E C O N O M I C S B U L L E T I N

The rocky ride of break-even inflation rates

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Abstract

The correlation matrix between break-even inflation rate movements and real interest rate movements across several countries shows puzzling features. Correlation is significantly positive for nearly all cross-border pairs whereas it is nil, positive or negative unsystematically within countries. By means of a correlation matrix decomposition, we give an explanation for this puzzle.

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1. Introduction

The break-even inflation rate (BEIR) is the spread between the nominal bond yield (NBY) and the real bond yield (RBY). According to the Fisher hypothesis, the BEIR conveys the inflation expectations of capital market participants. In practice, however, a series of studies surveyed by Christensen, Dion and Reid (2004) report that the BEIR is being distorted by certain market-related factors. Market liquidity is mentioned as one of them, for example by Shen and Corning (2001), Craig (2003) and Shen (2006), who observe a liquidity premium on inflation-linked bonds as opposed to nominal bonds. Others argue that there is a risk premium priced in the BEIR, which varies depending on the aversion to inflation uncertainty among the market participants (see for example Hördahl and Tristani, 2007, on euro area data, Emmons, 2000, on US data, Evans, 1998, on US and UK data and Côté *et al.*, 1996, on Canadian data). Ejsing, Garcia and Werner (2007) show, using euro area data, that the seasonality in consumer prices over the year is also adding to the distortion in the calculated BEIR. These sources of price distortion are all time-varying[1]. In this respect, it is often pointed out that information extracted from BEIR data should be used cautiously when assessing market players' inflation expectations and is not fully reliable for evaluating central bank credibility.

All studies conclude that market-related factors are *de facto* giving a rocky ride to break-even inflation rates. We show in this paper that it is symptomatic that the comovements of the BEIR in various countries with those of the RBY are being distorted as well. The correlation matrix between changes in BEIR and changes in real interest rates across several countries shows puzzling features. We analyse these features and provide an explanation for them.

2. The data

Our analysis is based on data from Barclays' World Government Inflation-Linked Index covering Inflation-Linked Gilts (ILG) in the United Kingdom, Treasury Inflation Protected Securities (TIPS) in the United States, Obligations Assimilables du Trésor indexées sur l'Inflation (OAT$\in$I) in the euro area, Treasury Indexed Bonds (TIB) in Australia, Index-Linked Treasury Bonds (ILTB) in Sweden and Real Return Bonds (RRB) in Canada. Japan, which entered the index in 2004, has been discarded due to its short data history. Minimum requirements on aggregate issuance and bond rating are set on index entrance so as to make direct comparison possible. We retrieve the nominal bond yields from the Barclays Capital database as well. We use the 10-year yields between July 2002 and June 2008 on a weekly data frequency.

3. An empirical puzzle

Table 1 displays the correlation matrix between the variation in the break-even rates and the variation in the real bond yields of the six countries under study. Standard (Pearson) correlations are measured over the estimation period. Surprisingly, correlation (i) can be nil, positive or negative unsystematically within a country, (ii) whereas it is almost always significantly positive for the cross-border pairs. The nil observations within countries are in line with economic theory. As a real bond offers, by construction, protection against inflation

[1] Using US data, Hunter and Simon (2005) show that because of the liquidity and risk premiums, real bond issuance may have actually increased rather than reduced the US Treasury's borrowing costs to date.

uncertainty, we would expect its yield movement to be uncorrelated to the movement in break-even rates that capture inflation uncertainty. But how should the positive cross-correlation be interpreted? For example, how can it be explained that someone who buys a TIPS is not exposed to inflation in the US but seems to be exposed to inflation in Canada? We note that this exposure represents mark-to-market risk, which is relevant for holders if they intend to sell the bond before its maturity date. For the US Treasury it is important to understand why the domestic BEIR is correlated to the Canadian real bond market.

Table 1
Correlation matrix between changes in break-even rates (BEIR) and changes in real interest rates (RBY)

		RBY					
		Australia	Canada	Euro area	Great Britain	Sweden	United States
BEIR	Australia	**0.27*****	0.19***	0.37***	0.33***	0.41***	0.34***
	Canada	0.30***	**-0.06**	0.37***	0.33***	0.29***	0.45***
	Euro area	0.20***	0.04	**-0.18*****	0.09	0.11**	0.13**
	Great Britain	0.20***	0.14**	0.31***	**-0.07**	0.28***	0.29***
	Sweden	0.30***	0.19***	0.43***	0.39***	**0.13****	0.37***
	United States	0.19***	0.10*	0.10*	0.15***	0.13**	**-0.03**

***: significant at the 1% level (critical value at 0.15); **: significant at the 5% level (critical value at 0.11); *: significant at the 10% level (critical value at 0.09) using an asymptotic *T*-test with *T*=312.

This empirical puzzle, which has not been identified in the literature to our knowledge, is not a random result. As can be observed in Table 1, it is the case for nearly all pairs of countries. In complementary tests displayed in the Appendix, we verify that this result is robust to the choice of test period and data frequency. How can these results be explained?

4. Decomposition

We decompose the correlation matrix into two components, one reflecting the overall comovement in all countries, and one reflecting the idiosyncratic movements. For this, we first decompose the individual variables.

- *Variable decomposition*

We decompose the individual variables *Y* as follows:

$$\Delta Y_{i,t} = \beta_i \cdot \gamma_t + \varepsilon_{i,t} \quad (1)$$

where *i* is the country index, *t* the time index, $\Delta Y_{i,t} = Y_{i,t} - Y_{i,t-1}$, γ_t is the common movement at time *t* and β_i the sensitivity of variable *Y* in country *i* to the common movement. From this, we obtain for each country *i* and each variable *Y* the simple variance decomposition: $Var(\Delta Y_{i,}) = Var(\beta_i . \gamma) + Var(\varepsilon_{i,})$, where the first term represents the changes in comovements and the second term the idiosyncratic ones.

We calculate the share of comovements and idiosyncratic movements in the variance of ΔY_i, $S_{Y_i}^{com} = {Var(\beta_i . \gamma)}/{Var(\Delta Y_i)}$ and $S_{Y_i}^{idi} = {Var(\varepsilon_i)}/{Var(\Delta Y_i)}$ summing to one. The result of this calculation is given in Table 2 for the three variables (NBY, RBY and BEIR) in the six countries.

Table 2
Share of the comovements in the variance of the variables - %
NBY: Nominal bond yield; RBY: Real bond yield; BEIR: Break-even inflation rate

	Australia	Canada	Euro area	Great Britain	Sweden	United States
NBY	59	70	85	80	79	80
RBY	39	41	77	69	63	77
BEIR	44	55	24	29	50	39

Note: the share of idiosyncratic movement is the complement to 100%.

We can interpret the pricing of nominal bonds as the most international and the pricing of break-even rates (through inflation swaps) as the least international.

Table 3 gives the β_i terms resulting from the estimation of relation (1), for each of the three variables and each of the six countries.

Table 3
β_i resulting from the estimation of relation (1)
NBY: Nominal bond yield; RBY: Real bond yield ; BEIR: Break-even inflation rate

	Australia	Canada	Euro area	Great Britain	Sweden	United States
NBY	1.05	0.76	0.95	0.98	0.99	1.26
RBY	0.77	0.55	1.19	0.12	0.85	1.47
BEIR	1.26	1.19	0.59	0.69	1.15	1.05

It is interesting to note that the US nominal bond market and real bond market are more reactive than average.

- *Correlation matrix decomposition*

We denote the correlation matrix displayed in Table 1 as Γ and the corresponding covariance matrix as V. Per definition:

$$\Gamma = \Sigma_{BEIR}^{-1/2} * V * \Sigma_{RBY}^{-1/2} \quad \text{where } \Sigma_Y = \begin{bmatrix} Var(\Delta Y_1) & & 0 \\ & \ddots & \\ 0 & & Var(\Delta Y_6) \end{bmatrix}, \text{ Y=BEIR, RBY.} \qquad (2)$$

We decompose the covariance matrix and express it in correlation notation:

$$\Gamma = \Sigma_{BEIR}^{-1/2} * \begin{pmatrix} V^{com\ com} & V^{com\ idi} \\ V^{idi\ com} & V^{idi\ idi} \end{pmatrix} * \Sigma_{RBY}^{-1/2} =$$
$$\Sigma_{BEIR}^{-1/2} * \left(\begin{bmatrix} \Sigma_{BEIR}^{com} & \Sigma_{BEIR}^{idi} \end{bmatrix}^{1/2} * \begin{pmatrix} \Gamma^{com\ com} & \Gamma^{com\ idi} \\ \Gamma^{idi\ com} & \Gamma^{idi\ idi} \end{pmatrix} * \begin{bmatrix} \Sigma_{RBY}^{com} \\ \Sigma_{RBY}^{idi} \end{bmatrix}^{1/2} \right) * \Sigma_{RBY}^{-1/2} \qquad (3)$$

where, for example, $V^{com\ com}$ represents the *6x6* covariance matrix between the common BEIR variation and the common RBY variation.

Introducing the definition of variance shares simplifies the equation to:

$$\Gamma = \begin{bmatrix} S_{BEIR}^{com} & S_{BEIR}^{idi} \end{bmatrix} * \begin{pmatrix} \Gamma^{com\ com} & \Gamma^{com\ idi} \\ \Gamma^{idi\ com} & \Gamma^{idi\ idi} \end{pmatrix} * \begin{bmatrix} S_{RBY}^{com} \\ S_{RBY}^{idi} \end{bmatrix} \tag{4}$$

We rewrite the correlation matrix as a weighted sum of the four component correlation matrices, the weights being the respective share of variance explained. Table 4 displays the empirical numbers.

Table 4

Decomposed correlation matrix between the variation in break-even rates and the variation in real interest rates

$$\begin{pmatrix} \Gamma^{com\ com} & \Gamma^{com\ idi} \\ \Gamma^{idi\ com} & \Gamma^{idi\ idi} \end{pmatrix} =$$

$$\left(\begin{matrix} \begin{bmatrix} \mathbf{.48} & \mathbf{.48} & \mathbf{.48} & \mathbf{.48} & \mathbf{.48} & \mathbf{.48} \\ \mathbf{.48} & \mathbf{.48} & \mathbf{.48} & \mathbf{.48} & \mathbf{.48} & \mathbf{.48} \\ \mathbf{.48} & \mathbf{.48} & \mathbf{.48} & \mathbf{.48} & \mathbf{.48} & \mathbf{.48} \\ \mathbf{.48} & \mathbf{.48} & \mathbf{.48} & \mathbf{.48} & \mathbf{.48} & \mathbf{.48} \\ \mathbf{.48} & \mathbf{.48} & \mathbf{.48} & \mathbf{.48} & \mathbf{.48} & \mathbf{.48} \\ \mathbf{.48} & \mathbf{.48} & \mathbf{.48} & \mathbf{.48} & \mathbf{.48} & \{\mathbf{.48}\} \end{bmatrix} & \begin{bmatrix} .11 & -.19 & .02 & -.03 & -.02 & .00 \\ .11 & -.19 & .02 & -.03 & -.02 & .00 \\ .11 & -.19 & .02 & -.03 & -.02 & .00 \\ .11 & -.19 & .02 & -.03 & -.02 & .00 \\ .11 & -.19 & .02 & -.03 & -.02 & .00 \\ .11 & -.19 & .02 & -.03 & -.02 & \{.00\} \end{bmatrix} \\ \begin{bmatrix} .12 & .12 & .12 & .12 & .12 & .12 \\ .10 & .10 & .10 & .10 & .10 & .10 \\ -.19 & -.19 & -.19 & -.19 & -.19 & -.19 \\ -.02 & -.02 & -.02 & -.02 & -.02 & -.02 \\ .10 & .10 & .10 & .10 & .10 & .10 \\ -.26 & -.26 & -.26 & -.26 & -.26 & \{-.26\} \end{bmatrix} & \begin{bmatrix} -\mathbf{.08} & .04 & .00 & .00 & .19 & -.05 \\ -.05 & -\mathbf{.43} & -.02 & -.04 & -.10 & .25 \\ .16 & .10 & -\mathbf{.60} & .07 & .12 & .15 \\ -.01 & .09 & .21 & -\mathbf{.57} & .18 & .16 \\ -.04 & .05 & .16 & .14 & -\mathbf{.45} & .02 \\ .12 & .21 & .02 & .18 & .12 & \{-\mathbf{.33}\} \end{bmatrix} \end{matrix} \right)$$

$$\begin{bmatrix} S_{BEIR}^{com} & S_{BEIR}^{idi} \end{bmatrix} = \left[\begin{bmatrix} .66 & & & & & 0 \\ & .74 & & & & \\ & & .49 & & & \\ & & & .54 & & \\ & & & & .71 & \\ 0 & & & & & .63 \end{bmatrix} \begin{bmatrix} .75 & & & & & 0 \\ & .67 & & & & \\ & & .87 & & & \\ & & & .84 & & \\ & & & & .71 & \\ 0 & & & & & .78 \end{bmatrix} \right]$$

$$\begin{bmatrix} S_{RBY}^{com} & S_{RBY}^{idi} \end{bmatrix} = \left[\begin{bmatrix} .63 & & & & & 0 \\ & .64 & & & & \\ & & .88 & & & \\ & & & .83 & & \\ & & & & .80 & \\ 0 & & & & & .88 \end{bmatrix} \begin{bmatrix} .78 & & & & & 0 \\ & .77 & & & & \\ & & .48 & & & \\ & & & .56 & & \\ & & & & .60 & \\ 0 & & & & & .48 \end{bmatrix} \right]$$

The decomposition is helpful in solving the correlation puzzle. Two sets of correlation numbers are particularly significant, i.e. all coordinates in the top left matrix of Γ and the coordinates on the diagonal in the bottom right matrix, indicated in bold. Since the weights in the variance share matrices are fairly homogeneous we can ignore them. The same applies for the numbers in the two cross matrices of Γ as they are relatively small and unsystematic. Thus, the two sets in bold determine to a large extent the total correlation. To take an example, let us look at the numbers in braces that define the correlation between the BEIR and RBY in the United States. The near-zero total correlation between these two interest rates is the net result of a strongly positive correlation between the global comovements of the two and a strongly negative correlation between the idiosyncratic movements specific to the United States. The decomposition reveals that there is significant correlation on a world scale between break-even and real interest rates, yet that within countries this is offset by the idiosyncratic negative correlation.

The negative idiosyncratic correlation is a direct consequence of the time-varying distortions discussed in the literature and reiterated in the introduction. As soon as the RBY moves due to a market-related event, which is typically not mirrored by the NBY, the BEIR moves exactly in the opposite direction.

The positive correlation between BEIR and RBY on a world scale is an interesting market phenomenon. Market practitioners recognise this phenomenon indirectly when they cite the "beta effect" (see, for example, Pond, 2008). It is very often observed that the RBY moves in the same direction as the NBY but with a smaller magnitude. From a macroeconomic standpoint, the two interest rates could move together with the same magnitude after a shock that has no significant impact on inflation expectations (for example, at the first order, a technological shock). Or the nominal interest rate could move alone after a 'pure' inflation shock. The fact that most of the time we observe the net result of the two scenarios means that the two types of shock very often coincide or that somehow shocks combine the two types of effect.

5. Concluding remarks

We have provided an interpretation of an empirically observed puzzle. Someone who buys a TIPS is factually unexposed to the US inflation risk, since the common positive correlation between RBY and BEIR is offset by the idiosyncratic negative correlation. But the common correlation vis-à-vis Canada is not offset. This solves the puzzle, however, it does not answer all the questions concerning the pricing of real bonds.

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Appendix

Correlation matrix between variation in the break-even inflation rates (BEIR) and variation in real bond yields (RBY)

Based on monthly data from 2002 to 2007

		RBY					
		Australia	Canada	Euro area	Great Britain	Sweden	United States
BEIR	Australia	**0.24****	0.24**	0.51***	0.43***	0.33***	0.49***
	Canada	0.40***	**-0.18**	0.32***	0.44***	0.25**	0.34***
	Euro area	0.33***	0.01	**0.01**	0.26**	0.20*	0.18
	Great Britain	0.31***	0.10	0.25**	**0.01**	0.27**	0.20*
	Sweden	0.30**	0.18	0.34***	0.24**	**-0.34*****	0.20*
	United States	0.17	0.04	0.14	0.15	0.30**	**0.15**

***: significant at the 1% level (critical value at 0.30); **: significant at the 5% level (critical value at 0.23); *: significant at the 10% level (critical value at 0.19) using an asymptotic *T*-test with *T*=72.

Based on weekly data from 1999 to 2004

		RBY					
		Australia	Canada	Euro area	Great Britain	Sweden	United States
BEIR	Australia	**0.24*****	0.29***	0.36***	0.34***	0.14**	0.36***
	Canada	0.31***	**0.04**	0.32***	0.34***	0.12**	0.41***
	Euro area	0.18***	0.14**	**-0.03**	0.22***	0.08	0.23***
	Great Britain	0.13**	0.12**	0.31***	**-0.05**	0.12**	0.30***
	Sweden	0.22***	0.19***	0.27***	0.27***	**-0.34*****	0.27***
	United States	0.25***	0.18***	0.17***	0.24***	0.09	**0.15*****

***: significant at the 1% level (critical value at 0.15); **: significant at the 5% level (critical value at 0.11); *: significant at the 10% level (critical value at 0.09) using an asymptotic *T*-test with *T*=312