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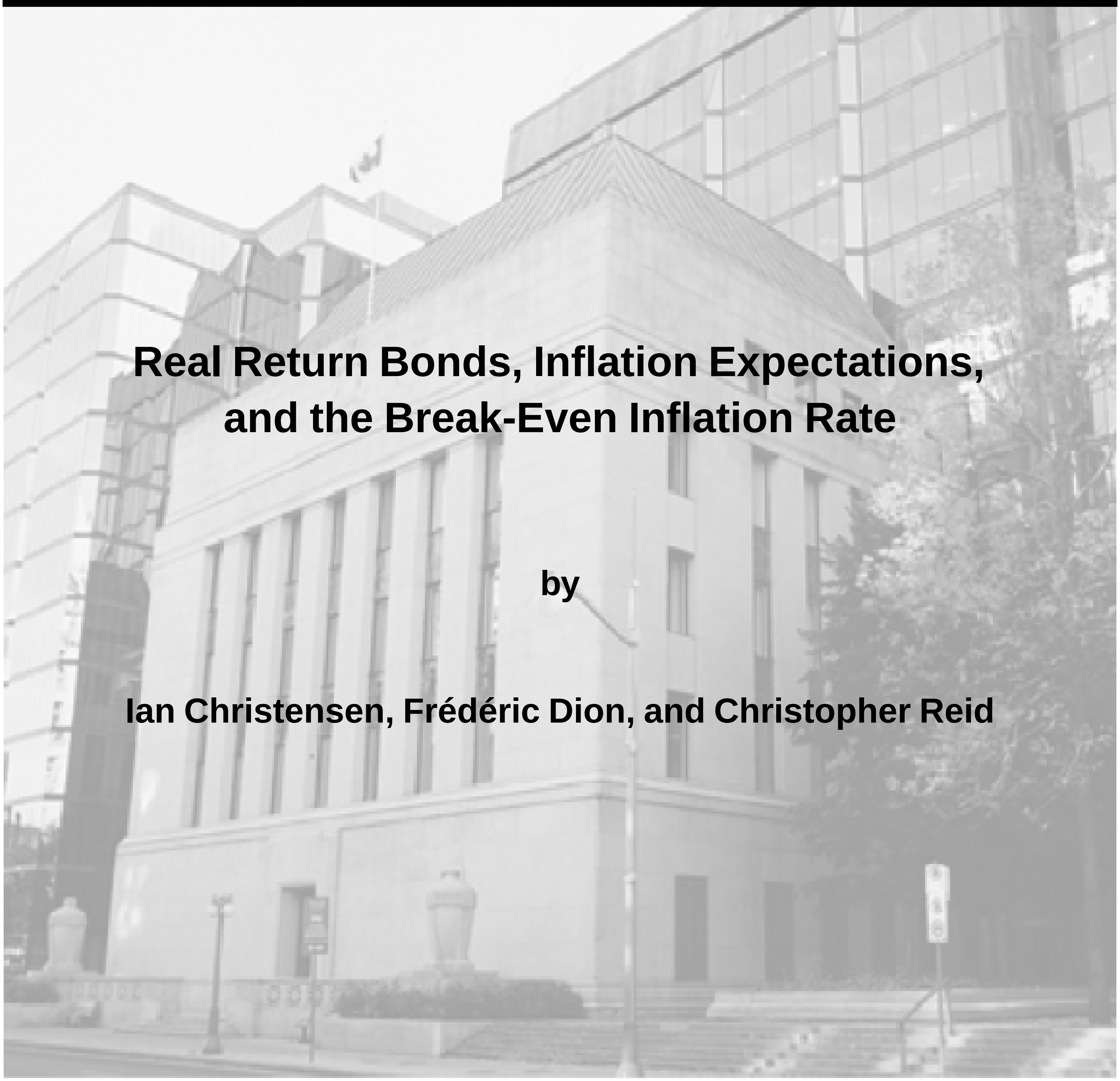

Real Return Bonds, Inflation Expectations, and the Break-Even Inflation Rate

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Contents

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Abstract

According to the Fisher hypothesis, the gap between Canadian nominal and Real Return Bond yields (or break-even inflation rate) should be a good measure of inflation expectations. The authors find that this measure was higher, on average, and more variable than survey measures of inflation expectations between 1992 and 2003. They examine whether risk premiums and distortions embedded in this interest rate gap can account for these facts. Their results indicate that distortions were likely an important reason for the high level and variation of this measure over much of the 1990s. There is little evidence that the distortions examined were as important between 2000 and 2003, but the high level of the break-even inflation rate in 2004 may be evidence of their return. Given the potential distortions, and the difficulty in identifying them, the authors conclude that it is premature to consider this measure a reliable gauge of monetary policy credibility. In addition, it is not as useful as competing tools for short- and medium-term inflation forecasting.

JEL classification: E31, E43
Bank classification: Interest rates; Inflation and prices; Market structure and pricing

Résumé

Selon l'hypothèse de Fisher, l'écart de rendement entre les obligations canadiennes à rendement nominal et à rendement réel (ou taux d'inflation neutre) devrait être un bon indicateur des attentes d'inflation. Les auteurs constatent qu'entre 1992 et 2003, cet écart a été supérieur, en moyenne, aux mesures de l'inflation attendue établies par enquête, et plus variable également. Ils cherchent à savoir si les primes de risque et les distorsions comprises dans l'écart de rendement y sont pour quelque chose. D'après leurs résultats, les distorsions expliquent probablement en bonne partie le niveau élevé et les variations de l'écart de rendement durant la majeure partie des années 1990. Rien ne porte à croire qu'elles aient été aussi importantes entre 2000 et 2003, mais le niveau élevé du taux d'inflation neutre en 2004 pourrait être le signe de leur résurgence. Étant donné les distorsions possibles et la difficulté de les prendre en compte, les auteurs concluent qu'il est prématuré de considérer cette mesure comme un baromètre fiable de la crédibilité de la politique monétaire. En outre, le taux d'inflation neutre n'est pas aussi utile que les autres outils existants pour la prévision de l'inflation à court et à moyen terme.

Classification JEL : E31, E43
Classification de la Banque : Taux d'intérêt; Inflation et prix; Structure de marché et fixation des prix

1. Introduction

According to the Fisher hypothesis, the spread between nominal and real interest rates should provide a good measure of inflation expectations. Real interest rates can be derived from the price of Real Return Bonds (RRBs) (inflation-indexed bonds issued by the Government of Canada), because they compensate the investor for realized inflation, guaranteeing the real value of coupon payments and principal. Nominal interest rates from conventional bonds compensate the investor for the future inflation rate expected at the time of sale. The spread between nominal and real interest rates is commonly referred to as the break-even inflation rate (BEIR), because it is the inflation rate that equates returns across the two types of bond. Since Canada issues only RRBs that have a 30-year maturity, the BEIR is constructed from yields on long-term bonds and (in the absence of distortions) indicates the expected average inflation rate over a 25- to 30-year horizon that is priced into the market.

To determine whether the BEIR is a good measure, we examine the historical experience for conformance with our priors about the behaviour of long-run inflation expectations. The broad trends do conform, but the BEIR is volatile and at times shows persistent movements in the opposite direction from other measures of inflation expectations. This paper examines whether these movements can be attributed to changes in risk premiums and other distortions that affect the BEIR, rather than changes in inflation expectations.

It is useful for the conduct of monetary policy to have a good measure of inflation expectations. The worth of the BEIR in this capacity depends on how it is to be used and over what horizon. Based on the experience to the end of 2003, we argue that the BEIR shows promise as a measure of agents' views about the long-run credibility of a central bank's commitment to keep inflation near its target. Nonetheless, events in 2004 suggest that premiums and distortions may recur. Due to the difficulty in identifying and quantifying these distortions, one should not place much weight on the BEIR as a measure of credibility at this time. In addition, the Canadian BEIR is a less reliable tool than competing methods used to obtain short-term inflation forecasts.

2. Methodology and Previous Findings

We consider the usefulness of the BEIR from two perspectives: as a measure of monetary policy credibility and as an aid to inflation forecasting. Monetary policy is credible when agents expect that future inflation will be near the inflation target. If the BEIR captures inflation expectations accurately, its position relative to the target should be a good measure of credibility. Since the true expected inflation rate is unobservable, we must find indirect ways to assess the accuracy of the BEIR. In this paper, we assess whether the BEIR's behaviour over its 12-year history fits with what we think we know about inflation expectations. Survey data serve as the primary basis for comparison. We find that the BEIR and survey measures of inflation expectations are sometimes at odds over our sample; we therefore evaluate the ability of premiums and distortions in the BEIR to explain these divergences. The BEIR may also be useful if it improves our ability to forecast inflation. We assess the forecast performance of the BEIR relative to survey measures of expectations and other simple models.

Many of the studies in the literature rely on the use of survey measures of inflation expectations as the benchmark for comparison, and we continue this practice. Nonetheless, consensus survey measures have been criticized for a number of reasons. Survey respondents are weighted equally, regardless of their convictions or ability to forecast inflation well. They may also have little incentive to reveal private information.[1] In principle, market-based measures do not have these shortcomings. They are determined by *actions*, which are more revealing than *opinions*. The convictions of market players are "weighted by their 'dollar votes,' which reflect the confidence and stake people have in their predictions" (Haubrich and Dombrosky 1992). Market participants who have good information can profit at the expense of those who are irrational or who have poor information. In addition, market-based measures are available at a much higher frequency than survey data, and they therefore should provide more current information about expectations.

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1. Professional forecasters may behave strategically, providing forecasts that are close to consensus—rather than reflecting their true forecast—to avoid being the only one who was wrong. Conversely, they may make contrarian forecasts to attract more attention to their products.

We use survey measures of inflation expectations as a benchmark for comparison because true expectations are unobservable and survey measures are the main alternative source of information. They are not subject to inflation uncertainty, liquidity risk, and the other distortions that are potential sources of bias in the BEIR. Nonetheless, differences between survey measures and the BEIR may be due to biases in the survey measures, in addition to those in the BEIR. An exploration of the size and nature of survey biases, however, is beyond the scope of this paper.

2.1 Previous research

In countries that issue inflation-linked debt, the BEIR has often given a different signal than surveys of inflation expectations. The U.S. BEIR is, on average, lower than long-run inflation expectations obtained from surveys, and it is much more volatile. In addition, changes in the BEIR do not coincide with changes in survey measures. In contrast to the United States, long-term BEIRs in the United Kingdom are higher, on average, than consensus survey measures of inflation expectations over similar horizons (Scholtes 2002).

The literature that seeks to explain these findings investigates whether the Fisher hypothesis—the theoretical basis for the BEIR—is strictly applicable in the real world, where interest rates may contain premiums and distortions. Shen and Corning (2001) and Craig (2003) argue that the U.S. findings are due to the presence of a liquidity premium embedded in the BEIR. Shen and Corning further argue that variation in this premium may be the cause of the BEIR's volatility. Sack (2000) finds that the mismatched cash flows of the indexed and conventional Treasuries and term-varying inflation expectations explain only a fraction of the variability of the BEIR. Emmons (2000) points out that U.S. nominal bonds of 10+ years to maturity may possess a scarcity value, which may in part explain why the U.S. BEIR is lower than survey measures of inflation expectations.[2] In the United Kingdom, there is evidence that the inflation-risk premium is more important than in the United States, and that it is possibly time-varying (Evans 1998).

2. In addition, the status of the U.S. dollar as reserve currency may result in a disproportionate demand for nominal Treasuries, which would have the effect of lowering the BEIR.

Côté et al. (1996) argue that an inflation-risk premium and factors related to the small size of the Canadian RRB market make the level of the BEIR an unreliable indicator of the level of inflation expectations. Nonetheless, they hold out some hope that changes in the BEIR over time may be a good indicator of movements in long-term inflation expectations.

3. Premiums Embedded in the BEIR

If investors are risk-neutral and markets efficiently price a homogeneous real interest rate across markets, the difference in yields between a zero-coupon index-linked bond and a zero-coupon nominal bond of similar maturity would express the market's expected average inflation rate over the remaining period to maturity.[3] In this perfect world, the Fisher hypothesis is valid and the nominal interest rate is equal to the required real rate of return to the investor plus compensation for expected inflation:

$$\text{Fisher hypothesis: } (1+i) = (1+r)(1+p^{e}) \Rightarrow p^{e} = \frac{1+i}{1+r} - 1. \tag{1}$$

In the real world, however, the various assumptions that underlie the Fisher hypothesis may not hold strictly. The BEIR may contain distortions that mask the underlying information about inflation expectations. Nonetheless, even if the premiums and distortions were to shift the level of the BEIR away from "true" inflation expectations, the BEIR might still be a useful indicator if these distortions were relatively stable over time. If they were, changes in the BEIR would indicate when changes in inflation expectations were occurring. We are therefore interested not only in the magnitude of premiums and distortions, but the extent to which they may vary over time.

3.1 Mismatched cash flows

The RRB and nominal bond that are used to construct the BEIR have approximately the same maturity. Both bonds also pay a coupon, which complicates the comparison of their yields, because their cash flows are mismatched: the coupon payments of the RRB rise

3. This is true apart from the effect of Jensen's inequality, which means there is a negative bias in the BEIR.

with inflation, whereas those for the nominal bond are constant. Since the price of a bond is simply the sum of discounted cash flows, the two bonds will have different sensitivities to the expected path of real interest rates and real interest rate risk. As we discuss below, this will make the BEIR lower, on average, than true inflation expectations. In addition, mismatched cash flows will mean that changes in the expected path of real interest rates will cause the BEIR to fluctuate.

3.2 Term-varying inflation expectations

Another consequence of using coupon bonds to construct the BEIR is that it will be more sensitive to short-term inflation expectations than longer-term expectations. Implicit in the construction of the BEIR is an assumption that inflation expectations are roughly constant over the various horizons up to the maturity of the bonds. If both component bonds paid no coupon, this assumption would be innocuous. Instead, the nominal yields of these bonds are influenced by the expected path of inflation, and not just the expected average inflation over the period to maturity. As a result, when the term structure of inflation expectations—the set of expectations at increasing horizons—is not flat, a bias is introduced into the BEIR, and this bias is most sensitive to changes in inflation expectations at short horizons. This effect could be important, since short-term inflation expectations are likely to be more variable than long-term ones: inflation shocks are more likely to offset in the long term. Term-varying inflation expectations could temporarily change the level of the BEIR, thereby adding to its variability even when the expected average of inflation over the long run is unchanged.

3.3 Inflation risk

Inflation risk reflects the probability that the actual inflation rate will not match the expected inflation rate. A person’s inflation expectations are the mean of their subjective probability distribution for inflation, and inflation uncertainty is the variance around the mean. If inflation is significantly higher over the term of a nominal bond than was expected at the time of purchase, the realized real rate of return will be lower than the expected real rate of return. Investors in conventional bonds require compensation for this risk, which results in higher nominal yields *ceteris paribus*. In contrast to nominal bonds, inflation risk is retained by the issuer of RRBs not passed on to the investor. For this reason, the BEIR contains a positive inflation-risk premium.

The value of the protection from unexpected higher inflation should depend on the degree of uncertainty about future inflation and the degree of risk aversion.[4] The size of the inflation-risk premium will vary as inflation uncertainty changes. Inflation uncertainty is positively correlated with the level of inflation or inflation expectations, so the BEIR will tend to rise to a greater degree than the increase in inflation expectations.

If the BEIR is to be used to indicate the credibility of the central bank, the existence of the inflation-risk premium is not a drawback, since uncertainty about future inflation developments must reflect investors' views about the central bank's willingness and ability to take actions to control future inflation. A lower or less-variable inflation-risk premium would signal increased credibility.

3.4 Liquidity risk

Liquidity risk is the risk that investors will not be able to sell an asset without incurring large costs either from the price pressure they create or the length of time it takes to sell their asset. In Canada, the secondary market for RRBs is much smaller than the market for nominal bonds, so there may be an important liquidity-risk premium differential. To compensate, investors may demand a higher expected return for this product, which would lead to a higher RRB yield and, *ceteris paribus*, a narrowing of the BEIR. This liquidity premium should decline over time as the RRB market develops, but this gradual decline should not be an important short-run source of variation in the BEIR.

The amount of liquidity risk may vary over time, in line with the market's perception of overall risk. In times of financial distress or rising economic uncertainty, investors are willing to pay a premium (accept a lower return) for the safest, most liquid assets. During these times, the RRB yields may rise and the nominal yields may fall, reducing the BEIR until investor behaviour returns to normal.

4. Jensen's inequality implies that, if investors are risk-neutral, the yield spread between real and nominal bonds will understate inflation expectations by an amount that increases with the uncertainty that surrounds inflation.

3.5 Market segmentation

Côté et al. (1996) and Mayer (1998) argue that the BEIR may not reflect the market's overall view on inflation expectations, but rather reflect the view of those with the highest inflation expectations or inflation-protection needs. The argument that the RRB market is segmented, having investors with very different characteristics than average investors, requires that the supply of RRBs be relatively inelastic. If only a small amount of inflation-linked debt is supplied, it is likely to be owned by those who have the highest inflation expectations or the biggest need for inflation protection. Inflation-sensitive investors may have higher forecasts of inflation or be more averse to inflation risk, and therefore value the certainty of RRBs more highly. If the RRB yield reflects their views and preferences, it will be lower, and the BEIR will be higher, than if the market was not segmented.

In Canada, some investors are exempt from the taxes applicable to RRBs, which is another source of segmentation. The tax burden to RRB holders depends on inflation outcomes, since both income and capital gains taxes are applied to the inflation-uplifted coupon and principal components.[5] Life insurance companies and pension funds that are exempt from these taxes are willing to pay more for RRBs than the average investor. In addition, RRBs are attractive to these firms because they have real liabilities and need to match their assets to inflation.

Market segmentation is not likely to lead to more variability in the BEIR on its own. It may, however, magnify the shifts in the BEIR that result from changes in inflation uncertainty. Changes in the degree of segmentation of the RRB market, perhaps as a result of changes in the tax code, would likely lead to permanent changes in the level of the BEIR.

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5. Given this tax treatment, the majority of RRBs are held by tax-exempt institutions or in tax-exempt accounts, such as RRSPs. The tax implications are therefore a driving force behind the segmentation of the market.

4. RRBs: The Historical Experience

The Government of Canada first issued RRBs in December 1991. Formal inflation targets, which specified the rate of inflation to be achieved over a 2-year horizon, were adopted in Canada in February of 1991, and subsequently lowered to the current target of 2.0 per cent. Figure 1 shows the RRB yield, the yield from a 30-year nominal Government of Canada bond, and the BEIR calculated from these two yields.

Figure 1: Nominal and RRB Yield and BEIR

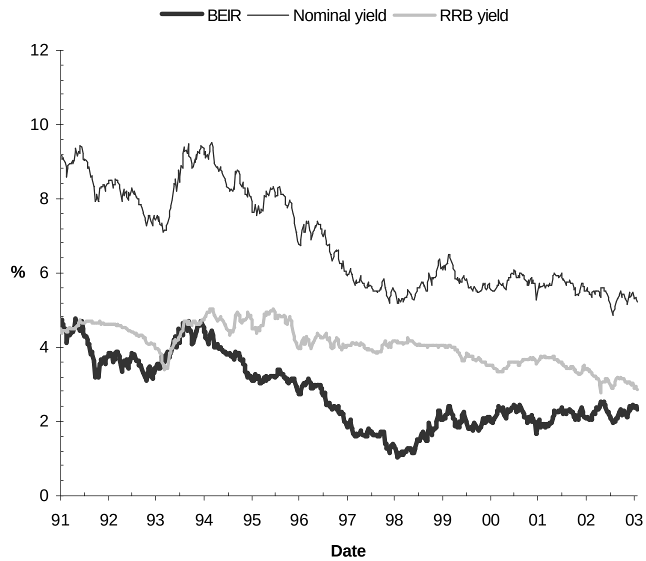


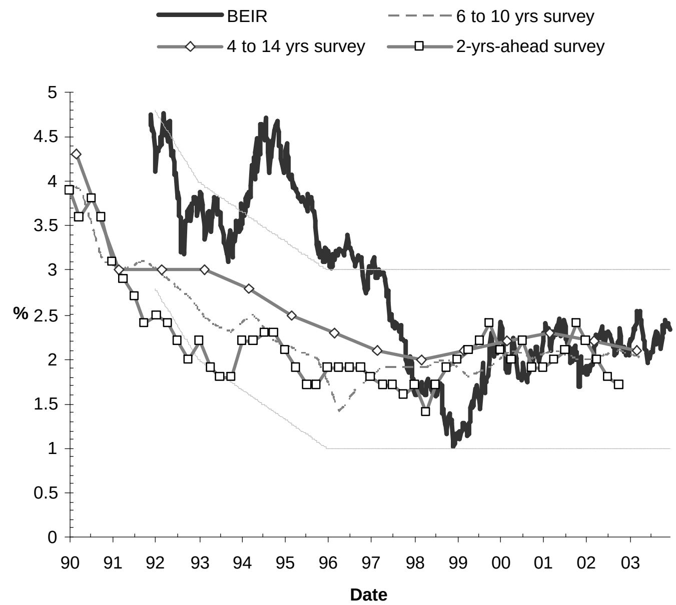
Table 1 shows the sample means and measures of the variability of the nominal and real yields and the BEIR. The drop in the mean and variability of the BEIR in the latter half of the sample coincides with a drop in the mean and variability of the nominal yield, which is what we would expect if inflation expectations or inflation uncertainty were falling over the sample. The real yield also dropped, on average, in the latter half of the sample, but its variability was relatively unchanged. This is consistent with a fall in the liquidity premium.

Table 1: Full and Subsample Statistics, Nominal and Real Yields and BEIR

	Mean			Standard deviation		
	1992–2003	1992–1997	1998–2003	1992–2003	1992–1997	1998–2003
Nominal	6.83	8.02	5.64	1.35	0.86	0.26
RRB	4.06	4.45	3.66	0.53	0.33	0.37
BEIR	2.74	3.52	1.96	0.95	0.66	0.36

Figure 2 shows that the BEIR was above the inflation target (the midpoint of the target band is shown in the figure) in the early to mid-1990s, below it from late 1997 to late 1999, and very close to target since that time. Longworth (2002) and others state that the falling level of the BEIR between 1992 and 1997 is consistent with monetary policy becoming more credible.

Figure 2: Four Measures of Inflation Expectations



Also shown in Figure 2 are three measures of inflation expectations from surveys of professional forecasters: the median expected average rate of inflation 4 to 14 years ahead, from an annual survey conducted by Watson Wyatt; the mean expected average rate of inflation 6 to 10 years ahead, from a semi-annual survey by Consensus Economics; and 2-years-ahead inflation expectations, from the Conference Board's quarterly *Survey of Forecasters.*[6] The BEIR is higher than the other measures of inflation expectations for the first half of the sample—at times by more than 150 basis points. It registers both the highest reading (4.9 per cent in March 1992) of the four measures and the lowest reading (about 1.0 per cent in late 1998). It also falls much more slowly than the survey measures. From 2000 to 2003, however, it was very close to 2.0 per cent, the middle of the Bank of Canada's target range for inflation, along with the other measures of inflation expectations. Over this recent period, any permanent distortions to the level of the BEIR were either small or offsetting, on average.

Even if all of these series were perfect measures of inflation expectations, we would not expect their levels to be identical over this sample, because they capture expectations over different horizons. For example, if a recent shock to inflation is expected to be short-lived, we might expect near-term inflation expectations to rise with little impact on longer-term expectations. The measures of inflation expectations are, in fact, quite

6. Two-years-ahead inflation is the expected rate of inflation for the following calendar year, rather than over the next 12 months. The other survey measures are defined similarly.

different. The mean level of the BEIR over the 1992 to 2002 sample is 2.8 per cent, above that of the 4- to 14-year expectations (2.5 per cent), the 6- to 10-year expectations (2.1 per cent), and the 2-years-ahead expectations (2.0 per cent). The longer the horizon over which the expectation applies, the higher its average over the past 11 years. This is consistent with slowly increasing monetary policy credibility, because expectations over longer horizons fall more slowly. It is puzzling, however, that the long-term measures are so different from each other. For example, it seems unlikely that there is enough additional information about inflation developments 10 to 30 years in the future to justify a difference of 0.8 percentage points between the BEIR and the 6- to 10-year survey measure. Such a wide difference may reflect uncertainty regarding the monetary policy regime over the longest horizons, or the influence of premiums embedded in the BEIR.

The BEIR is the most variable measure, showing an average annual absolute change of 0.56 percentage points, at least double that of the survey measures at any horizon. This is still true if we consider only the latter half of the sample. The first differences in those measures show very little correlation, which suggests that changes in one (or both) of these measures reflect some phenomenon other than changing inflation expectations.[7] On the basis of similar evidence, Shen and Corning (2001) argue that the U.S. BEIR may be too volatile to be a reliable proxy of inflation expectations. The higher peaks and lower troughs of the BEIR are mainly linked to two episodes: 1993–95, when the BEIR increased rapidly as other measures stabilized or fell, and 1997–99, when the BEIR dropped sharply while other measures fell moderately or flattened.

5. Calculating the BEIR

The current value of a bond is the sum of its discounted future cash flows and principal (equation (2)). Using market data on bond prices (B_t), the coupon rate on the bond (c), and setting the value of principal to \$100, we can solve for the yield to maturity (*ytm*) using this relationship. The *ytm* is the average annual return over the remaining life of the bond:

7. Alternatively, longer-horizon expectations may behave differently.

$$B_t = \sum_{n=1}^{N} \frac{c \cdot 100}{\left(1+i_{ytm,t}\right)^n} + \frac{100}{\left(1+i_{ytm,t}\right)^N}\,. \tag{2}$$

In the case of a nominal bond, we obtain a nominal *ytm*. In the case of the RRB, we use the market price and the real coupon rate to obtain a real *ytm*. In the absence of distortions, the spread between the yield on a nominal 30-year Government of Canada bond and a 30-year RRB provides a measure of the expected average annual rate of inflation over the 30-year horizon.

To understand the short-run impact of a large increase in the CPI on the RRB price, we need to consider how the RRB coupon payments are calculated. In this section, we follow the exposition of Sack and Elsasser (2004) closely.

RRBs guarantee their holder a real return, protecting them from lower returns caused by inflation. To do so, the coupon payment and the principal repaid at maturity are adjusted to include compensation for inflation that has occurred since the issuance of the bond:

$$RRB_t = \sum_{n=1}^{N} \frac{c \cdot 100 \cdot \left(P_{t+n} / P_t\right)}{\left(1+i_{n,t}\right)^n} + \frac{100 \cdot \left(P_{t+N} / P_t\right)}{\left(1+i_{N,t}\right)^N}\,. \tag{3}$$

An RRB issued at time t, with a real coupon rate c, a maturity of N years, and a par value of \$100 has a coupon payment of $c \cdot 100 \cdot \left(P_{t+n} / P_t\right)$, and returns a principal payment of $100 \cdot \left(P_{t+N} / P_t\right)$ at maturity. The index ratio $\left(P_{t+n} / P_t\right)$ is rewritten in equation (4) as $\left(1+p_{n,t}^{e}\right)^n$, where $p_{n,t}^{e}$ is the expected average annual rate of inflation over the next n periods. $i_{n,t}$ is the n-period zero-coupon interest rate at time t (i.e., the return on a bond that pays no coupon and matures in period n). The set of $i_{n,t}$ for all n periods gives the zero-coupon yield curve:

$$RRB_t = \sum_{n=1}^{N} \frac{c \cdot 100 \cdot \left(1+p_{n,t}^{e}\right)^n}{\left(1+i_{n,t}\right)^n} + \frac{100 \cdot \left(1+p_{N,t}^{e}\right)^N}{\left(1+i_{N,t}\right)^N}\,. \tag{4}$$

Define the *n*-period zero-coupon real interest rate by the following:

$$\left(1+r_{n,t}\right)=\frac{\left(1+i_{n,t}\right)}{\left(1+p_{n,t}^{e}\right)}. \tag{5}$$

Equation (4) then becomes the following:

$$RRB_t=\sum_{n=1}^{N}\frac{c\cdot 100}{\left(1+r_{n,t}\right)^n}+\frac{100}{\left(1+r_{N,t}\right)^N}, \tag{6}$$

which is essentially the equation for valuing a nominal bond (equation (2)), except that coupon payments are discounted by real interest rates, rather than nominal ones. Therefore, we can derive the real *ytm* using only the fixed coupon rate and market information about the bond price.

If future inflation is known, the returns from an investment making a real payment in *n* periods and one making a nominal payment must equate, which implies that

$$\left(1+r\right)^N=\left[\frac{\left(1+i\right)}{\left(1+p^{e}\right)}\right]^N. \tag{7}$$

The yield spread between a nominal and an indexed zero-coupon bond should be equal to the expected average rate of inflation over the life of the bond when premiums are not present. When bonds also pay a coupon, however, this relationship becomes more complicated. The path of inflation affects the size of the coupon payments of the RRB and, as a result, different expected paths for inflation may cause the bond price to change—even when the average annual inflation rate over the life of the bond is kept constant. Under the assumption that inflation is expected to be stable at the level p over time, we can replace the zero-coupon interest rates in equation (7) with the *ytm* from the RRB and nominal coupon bonds:

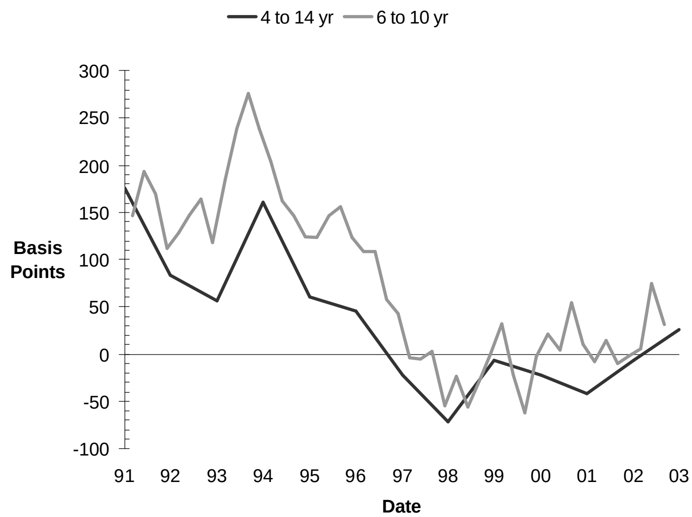
$$\left(1+r^{ytm}\right)=\frac{\left(1+i^{ytm}\right)}{\left(1+p^{e}\right)}\Rightarrow p^{e}=\frac{\left(1+i^{ytm}\right)}{\left(1+r^{ytm}\right)}-1. \tag{8}$$

This equation can be approximated by $i^{ytm} - r^{ytm} = p^{e}$; however, the geometric difference (equation (8)) is usually used. The BEIR is supposed to capture the expected average annual inflation rate over the remaining life of the bond.

6. How Important Are the Risk Premiums/Distortions?

If the BEIR is a biased measure of inflation expectations, it would be of greater use to policy-makers or investors if this bias could be estimated or removed. Alternatively, if the factors creating the bias are stable over time, then changes in the yield spread would reflect movements in long-run inflation expectations. Figure 3 shows the difference between the BEIR and the two measures of long-term inflation expectations as a proxy for the risk premiums in aggregate.[8] If survey expectations are the relevant benchmark, the differences should also capture any premium contained in the BEIR, and not just the inflation-risk premium.

Figure 3: Difference Between BEIR and Surveyed Expectations



The proxies for the aggregate of the risk premiums are positive before 1997 and negative between 1997 and 1999. Between 1999 and 2003, they are somewhat smaller and take different signs, which suggests that the risk premiums were close to zero, on average, over this period. These proxies suggest that the impact of these premiums and distortions can be sizeable and different premiums must be active at different times. For example, the large and positive differential between the BEIR and surveys before 1997 might be an inflation-risk premium, but even if this premium went to zero it could not explain the

8. Using the BEIR adjusted for the effect of the mismatched cash flows (described in section 6.1) does not change this picture significantly.

negative premium in the subsequent two years. In sections 6.1 to 6.5, we will use economic data and information available from financial markets to assess the likelihood that the differential between the BEIR and the surveys was due to risk premiums and distortions.

One important caveat is that the individual distortions in the BEIR measure may not be independent of inflation expectations or each other. For example, inflation uncertainty will rise with inflation expectations. Also, higher inflation uncertainty may cause a larger change in the BEIR than it would if market participants had the same aversion as the average person to inflation risk. The importance of interactions between the distortions and inflation expectations is a subject for future research. These interactions will complicate any attempt to estimate the impact of these distortions econometrically. We examine these distortions independently as a first step.

6.1 Mismatched cash flows

Extracting inflation expectations by comparing the RRB *ytm* to that of a nominal bond of the same maturity may lead to a biased measure. Even though both assets have the same maturity, there are differences between the patterns of their coupon payments (i.e., the duration and the convexity of each bond may differ greatly, exposing each bond to different discount factors). These differences will influence the yield spread between the securities for reasons unrelated to expected future inflation, and will introduce a bias when measuring inflation expectations. This bias will not be constant through time, because the size of the impact on the BEIR is a function of (i) the coupon and maturity of the real and nominal bonds, and (ii) the term structure of interest rates.[9]

Typically, payments on an RRB are more back-loaded than those of a standard nominal coupon bond. Expressed in real terms, the payments of the RRB are fixed, while those of the nominal security decline over its maturity as inflation erodes their real value. Since

9. In practice, the 30-year nominal bonds and RRB do not have the same maturity. Since the beginning of the RRB program, mismatches of up to six years have been observed. This will directly influence the impact of mismatched cash flows.

payments that arrive later in time are usually more heavily discounted, the RRB price will be lower, and therefore the BEIR will be narrower.

In a study of Treasury inflation-indexed securities (TIIS) in the United States, Sack (2000) compares two measures of inflation expectations: the standard BEIR (i.e., yield difference, as shown in equation (8)) and a measure that takes the slope of the yield curve and mismatched cash flows into account. He finds that adjusting for mismatched cash flows has only a modest impact on the BEIR. Those results, however, need not apply to the Canadian context, because in the United States inflation expectations are derived from 10-year bonds. In Canada, only RRBs that have a maturity of 30 years have been issued, which allows for greater mismatched cash flows.

Instead of comparing the *ytm* of the RRB with that of a nominal bond, we extract inflation expectations by comparing the *ytm* of the RRB with that of a synthetic nominal bond (created from a zero-coupon yield curve) that has exactly the same stream of cash flows as the RRB. Stated differently, by discounting the cash flows with a zero-coupon curve, we solve iteratively for the constant inflation expectation that is consistent with the observed price.[10]

Our methodology relies heavily on the quality of the zero-coupon yield curve. We use the Merrill Lynch exponential-spline methodology to extract the yield curve (Brenner et al. 2001), as calculated by Bolder, Johnson, and Metzler (forthcoming). In a recent study, Bolder and Gusba (2002) find this methodology to be the most accurate.

10. The RRB price data we use do not take into account all information regarding known past inflation. To get a daily or weekly RRB price, a CPI index ratio (the ratio of the current price level to the price level at the bond's issue date) of the same frequency is required. By convention, the CPI index ratio used to calculate the RRB price at the first of the month is the CPI from the third preceding month divided by the CPI at issuance. In subsequent trading days, the index ratio is calculated using linear interpolation from the third preceding month to the second preceding month to the CPI for the next month (which is already available). We adjust our measure to take this into account by using the latest CPI data when they become available.

Figure 4: The BEIR Adjusted for Mismatched Cash Flows

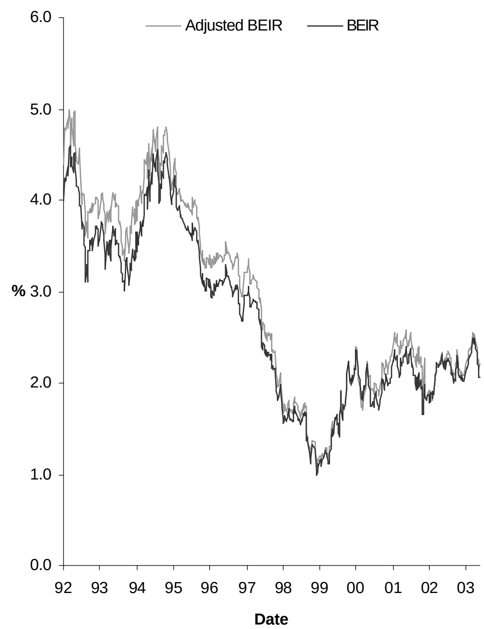


Figure 5: Impact of Cash Flow Mismatch on the BEIR

(BEIR - adjusted BEIR)

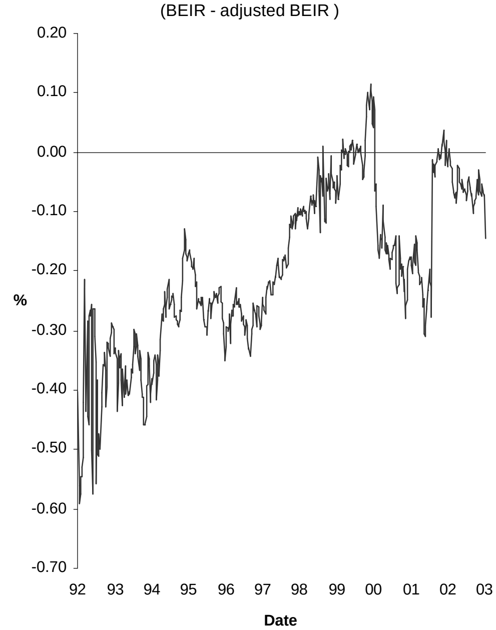


Figure 4 shows a weekly measure of the BEIR adjusted for mismatched cash flows (hereafter, the adjusted BEIR) versus the BEIR. Both measures are reasonably close throughout the period. From time to time, however, important differences occur. Figure 5 shows the difference between the two measures, which capture the bias introduced by mismatched cash flows. The average bias over the entire sample (January 1992 to May 2003) was 20 basis points (bps) (Table 2). In other words, inflation expectations computed from the standard measure would understate inflation expectations by 20 basis points, on average. Over a more recent period (January 1999 to May 2003), the average bias was 8 basis points.

Table 2: Inflation-Expectation Differences – Level and Variation

Sample		Average bias (bps)	Standard deviation	Min difference	Max difference	1st percentile	99th percentile
Jan 92 to	Level	-0.20	0.14	-0.59	0.12	-0.55	0.08
May 03	First difference	0.00	0.04	-0.24	0.31	-0.13	0.11
Jan 99 to	Level	-0.08	0.09	-0.31	0.12	-0.29	0.10
May 03	First difference	0.00	0.03	-0.14	0.26	-0.07	0.07

Figure 5 also shows that the difference between both measures is volatile and non-stationary. From January 1992 to May 2003, the standard deviation was 14 basis points and the minimum and maximum differences were -59 and 12 basis points, respectively. The maximum positive and negative weekly variations were 12 and -31 basis points (26 basis points and -14 basis points over the more recent period). This analysis suggests that changes in the BEIR may be due to the mismatched cash flows and not to changes in inflation expectations. These results differ strongly from those obtained by Sack (2000), who finds that the impact of mismatched cash flows for the U.S. BEIR is small, typically under 5 basis points, and much less volatile. Our results imply that Sack's conclusions do not apply to BEIRs that are calculated using bonds of longer maturities.

6.1.1 The impact of mismatched cash flows and the shape of the yield curve

The different cash-flow structures of the RRB and nominal bond result in the bonds having different durations and different *ytm* if the yield curve is not flat. The cash flows of an RRB are more back-loaded, leading to a higher modified duration.[11] We define modified duration as the exposure of a bond to real interest rate variation (modified duration = dp/dr).[12] Figure 6 plots the modified durations (measured in years) of the two bonds used to measure inflation expectations. Throughout the period, the nominal bond duration has increased and the duration difference has narrowed, mainly due to falling nominal rates. Figure 7 shows that the bias (the difference between the BEIR and the adjusted BEIR) is partly explained by duration variations. Particularly, large shifts in duration due to the issuance of new benchmark bonds have had an important impact on the BEIR. For example, in November 2001, a new RRB was introduced to the market, which increased the benchmark's duration by 1.9 years. This shift in duration led to a decline of 26 basis points in the measure of the bias. Therefore, the level and variation of the BEIR not only reflect inflation expectations, but also the different exposures of each bond to interest rate risk.

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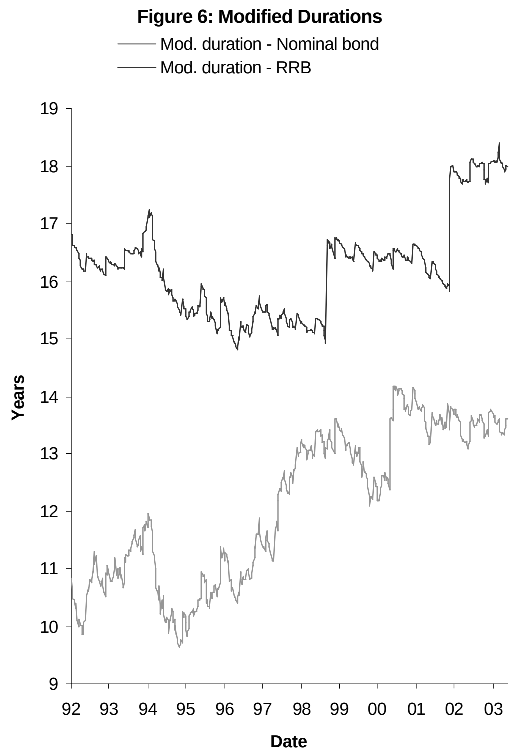
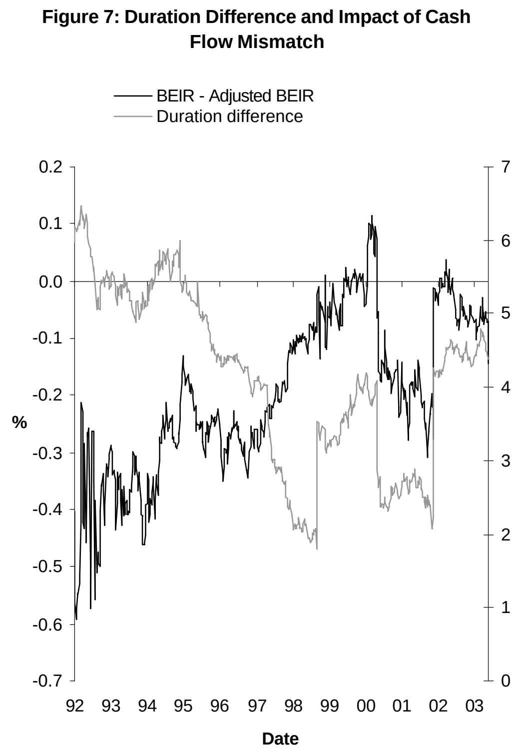
11. We use duration as a proxy for the cash-flow structure.
12. See Rudolph-Shabinsky and Trainer (1999) for more details on the duration of inflation-indexed securities.

The bias is also a function of the term structure. The BEIR is especially sensitive to the yields at the long end of the curves (the 20- to 30-year maturity range), given the long





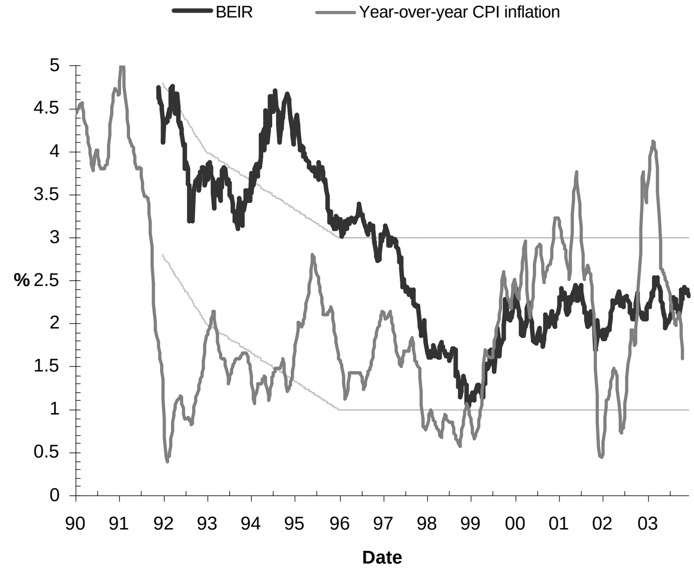
maturity of the component bonds. In October 1996, the yield curve was particularly steep, which caused the BEIR to understate inflation expectations by 31 basis points. In March 2000, it was relatively flat and inverted (i.e., 30-years *ytm*, significantly lower than the 20-years *ytm*), and inflation expectations were overstated by 10 basis points. This analysis suggests that the BEIR is relatively sensitive to the term structure, and that accounting for it will improve the measure of inflation expectations from RRBs.

6.2 The term structure of inflation expectations

Sack (2000) finds that the BEIR in the U.S. showed a surprising degree of responsiveness to the contemporaneous rate of CPI inflation between the beginning of 1997 and the end of 1999. This may have also been true in Canada, since the Canadian BEIR tracks Canadian CPI inflation much closer than surveyed expectations in this period

(Figure 8).[13] There is also evidence that the Canadian BEIR has explanatory power for 1-year-ahead inflation expectations in the post-1997 sample (IMF 2004).

Figure 8: The BEIR and Contemporaneous Inflation



In this section, we consider the extent to which current CPI can affect the BEIR even when longer-term inflation expectations are unchanged. This can occur because the current CPI helps form short-term inflation expectations. Recall that, because of the coupon structure of the component bonds, the BEIR will be more sensitive to short-term inflation expectations than to longer-term expectations. In other words, because of the coupon structure, the nominal *ytm* of an RRB will be a function of the inflation path. An expected temporary increase in inflation tomorrow raises the expected coupon payments over the entire life of the bond, whereas an equal increase in inflation expectations one year before maturity increases only the final two coupon payments. In each case, the impact on the actual average rate of inflation over the period to maturity is identical, but investors are willing to pay more nominal dollars for RRBs in the first case. Similarly, the nominal *ytm* of nominal bonds is a function of the overall zero-coupon curve (see the appendix for the derivation). Therefore, when the term structure of inflation expectations is not constant, a bias is introduced into the BEIR, and this bias is biggest when short-term inflation changes.

To measure the sensitivity of the BEIR to the inflation-expectations term structure, we solve equation (4) using a flat real-yield curve (and a consistent nominal curve computed using the Fisher relationship) and a variety of inflation paths consistent with differing

13. Figure 8 shows CPI inflation excluding the impact of changes in indirect taxes.

short-term and long-term inflation expectations.[14,15] This gives the net present value of the RRB in each case. Next, we put that price, along with the fixed coupon rate, into equation (6), to get the real *ytm* consistent with our hypothetical profiles of beliefs about future inflation. We then calculate the spread between the real *ytm* and a *ytm* for a nominal bond to obtain our measure of inflation expectations.

The sensitivity analysis reported in Table 3 shows the BEIR that would be obtained under different levels of short-term inflation expectations that last for varying lengths of time before returning to the inflation target. For example, if inflation is expected to be 3.0 per cent for the next six months and 2.0 per cent for the remainder of the 30 years to maturity, we should observe a BEIR of 2.03 per cent. But if we assume that inflation is going to be 5 per cent for six months, then a consistent BEIR would be 2.08 per cent. In general, the difference is less between the BEIR and long-term inflation forward rates (2.0 per cent in this example) when the credibility of the targeting regime is high, since shocks to inflation become less persistent. This may be one reason for the reduced volatility of the BEIR shown in Table 1.

Table 3: The BEIR under Different Inflation Term Structures

BEIR (left) **and average inflation** (right)

Interim period of high expected inflation before returning to the target (2%)	**3% expected inflation for interim period**		**4% expected inflation for interim period**		**5% expected inflation for interim period**		**10% expected inflation for interim period**	
6 months	2.03%	2.02%	2.05%	2.03%	2.08%	2.05%	2.21%	2.13%
1 year	2.05%	2.03%	2.11%	2.07%	2.16%	2.10%	2.42%	2.26%
2 years	2.10%	2.07%	2.21%	2.13%	2.31%	2.20%	2.83%	2.51%
5 years	2.25%	2.17%	2.50%	2.33%	2.76%	2.49%	4.05%	3.29%
7 years	2.34%	2.23%	2.69%	2.46%	3.03%	2.69%	4.83%	3.81%
10 years	2.47%	2.33%	2.94%	2.66%	3.42%	2.99%	5.94%	4.60%
15 years	2.65%	2.50%	3.30%	3.00%	3.97%	3.49%	7.52%	5.92%
30 years	3.00%	3.00%	4.00%	4.00%	5.00%	5.00%	10.00%	10.00%

Table 3 also provides the average inflation rate for the 30-year horizon, assuming that the path of inflation is exactly as was expected. The BEIR will overstate average inflation

14. We do not need a new yield curve for each inflation path, since we are trying to find paths that are consistent with observed nominal interest rates.
15. The computed BEIRs in Tables 3 and 4 assume a 30-year maturity with a 5.75 per cent semi-annual coupon rate nominal bond and a 30-year maturity with a 4.00 per cent semi-annual coupon RRB. These coupon rates are similar to recent benchmarks.

expectations when short-term expectations are higher than those for the longer term (i.e., the term structure of inflation expectations is downward sloping). For example, if inflation is expected to be 5 per cent for the next 10 years and 2 per cent for the subsequent 20 years, the BEIR would be 3.42 per cent, even though actual average inflation expectations over 30 years are 2.99 per cent.

Table 4 shows the impact (in basis points) on the BEIR of a 1 per cent increase in inflation expectations for a six-month period with different starting dates. A 1 per cent shock to inflation that lasts six months will increase the average actual inflation by 1.7 basis points, regardless of when it happens. If expected inflation over the first six months rises by 1.0 per cent, however, the BEIR will increase by 2.8 basis points. If, instead, the inflation rate expected over the last six months before maturity rises by 1.0 per cent, the BEIR will change by only 0.8 basis points.

Table 4: Impact of Forward Inflation-Expectations Shock

BEIR (left) **and average inflation** (right)

6 months 1% inflation shock (bps)	**bps**	
0 to 6 months	2.7	1.7
6 to 12 months	2.6	1.7
18 months to 2 years	2.6	1.7
4.5 to 5 years	2.3	1.7
6.5 to 7 years	2.2	1.7
9.5 to 10 years	2.0	1.7
14.5 to 15 years	1.6	1.7
29.5 to 30 years	0.8	1.7

To assess the possible impact, we need to investigate the extent to which inflation expectations with different horizons can diverge. The experience of countries with index-linked bonds of different maturities suggests that expectations over different horizons do diverge. Figure 2 shows that survey measures for different horizons also differ. Typical divergences, however, are insufficient to create a significant bias in the measure of average inflation expectations. We estimate that the typical bias will not be bigger than 3 to 4 basis points. Nonetheless, this effect adds volatility to the measure of inflation expectations, because it increases the sensitivity of the BEIR to short-term inflation expectations. Furthermore, the bias will most likely be at its maximum (approximately 10 basis points) at critical times, perhaps following a large relative price shock, when monetary authorities will be looking for evidence that the bias is feeding into inflation expectations.

The simultaneous decline in the BEIR and contemporaneous CPI inflation in the 1997–98 period is probably not due to bias from term-varying inflation expectations. An alternative argument is that this period was characterized by a large shift in the liquidity premium that happened at the same time as the drop in inflation. Large subsequent fluctuations in inflation were not matched by large movements in the BEIR. We explore this hypothesis in section 6.4.

6.3 Inflation-risk premium

Little empirical work has been done on the existence of an inflation-uncertainty premium in nominal yields and its importance for the level of changes in the BEIR. The existing work often uses the difference between variants of the BEIR and survey measures of expected inflation as a proxy for the inflation-uncertainty premium, despite the possibility that it includes other distortions. Evans (1998) finds a positive and significant correlation between the level of his U.K. BEIR and this proxy, providing evidence for a time-varying inflation-uncertainty premium.[16] In a study of index-linked bonds in Israel, Kandel, Ofer, and Sarig (1996) regress this proxy on another measure of inflation uncertainty—lags of the monthly dispersion of relative prices in a consumer price index—and find a positive and significant relationship.[17] The relationship is not significant in a low-inflation subsample. Both Evans (1998) and Kandel, Ofer, and Sarig (1996) consider BEIRs that have much shorter horizons than the ones in our work. Côté et al. (1996) use similar reasoning in their analysis of the Canadian BEIR, arguing that its rise in 1994, when other survey measures of long-run inflation expectations were flat or declining, suggests that the inflation-risk premium was rising. Campbell and Shiller (1996) use a capital-asset-pricing model to estimate the inflation-risk premium in the United States and find it to be between 50 and 100 basis points.

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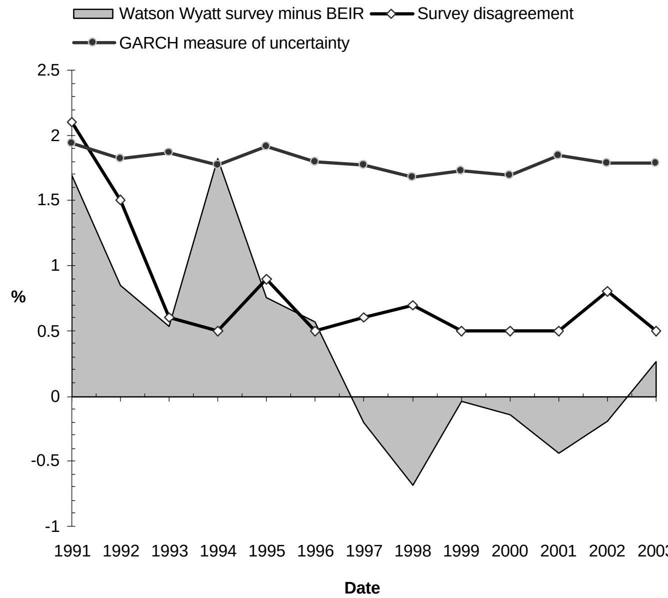
16. Evans argues that this is not due to forecast errors in the survey measure, because he obtains similar results when the left-hand-side variable is the difference between the interest rate measure and realized inflation.
17. Kandel, Ofer, and Sarig justify this proxy with the following example: in a given month, investors do not transact in all goods included in the CPI basket, so they are likely to get a less-accurate picture of inflation when relative price variability is high. For this reason, if the most recent CPI release shows a large degree of relative price dispersion, investors will be more uncertain about their current views on inflation.

Figure 9 shows two measures of long-run inflation uncertainty. The first is a measure of the disagreement among the forecasters who responded to the Watson Wyatt survey, calculated as the difference between the upper and lower quartiles of reported inflation expectations.[18] The second is a measure of inflation uncertainty over a 5-year forecast horizon derived from a generalized autoregressive conditional heteroscedasticity (GARCH) model developed by Crawford and Kasumovich (1996).[19]

Figure 9: BEIR/Survey Difference and Inflation Uncertainty



Both measures of inflation uncertainty fail to indicate a rise in inflation uncertainty in 1994, or an important decline in 1997. Crawford and Kasumovich's measure of inflation uncertainty fell dramatically during the 1980s, but has been relatively stable since 1992. If inflation uncertainty has changed little, it cannot be driving the movement of the BEIR. Survey disagreement fell between 1991 and 1994. It also fluctuated to a greater degree than the GARCH measure, but not during the 1994 or 1997 periods, when the BEIR was moving in the opposite direction from the survey measures. In addition, although the timing varies, more forward-looking Markov regime-switching models of inflation uncertainty show a similar trend over the 1980s and 1990s (e.g., Demers 2003). Based on this evidence, the deviations of the BEIR from survey measures of inflation expectations do not appear to result from changing inflation uncertainty.

18. Giordani and Söderlind (2003) argue that disagreement on point forecasts from survey respondents has a high correlation with movements in more theoretically appealing measures of uncertainty.
19. Similar analyses were undertaken using long-term swaption implied volatilities as a proxy for long-term inflation uncertainties in the subsample 1997–2003. We were not able to identify any relationship.

The measures of inflation uncertainty are contrary to the explanation given by Côté et al. (1996) for the events in 1994. They argue that this rise in the BEIR was related to concerns about the ability of governments to deal with their rising debt in the context of increasing world interest rates. In this environment, investors saw an increased risk that government would resort to higher inflation to ease the costs of servicing government debt. This view would have been particularly relevant to investors in government bond markets, but perhaps it had little impact on the expectations or uncertainty of those outside the bond markets. Côté et al. also note that similar movements in the nominal–real interest rate spread in this period were observed in other countries with index-linked bonds.

6.4 Liquidity-risk premium

Investors may demand a higher yield on RRBs to compensate for the risk that they will not be able to sell them quickly or will have to sell at unfavourable prices. If this liquidity-risk premium is present, it should fall over time as more RRBs are issued and traded. Even then, however, this premium may rise during episodes when investors experience a heightened need for assets that are highly liquid. A dramatic deterioration in liquidity, if there was one, might explain the declining differential between the BEIR and survey measures of inflation expectations over the mid-1990s.

In fact, there has been an improvement in liquidity since the beginning of the RRB program. The stock of RRBs outstanding increased from $4.1 billion at the end of 1994 to $17.3 billion at the end of 2003, rising from 9 per cent to 26 per cent of federal government marketable debt with a maturity of 10 years or greater. The greater supply of debt should have improved liquidity, *ceteris paribus*.

The secondary market for RRBs is still much smaller than the market for nominal bonds in Canada. The average monthly RRB trading volume in 2003 was $1.6 billion, only slightly above the earlier peak of $1.5 billion in 1997, despite the increase in the outstanding stock of RRBs. Secondary market RRB turnover, the ratio of the volume traded to the stock outstanding, is less than one-fifth that of nominal bonds with a maturity of 10 years or more (Table 5). Moreover, the turnover ratio for RRBs has been relatively low since it peaked in 1997.

Table 5: Average Monthly Turnover

Volume traded/bonds outstanding, %	1994	1997	1998	2003
Nominal government bonds, maturity over 10 years	92	95	83	44
Real Return Bonds	15	18	10	8

There is some evidence for improved liquidity in secondary markets. The typical bid/ask spread on the benchmark RRB has fallen from around 15 cents before 1997 to about 10 cents in 2003. Bid/ask spreads in the RRB market have moved closer to those of the nominal 30-year benchmark bond. Market participants have stated that liquidity in the secondary market for RRBs has improved over time, but remains low compared with its nominal counterpart,[20] in part because RRB investors typically buy the security and hold it to maturity. This assertion is consistent with the observed low turnover. Accordingly, if most RRB investors are buy-and-hold types, the premium demanded for liquidity risk must be quite small. A declining liquidity penalty, however, should result in an increasing BEIR, *ceteris paribus*, so it cannot account for the decline in the BEIR in the post-1997 sample.

Nonetheless, the liquidity-risk premium may have risen significantly during periods of market turbulence; for example, in 1997–98, the Russian debt crisis and the collapse of Long-Term Capital Management increased investors' desire for liquid assets. One would expect the real yield to rise as investors demand a higher return to compensate for higher liquidity risk. The decline in the BEIR, however, is due largely to a drop in the nominal yield, rather than to a large increase in the real yield.[21] The falling BEIR may reflect a generalized flight by investors to more liquid securities from illiquid assets other than RRBs.

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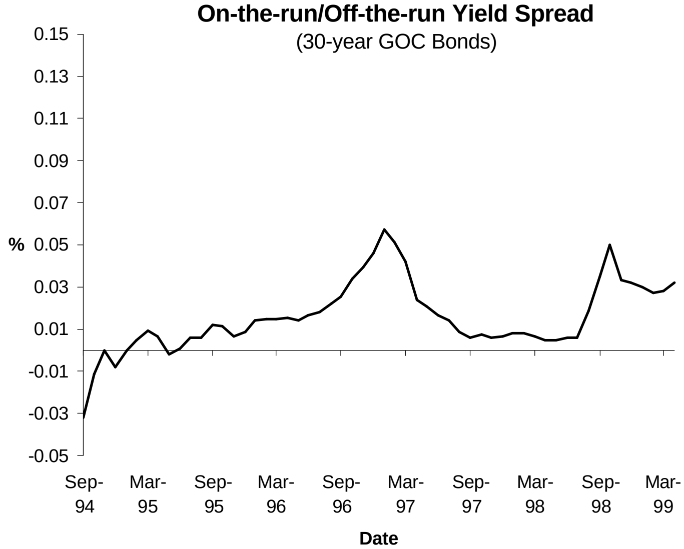
20. See the Bank of Canada's "2003 Market Consultations on Real Return Bonds," available at http://www.bankofcanada.ca/en/notices_fmd/market_consult03.htm.
21. It is also possible that the rising liquidity premium was offset by some other factor, such as a decline in the expected future real interest rates.

Shen and Corning (2001) use the yield spread between on-the-run and off-the-run conventional 10-year U.S. Treasuries as a proxy for the liquidity premium, since the only difference between these bonds is the lower liquidity of the off-the-run Treasury. Since Treasury inflation-indexed securities are even less liquid than the off-the-run Treasuries, this spread is considered a lower bound on the liquidity premium embedded in the TIPS. From this measure, Shen and Corning conclude that the liquidity premium in U.S. TIPS yields rose during the 1997–98 period.

We calculate a similar measure for Canada based on the 30-year nominal Government of Canada bond. In Canada, the off-the-run bond has a shorter maturity than the on-the-run bond by at least two years, which means that the proxy may be affected by movement in the long end of the yield curve to a greater degree than in the Shen and Corning measure. Since this proxy is only a lower bound, conclusions about the size of the premium are not possible. Though two peaks in this proxy occur in 1997 and the fall of 1998 (Figure 10), it is low for most of the 1997–98 period, providing further evidence that the liquidity-risk premium in RRBs is not the main reason for the low BEIR over this period.

Figure 10: Liquidity Measure
On-the-run/Off-the-run Yield Spread
(30-year GOC Bonds)



6.5 Market segmentation

Côté et al. (1996) suggest that demand for RRBs may be subject to a “clientele effect,” which means that a subset of investors who possess a stronger-than-average aversion to inflation uncertainty or higher inflation expectations have a disproportionate impact on RRB yields. In Canada, as in most countries, a large portion of RRBs are held by life insurance and pension funds, mainly because their liabilities rise with inflation and they are exempt from paying tax on the returns. This subset of investors would be willing to accept a lower real return than the average investor, or, alternatively, would be willing to pay more for inflation protection.

The pricing of RRBs should reflect the behaviour of only this subset of investors if RRBs are in short supply. This would occur if the supply and expected supply of RRBs and close substitutes were very inelastic.[22] As described, however, the "clientele effect" contrasts with theories on market efficiency. One might expect supply constraints in the short term (e.g., rigid government funding policies or lack of awareness of inflation-linked structures by corporations), but supply should adjust in the long run to take advantage of lower funding costs. As a result, the expected supply of RRBs should not be inelastic.

Mayer (1998) provides a hypothetical example to illustrate the clientele effect. He argues that, in an economy where 5 per cent of the debt is linked to inflation, the supply of indexed-linked debt is fixed, and no substitutes exist, the BEIR should reflect the views of the 5 per cent of investors with the highest inflation expectations. Using the available data from Watson Wyatt, we plot in Figure 11 the surveyed maximum and upper quartile cut-off of inflation expectations, and the BEIR. Until 1996, the BEIR is usually inside the upper quartile of inflation expectations, and subsequently it falls below this range.

Figure 11: The BEIR and Top Quartile of Surveyed Inflation Expectations

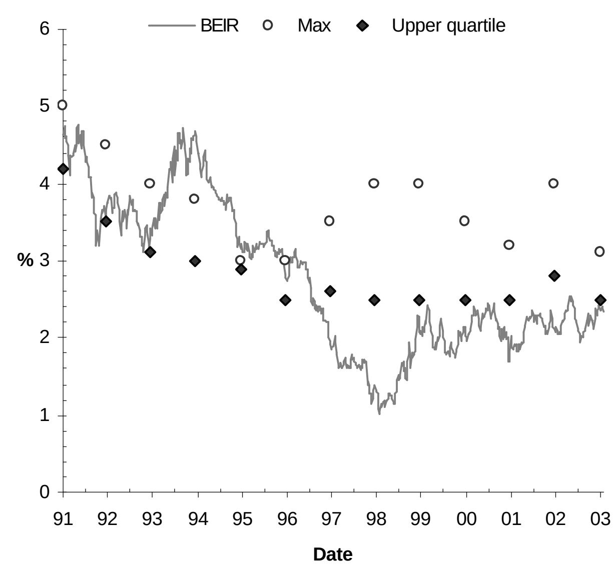


Figure 11 is consistent with the existence of a clientele-effect distortion in the RRB market in its early years (1991–96). In 1991, Canada became the only supplier of inflation-linked securities in North America. Also, it is unlikely that investors expected a strong increase

22. Many have argued that a well-diversified equity portfolio or short-term fixed-income securities offer inflation protection (for example, see Campbell and Shiller 1996).

in supply, because the Canadian RRB program was expected to grow slowly. Consistent with the expected tight supply, the BEIR at that time may have reflected the views of investors who had higher-than-average inflation forecasts or an aversion to inflation uncertainty. It is interesting that the break in the relationship between the BEIR and the upper quartile diminished in 1996, when the United States announced the launch of the TIPS program. Not only did TIPS provide a better global supply and expected supply through government issuance, it may have raised expectations about the development of a market for corporate inflation-linked securities and led to more interest in, or acceptance of, Canadian RRBs.

As the inflation-linked security market matures, the clientele effect should diminish. An increased awareness among investors and issuers, and developments in other countries, such as the emergence of the U.S. CPI futures market, suggest that the RRB market will continue to develop.

7. Inflation Expectations

In the previous sections, we discussed the evidence for risk premiums and distortions in the BEIR. If premiums and distortions are unable to account for the movements in the BEIR over history, there is a higher probability that it reflected long-term inflation expectations. If the BEIR’s movements reflect either inflation expectations or the inflation-risk premium, then it should be a good indicator of the credibility of monetary policy. Of course, our conclusions can only be as strong as our ability to identify the risk premiums and distortions.

Over the 1990s, it is likely that most of these premiums and distortions were present in some form. The mismatched cash flows of the two component bonds of the BEIR had an important effect on the BEIR, especially in the early to mid-1990s. Correcting for this bias, however, increases the divergence between the BEIR and survey measures of inflation expectations. The impact of term-varying inflation expectations is too small to explain the swings in the BEIR. Given the inferior liquidity of the RRB market relative to that for nominal bonds, we would expect that a liquidity premium was embedded in the BEIR. If a liquidity premium did exist, it was dominated by other distortions until the 1997–98 period. From 1997–98, heightened investor demand for liquid assets may have lowered conventional bond yields, reducing the BEIR even if it had only minor effects on RRB yields. A measure of the survey disagreement provides some evidence that the inflation-uncertainty premium was still falling until about 1993, but this decline is too early to explain the decline in the BEIR. The small and segmented RRB market meant that the marginal RRB investor was willing to accept a lower real yield than typical investors in other markets, possibly due to their higher inflation expectations, greater inflation risk aversion, or special tax status. Although other factors are present, this is a leading candidate to explain much of the divergence between the BEIR and surveys until 1997.

Given these findings, there is reason to doubt that the BEIR was a good measure of credibility before 1997. It may have indicated the inflation expectations, inflation risk, and risk aversion of a set of market participants who had more extreme views than most other people. If their changing views differed from the average investor in magnitude, but not direction, the BEIR might have been a useful warning signal that a more generalized change in credibility was likely.

It seems implausible that changes in long-run inflation expectations were consistent with movements in the BEIR in 1994. At that time, the consensus on the 6- to 10-years-ahead inflation expectations rose slightly, but the 4- to 14-year survey measures did not. Since the upper quartile of the 4- to 14-year survey fell slightly, the rise in the BEIR at that time was probably not due to higher long-term inflation expectations among those with more extreme views (Figure 11). We are unable to provide any evidence to support Côté et al.'s report of an increase in the inflation-risk premium in 1994, although a large body of empirical research argues that it would rise with inflation expectations.

In 1998, declines in the long-run expectations are more plausible. The BEIR fell below target in a context of heightened investor demand for liquidity, but we have found little evidence to explain the persistence of this effect. Since it is not easily identified by a persistent increase in the real yield, it is possible that long-term inflation expectations also dropped at the time. A decline in long-run inflation expectations is consistent with the sharp tightening of monetary policy in the fall of 1998, because the average annual inflation rate (CPI excluding taxes) over the previous six years had been below target

(1.5 per cent). If this decline was partly because of lower long-term inflation expectations, it was not enough to suggest a serious deterioration in credibility, since the BEIR remained within the target bands.

Over the four years from 2000 to 2003, survey measures of inflation expectations were relatively stable and near 2.0 per cent. Over the same period, the mean of the BEIR was 2.2 per cent, and 95 per cent of the time it was between 1.8 and 2.6 per cent. If surveys are an appropriate benchmark, this suggests that, in total, the premiums were small relative to the past and the BEIR better reflected the expected average rate of inflation over the subsequent 30 years.

The variability of the BEIR has fallen over the sample, but from week to week it is not uncommon to see changes of up to 17 basis points in either direction. This volatility seems contrary to the widely held view that long-term inflation expectations are relatively stable. Though the premiums and distortions that we have identified are likely much smaller today than in the early 1990s, we cannot say that they are zero in any given short period. In fact, the BEIR has risen above the survey measures again in 2004, raising questions about our ability to interpret its movements (Reid, Dion, and Christensen 2004). Since short-term distortions may still occur, it is prudent to look at trends in the BEIR over a longer period.

Although we have examined the premiums and distortions that are most prevalent in the literature, it is possible that other factors will at times influence the BEIR. Recently, some observers have argued that a re-evaluation of equity risk after the sharp declines in equity markets is driving strong demand for alternative means to hedge against inflation and increase portfolio diversification.[23] This search for alternative inflation hedges may have increased investor demand for RRBs. Because of the relatively fixed short-run supply of index-linked debt, this demand could drive the real yield on RRBs temporarily below the long-run expected real interest rate, thereby raising the BEIR.

23. See the Bank of Canada's "2003 Market Consultations on Real Return Bonds," available at http://www.bankofcanada.ca/en/notices_fmd/market_consult03.htm.

8. Forecasting Power

If the BEIR is able to forecast average rates of inflation over the subsequent 30 years, its value as an indicator of inflation would be clear. It would also suggest that the premiums discussed above are of little practical importance. If its forecast performance is poor, however, it is less clear what conclusion could be drawn. A measure that accurately captures inflation expectations could forecast poorly simply because people are bad long-run forecasters, or because long-run forecasts are particularly difficult to do. Indeed, measures of inflation expectations may be poor at forecasting, since policy may react to the expectations themselves. It may be more relevant to know what financial market participants expect than whether they are correct, since their expectations have an impact on today's long-term interest rates (Hetzel 1992).

The relatively short span of the data does not permit us to compare the level of the BEIR with the average rate of inflation over the subsequent 30 years.[24] There is some evidence from the United Kingdom, where inflation-linked government bonds at various maturities have existed for more than 20 years, that interest rate measures are useful to forecast inflation at short horizons. Scholtes (2002) finds that the forecast accuracy of break-even inflation forward rates, constructed using index-linked gilts with a 2-year maturity, is better than that of survey measures of inflation expectations. Earlier work by Breedon and Chadha (1997) suggests that inflation forecasts derived from the real and nominal term structure of interest rates are at least as good at forecasting future changes in inflation as macroeconomic models. Barr and Campbell (1997) find that measures of inflation expectations calculated from the U.K. government's nominal and indexed debt forecast inflation more accurately than do nominal yields at the 1-year horizon.

The BEIR should be influenced by inflation expectations over many different horizons, and we are also interested in determining whether the BEIR contains useful information about inflation (CPI excluding taxes and core inflation) over a policy-relevant horizon. Instead of assessing the forecast performance of the BEIR for long-term inflation, we

24. This is partly because the government issuance of RRBs is relatively recent, but also because these securities have long maturities and therefore require a long time series to rigorously assess the BEIR's forecasting properties.

examine the forecast performance for short- and medium-term inflation relative to other measures of inflation expectations. In particular, we examine a 6-months-ahead forecast from the Conference Board of Canada's *Business Confidence Survey* (quarterly); the 2-years-ahead consensus forecast for the Conference Board's *Survey of Forecasters* (quarterly); and the 6- to 10-years-ahead expected average inflation rate from Consensus Economics (semi-annual).[25] We also include the forecast performance of simple averages of past inflation, for comparison. Tables 6 and 7 compare the forecast accuracy of various indicators for realized year-over-year inflation rate one, two, and three years ahead.

As Table 6 shows, the BEIR has the worst forecast performance for CPI excluding taxes in terms of root mean squared errors (RMSEs). Over all horizons, survey measures and even backward-looking past average inflation rates have lower RMSEs than the BEIR. The volatility in the BEIR caused by premiums and distortions that were active in the first part of the sample is one potential explanation for its poor near-term forecast performance. The 6- to 10-year survey expectations are a long-run measure, however, and they have a much better forecast performance, with RMSEs that are roughly half as large as those of the BEIR. This survey measure of long-term inflation was much closer to the inflation target for the whole sample. The best forecast performance over all forecast horizons comes from the expectations surveys. Surprisingly, there is little difference in forecast performance between surveys of short-term inflation expectations and those for the long term, even at the 1-year horizon.

If we calculate RMSEs using only the latter half of the sample, a different picture emerges. The BEIR's forecast performance improves substantially from an RMSE of about 1.8 percentage points at the 2-year horizon to 1.2 percentage points. Over this sample, it has lower RMSEs than the backward-looking measures of inflation expectations and performs similarly to the survey measures. In contrast, the forecast performance of the medium- and long-term survey measures does not improve in the

25. We did not use the 4- to 14-year forecast conducted by Watson Wyatt, because of insufficient data.

Table 6: RMSEs of the BEIR and Other Measures of Inflation Expectations for Total CPI Inflation, Excluding Taxes

	Forecast horizon					
	1 year	2 years	3 years	1 year	2 years	3 years
	Sample starting 1992			Sample starting 1998		
BEIR						
BEIR	1.67	1.82	1.80	1.02	1.15	0.97
Naïve measures						
Inflation over the past 12 months	1.16	1.07	1.06	1.46	1.40	1.27
Inflation over the past 24 months	1.01	1.00	1.02	1.24	1.23	1.23
Inflation over the past 36 months	0.97	0.98	1.08	1.12	1.17	1.28
Survey measures						
6 months ahead	0.85	0.84	0.79	1.02	1.10	0.94
2 years ahead	0.86	0.92	0.90	0.93	1.10	1.00
6-10 years ahead	0.85	0.86	0.94	0.79	-	-

Table 7: RMSEs of the BEIR and Other Measures of Inflation Expectations for Core Inflation

	Forecast horizon					
	1 year	2 years	3 years	1 year	2 years	3 years
	Sample starting 1992			Sample starting 1998		
BEIR						
BEIR	1.28	1.48	1.64	0.45	0.48	0.62
Naïve measures						
Inflation over the past 12 months	0.54	0.61	0.75	0.56	0.74	0.95
Inflation over the past 24 months	0.51	0.65	0.73	0.60	0.78	0.91
Inflation over the past 36 months	0.57	0.68	0.76	0.63	0.77	0.83
Survey measures						
6 months ahead	0.50	0.41	0.51	0.58	0.43	0.53
2 years ahead	0.45	0.47	0.58	0.48	0.42	0.57
6-10 years ahead	0.47	0.57	0.63	0.46	-	-

latter subsample. The improved performance of the BEIR may indicate that inflation expectations over a very long horizon have become more tightly linked to the inflation targets (and therefore to realized inflation) over the past few years. Enhanced policy credibility manifested in a lower, and less volatile, inflation-risk premium may explain why the BEIR's forecast performance has improved and why the performance of the survey measures has not. This is equally consistent, however, with the reduced impact of the risk premiums and other distortions in the BEIR measure. Nonetheless, in light of our earlier findings, the relatively good forecast performance of the BEIR in the second half of the sample should not be due to an oversensitivity to short-term inflation expectations.

Table 7 shows that the results are similar when we compare the forecast performance for core inflation. All measures of expectations show better forecast performance for core inflation, but the improvement for the BEIR in the recent subsample is even more pronounced.

The results for the full sample suggest that survey measures provide the most useful information about short- and medium-term inflation expectations. This is actually reassuring, in that it shows the BEIR does not simply reflect changes in short-run inflation expectations. This study has also shown that the near-term forecast performance of the BEIR can change substantially. This possibility may be due to the presence of a time-varying inflation-risk premium (and other distortions) in the BEIR, which is a disadvantage from the perspective of inflation forecasting.

9. Conclusions and Suggestions for Future Research

We have assessed the merit of the gap between the nominal and real interest rates as a measure of long-term inflation expectations. The difference between the BEIR and various survey measures of expectations has provided evidence that risk premiums and distortions have been important in many periods over the 12-year history of this measure. This finding is consistent with international evidence.

Other evidence suggests that the size and importance of the various premiums have changed over time. We directly accounted for the impact of mismatched cash flows on the BEIR. We also assessed the importance of term-varying inflation expectations. Neither of these factors could account for the differences between the BEIR and survey data. We also examined whether changes in proxies for the liquidity and inflation-risk premiums are associated with changes in the BEIR. These proxies suggested that the premiums did change over the sample, but the timing of the changes did not coincide with swings in the BEIR. We have argued, however, that the segmentation of the RRB market was an important reason why the BEIR was higher than survey measures from 1992 to 1997. Many of the premiums were important before 1997, but over the period from 2000Q1 to 2003Q4 they were small (or offsetting), on average, and less variable, suggesting that the BEIR holds promise as a measure of inflation expectations.

Our approach is based on the theory that information from other sources is useful when deciding whether a given change in the BEIR is due to inflation expectations or some other factor. To the extent that this approach is successful, the BEIR will be a useful measure of monetary policy credibility. Our conclusions based on the period to the end of 2003 are already being tested in 2004, with the BEIR reaching a level of 3.0 per cent, the top of Canada's inflation-target band, while survey measures of long-term inflation remain close to 2 per cent. Some of the distortions we have investigated are unlikely to be present, but the reason the BEIR reached this level remains an open question (Reid, Dion, and Christensen 2004). Bond market participants may be less convinced that inflation will stay near 2.0 per cent in the long run, but to get the BEIR even to 2.8 per cent, expectations would have to be 3 per cent for more than 15 years. There is little other evidence to suggest that this has happened. Alternatively, distortions related to the size of the RRB market, or some other factor that we have not investigated, may have (re-)emerged. This episode illustrates that using index-linked bonds to extract inflation expectations from nominal yields remains a challenge. The potential distortions, the possibility that they may change over time, and the difficulty in quantifying them mean that the BEIR should not be given a lot of weight as a measure of monetary policy credibility at this time.

With further research in this area and the continuing development of the RRB market, some of the distortions will diminish and others may be better quantified. In the future, the BEIR could become better suited as a gauge of the credibility of monetary policy. It is not, however, as useful as competing tools for short- and medium-term inflation forecasting. In addition, week-to-week variation in the BEIR can still be substantial, suggesting a focus on more long-term trends of this measure.

There are a couple of avenues for future research. We have not analyzed the real yield calculated from the RRB price on its own. To the extent that it looks and behaves like a real ex ante interest rate, there should be less concern about the impact of market segmentation on the BEIR. Evidence from the United States suggests that this real yield might be a useful measure of the equilibrium real interest rate (Bomfim 2001). If a measure of the interest rate gap based on the RRB yield is a good measure of the policy stance in Canada, it will provide more evidence that it is capturing the expected long-run real interest rate, rather than reflecting the views of a non-representative subset of investors. Such results would lend support to using the RRB yield in the calculation of the BEIR. In addition, examining the response of the real and nominal yields to surprise macroeconomic and monetary news, as in Gurkaynak, Sack, and Swanson (2003), may provide evidence that these yields contain the information we think they do.

This research has put a good deal of faith in surveys of long-run inflation expectations, using them as the benchmark for comparison. An avenue for future research would be to model explicitly the formation of inflation expectations and compare the model's forecasts with the BEIR and survey measures. A comparison with other financial market-based measures of inflation expectations, such as nominal yields on government bonds on their own, would also be useful.

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Appendix: Why Is the Inflation-Expectation Term Structure Important?

Because the BEIR is computed from coupon-paying bonds, the increase in a particular forward inflation rate will not impact the BEIR by the same amount as it will affect the average inflation over the period ending at the bond maturity.

Essentially, this is similar to comparing the impact of an increase in a forward rate on the *ytm* of a nominal coupon bond versus the impact on a zero bond *ytm* with the same maturity.

In equation (A1), we rewrite equation (4) using a forward 1-year inflation rate (f), where $p_t^n = \left[\Pi_{m=1}^{n}(1+j\ )^{m}\right]^{1/n} - 1$:

$$RRB_t = \sum_{n=1}^{N} \frac{c \cdot 100 \cdot \Pi_{m=1}^{n}\left(1+j_{\ m,t}\right)}{\left(1+i_{n,t}\right)^n} + \frac{100 \cdot \Pi_{m=1}^{N}\left(1+j_{\ m,t}\right)}{\left(1+i_{N,t}\right)^N}. \qquad \text{(A1)}$$

In equation (A2), we derive the RRB price with respect to the 1-year forward inflation rate. From this equation, it is clear that the 1-year forward inflation rate will have a different impact on the RRB price, depending on the date of the shock:

$$\frac{\partial RRB_t}{\partial j_{\ p}} = \sum_{n=p}^{N} \frac{c \cdot 100 \cdot \left[\Pi_{m=1,m\neq p}^{n}\left(1+j_{\ m,t}\right)\right]}{\left(1+i_{n,t}\right)^n} + \frac{100 \cdot \left[\Pi_{m=1,m\neq p}^{N}\left(1+j_{\ m,t}\right)\right]}{\left(1+i_{N,t}\right)^N}. \qquad \text{(A2)}$$

Also from equation (A2), we can see that an earlier inflation shock will have a larger impact, since it will positively influence all subsequent coupons. Because of the coupon structure of the bond, we obtain:

$$\frac{\partial RRB_t}{\partial j_{\ p}} - \frac{\partial RRB_t}{\partial j_{\ p+1}} = \sum_{n=p}^{N} \frac{c \cdot 100 \cdot \left[\Pi_{m=1,m\neq p}^{n}\left(1+j_{\ m,t}\right)\right]}{\left(1+i_{n,t}\right)^n} - \sum_{n=p+1}^{N} \frac{c \cdot 100 \cdot \left[\Pi_{m=1,m\neq p}^{n}\left(1+j_{\ m,t}\right)\right]}{\left(1+i_{n,t}\right)^n}, \qquad \text{(A3)}$$

$$\frac{\partial RRB_t}{\partial j_{\ p}} \succ \frac{\partial RRB_t}{\partial j_{\ p+1}}. \qquad \text{(A4)}$$

Furthermore, the bigger the coupon is, the larger the impact on the BEIR of a non-stable inflation rate:

$$\frac{\partial RRB_t}{\partial j_p \partial c} - \frac{\partial RRB_t}{\partial j_{p+1} \partial c} = \sum_{n=p}^{N} \frac{100 \cdot \left[\Pi_{m=1, m \neq p}^{n} \left(1 + j_{m,t}\right)\right]}{\left(1 + i_{n,t}\right)^n} - \sum_{n=p+1}^{N} \frac{100 \cdot \left[\Pi_{m=1, m \neq p}^{n} \left(1 + j_{m,t}\right)\right]}{\left(1 + i_{n,t}\right)^n}, \tag{A5}$$

$$\frac{\partial RRB_t}{\partial j_p \partial c} \succ \frac{\partial RRB_t}{\partial j_{p+1} \partial c}. \tag{A6}$$

Therefore, the larger the coupon is, the larger the bias on the measure of average inflation expectations.

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