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Inflation-linked Bonds: An Introduction

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Abstract

This paper gives an overview of inflation-linked bonds (ILBs). In the first part, it describes the characteristics of inflation-linked bonds and their pricing mechanics. This is followed by an illustrative example which compares the cashflow structure of the two types of fixed income securities. An analysis of the historical performance of inflation-linked bonds relative to their nominal counterparts[1] follows on the basis of the Bloomberg Barclays total return indices for the US and Germany. Correlations between ILBs and fixed coupon bonds were computed.

Keywords: inflation linked bonds, real cashflows, US, Euroarea, Germany, France, Breakeven inflation rate
JEL: D53, E44, G1

[1] For the purpose of this analysis we considered the sovereign asset class given that it is the largest and one of most liquid bond markets.

Contents

1. Definition

Inflation-linked bonds (ILBs) or linkers are fixed income securities whose principal and coupons are linked to inflation[2] through a price index (Krämer, 2017). They are designed to eliminate the risk of unexpected inflation or to hedge against long-run inflation risk to the holders of the bonds. Most of the bonds are issued with the floor clause so that in the event of deflation this will prevent the capital at maturity from being below the original investment[3].

A factor affecting nominal bond prices is expected future inflation. As inflation expectations increase, yields tend to increase and prices fall, maintaining other factors constant. Inflation-linked bonds, on the other hand, provide protection against unexpected inflation as their coupon and principal value adjust based on changes in the underlying price index. Thus, inflation-linked bonds are usually used to protect against a decline in purchasing power and are a means of portfolio diversification (Krämer, 2017).

Among the developed countries, the UK was the first country to supplement its government bond issue programme with ILBs in 1981. This was followed by Australia (1985), Canada (1991), Sweden (1994), the US (1997), France (1998), Italy (2003), Japan (2004) (in spite of a deflationary environment), Germany (2006) and Spain (2014) (Wrase, 1997). For the purpose of our analysis we will focus on the US, German and French ILB markets.

In the US, Treasury Inflation Protected Securities (TIPS) are referenced to the Consumer Price Index for All Urban Consumers (i.e. CPI-U). This is a measure of the average change over time in the prices paid by urban consumers for a market basket of consumer goods and services as published by the Bureau of Labour Statistics. In the Euroarea, most sovereign ILBs are indexed against the Harmonized Index of Consumer Prices (HICP) [4] excluding tobacco published every month by Eurostat.

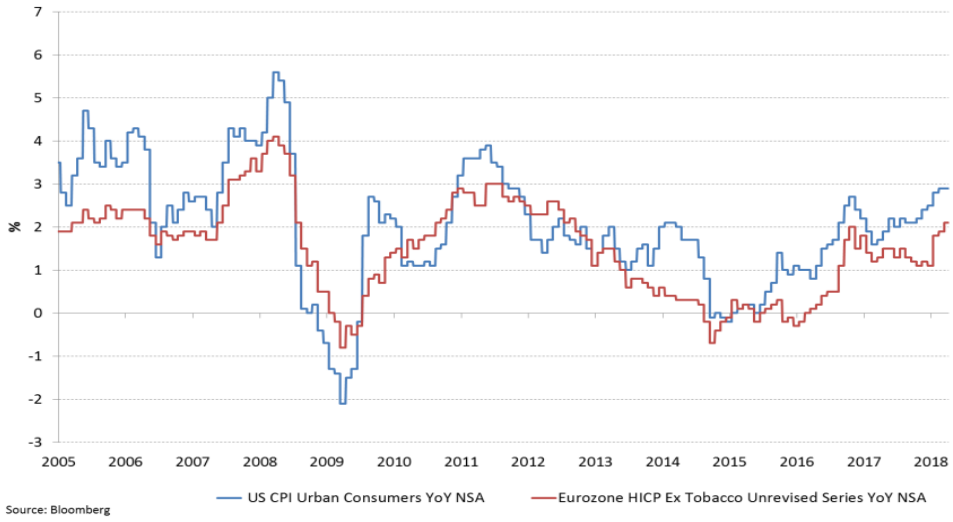

Figure 1: Actual inflation figures for the US and Eurozone.

[2] Inflation is the rate at which the general price level for goods and services in a country is increasing, measured as an annual percentage change. The measure is an indication of the loss in purchasing power. Conversely, a decrease in the general price level would result in deflation. It is measured by using an index of prices of goods and services in a weighted basket of goods.

[3] Many ILB issuing countries, such as the US, Australia, France and Germany offer deflation floors at maturity. Coupon payments are not protected against deflation (Pimco, 2016).

[4] The scope of the HICP includes the prices of all goods and services included in household final monetary consumption expenditure and those by incoming tourists. Non-consumption expenditure such as financial transactions, transfers and purchases of financial assets, is excluded (Eurostat).

1.1 Breakeven Inflation Rate

The breakeven inflation (BEI) rate is derived from the Fisher equation which states that BEI is the difference between the nominal and real yield.

Fisher Equation $(1 + n) = (1 + r)(1 + f)(1 + p)$

$$\pi = f + p = \text{Breakeven inflation} \quad [i]$$

$$n = r + \pi \quad [ii]$$

Where:

n = nominal yield
r = real yield
f = expected inflation
p = risk premium

The Fisher equation states that investors require nominal yields which include a spread above real yields to compensate them for expected inflation and risk premia. Hence, the BEI rate is the sum of the expected inflation and the risk premium. It is called the breakeven inflation rate because the investor would receive the same total return on an ILB as he would on a nominal fixed rate sovereign bond if inflation averages expected inflation over the lifetime of the bond (Schofield, 2015).

1.2 Main factors influencing real yields

1. **Short term interest rates –** as monetary policy becomes more hawkish, inflation is generally expected to decline and so real yields rise.
2. **Demographics –** as the ratio of dependants to workforce increases, savings fall, leading to a lower supply of available funds resulting in an upward pressure on real yields.
3. **Fiscal policy –** expansionary fiscal policy raises real yields, whilst a tighter fiscal policy tends to lower real yields.
4. **Net supply of linkers –** as demand for linkers relative to their supply increases their price rises causing real yields to decline (Schofield, 2015).

↑ BEI	**Scenario 1** Linker (+) > Nominal (+/-)	**Scenario 2** Linker (-) > Nominal (-/ -)
↓ BEI	**Scenario 3** Linker (+) < Nominal (+/+)	**Scenario 4** Linker (-) < Nominal (+/-)
	↓ Real Yield	↑ Real Yield

Table 1: Price sensitivity (ILBs vs Nominal bonds). Source: MAO

Table 1 above shows the relative performance of ILBs vs nominal bonds under different scenarios.

Scenario (1): BEI rises due to higher inflation expectations resulting in higher demand for ILBs (real yield declines)

In this case, we assume that inflation expectations increase whilst the risk premium remains constant resulting in higher BEI (as per eqn. i). The higher inflation expectations make ILBs more attractive, thereby increasing their demand and lowering the real yield. The nominal yield increases by the higher BEI and declines due to the fall in real yields (as per eqn. ii). If the increase in BEI overcompensates the fall in real yields, nominal yields increase resulting in an outperformance of ILBs over nominal bonds.

Scenario (2): BEI increases due to higher risk premium and the real yield rises

An increase in the risk premium (with no change in inflation expectations) raises the BEI and decreases the attractiveness of ILBs. The lower demand for ILBs results in a higher real yield. The nominal yield, however, increases by a larger amount as it is affected positively by both real yields and BEI (as per eqn. ii). As a result, nominal bonds underperform ILBs.

Scenario (3): BEI and real yields decline

Consider a scenario where inflation expectations increase but the risk premium falls by a larger amount resulting in an overall lower BEI (as per eqn. i). The lower BEI in a context of increasing inflation expectations make the ILBs more attractive resulting in a lower real yield. At the same time, nominal yields fall both due to the lower real yields as well as to the fall in BEI. Thus, whilst the prices of both ILBs and nominal bonds increase, the latter would outperform.

Scenario (4): BEI falls and real yields rise

A decline in inflation expectations decreases the BEI, assuming the risk premium remains constant. This makes ILBs less attractive, resulting in lower prices and higher real yields. The impact on nominal bonds depends on the relative changes in BEI and real yields as a lower BEI depresses nominal yields whilst higher real yields push nominal yields upwards. However, given the unattractiveness of ILBs in this scenario, nominal bonds tend to outperform.

2. Pricing Mechanics

All ILBs issued after 2005 are priced using the Canadian Model[5]. These securities use an index ratio to adjust the principal and coupon by actual inflation to maintain a constant real value. The mechanics of the Canadian style model are displayed in Table 2 below[6]. Whereas the real cash flow of a fixed rate bond decreases over the lifetime of the bond due to inflation, the real cash flow of an ILB remains constant as it is continuously adjusted for inflation. Hence, the real return of an ILB is predetermined at inception (Norges Bank Investment Management, 2012).

Example: A fixed rate bond and an ILB with the same coupon rate and principal in an expansionary macro-economic scenario.

		Fixed Rate Bond				Inflation Linked Bond			
Period	Inflation Rate	Price index at period end		Real Cash Flow		Price index at period end		Nominal Cash Flow	
				(Coupon/Index ratio)				(Coupon * Index ratio)	
0		100.00		-100		100.00		-100	
1	1.0%	101.00		5/ (1.01)		101.00		5*(101.00/100)	
2	2.0%	103.02		5/(1.0302)		103.02		5*(103.02/100)	
3	5.2%	108.38		5/(1.0838)		108.38		5*(108.38/100)	
4	4.0%	112.71		5/(1.1271)		112.71		5*(112.71/100)	
5	5.0%	118.35		105/(1.1835)		118.35		105*(118.35/100)	
Period	Inflation Rate	Nominal Cash Flow	Real Coupon	Nominal Coupon	Principal	Nominal Cash Flow	Real Coupon	Nominal Coupon	Principal
0									
1	1.0%	5.00	4.95	5.00	0	5.05	5.00	5.05	0
2	2.0%	5.00	4.85	5.00	0	5.15	5.00	5.15	0
3	5.2%	5.00	4.61	5.00	0	5.42	5.00	5.42	0
4	4.0%	5.00	4.44	5.00	0	5.64	5.00	5.64	0
5	5.0%	105.00	4.22	5.00	100.00	124.27	5.00	5.92	118.35
		125.00	23.08	25.00	100.00	145.52	25.00	27.17	118.35

Table 2: Cashflow structure of Fixed rate bond vs ILB.

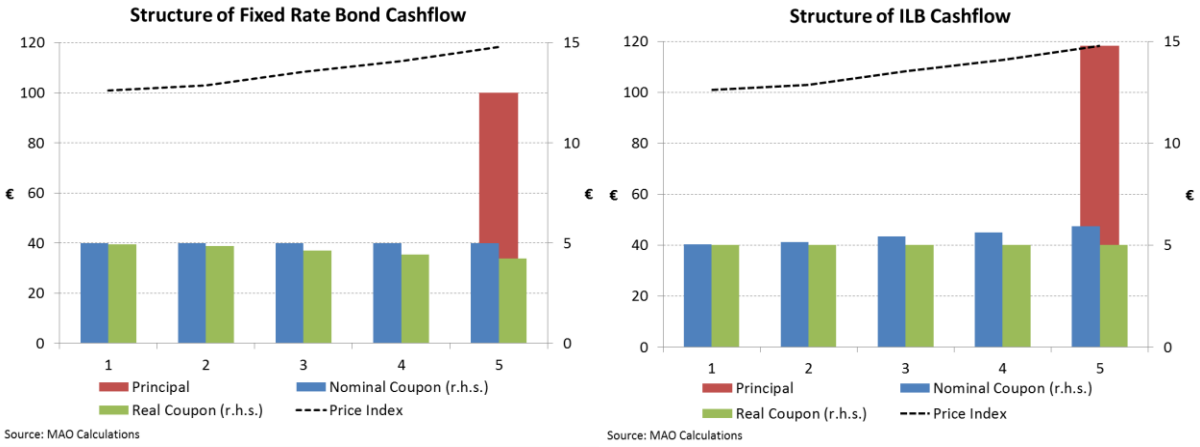

Figure 2: Indexation mechanics of the Canadian model. Source: MAO.

The example above illustrates a 5 year ILB and nominal bond, both issued with a real coupon of 5%. At issuance, the price index starts at 100 and is compounded annually by the inflation rate. Each year, the coupon and the principal of the ILB are adjusted by the price index to derive the nominal cash flows.

[5] The UK model was used prior to June 2005 but it was replaced by the Canadian model due to a more accurate calculation of the ILB's price as under the latter model the index ratio is updated daily. Additionally, under the UK model the cash flow calculations considered inflation with an 8 month lag whereas the Canadian model has a 3 month lag (Fixed Income Investor, 2010).

[6] Note that for simplicity, only inflation is being included in the above examples and other discount factors are not considered.

The main difference between the cashflow structure of ILBs and fixed rate bonds is that nominal cash flow payments of a fixed rate bonds will be constant throughout its lifetime whereas those of an ILB will increase in line with inflation, also resulting in a higher lump-sum payment at maturity.

In the case of a deflationary period the principal of an ILB would be protected by a floor clause that guarantees the par value upon maturity. However, this floor protection does not apply for the coupon payments (Norges Bank Investment Management, 2012).

2.1 ILBs for active portfolios

From a market perspective, if ILBs are not bought to be held-to-maturity, one needs to take into account other factors besides realised inflation relative to the BEI rate. One of these factors is the relative pricing at the end of the holding period. For example, even if inflation is higher than the breakeven rate over the next year, TIPS could underperform if nominal yields fell versus TIPS yields.

2.2 Sensitivity to interest rates

Similar to nominal bonds, if not held-to-maturity, prices of ILBs are subject to changes in real interest rates. However, whereas in the case of nominal bonds, the nominal interest rate is considered, ILBs are sensitive to changes in real interest rates. ILB prices will increase as real yields decline and fall as real yields rise. ILBs have a higher cashflow at maturity compared to nominal bonds resulting in a relatively higher duration. This makes them more sensitive to real interest rate changes but historically real interest rates tend to be less volatile than nominal interest rates. Hence, ILBs tend to be less volatile relative to their nominal counterparts. Thus, ILBs' duration is not a measure of risk for the purpose of comparing it with traditional bonds, but it is instead a measure of the risk of linkers alone (Krämer, 2017).

2.3 Pros & Cons of ILBs

Advantages

- **Optimal protection against unexpected inflation** – Best performance in times of declining growth rates and rising inflation.
- Historically ILBs have **a low correlation with stocks and traditional bonds.**
- Over the long-term ILBs have approximately the same returns as traditional bonds with lower volatility. Useful for **risk reduction** when used as part of a portfolio.
- Taking short-term positions, to express views on inflation.
- Offer **diversification** for long-term investors

Disadvantages

- ILBs market remains substantially **less liquid** than government bonds. Limited number of indexed bonds, so not all maturities are covered.
- Reference index may not accurately reflect the true cost of living and there is an index lag.
- Changes to the way the reference index is computed may put investors at a disadvantage.
- Do not protect against default risk
- Yields tend to be lower than yields on nominal bonds

3. Relative Performance of ILBs

Breakeven Inflation		
Nominal Bond T 15/02/2024	BEI = 2.01%	Inflation Linked bond TII 15/01/2024
Nominal Yield: 2.7623%		Real Yield: 0.7485%
Coupon: 2.75%		Coupon: 0.625%
BEI = Nominal Yield - Real Yield = 2.76% - 0.75% = 2.01%		
Realised inflation = 2.01% Fixed rate bond = Inflation linked bond		
Realised inflation > 2.01% Fixed rate bond < Inflation linked bond		
Realised inflation < 2.01% Fixed rate bond > Inflation linked bond		

Table 3: ILB performance vis-a-vis realised inflation.

In Table 3 above we obtain the BEI at the time of purchase, found by subtracting the yield of the ILB from a similar maturity nominal bond. The performance of the ILB relative to the nominal bond can be summarised by the following 3 scenarios when considering only changes in inflation.

- If realised inflation is equal to 2.01%, the performance of both bonds will be equivalent.
- If the realised inflation exceeds 2.01%, the ILB will outperform the fixed rate bond.
- If the realised inflation is lower than 2.01%, the fixed rate bond will outperform the ILB.

4. Historical Total Return

The historical performance of US TIPS against nominal Treasuries as shown in Figure 3 indicates that ILBs have outperformed their fixed rate counterparts in most periods. In fact, nominal Treasuries have outperformed TIPS in only two periods coinciding with instances of very low inflation and deflation as shown by the shaded area.

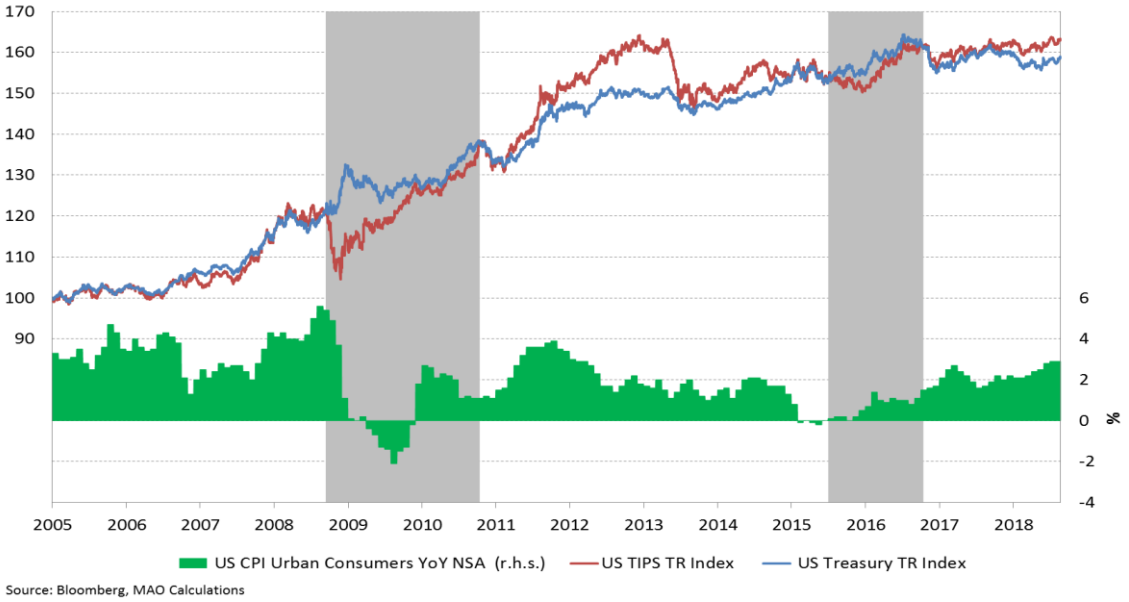

Figure 3: Bloomberg Barclays total return indices for US TIPS and US fixed rate Treasuries. Rebased 2005 = 100.

A similar picture is obtained for the European issuers. ILBs for Germany and France have consistently outperformed nominal sovereign bonds since mid-2017[7], as shown below. One must note that during the period under consideration, the Eurozone did not experience deflation, but registered an HICP of around and above 1%. Unfortunately, due to the lack of data coverage such conclusions cannot be extended to different periods of the economic cycle.

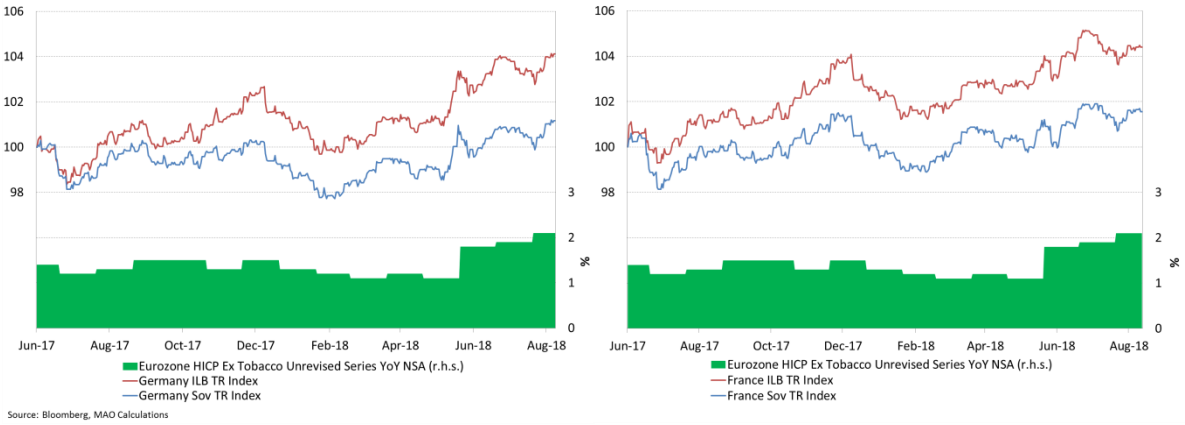

Figure 4: Bloomberg Barclays total return indices for German and French inflation-linked and nominal bonds. Rebased Jun-2017 = 100.

[7] No data is available for Bloomberg Barclays total return indices for Germany and France prior to 2017.

5. Correlation

As shown in Table 4 below, the correlations between sovereign ILBs and fixed rate bonds are significant[8]. One notable exception is Spain with a weaker correlation at 0.57[9].

EA ILB vs EA Nominal	**0.805**
German ILB vs German Nominal	**0.744**
Spanish ILB vs Spanish Nominal	**0.572**
French ILB vs French Nominal	**0.959**
Italian ILB vs Italian Nominal	**0.846**
US TIPS vs US Nominal	**0.822**

Table 4: Correlation between inflation-linked bonds and similar maturity fixed rate bonds.

By observing the correlation between individual bonds, one can note a lower (and sometimes negative) correlation between ILBs and fixed rate bonds with a lower maturity. Additionally, ILBs in the belly of the curve are even less correlated with fixed rate bonds with higher maturities (see DBRI 23, 36 and TII 22, 23, 24 in Tables 5 and 6 respectively).

		Germany Fixed Rate Bonds				
		DBR 20	*DBR 23*	*DBR 26*	*DBR 30*	*DBR 46*
Germany ILB	*DBRI 20*	0.93	0.85	0.45	0.79	0.55
	DBRI 23	-0.03	0.21	0.44	0.09	0.15
	DBRI 26	-0.07	0.26	0.60	0.18	0.33
	DBRI 30	0.31	0.62	0.86	0.62	0.77
	DBRI 46	0.24	0.54	0.80	0.58	0.79

Table 5: Correlation between German sovereign ILBs and Fixed rate bonds.

		UST Fixed Rate Bonds									
		UST 19	*UST 20*	*UST 21*	*UST 22*	*UST 23*	*UST 24*	*UST 25*	*UST 26*	*UST 27*	*UST 28*
US TIPS	*TII 19*	0.57	0.25	0.59	0.46	0.41	0.60	0.91	0.84	0.83	0.73
	TII 20	0.65	0.42	0.69	0.58	0.54	0.69	0.89	0.85	0.85	0.78
	TII 21	0.70	0.57	0.76	0.70	0.66	0.76	0.84	0.83	0.83	0.80
	TII 22	0.47	0.67	0.55	0.62	0.62	0.54	0.24	0.33	0.34	0.43
	TII 23	0.43	0.64	0.52	0.59	0.60	0.52	0.21	0.30	0.31	0.41
	TII 24	0.59	0.67	0.68	0.71	0.71	0.70	0.53	0.59	0.60	0.66
	TII 25	0.67	0.48	0.74	0.67	0.64	0.77	0.91	0.89	0.89	0.85
	TII 26	0.69	0.56	0.77	0.72	0.70	0.81	0.86	0.87	0.87	0.86
	TII 27	0.70	0.56	0.78	0.73	0.71	0.81	0.88	0.88	0.88	0.87
	TII 28	0.63	0.43	0.71	0.63	0.61	0.75	0.92	0.89	0.89	0.85

Table 6: Correlation between US TIPS and Fixed rate Treasuries.

[8] Data limitations impinge on the robustness of the values in Table 4.
[9] The low correlation figure for Spain is most likely due to the divergence between domestic inflation, which is priced in the nominal yields, and Euroarea inflation. Inflation of core European countries (like Germany) is closer to the Euroarea HICP.

5.1 Correlation between BEI and Inflation Expectations

The variation in the 2 year spread between nominal USTs and TIPS, or BEI, was mainly due to fluctuations in TIPS 2 year yields, as yields of fixed rate USTs followed a smoother path.

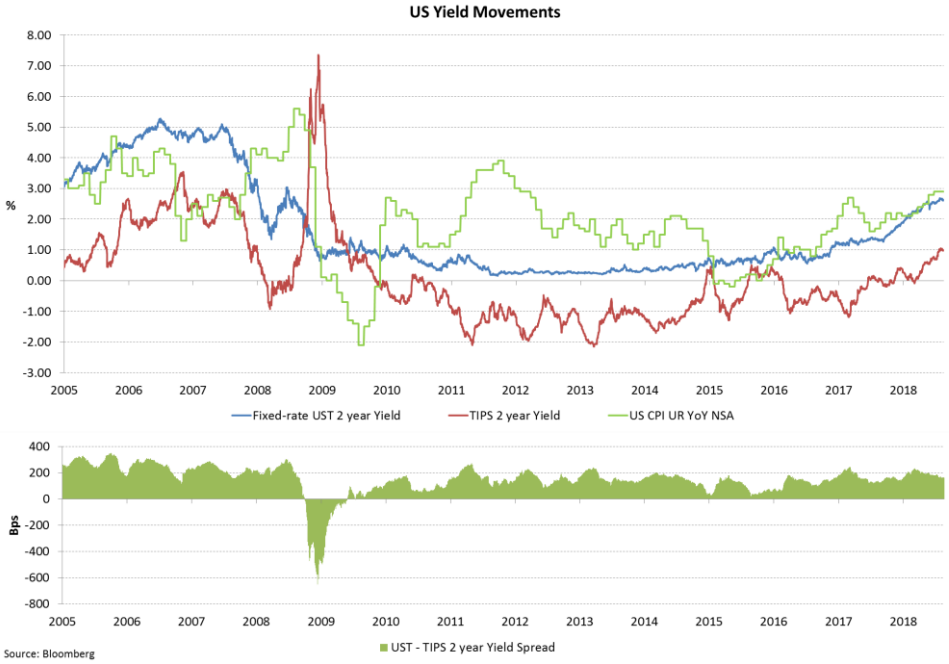

Figure 5: US fixed rate and inflation-linked bonds yields and realised inflation.

Considering the 2 year yield spread and comparing it with the monthly US CPI-U year-on-year (NSA) figures one can note a correlation between the two, with the yield spread preceding the movements in US Urban CPI by several months. For this reason, we also plot the US 2Y1Y forward rate as a proxy for inflation expectations[10]. The correlation between the 2 year spread and the US 2Y1Y forward rate is evident over the period under consideration.

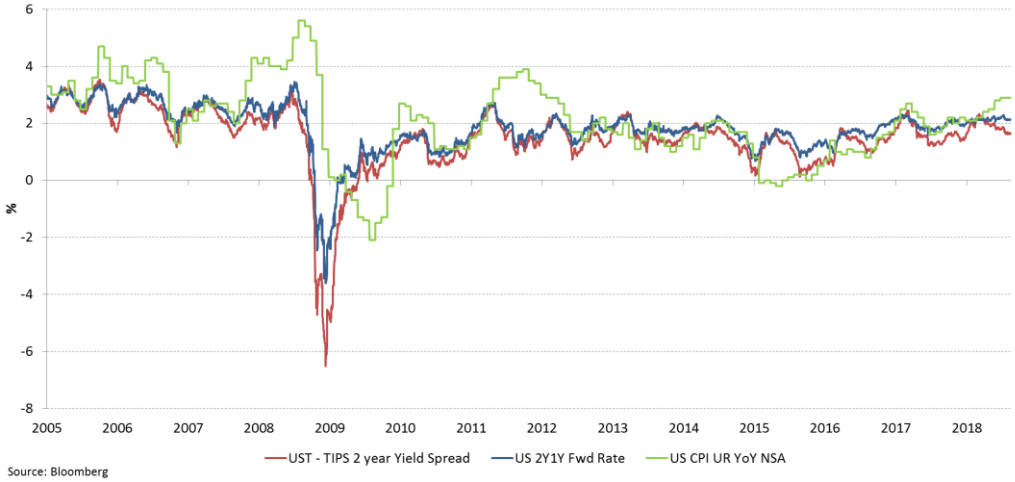

Figure 6: Correlation between the US 2 year BEI and the US 2Y1Y forward rate.

[10] The 2Y1Y forward rate is extracted from the zero coupon inflation swap rates and measures the average expected inflation over one year starting from the following two years.

For Germany, we consider the 5 year segment due to lack of data for the other tenors. In this case, changes in BEI were also driven by changes in yields of fixed rate bonds[11]. In most cases however, yields on for ILBs and fixed rate bonds followed the same trend.

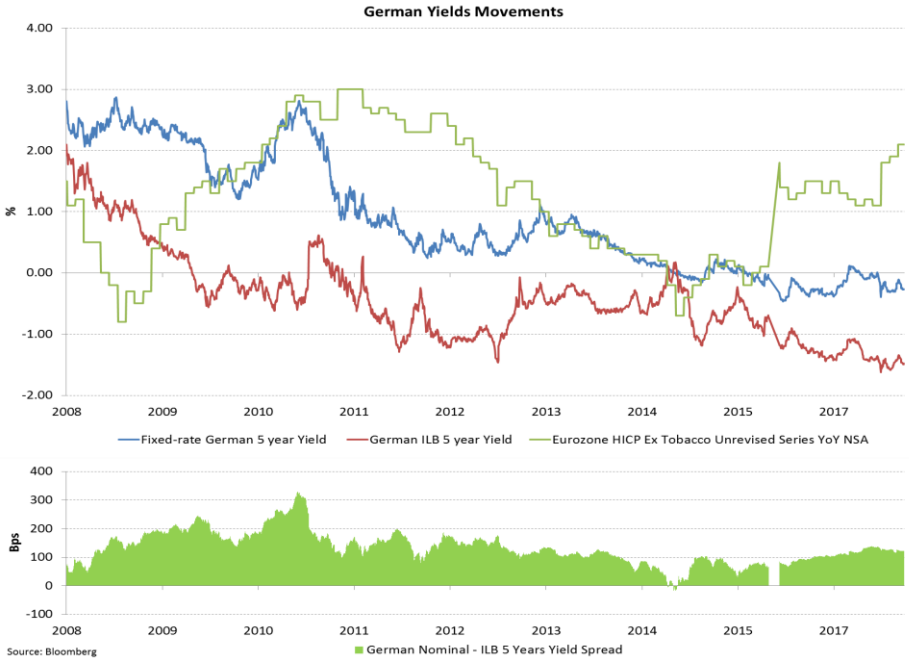

Figure 7: German fixed rate and inflation-linked bond yields and realised inflation.

The correlation between German BEI and inflation expectations is weaker than that for the US counterparts. However, in most instances both follow the same direction.

Figure 8: Correlation between the German 5 year BEI and EA 5Y1Y forward rate.

5.2 Price Volatility

Historically, prices of European ILBs tended to be less volatile than those of nominal bonds (see Table 8 in Appendix). On the other hand, in the US, prices of TIPS tended to fluctuate more than their nominal counterparts (see Table 9 in Appendix). However, in periods of increasing inflation expectations, TIPS were more stable than nominal bonds (see Table 10 in Appendix).

[11] Data between 18/12/2015 and 22/05/2017 was omitted due to no data being available for ILB yields.

6. Conclusion

This analysis highlights the specific characteristics of ILBs and their behaviour under different inflation scenarios. The main conclusion is that ILBs outperform nominal bonds during periods of increasing inflation expectations due to the higher cashflow adjustments. This different nominal cashflow structure may be attractive for investors seeking to preserve the real value of their future cash flows. As an additional benefit, ILBs can be used to reduce overall portfolio risk due to their lower inherent price volatility.

Appendix

Market Issuance

Country	Linker Name	Amount Outstanding	Inflation Index	Index Lag (Months)	Floor Protection
US	TIPS	$500 bn	Unrevised non-seasonally adjusted U.S. City Average All Items Consumer Price Index for All Urban Consumers (CPI-U), published monthly by the Bureau of Labor Statistics (BLS).	3	Yes
Germany	iBund	€64.5bn	Non-revised HICP – all items excluding tabacco as calculated by Eurostat.	3	Yes
France	OATi	€62.3bn	Consumer price index (CPI) excluding tobacco for all households residing in mainland France, published every month by the INSEE.	3	Yes
	OAT€i	€129.7bn	Euroarea HICP, the consumer price index excluding tobacco for the Euroarea published every month by Eurostat.	3	Yes
Spain	SPGB€i	€47.7bn	Euroarea HICP, the consumer price index excluding tobacco for the Euro area published every month by Eurostat.	3	Yes

Table 7: Characteristics of the different ILB markets.

Volatility

	Germany 2020 (from 10/11/2009)		France 2022 (from 31/01/2012)		Spain 2024 (from 13/06/2014)	
	Nominal	*ILB*	*Nominal*	*ILB*	*Nominal*	*ILB*
Mean	111.11	111.13	112.99	110.14	110.62	112.07
Standard Deviation	**4.95**	**3.90**	**5.05**	**3.68**	**3.58**	**3.67**
Sample Variance	24.49	15.19	25.55	13.51	12.81	13.49
Minimum	98.74	102.14	98.77	98.26	98.44	102.30
Maximum	118.26	120.05	120.45	118.28	116.57	120.59

Table 8: Volatility of European ILB.

	US 2019 (from 15/07/2009)		US 2026 (from 31/01/2006)	
	Nominal	*TIPS*	*Nominal*	*TIPS*
Mean	103.83	110.18	128.39	109.41
Standard Deviation	**4.62**	**5.97**	**10.36**	**11.18**
Sample Variance	21.33	35.60	107.25	124.91
Minimum	91.31	100.30	105.91	81.45
Maximum	112.45	123.79	151.01	133.93

Table 9: Volatility of US ILB.

Periods of rising inflation expectations

PERIOD 1: 11/12/2008 to 04/05/2010

	US 2019		US 2026	
	*Nominal**	*TIPS**	*Nominal*	*TIPS*
Mean	93.95	103.70	123.37	97.82
Standard Deviation	**1.11**	**1.74**	**6.12**	**3.38**
Sample Variance	1.22	3.04	37.48	11.39
Minimum	91.31	100.19	114.78	89.38
Maximum	96.73	107.22	143.39	104.72

*Data for 2019 bonds from 15/07/2009

PERIOD 2: 18/02/2016 to 03/02/2017

	US 2019		US 2026	
	Nominal	*TIPS*	*Nominal*	*TIPS*
Mean	104.49	107.40	136.32	115.78
Standard Deviation	**0.81**	**0.72**	**4.05**	**1.81**
Sample Variance	0.65	0.52	16.42	3.26
Minimum	102.98	105.86	127.95	110.52
Maximum	105.55	108.80	142.20	119.38

Table 10: Volatility of US ILB during increasing inflation expectations.

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