t=f} \frac{c_t}{(1+y_f)^t} - i_f$$

If we look at a real example:

On May 29, 2020 (June 1, 2020 settle), the TII 0.125% Jan-30 traded at a spot real clean price of 106.2935, or a real yield of -0.512%. The index ratio at spot settle is 1.00323 and the spot real coupon accrued is 0.04754. On June 30, 2020, the index ratio is 0.99652, reflecting the 0.67% decline in CPI-U in April, and the real coupon accrued is 0.05749. We use a 1-month General Collateral repo rate of 0.13%.

The spot cash dirty price would be (real clean price + real accrued interest)*(spot index ratio) = (106.2935+0.04754)* 1.00323 = 106.6846

Applying the formula above for the forward clean price in Equation 2:

P_f =(1.00323 /0.99652)*(106.2935+0.04754)x(1+0.13%*30/360)-0.05749= 107.0112

Solving for y_f in Equation 3, y_f = -0.588%

So given the forward and spot yields, the carry is

-0.588%-(-0.512%) = -7.6bp

Carry in an inflation breakeven trade: An inflation breakeven trade combines a long (short) position in a linker versus a short (long) duration-adjusted position in a similar-maturity nominal bond. As a result, the carry of such a trade can be thought of as the difference between the carry of the two legs. For example, if an investor goes long breakevens (buys TIPS and sells nominals), then the breakeven carry will equal (carry on TIPS) minus (carry on nominals). In general, carry on the trade will be positive when the accrued inflation (annualized) is higher than the level of the inflation breakeven.

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