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AN ASSESSMENT OF RECENT TRENDS IN MARKET-BASED EXPECTED INFLATION IN THE EURO AREA

by Marcello Pericoli*

Abstract

This paper presents estimates of expected inflation and the inflation risk premium in the euro area as deduced from asset prices. The preferred model uses both nominal and real government bond returns, takes into account market liquidity and exploits measures based on the survey of inflation expectations. The resulting estimate of expected long-term inflation is rather variable over time and has significantly decreased since the end of 2018. In contrast, an alternative model based on inflation swap returns provides a measure of expected inflation that remains almost unchanged for the entire reference period.

JEL Classification: C32, E43, G12.
Keywords: affine term structure model, expected inflation, inflation risk premium.
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Contents

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1 Introduction*

All measures of inflation compensation, whether directly derived from the yields on inflation swaps or inferred from the nominal and real term structure of sovereign interest rates, necessarily conflate both an expected inflation component and a risk-premium term. To identify those two components several approaches are available, ranging from purely statistical techniques to model-based methods. Among the latter, affine term structure models (ATSMs), which hinge on a set of no arbitrage conditions that drive the term structure of interest rates, are extensively used in central banks. The specific assumptions underlying different ATSMs may result in very different estimates of inflation expectations.

This paper presents two alternative models to estimate euro area expected inflation and the inflation risk premium based on asset prices: (i) a standard ATSM estimated using both nominal and real bond yields; the model also corrects real yields for market liquidity and make use of survey-based expectations; (ii) an ATSM based on an affine term structure representation of inflation swaps.

In the literature, measures of breakeven inflation have been derived using both classes of models. Abrahams et al. (2016), D'Amico et al. (2018), Christensen et al. (2010), García and Werner (2010), Haubrich et al. (2012), Hördahl and Tristani (2014), Joyce et al. (2010), Pericoli (2012) use both the term structure of nominal government bond yields and the term structure of index-linked government bond yields; expected inflation is given by the difference between expected nominal bond yields and expected index-linked bond yields, while the inflation risk premium is the difference between the nominal term premium and the real term premium. These models have been recently further refined, by anchoring model-implied expected inflation to survey measures of inflation expectations (Kim and Orphanides, 2012) and by taking liquidity considerations into account (Abrahams et al., 2016; Christensen et al., 2010). An example of the second class of models is instead Camba-Méndez and Werner (2017) and Kaminska et al. (2018) – IS model from here on. Other models jointly use the nominal bond yields and the inflation swaps instead of index-linked bond yields (Haubrich et al., 2012).

In principle, in a frictionless world the measures of inflation compensation underlying those two classes of models should be identical. If they differed, arbitrageurs would step in and any misalignment would quickly vanish. In practice, however, this is not the case,

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because of specific features of the various markets (e.g., the supply-demand imbalance in the inflation swap market; the different liquidity of the nominal bond market, the index-linked bond market and the inflation swaps market; these features are described in the Appendix).

From a methodological viewpoint, in the standard ATSM the factors that drive nominal and real rates need not be the same. By contrast, the use of inflation swaps alone implicitly assumes that the same factors drive both nominal and real interest rates.

The results of the standard ATSM approach and the IS model differ sharply: estimates of five year ahead five-year (5y5y) expected inflation obtained with the former approach fluctuate over time and show a tendency to decline starting in late 2018. By contrast, the IS model yields inflation expectations that are virtually unchanged throughout the whole sample period, at levels that are not far from 2 percent; accordingly, the risk-premium component is the main driver of fluctuations in inflation compensation.

This note is structured as follows. Section 2 presents alternative measures of breakeven inflation; Section 3 describes the two models used to decompose inflation compensation into expected inflation and the inflation risk premium; Section 4 presents the results of the decompositions; Subsection 4.1 focuses on the inflation expectation estimates for 2018-19; Section 5 concludes.

2 Alternative measures of breakeven inflation

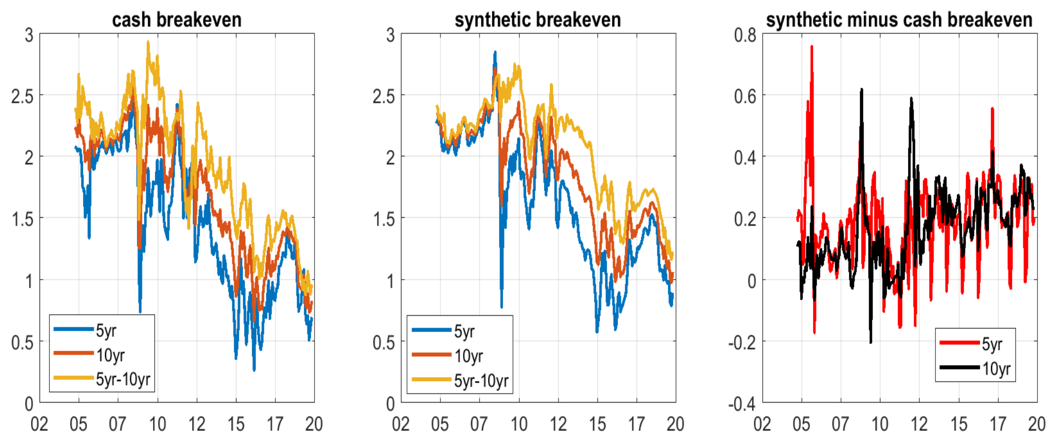
Two alternative measures of inflation compensation can be computed using financial markets data: (i) the first is given by the difference between nominal government bond yields and index-linked government bond yields (the so-called cash breakeven); (ii) the second is obtained from the yields on zero-coupon inflation swaps, a derivative instrument that is used to transfer inflation risk from one counterparty to another (the so-called synthetic breakeven, or inflation swap rate).

Even if cash and synthetic breakeven are in principle linked by arbitrage relations, their level and volatility may differ because of the different liquidity of the underlying instruments and market segmentation:[1] for the 5- and 10-year tenors, the cash breakeven tends to be lower by around 10 bp, on average, from 2004 to 2011 and by three times as much from 2012 to 2019 (Figure 1).

Given that risk-averse investors require a premium for bearing inflation risk, models are needed to break down both the cash and the synthetic breakeven inflation into expected in-

[1]See the Appendix for further details.

Figure 1: Measures of breakeven inflation



Notes: The cash breakeven is the difference between nominal zero coupon government bond yields and real zero coupon government bond yields; real bond yields are computed with French and German index-linked bonds indexed to the euro-area HICP ex tobacco. The synthetic breakeven is the zero-coupon inflation swap.

flation and the inflation risk premium. In the next Section we discuss how ATSMs, which are commonly used to break down the term structure of any type of interest rates (nominal yields, real yields, corporate bond yields, etc.) into an expected component and the risk-premium component, can be adapted to break down inflation compensation into the corresponding expected inflation and risk-premium components.

3 ATSM for inflation-related assets

An ATSM is defined by a set of equations

$$y_t = A + BX_t \quad , \tag{1}$$
$$X_{t+1} = \overline{\mu} + \overline{\rho}X_t + \Sigma v_t \tag{2}$$
$$X_{t+1} = \mu + \rho X_t + \Sigma u_t \quad , \tag{3}$$

where $y_t = [y_t^{(1)}, y_t^{(2)}, ..., y_t^{(N)}]'$ is a $1 \times N$ vector of zero-coupon bond yields from 1-period to N-period maturity, X_{t+1} is a $K \times 1$ vector of factors driving the yields, $A = [A^{(1)}, A^{(2)}, ..., A^{(N)}]'$ is a $1 \times N$ vector of parameters such that $A^{(n)} = f(A^{(n+1)})$ for every superscript n, and $B = [B^{(1)}, B^{(2)}, ..., B^{(N)}]$ is a $N \times K$ matrix of parameters such that $B^{(n)} = g(B^{(n+1)})$ for every superscript n, $v_t, u_t \sim N(0, I)$ are multivariate normal shocks, $\mu, \rho, \overline{\mu}, \overline{\rho}, \Sigma$ matrices and vectors to be estimated. μ, ρ are the parameters under the subjective probability measure – $\mathbb{P}$ – and $\overline{\mu}, \overline{\rho}$ are the parameters under the risk-neutral probability measures – $\mathbb{Q}$. An ATSM defines the risk-neutral yields y of (1) as linear functions of factors whose loadings, A, B, depend on $\overline{\mu}, \overline{\rho}, \Sigma, A^{(1)}, B^{(1)}$, and the yields under the subjective measure whose loadings are functions of $\mu, \rho, \Sigma, A^{(1)}, B^{(1)}$. The two generating processes (2)-(3) for X, whose existence is guaranteed by the assumption of no-arbitrage, implicitly define a market price of risk as a linear function of the factors, i.e. $\lambda = \lambda_0 + \lambda_1 X_t$. For a review of the ATSM see Piazzesi (2015). The ATSM model can be estimated with least square regression, when the factors X are known, or with maximum likelihood, when the factors X are latent and the system (1)-(2) is treated as a state-space model.

The subjective expected component of yields y is obtained by projecting the second equation τ periods ahead, i.e.:

$$E_t^{\mathbb{P}}(X_{t+\tau}) = \mu(I + \rho + \cdots + (\rho)^{\tau-1}) + (\rho)^{\tau} X_t \quad .$$

Plugging this into the first equation, the risk-neutral projection for the n-period yield becomes (analogously for projections at longer horizon):

$$E_t^{\mathbb{P}}(y_{t+\tau}^{(n)}) = A^{(n)} + B^{(n)}\mu(I + \rho + \cdots + (\rho)^{\tau-1}) + B^{(n)}(\rho)^{\tau} X_t \quad .$$

The n-period yield expected in τ periods is equal to the sum of 1-period expected yields over τ periods:

$$E_t^{\mathbb{P}}(y_{t+\tau}^{(n)}) = \sum_{j=1}^{\tau} E_t^{\mathbb{P}}(y_{t+j}^{(1)}) \ .$$

The n-period risk premium is the difference between the current yield and the expected component, i.e.

$$RP_t^{(n)} = y_t^{(n)} - E_t^{\mathbb{P}}(y_{t+\tau}^{(n)}) \ .$$

The generic ATSM described above may be adapted for the purpose of estimating market inflation expectations and the risk premium in two different ways, which rely on the two different breakeven inflation measures described in the previous Section. The standard model encompasses in a single specification both the nominal yields, y^N, and the index-linked yields,

y^R, i.e. equation (1) is substituted by (4):

$$\begin{aligned} \begin{bmatrix} y^N \\ y^R \end{bmatrix}_t &= \begin{bmatrix} A^N \\ A^R \end{bmatrix} + \begin{bmatrix} B^N & B^{NR} \\ B^{RN} & B^R \end{bmatrix} X_t \quad , & (4) \\ X_{t+1} &= \overline{\mu} + \overline{\rho} X_t + \Sigma v_t \quad , & (5) \\ X_{t+1} &= \mu + \rho X_t + \Sigma u_t \quad . & (6) \end{aligned}$$

The standard model (4)-(6) can also be refined by anchoring the model-implied expected inflation to survey-based expected inflation and introducing a liquidity factor for real interest rates. Thus, the parameters of the model are constrained such that the implied five-year ahead one-year subjective expected inflation is equal to the corresponding expected inflation based on the ECB Survey of Professional Forecasters (SPF), $E_t^{\mathbb{P}_{\mathbb{S}}}(\pi_{t+5}^{(1)})$, defined by the analysts' probability measure $\mathbb{P}_{\mathbb{S}}$, plus a measurement error.[2] Moreover, observed real interest rates, $\widehat{y}_t^R$, are corrected with a time-varying liquidity premium, LP_t.

$$\begin{aligned} \begin{bmatrix} y^N \\ y^R \end{bmatrix}_t &= \begin{bmatrix} A^N \\ A^R \end{bmatrix} + \begin{bmatrix} B^N & B^{NR} \\ B^{RN} & B^R \end{bmatrix} X_t \quad , & (7) \\ X_{t+1} &= \overline{\mu} + \overline{\rho} X_t + \Sigma v_t \quad , & (8) \\ X_{t+1} &= \mu + \rho X_t + \Sigma u_t \quad , & (9) \\ E_t^{\mathbb{P}_{\mathbb{S}}}(\pi_{t+5}^{(1)}) &= E_t^{\mathbb{P}}(y_{t+5}^{N,(1)}) - E_t^{\mathbb{P}}(y_{t+5}^{R,(1)}) + v_t \quad , & (10) \\ y_t^R &= \widehat{y}_t^R + LP_t \quad . & (11) \end{aligned}$$

Model (7)-(11) below is referred to as the "liquidity and survey-based expected inflation adjusted model", in what follows standard ATSM. Expected inflation is obtained by projecting equation (4) or (7) forward and taking the difference between projected nominal and real interest rates; the inflation risk premium is then obtained by taking the difference between current inflation and expected inflation.

If only inflation swaps are used, i.e. $y = IS$, equation (1) is substituted by (12):

$$\begin{aligned} IS_t &= A + BX_t \quad , & (12) \\ X_{t+1} &= \overline{\mu} + \overline{\rho} X_t + \Sigma v_t \quad , & (13) \\ X_{t+1} &= \mu + \rho X_t + \Sigma u_t \quad . & (14) \end{aligned}$$

[2]The constraint imposes that the five-year ahead one-year nominal interest rate minus the five-year ahead one-year real interest rate is equal to the survey-based expected inflation plus an error term.

Model (12)-(14) is referred to as the IS model. Expected inflation is obtained by projecting equation (12) forward; the inflation risk premium is obtained by taking the difference between current inflation and expected inflation.

The advantage of simultaneously using the yields on both nominal and index-linked bonds (as in the standard ATSM) is that, in this approach, nominal and real returns are not constrained to be determined by the same factors in exactly the same way, as they implicitly are, instead, in the IS model. Also, the standard ATSM provides an anchor for both nominal and real interest rates; on the contrary, when expected inflation is directly estimated from the term structure of inflation swaps, the underlying implied nominal and real interest rates are not modelled and may in principle assume any value in the long run.

It is worth emphasizing that even within linked institutions, similar models are used that provide different results; for example, the New York Fed uses the Abrahams et al. (2016) model, which provides almost constant expected inflation, while the Cleveland Fed uses the Haubrich et al. (2012) model, which provides an almost constant inflation risk premium.[3] Also at the ECB different models have been developed, for example those by García and Werner (2010) and by Camba-Méndez and Werner (2017).

4 Empirical results

In general, the results of the breakdown of inflation compensation into its components differ considerably between models. For example, in Haubrich et al. (2012), Joyce et al. (2010), Kaminska et al. (2018) and Pericoli (2012) the inflation risk premium is stable or does not vary too much and most of the variation in current inflation is explained by expected inflation. Conversely, in Abrahams et al. (2016), Camba-Méndez and Werner (2017), Christensen et al. (2010), D'Amico et al. (2018) and Hördahl and Tristani (2014) inflation risk premiums vary and explain most of the changes in current inflation while expected inflation remains almost constant. For the US, Kupfer (2018) shows that estimates of the inflation risk premium are very different depending on the used model.

This Section presents the breakdown of inflation compensation and of the five year five-year forward (5y5y) inflation compensation from January 2012 to August 2019[4] for the stan-

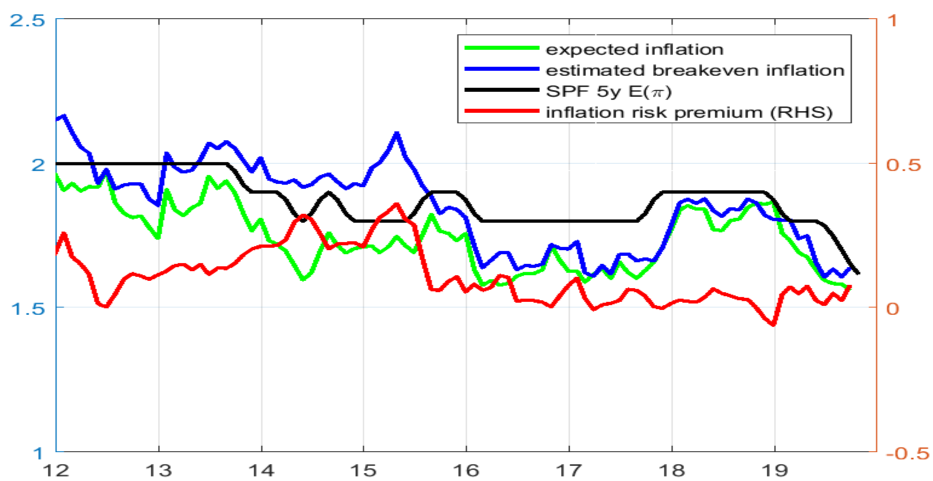
[3]For the New York Fed the reference is the staff report `https://www.newyorkfed.org/research/staff_reports/sr570.html` while for the Cleveland Fed the inflation decomposition is updated regularly at `https://www.clevelandfed.org/our-research/indicators-and-data/inflation-expectations.aspx`.

[4]End-of-month nominal euro-area zero coupon interest rates are from the ECB; end-of-month real euro-area zero coupon interest rates are computed with French and German government index-linked bonds indexed to the euro-area ex-tobacco HICP, HIPCxT, as in Pericoli (2014). End-of-month inflation swaps are from

dard ATSM (7)-(11) and the IS model (12)-(3). The 5y5y inflation is chosen because it is a measure of long-term inflation that, in principle, should be relatively unaffected by transient shocks and hence it may be interpreted as a measure of the credibility of monetary policy. As expected, the results depends on the used model. Based on the state space representation in (7)-(11), the standard ATSM factors are filtered according to the Kalman filter and the parameters are estimated by maximum likelihood. The IS model is estimated using the Joyce et al. (2010) and the Adrian et al. (2013) approaches, whose results are similar; in what follows estimates obtained with the Adrian et al. (2013) methodology are shown.

According to the standard ATSM, expected inflation declines between 2012 and 2015, hovers around 1.5% in 2016-2017, rises slightly in 2018 (to 1.7%), falls again starting at the end of last year (Figure 2).

Figure 2: standard ATSM model



Notes: Breakdown of the 5y5y inflation with the standard ATSM model with liquidity correction and survey-based expected inflation, model (7)-(11). Computation of Banca d'Italia on ECB and Refinitiv Datastream data. The blue line is the 5y5y cash breakeven inflation rate computed with nominal and inflation-linked bonds. The green line is expected inflation, the red line is the inflation risk premium. The dashed black line is the median expected 4 year forward 1-year inflation surveyed by SPF.

The estimates obtained with the IS model, where only inflation swaps are used in the estimation, are shown in Figure 3): the 5y5y expected inflation is very stable throughout the whole sample, slightly below 1.7%; conversely, the 5y5y inflation term premium entirely explains the variation in inflation compensation. These features appear questionable. In particular, the stability of inflation expectations estimated with the IS model contrasts with

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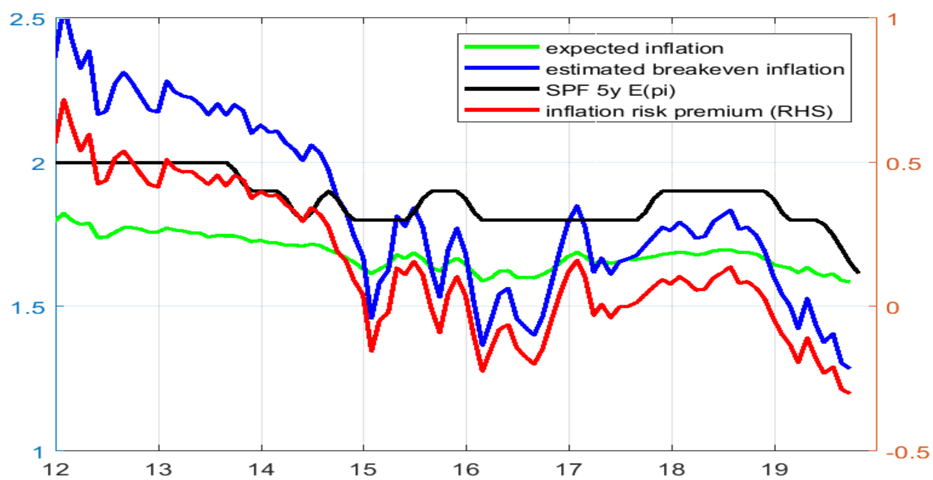
the decline in survey-based expected inflation, which is particularly pronounced starting in late 2018; furthermore, the IS model delivers an estimate of expected inflation that is basically unresponsive to macroeconomic developments and monetary policy measures. Kaminska et al. (2018) show that, using inflation surveys in an IS-type model, expected inflation is more volatile and absorb part of the changes in breakeven inflation.

Figure 3: IS-type model



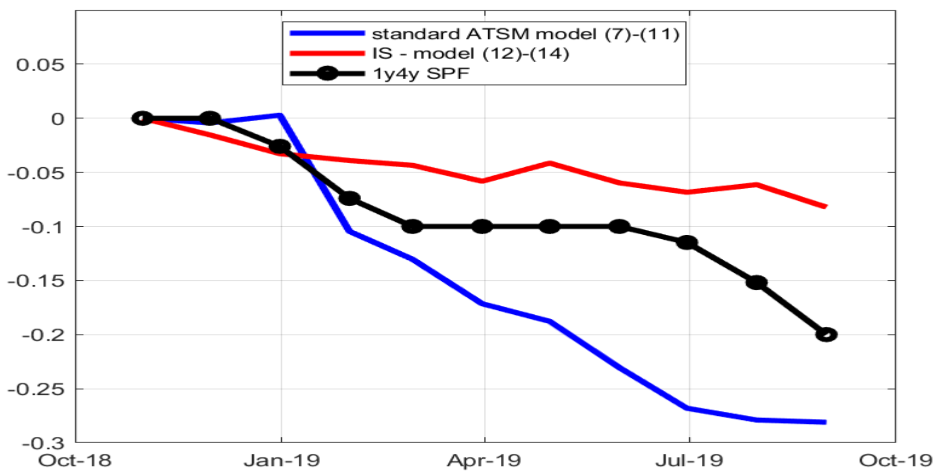
Notes: Breakdown of the 5y5y inflation with the IS-type model, model (12)-(14). Computation of Banca d'Italia on ECB and Refinitiv Datastream data. The blue line is the 5y5y cash breakeven inflation rate computed with nominal and inflation-linked bonds. The green line is expected inflation, the red line is the inflation risk premium. The dashed black line is the median expected 4 year forward 1-year inflation surveyed by SPF.

4.1 Recent developments in market-based inflation expectations

The level of inflation expectations derived with either the standard ATSM or the IS model is strongly affected by the estimation period. This is not the case for changes in inflation expectations, whose estimates are less sensitive to the specific choice of the sample period. For this reason, this Section focuses on the dynamics of inflation expectations in the course of 2019 (Figure 4 and Table 1), which also corresponds to the period in which SPF-based long-term expected inflation measures show a steady tendency to declined sharply, to historically low levels.

According to the standard ATSM, inflation expectation dropped by 18 basis points between January and August 2019; this is close to the decline in the SPF measure (13 basis

Figure 4: Cumulative change in expected inflation



Notes: Cumulative change in 5y5y expected inflation from October 2018; percentage points. Computation of Banca d'Italia on ECB and Refinitiv Datastream data. The blue line is the 5y5y expected inflation from the standard ATSM, the red line is the the 5y5y expected inflation from the CMW-type model, the black line is the 1y4y expected inflation from SPF.

points). The IS model seems to deliver a much more reassuring pictures: the estimated fall in expected inflation amounts to only 4 basis points, while the inflation risk premium virtually accounts for the entire fall in inflation compensation. However, even if this was indeed the case, recent developments should be a source of concern: the fall of the inflation risk premium deep into negative territory signals that agents are assigning a high probability to a scenario of very low inflation, or possibly even deflation.

5 Conclusions

This paper presents estimates of expected inflation and the inflation risk premium in the euro area inferred from asset prices. A model is developed that exploits both nominal and real bond yields, corrects for market liquidity and makes use of survey-based measures of inflation expectations. The estimates of long-term inflation expectations provided by this model are compared with those estimated using inflation swap yields. In principle, making joint use of nominal and real bond yields, as is done in the former approach, seems preferable as this allows exploiting a richer information set and does not impose the implicit assumption that the nominal and real term structure of interest rates is driven by different factors, as is

Table 1: Change in expected inflation and inflation risk premium

	expected inflation		inflation risk premium	
	standard ATSM (7)-(11)	IS (12)-(14)	standard ATSM (7)-(11)	IS (12)-(14)
Jan-14 - Aug-19	-15	-12	-19	-69
Jan-19 - Aug-19	-18	-4	-2	-19

Notes: The Table reports the cumulative change in basis points in 5y5y expected inflation and inflation risk premium between January 2014 and August 2019 and between January 2019 and August 2019.

instead the case with the latter approach.

The empirical results for the two models differ markedly. When both nominal and real bond yields are used, both the risk premium and expected inflation vary over time, with a sharp drop in the latter variable since late 2019. By contrast, when inflation swap yields are used, expected inflation barely moves over the whole sample period, including 2019, and is even more stable that the (sluggishly moving) survey-based measures; conversely, changes in inflation compensation are almost exclusively accounted for by changes in the inflation risk premium.

The findings suggest that it is important to combine both market-based and survey-based measures and to correct for specific market features, such as time-varying liquidity premia. They also signal that if the model that exploits a richer set of information is used, long-term inflation expectations in the euro area have significantly decreased over the last year, signaling possible risks of de-anchoring of inflation expectations.

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A Appendix – markets for inflation-related assets

The market for transferring inflation risk is mainly made of index-linked bonds – issued by sovereign entities, government agencies and corporations – inflation swaps and inflation derivatives, typically caps and floors on year-on-year inflation. The broader inflation-related market provides instruments both for pricing inflation swaps and for hedging positions taken in the nominal and index-linked market. Since this market offers hedging against the inflation risk, one may wonder why these products are still traded when inflation is low, stable or on a decreasing trend. In fact, this market remains useful also in the current scenario for those investors who want to hedge the risk of their nominal assets/liabilities.

Since these products have the same underlying instrument, they must be linked by arbitrage relationships that prevent the appearance of differences in the measurement of inflation. Without friction, the two measures of breakeven inflation (that obtained from bonds, i.e. cash, and that obtained from inflation swap, i.e. synthetic) should be identical since, otherwise, the arbitrageurs could intervene, make profits and cancel any differences. In practice, several factors can put a wedge between cash and breakeven inflation such as an excess demand for inflation protection, different liquidity, changing regulation and market segmentation.

First, as Figure 1 shows, the synthetic inflation, as measured by inflation swaps, is consistently above the cash breakeven measure. Among the culprits, the supply-demand imbalance in the inflation swap market plays an important role: since there is an excess demand to receive inflation – i.e. to purchase inflation protection – and no natural regular payer of inflation – i.e. supplier of inflation protection – other than the government via index-linked bonds, investors must pay a higher fixed rate versus receiving inflation. Thus, given this technical imbalance, inflation swaps will give a higher breakeven measure than the other measure derived from index-linked bonds. Differences may persist if there is no arbitrage capital to exploit mispricing in one of the two markets, as in the episodes following the financial crises of 2008 and 2011. Second, we may have different liquidity between the nominal bond market, the index-linked bond market and the inflation swaps market; these differences can put a wedge between the two breakeven measures. According to market intelligence, in the euro area the inflation swap market is liquid, both in absolute terms and relative to the index-linked government bond market. On the contrary, in the US and in the UK the inflation swap market is less liquid than the index-linked government bond market.

A.1 Index-linked bonds

The earliest recorded index-linked bond was issued by the Commonwealth of Massachusetts in 1780 during the American Revolutionary War. Much later, emerging market countries began issuing index-linked bonds in the 1960s. In the 1980s, the UK was the first major developed market to introduce "linkers" on the market. Numerous other countries followed, including Australia, Canada, Mexico and Sweden. In January 1997, the US began issuing Treasury Inflation-Protected Securities (TIPS), now the largest component of the global index-linked bonds market. In the euro area, the French government started issuing in 1998 with the OATi indexed to the French CPI and continued in 2001 with the OAT€i indexed to the euro-area Harmonized Index of Consumer Prices ex-Tobacco, HIPCxT. More recently, index-linked bonds were also issued by the German government (linked to the euro-area HIPCxT in 2006, Bund€i) and by the Italian government (linked to the euro-area HIPCxT in 2003, BTP€i, and to the Italian CPI inflation in 2012, BTPi). In the euro area, also Greece, in 2003, Spain, in 2014, the Belgium, in 2015, and Ireland, in 2017, started issuing linkers indexed to the euro area HIPCxT.

On the supply side of the inflation market, index-linked bonds are typically sold by governments in an effort to reduce borrowing costs and broaden their investor base; corporations occasionally issue inflation-linked bonds for the same reasons, but the total amount is relatively small. On the supply side, in addition to sovereigns and companies, which issue to reduce financing costs, are also utilities and infrastructure companies, whose goal is to hedge inflation-linked revenues. These firms, which by statute raise their prices by an amount closely linked to inflation, are keen to match the structure of their liabilities with that of their revenues. To do so, instead of issuing directly index-linked bonds, they may instead issue nominal fixed-rate debt (more liquid and easier to sell than index-linked bonds) and enter into an inflation swap where they pay inflation and receive the fixed rate.

On the demand side of the inflation market, the traditional players include long-term liability managers as pension schemes and insurance companies, seeking to hedge liabilities stemming from inflation-adjusted payouts. Typically, these investors hold index-linked bonds until maturity and this substantially reduces the float available on the market. On the demand side, anecdotal evidence suggests that the market on inflation-related products has shrunk over the past five years. Contacts with market sources, mainly Italian and international large banks, indeed suggest that the demand for inflation protection from these players has fallen dramatically since 2016, in line with the reduction in the expected inflation rate. By contrast, the same sources suggest that hedge funds and large international banks continue to be actively engaged in the supply of inflation swap market with most of the trading occurring at the medium and long-term horizon (over 5 years).

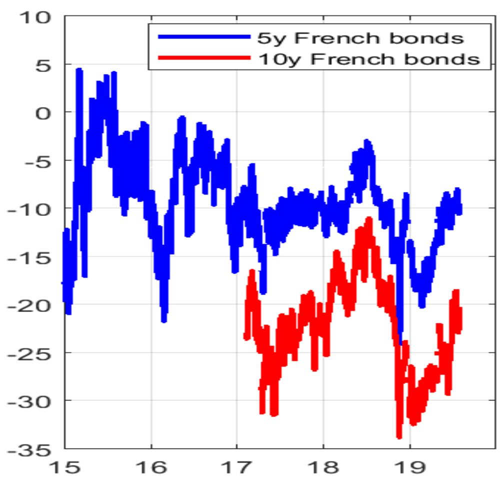
The literature corrects standard ATSMs for a liquidity factor of index-linked bond yields because these are characterized not only by lower traded volumes but also by some market segmentation, especially when compared to the corresponding nominal bonds. Here, I present some evidence on the liquidity of the euro-area index-linked bond yields; the next section presents an analysis of the liquidity of euro inflation swaps, recently questioned by Speck (2019). This evidence suggests that there is a liquidity premium between the nominal and index-linked market and motivates the use of a liquidity factor in the ATSM. On the other side, the inflation swaps market suffers from similar problems. In general the different liquidity between the two markets is due to the particular nature of nominal bonds in today's financial markets.

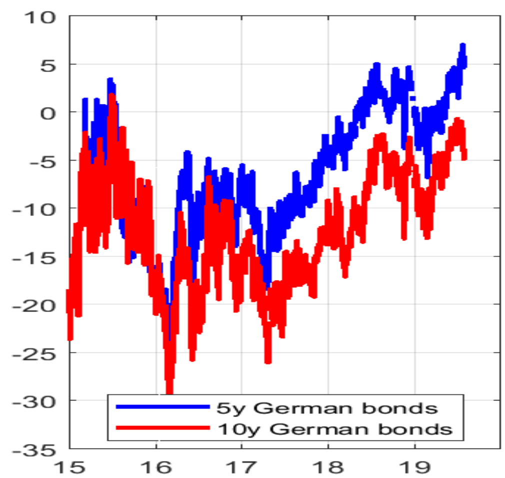
By assuming that nominal euro-area government bonds are extremely liquid, we compare the Asset-Swap Spread (ASW) of nominal and index-linked government bonds to measure the liquidity premium of the latter.[5] An ASW is a synthetic asset that pays the fixed spread

[5]Most market participants supplying inflation protection in the euro area inflation swap market are levered investors such as hedge funds and banks proprietary trading desks. These investors typically hedge their inflation swap positions by simultaneously taking long positions in index-linked bonds and short positions in nominal bonds in the asset swap market. A buying position in an asset swap is functionally similar to a levered position in a bond. In an asset swap, one party pays the cash flows on a specific bond, and receives in exchange LIBOR plus a spread known as the asset swap spread. Typically, this spread is negative and its absolute magnitude is larger for nominal bonds than for index-linked. Thus, a levered investor paying inflation, i.e. selling inflation protection, in an inflation swap faces a positive financing cost derived from his

plus the LIBOR and replicates the cash flow of the government bond; the ASW is a measure of credit risk and is negative for a risk-free asset (i.e. Treasuries, OAT and Bunds) since the credit rating of the bond issuer is higher than that of the counterparty – Appendix **??** presents the explanation for a negative government bond asset swap spread. We claim that the differential between the ASWs on a nominal bond and an index-linked bond is due to the lower liquidity of the latter. Since 2017, the relative difference in the ASW between nominal and real bonds has fluctuated at around $10 - 30$ basis points for French bonds (Figure 5, left panel), while it was in a narrower range for the German bunds ($0 - 20$ basis points, Figure 5, right panel).

Figure 5: Liquidity measures





Notes: Source is JP Morgan. Daily data, basis points. A negative differential indicates a liquidity premium requested for index-linked vs nominal bonds. For French assets I consider the par-ASW on OAT 0.250 25-lug-2024 , OAT€i 1.750 25-Nov-2024, OAT 0.100 01-Mar-2028, OAT€i 2.750 25-Oct-2027; for German assets the par-ASW for Bund 0.100 15-Apr-2026, Bund€i 1.500 15-May-2024, Bund 0.500 15-Apr-2030 and Bund€i 4.750 04-Jul-2028.

A.2 Inflation swaps

The euro-area inflation swaps market is relatively new respect to the index-linked bond market, having developed since the early 2000s. In general, the market is characterized by low trade frequency concentrated in the 5- and 10-year tenors, with large and fairly standardized trades, and small or nil bid-ask spreads.

long-short index-linked/nominal bond position.

Recent information on the inflation swaps comes from a recent report by the Global Association of Clearing Counterparties (CCP12 Report, 2019); clearing counterparties are playing increasing role intermediating most of the inflation swap trading as a result of regulatory changes occurred in recent years. During 2015 and early 2016, the clearing rate of inflation swaps was just 10%; this rate jumped to 75% in September 2016, when Uncleared Margin Rules (UMR) were implemented in Europe.[6] The clearing rate is now at 83%. Importantly for the market, volumes have also grown since the move to clearing (Figure 6).

According to market intelligence collected in the summer 2019, the inflation swaps market is liquid, with institutional investors (insurance companies and pension funds, ICPFs) actively engaged in it for the purpose of optimally managing their portfolios, along with hedge funds. Against this increasing demand from institutional investors, in the last two years the demand of inflation protection to hedge against the risk of inflation from investors has fallen, with most operators reporting lack of confidence that the ECB will achieve its inflation aim in the medium term. All in all, these two contrasting factors support the practice of using inflation swaps for structured products in asset-liability management in particular segments of the market (notably the 5 and 10 year tenor).

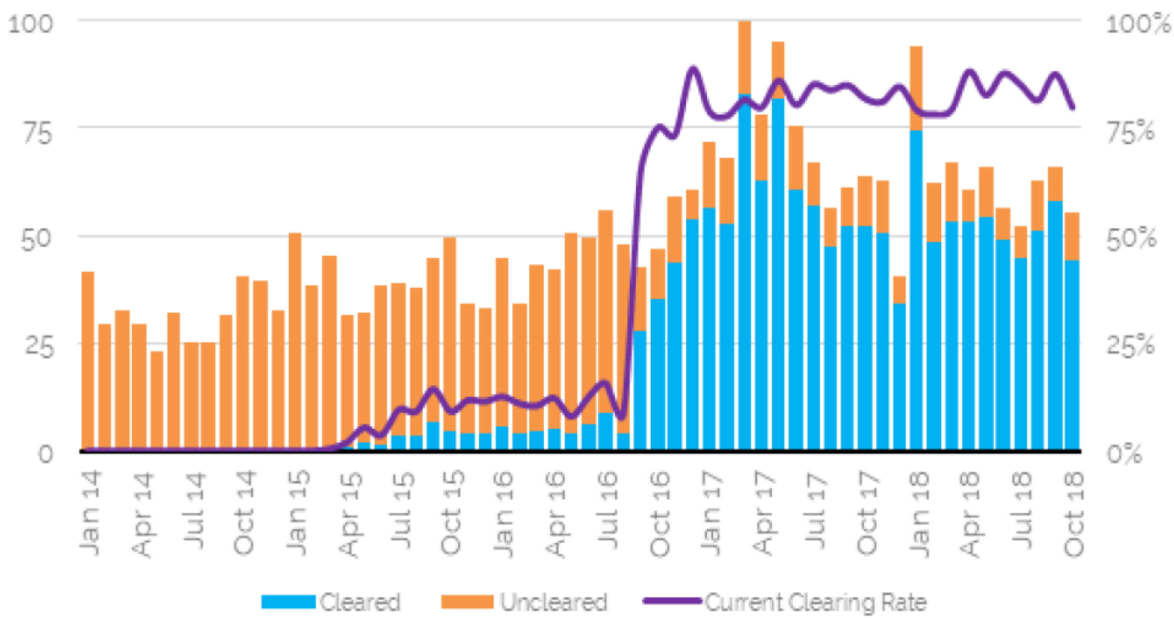
Domanski et al. (2017) document that German and Austrian ICPFs seek to limit their maturity mismatches arising from falling nominal rates, and show a demand for nominal long-term government bonds increasing in their price. Therefore, the decline in inflation swaps observed since October 2018 may be driven by the decline in nominal bond yields, due to the portfolio rebalancing of German and Austrian ICPFs.[7] Accordingly, some analysts have observed that the close movement of 5y5y inflation swaps with the 10y German Bund yield can be largely explained by the greater liquidity of Bunds with respect to inflation swaps. This evidence points to the conclusion that inflation swaps can be a biased indicator of breakeven inflation for "technical reasons".

However, we should also note that in the euro area other ICPFs, especially those in France and the Netherlands, have large exposures in inflation-linked liabilities as well, so the downward pressure should also apply for index-linked bonds (OECD, 2018, 2019).

[6] One of the key reforms implemented for non-cleared markets has been to require sounder risk management practices similar to cleared derivatives markets, i.e. Uncleared Margin Rules (UMR), imposing daily exchange of Variation Margin (VM) and/or Initial Margin (IM).

[7] Austrian and German ICPFs have nominal long term liabilities and a negative duration gap close to 5; therefore, a 1 percentage point decrease in interest rates lead to an increase in the purchase of nominal bonds of 5% leading to a positive relationship between demand nominal bonds and their price.

Figure 6: Inflation trading



*Notes:*Inflation swaps in USD, GBP, EUR and JPY. Notionals are expressed in billions of USD equivalent amounts. Source: Global Association of Clearing Counterparties.

A.3 Inflation options

The euro-area inflation option is also young respect to the index-linked bond market. Inflation options (i.e., caps and floors) provide protection if the euro-area HIPCxT moves above or below (cap and floor options, respectively) a given threshold (i.e., the strike inflation rate). As in the case of inflation swaps, they are traded over the counter, without a central clearing counterparty that could reduce the collateral credit risk. The market for inflation options is more developed for the euro area than for other currency areas, in line with the development of inflation swaps that are used as the underlying asset. Market contributors provide information on cap and floor options for both zero-coupon (single option with different maturities), and year-on-year options (portfolio of zero-coupon caps – caplets – and floors – floorlets – with periodical maturities as in a coupon bond, which can be considered a portfolio of strips). Inflation options with different strike rates give additional information about the uncertainty/risk surrounding the mean rate, potentially producing a full density distribution.