Conditional Indexation Bias in Yields Reported on Inflation-Indexed Securities with Special Reference to UDIBONOS and TIPS

George M. von Furstenberg and Michael T. Gapen*

Abstract: The real rate of return on inflation-indexed government securities is calculated and published as if indexation succeeded perfectly in keeping the real value of coupon and principal payments unchanged. In fact the procedure of indexing to the lagged momentum of the seasonally unadjusted CPI gives rise to three types of indexation bias that may change the expected real value of the future stream of payments in relation to the current par value. These biases are due to *i)* seasonality, *ii)* non-seasonal fluctuations in reported inflation rates, and *iii)* any expected "permanent" changes in future rates of inflation (or the reporting thereof) being capable of creating predictable changes in the real value of the inflation-adjusted principal with the indexation procedure actually in force. They are one more, directly quantifiable, reason why the reported yields do not provide the long-sought definite revelation of the riskless real rate of interest and hence of the expected rate of inflation by comparison with nominal interest rates.

Resumen: La tasa real de retorno de valores gubernamentales indexados a la inflación se calcula y publica como si la indexación mantuviera perfectamente el valor real del pago del cupón y principal. El método de indexación al rezago del IPC no ajustado por estacionalidad genera tres tipos de sesgo, que pueden cambiar el valor real esperado del flujo futuro de pagos en relación con el valor actual "a la par". Esto se debe a *i)* la estacionalidad, *ii)* las fluctuaciones no estacionales en tasas de inflación reportadas, y *iii)* cualquier cambio "permanente" esperado en tasas de inflación futuras que pueda crear cambios predecibles en el valor real del principal, ajustado por inflación por el procedimiento en curso de indexación. Éstas son una

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razón más, directamente cuantificable, por la cual los retornos reportados no dan la buscada revelación de largo plazo de la tasa de interés real libre de riesgo, y por lo tanto de la tasa esperada de inflación en comparación con las tasas de interés nominal.

1. Motivation

In theory, the concept of the real rate of return appears simple enough in continuous time and even in discrete time: Given a price index, P*, that is perfect for the agent's purpose (*e.g.*, for long-term accumulation of purchasing power) and final in the sense of not ever being subject to revision, all that needs to be done is to divide the gross nominal return from period t to t + j by $(P_{t+j}/P_t)^*$. If the gross nominal rate of return is fixed, as it might be on a risk-free standard debt contract, the real rate of return on the face value of that contract would fluctuate inversely with the inflation rate. When dealing with a contract with a fixed *real* rather than *nominal* coupon rate, we could turn this procedure around and determine the corresponding gross nominal rate by multiplying the fixed gross real rate by $(P_{t+j}/P_t)^*$, still assuming, of course, that the correct price indexes are available with finality and without lags. The gross nominal rate of return would then fluctuate directly and precisely with the gross inflation rate to keep the real rate of return on the original investment and its inflation-adjusted par value constant as promised.

In actuality, there is a trade-off between the finality and suitability of price indexes. In addition such indexes, even if never revised, are published only with a lag of k weeks or months. Then, instead of multiplying by the ideal, instantly revealed, price ratio envisioned in theory, the actual multiplication is by P_{t+j-k}/P_{t-k}, where P is a seasonally unadjusted price index that is final but conceptually, and not just statistically, imperfect for the purpose on hand.

It turns out, therefore, that the inflation-indexed security — which is billed as providing a real coupon rate of return that is fixed — is, in fact, providing a rate that is variable in relation to a more perfectly indexed principal. The reason is that the indexation actually applied is predictably imperfect to the extent some of the differences between P_{t+j-k}/P_{t-k} and $(P_{t+j}/P_t)^*$ can already be anticipated at time t + j. Then it would be inaccurate to attribute fluctuations in the market price of this security relative to its imperfectly indexed par value as fully revealing changes in the real rate of return required in its market.

Because changes in the required real rate of return are crucial to much of economic analysis — say, of the near-term impact of monetary policy, or of supply shocks, or of innovations in future income and profit expectations — an accurate measure and open signal of these changes is desirable. This paper suggests that, without considerable effort at making necessary adjustments, changes in the real yield reported on inflation-indexed securities do not provide the desired conclusive identification. In particular, the longer the indexation lag of the security (which is partly a function of the frequency with which the consumer price index [CPI] is reported), the more pronounced the seasonality of the seasonally unadjusted CPI, the greater the risk that its statistical derivation is changed, and the less even are the movements of the seasonally-adjusted CPI over time in both the high-frequency and the low-frequency domains, the more muddied is the identification of the real yield.

Although our own demonstration empirically will be limited to the first year of experience with inflation-indexed securities in the United States, we hope that the adjustment methodology developed will be useful also for refining real-yield calculations in other countries, particularly in Mexico. Beyond this, finance specialists all over the world may take note and see the yields officially reported on such securities in a more discerning light.

2. Introduction

First issued in January 1997, the U. S. Treasury's Inflation-Indexed Securities, popularly referred to as Inflation-Protection Securities (TIPS), are an innovative addition to the menu of financial assets. The early months in the life of any such security that brings new features to the capital market are devoted to market testing and seasoning. During this process, data on liquidity and depth of the market and dealer participation develop, and volatility and covariance patterns of returns are established. These patterns reveal the niches which the new security may occupy in portfolios and what, if any, contribution it may make to the completion of asset markets.

Seasoning, however, also allows design features and idiosyncracies of the new security and its reported real yield to be understood and to be priced out. To obtain an international perspective on the design and yield characteristics of TIPS, we briefly compare them to the Mexican UDIBONOS, introduced in 1995, which, like TIPS, involve the payment of half-yearly real interest on inflation-adjusted principal and appear particularly well designed.

Because price index movements, as opposed to movements in individual prices, can not be observed concurrently on account of the sampling and processing time required, indexation even to a high-frequency index, such as the consumer price index, can not guarantee maintenance of the real value of principal on a current basis. We are interested only in those conditions under which failure to do so becomes *predictable* so that there is *expected* indexation bias under defined conditions that should affect the reported yield in a measurable way. Such bias arises both from the use of a price index with a predictable seasonal component and from the use of lagged-momentum indexation.[1] Imperfections from the latter source come to bear either when there are blips in the inflation rate that can be recognized as deviations from the underlying rate when they occur, or when a permanent change in the rate of inflation is in store for the future. An anticipated regime change could presage such a change in inflation fundamentals, as could an observed innovation in monthly inflation rates if such rates are characterized by a moving-average process so that they contain an element of random walk.

While the possible importance of indexation lags, particularly in UK index-linked bonds, has been noted by others as described by Barr and Campbell (1997, pp. 363-364), we offer a precise treatment on the assumption that the underlying rate of inflation is known to market

[1] Lagged indexation and lagged-momentum indexation are often confused. Lagged price-level indexation is involved, for instance, in COLA clauses that state that the contract wage will be raised 3 percent if, and soon after the time when, the reported consumer price index has risen by at least 3 percent above the base level specified in the contract. In the United States as elsewhere, tax brackets and social security benefits are subject to such lagged-level indexation.

TIPS, like most traded inflation-protection securities in the world, work quite differently. Instead of the par value sitting still while waiting to be adjusted periodically by use of the lagged CPI, they hit the ground running: Inflation adjustment starts the very next day after the issue date, or dated date, if different, by applying the recently observed inflation momentum. As best exemplified by Mexico's *Unidad de Inversión* (UDI), introduced in 1995, or Chile's *Unidad de Fomento* (UF), in use since 1967, changes in the money value of these units are driven by lagged-momentum indexation. Hence imperfections in indexation arise on these units only when the currently observed inflation rate differs from the lagged inflation rate entering the indexation process.

With lagged-level as opposed to lagged-momentum indexation, on the other hand, indexation would be imperfect whenever the current inflation rate is anything other than zero. Kandel, Ofer and Sarig (1996, pp. 207-209) model the derivation of the ex-ante real interest rate in an environment of lagged-level indexation where some fraction of the bond payments is not indexed and therefore discounted at a nominal interest rate.

participants from a univariate forecasting process. We also offer concrete first estimates of seasonal indexation bias on the assumption that investors expect the seasonal pattern of the consumer price index to be stable. Before getting to this, we contrast specific features of TIPS with those of similar securities widely issued in other countries, particularly in Mexico, to assess the design of the TIPS from a comparative perspective and to submit tentative recommendations in this regard. This is the first purpose of the present paper.

The second, more central, purpose is to alert future users of the series of real yields reported on TIPS and similar securities throughout the world that the reported yield will have a seasonal component, react to inflation surprises that are revealed with a lag, and react to news about impending changes in the monetary regime or the inflation target. The fortunes of investors in such "real-valued" securities thus can not be separated from the outlook for inflation. Nor can they be separated from its official measure. Rather, the reported yield is bound to react to news about revisions in statistical procedures that predictably change the measure of inflation when the true rate of inflation is unchanged. Our method is designed to calibrate the size of the reactions that can reasonably be attributed to these factors beforehand so that reported yields can be adjusted for some or all of them, as shown in this paper.

An alternative future use that will become possible as the time series lengthens will be to add the factors producing indexation bias to the list of explanatory variables of the reported real yield, rather than to adjust that yield directly. This would mean entering *i)* seasonal dummies, *ii)* monthly inflation-surprise factors, such as $\ln[E_{t-1}(P_{t-1}/P_{t-2})/(P_{t-1}/P_{t-2})]$, constructed from the latest CPI report on the price level for the prior month (P_{t-1}), and *iii)* expected future changes in inflation rates (Δp_{t+i}) weighted by that fraction, ι, of a year that is equal to the lag in indexation momentum and discounted at the real discount factor R, $\iota\Sigma_{I=1\to\infty} R^i E_t(\Delta p_{t+1})$, into equations purporting to explain real interest rates. Such reduced-form equations typically have contained distributed lags of the real interest rate, of (oil price) supply shocks, and of demand shocks, such as money-supply surprises, as recently surveyed by Bischoff (1998). If the real yield on TIPS should be used as the regressor in such equations in the future, our procedure would explain what adjustment factors would need to be included and what — judging by the size of measurable indexation biases alone, without allowance for the attendant risks that would need to be compensated also — the range of reasonable coefficient estimates on such factors would be.

3. Review of the Instruments and of the Calculation of their Yield

During recent years, both Mexico and the United States have introduced new CPI-indexed government securities known, respectively, as UDIBONOS[2] and TIPS. Comparing the construction and valuation of these instruments provides insights into the quality of their design and the appropriateness of the real yields reported before the indexation biases affecting these rates are analyzed.

Unlike TIPS, UDIBONOS are specified in real investment units (UDIS) whose daily exchange rate (BdM, 1996b, p. 3: "tipo de cambio peso-UDI") with the new peso is announced by the central bank, rather than in inflation-adjusted nominal units.[3] Nevertheless it is fitting to use UDIBONOS as a comparator for TIPS since the real-yield calculations officially prescribed for each of these instruments involve only real magnitudes. Neither yield-calculation formula makes reference to the imperfect indexation process actually applied nor recognizes that there may be predictable changes in the real value of principal for which investors expect to be compensated.

3.1. Mexican Instruments Denominated in Real Units

While the introduction of TIPS was unrelated to any pressing need, in Mexico instruments denominated in UDIS were first created in 1995 in response to widespread debt-service problems. These problems were associated with the high nominal interest rates and implied accelerated real amortization that occurred soon after the external value of the peso had come under intense downward pressure in December 1994. The inflation rate reached 52 percent per annum in the ensuing exchange-rate, intermediation, and then general economic crisis (BdM, 1995b; 1996a, pp. 168-169, 231-232; 1997, p. 251). Thus, on April 4, 1995, the Banco de México (BdM) authorized "credit institutions to denominate their deposit liabilities with maturities exceeding three months, and credit operations of any term, in Investment Units and to establish a scheme of short and long positions on assets and liabilities linked to the National Consumer Price Index" (BdM, 1995a, p. 184; see also BdM, 1996a, pp. 231-232). Since that date, the BdM has been required to publish every fortnight (15 days) in *Diario Oficial* the daily values of UDIS in local currency for an equivalent period ahead (BdM, 1995a, p. 185; 1995b).

At yearend 1996, nonfederal credits restructured in UDIS had a current par value equal to almost 7% of Mexico's 1996 GDP (BdM, 1997, p. 150), and UDI had become a denomination option not only for bank deposits and (restructured) loans to business but also for notes issued by the federal government (BdM, 1996b). Obviously Mexico, like Chile before it, but unlike the United States, is building a deep financial

[2] UDIBONOS stands for bonos de desarrollo del gobierno federal denominados en unidades de inversión (UDI). From May 1996 to March 1997, the real yield on the 3 to 5 year UDIBONOS themselves has followed an up and down pattern (in percent): 7.13, 7.52, 8.61, 8.35, 8.42, 7.81, 7.46, 6.88, 6.63, 6.32, 6.46 (BdM, 1997, p. 267) with a range of 229 basis points. In Chile, almost all debt with maturities in excess of 90 days that is held by the central bank is indexed (Budnevich and Hurtubia, 1997), and the real interest rate in UF has been between 6.08 and 6.47 percent on 8 to 10 year PRCs (Pagarés Reajustables con Cupones) over the same period, still about twice as high as the yield required on TIPS in the United States. Côté *et al.* (1996, p. 51) plot long-term real return government bond yields for Australia, Canada, and the United Kingdom for 1992-1996.

Unlike the United States, neither Chile nor Mexico taxes the indexation gain on principal, and this tax treatment is consistent with their restricting the taxation of nominal interest (presumptively) to the ex post real component as well. In Mexico, a net tax bias in favor of the yield on UDIBONOS nevertheless exists: BdM (1995b, p. 12) explains that while unindexed debt securities are subject to a flat 20 percent tax on the first 10 percentage points of nominal interest, only the real interest on UDI, which has been less than 10 percent, is taxable, and the tax rate is a favorable 15 percent.

[3] The Mexican government has issued inflation-indexed securities in the 3 to 5 year maturity range for years. Since July 20, 1989, the federal government of Mexico has issued *ajustabonos* (bonos ajustables del gobierno federal) which are peso-denominated instruments whose principal, for calculating principal repayment and interest accrual, is indexed to the consumer price index (INPC). These 3-year ($3 \times 364 = 1\,092$ days) to 5-year ($5 \times 364 = 1\,820$ days, issued since November 22, 1990) instruments pay real interest *quarterly*. Interest rates on ajustabonos have fallen from their initial high of 16.33% in 1989 to as little as 3.20% in 1992 (BdM, 1995, p. 220). An annual coupon of x% is paid out as 91/360 times x% quarterly, just as an annual coupon of y% on UDIBONOS is paid out as 182/360 times y% semiannually. (For a technical description see the 18-page manual issued by the Asociación Mexicana de Casas de Bolsa, n.d.)

The convention of quoting interest rates on a 30-day per month, 360-day per year basis conforms to the convention of the International Association of Bond Dealers (IBD). It also applies to most short-term eurocurrency contracts, with the exception of those denominated in pound sterling and the Australian dollar, which use 365 days (Grabbe, 1996, p. 106). It does not apply to TIPS where the semi-annual coupon rate is paid simply at half the annual rate.

In Mexico, at the end of 1996, the federal government's domestic debt securities of N$160.8 billion included ajustabonos of N$25.4 billion and UDIBONOS valued at N$5.4 billion. CPI-indexed securities thus amounted to 19% of domestic federal debt, and 90% of these securities were held by firms and households (BdM, 1997, p. 283).

infrastructure for a standardized indexed denomination and the instruments based on it. Competition with hard-currency foreign assets may demand it.

As UDIBONOS represent Mexico's most recent entry in the market for real-valued government notes, they may be compared with the introduction of TIPS soon thereafter. Indeed, there is much to be learned from such a comparison about the appropriate design of indexed investment units and the degree to which they correspond to the economic concept of inflation-protection securities.

3.2. Calculation of the Real Rate of Yield on UDIBONOS and TIPS, and Unit Design

Both the Mexican and U. S. calculation of the annual real rate of yield to maturity, R, of purchasing 1 unit of these unamortized securities — with coupons fixed at the annual rate C and with h being the fraction of this coupon that is paid semiannually for a total of n prospective coupon due dates remaining on the issue — follow the same basic approach but differ in details of exposition and substance. The basic approach is to account for the current real-valued market value (MV) with the discounted real coupon payments remaining to maturity (SDC) plus the discounted value of the original real-valued principal due at maturity (DP) minus any accrued real interest due the seller (AI). In both countries' expositions, discounting is first done to the very next coupon payment due date. The resulting sum, SDC + DP, is then discounted further by the additional discount factor (ADF^{-1}) for the number of days remaining from the date of settlement or valuation to the next coupon date (L – T). AI is due to seller who has already earned accrued interest from the previous coupon date (or dated date) to the date of settlement or valuation for a total of T days out of the coupon period of length L days. Hence, the internal real rate of return, R, is implied by the equation:

$$MV = (SDC + DP)/ADF - AI. \tag{1}$$

For UDIBONOS and TIPS there are certain differences in the calculation of SDC and ADF which are highlighted in several of the equations (2) through (8) below. The formula used for ADF differs for Mexico, where an exponential construction is used for the part-period

discount factor, and the U. S. Treasury employing linear interpolation within the current coupon period in progress to establish the real rate of yield bid at auction. However, the yield reported on TIPS in the financial press is calculated by using interest compounded daily, as in Mexico. Differences between Mexico and the United States in the definition of h and L affect the calculations of SDC and ADF, as well as of DP. AI involves linear interpolation in both countries, with the market price quoted on this basis.[4] Differences in equations (4) and (5) below are purely expositional. We prefer the Mexican rendition since the U. S. use of n* in lieu of n-1 and of the intermediary variable a^{n^*} somewhat complicate the exposition. In Mexico, n is defined simply as the number of coupon due dates ahead (número de cupones por cortar, incluyendo el vigente) while the official U. S. definition of n* is difficult to follow (see U. S. Government, 1997, p. 346).

$$SDC = hC + (C/R)[1 - (1 + hR)^{-(n-1)}] \tag{2}$$

$$DP = (1 + hR)^{-(n-1)} \tag{3}$$

Mexico $$SDC + DP = hC + C/R + (1 - C/R)(1 + hR)^{-(n-1)},\ \mathbf{h_{MX} = 182/360} \tag{4}$$

U. S. $$SDC + DP = hC + hC(a^{n^*}) + (1 + hR)^{-n^*},$$

$$a^{n^*} \equiv [1 - (1 + hR)^{-n^*}]/hR,\ n^* = n - 1,\ \mathbf{h_{US} = 1/2} \tag{5}$$

Mexico $$ADF = (1 + hR)^{(1-T/L)},\ \mathbf{L_{MX} = 182\ days} \tag{6}$$

U. S.$_{\text{private sector}}$ $$ADF = (1 + hR)^{(1-T/L)},\ \mathbf{L_{US}\ varies\ (181 - 184\ days)} \tag{7}$$

U. S.$_{\text{Federal government calculation}}$ $$\mathbf{ADF = 1 + hR(1 - T/L)} \tag{7a}$$

Mex. and U. S. $$AI = hCT/L,\ T = 0, ..., L - 1 \tag{8}$$

[4] Dealers quote a gross price including accrued interest, so that the market price is obtained by subtraction of accrued interest from what is known in the trade as the "dirty" price. Hence any change in the calculation of accrued interest would be reflected in the reported (net) market price. For this reason, no such change is made here even though exponential accrual would be preferable (*e.g.*, for precision in taxation) to the linear formula actually in use.

Mexico: $h = 182/360$, $L = 182 \therefore hT/L = T/360$; U.S.: $h = 1/2$, L = actual number of days in current semiannual coupon period, say from January 15 to July 15 (181 days, 182 in leap years) and July 15 to January 15 (184 days). T = the number of days from the last coupon date (or dated date in the first coupon period) to the settlement date.

The practice of defining the original term to maturity in multiples of 182 days and to deduce semiannual coupon payments by multiplication by 182/360 from the 360-day coupon rate is common internationally for short- and medium-term issues and conforms to guidelines of the International Association of Bond Dealers. The U. S. procedure of spanning whole calendar years appears preferable, particularly for instruments with original maturities of more than four years. However, the U. S. practice of making half-yearly coupon payments at exactly half the annual rate on the same daily date of the month, even though the length of coupon periods may then differ by as much as three days,[5] is less precise than the Mexican procedure of dealing in standardized half years of 182 days each. Nevertheless, we settle for the U. S. definitions of T, L and h, such that L is the actual number of days in the current coupon period but h remains 1/2.

4. Review of Calculation of the Daily Inflation-Adjusted Principal of UDIBONOS and TIPS

Although the yield on both UDIBONOS and TIPS is calculated in real terms, settlement is made in national currency in both countries. TIPS contracts, like the earlier ajustabonos in Mexico, are stated in nominal units and can be settled only by determining the CPI-adjusted equivalent of their real issue price.

4.1. *UDIBONOS*

As explained in BdM (1995a, p. 34), the sampling-period and price-index-calculation lags reflected in the announced values of the UDI

[5] Greater precision in *h* could be achieved by leaving the daily coupon due dates the same as the daily date of the issue, but making the semiannual coupon payment equal to a fraction of the annual coupon rate given by the actual number of calendar days in the coupon period, divided by the number of days (365 or 366) in the "year" of the note in which the coupon payment occurs.

which are subject to daily changes from the moment they were first created on April 4, 1995, are as follows:

The series of UDI values is extended twice each month by use of the CPI values reported twice per month. The price level, P_{1ht}, sampled in the first half of any month t, dates 1 through 15, must be reported no later than by the 25th day of that month t; the price level, P_{2ht}, sampled in the second half of that same month t, dates 16 through 28-31, depending on the month, must be reported no later than by the 10th day of the following month, t + 1. Assume the value of the UDI on that date is $UDI_{10,t+1}$. Then the value of the UDI that must be announced no later than by the 10th day of each month for the succeeding 15 days (11 through 25) is such that the value on the last day of this period is $UDI_{25,t+1} = UDI_{10,t+1}(P_{2ht}/P_{1ht})$. All the daily values announced for the UDI during this interval grow at the constant percentage rate implied by repeated application of the fixed factor of $(P_{2ht}/P_{1ht})^{1/15}$ to generate successive daily values over the 15-day period from the 11th through the 25th of month t + 1.

Because the rate of change in the UDI from the 10th to the 25th of each month (centered on day 17 of month t + 1) reflects the behavior of prices from the first to the second half (centered on day 15) of the prior month, the lag in the application of the latest reading on the inflation rate to the determination of the UDI value is *one month* (plus two days).[6] Having thus arrived at the value of $UDI_{25,t+1}$, $UDI_{10,t+2}$ is calculated as $UDI_{25,t+1}(P_{1ht+1}/P_{2ht})$. In between, the daily percentage changes in the UDI values that must be announced on the 25th of each month for the succeeding 13 to 16 days, leading to day 10 of the next month, are again required to be constant.

The Mexican consumer price index rose 7% during 1994 (from December 1993 to that of 1994), 52% during 1995, and 28% during 1996 (BdM, 1997, p. 251). Later in 1997, the monthly rate of inflation returned to values below 1%. Hence, there have been large changes in the rate of inflation over a short period of time. Such changes are not recognized immediately under lagged-*momentum* indexation which refers to lags in allowing for changes in the rate of inflation rather than for changes in the price level, as already explained. In Mexico,

[6] Calculated in the same way, the lag in the updating of the inflation rate in Chile, although nearly as short as practicable with monthly, rather than bi-monthly, CPI data (as noted by Fontaine, 1994, p. 223), is almost twice as long. In Chile, the CPI reported by the fifth of each month for the previous month is not used for redetermining the momentum of indexation until after the ninth of each month, while in Mexico the use from the time of release is immediate.

however, the lag in picking up changes in the rate of inflation is as short as the twice-monthly CPI release dates allow.

4.2. TIPS

The nominal value of these securities is adjusted daily from the day they are first issued but at the rate of price change observed several months earlier. The lagged rate of price change is calculated from values of the *reference* CPI whose dating and uses are explained below. The monthly adjustment period mirrors the frequency of the U. S. CPI which is monthly, rather than bi-monthly as in Mexico. However, instead of beginning with the first day after the release of the CPI around the middle of each month, *i.e.*, as soon as practicable as in Mexico, the U. S. adjustment periods always start on the first of the month. Furthermore, instead of making the within-period adjustment by constant daily percentage changes in the index basis, as is done in Mexico, the U. S. interpolation procedure is linear, producing daily inflation adjustments in the principal value that are of equal absolute, rather than relative, size within any month.[7]

The *reference* CPI for the first day of any calendar month is the CPI reported around 1-1/2 months earlier for the third preceding calendar month. For example, the reference CPI for September 1, 1997 is the CPI for June that was reported at 8:30 a.m. on July 16 based on prices that were sampled in the period June 1-25, mostly in the first half of the month. The reference price for October 1, 1997 is the CPI for July that was reported on August 14. Then the inflation adjustment is such that the current dollar value of the basis on October 1 relates to that on September 1 as the seasonally unadjusted CPI reported for July relates to that reported for June. The inflation rate from one month to the next (June to July) thus is applied during the month after next (September). Hence the average lag in applying the current inflation rate is 2-1/2 months in the United States, compared with just over 1 month in Mexico. Because the frequency of CPI reporting and of changes in the rate of basis adjustment is half as large in the United States as in Mexico, the minimum application lag in the United States would be only twice as long as the minimum application lag in Mexico, in this case, 2 months.[8]

Having established the value of the basis on the first day of each of two adjoining months, the value of the basis on any day in between is obtained by linear interpolation, in this case by adding 1/30 of the difference for each day in September after the first until reaching October 1.

Unlike the seasonally adjusted CPI, the seasonally unadjusted CPI (series CPI-U) is never revised, but this advantage may be outweighed by disadvantages from imparting seasonal effects to reported yields.[9] The most obvious source of predictable variations in the real investment value of the index is seasonal because the seasonally unadjusted CPI contains known seasonal variations in the United States. All else equal, a par-value investment in TIPS at a time when its current-dollar par value has been propelled by lagged momentum indexation to a seasonal high clearly has a predictably lower real yield than an investment made at the same inflation-adjusted par value but at a time when the seasonal factor reflected in the nominal par value is at a low. For in the former case the investor would know that the coupon and principal payments to be received will be based on a par value embodying a lower seasonal component than the one reflected in the current par value.

In addition, depending on the data-generation process subsumed,

[7] When inflation is positive, linear rather than exponential adjustment of the principal sum for inflation raises its real value most during the middle of each monthly adjustment period compared with the correct exponential adjustment leading to the same monthly endpoint.

[8] This assumes roughly equal preparation lags in the United States and Mexico. The BLS (1995, p. 1) reports that "the entire process of keying, reviewing, analyzing and publishing is finished about 20 days after that last data are collected". In Mexico, this lag is shorter since publication occurs already 10 days after the end of the fortnight (quincena) to which the price index refers. For instance, if prices are collected mostly in the first week of each fortnight (though food prices are known to be collected every week, see BdM, 1995c, p. 21), the average lag, from the date the last prices are sampled to their reflection in published statistics, would be about 17 days.

[9] To eliminate predictable seasonal changes in the real value of the inflation-adjusted principal, use of the seasonally adjusted CPI, as first reported for any month, should be considered for future TIPS issues. The seasonally adjusted CPI, unlike the seasonally unadjusted CPI, is widely reported, but subsequently revised. Nevertheless, an index based on a series of seasonally adjusted CPI values as first reported leaves the CPI free of expected seasonality if the annual revisions in the seasonal adjustment factors are themselves unpredictable or minute. Because the seasonal adjustment factors are revised retroactively each year with the release of the CPI for January, use of a "first-release" series for the seasonally adjusted CPI could cause the monthly inflation rate implied in that series for December to January to differ from the rate first reported for that period by the BLS after applying the revised seasonal adjustment factor retroactively to the CPI for December. This cost may be worth the benefit of eliminating predictable seasonality from the index. The relevant federal regulations (U. S. Government, 1997, p. 342) already provide for index contingencies: "If a previously reported CPI is revised, Treasury will continue to use the previously reported CPI in calculating the principal value and interest payments".

the latest monthly inflation rates, even if devoid of any seasonal pattern, would not by themselves be the best predictor of the, as yet unreported, current and future inflation rates except under the assumption that the monthly inflation rate of a country is difference-stationary, rather than largely stationary as we assume. Given that a growing number of countries implicitly or explicitly target a low level of inflation, it is unlikely that inflation is appropriately represented as predominantly a random walk or as subject to a diffusion process. Rather, *the price level* will be a random walk with a drift that is contributed by a low underlying inflation rate under these circumstances, as Evans and Wachtel (1993) have suggested for the most recent years in their study. Such a description would be apt if permanent supply shocks to the level of sustainable output arise randomly, and the reaction to such shocks by the monetary authorities is expected to be passive or neutral so that the price level, but not the inflation rate, may be permanently disturbed. If special non-recurring factors can be identified that contribute to transitory disturbances of the inflation rate, automatic extrapolation of the most recent experience thus would not be warranted.

We will show formally in one of the next sections that if future inflation rates can be expected to differ from past inflation rates that figure in the indexation process, the market value of a security would not be at par even though this is what substituting R = C in equations (4) and (5), which do not allow for predictable changes in the real value of inflation-adjusted principal, imply. Hence the true R is misrepresented by its prior calculation in real terms that makes no reference to the indexation procedure actually applied. This makes the degree of inflation protection afforded by TIPS relative.

The next three sections provide analyses of the three sources of indexation risks and of biases that follow predictably from known events. Neglecting them can produce inaccuracies in the yield reported on TIPS which we refer to as biases. The risks to which holders of inflation-indexed securities are exposed from actual and impending changes in the statistical procedures used by the government to calculate the size of price index movements are discussed only in the concluding section of this paper. To the extent these much-discussed changes lead to any unexpected statistical depression of indexation benefits, they are tantamount to a capital levy on TIPS.

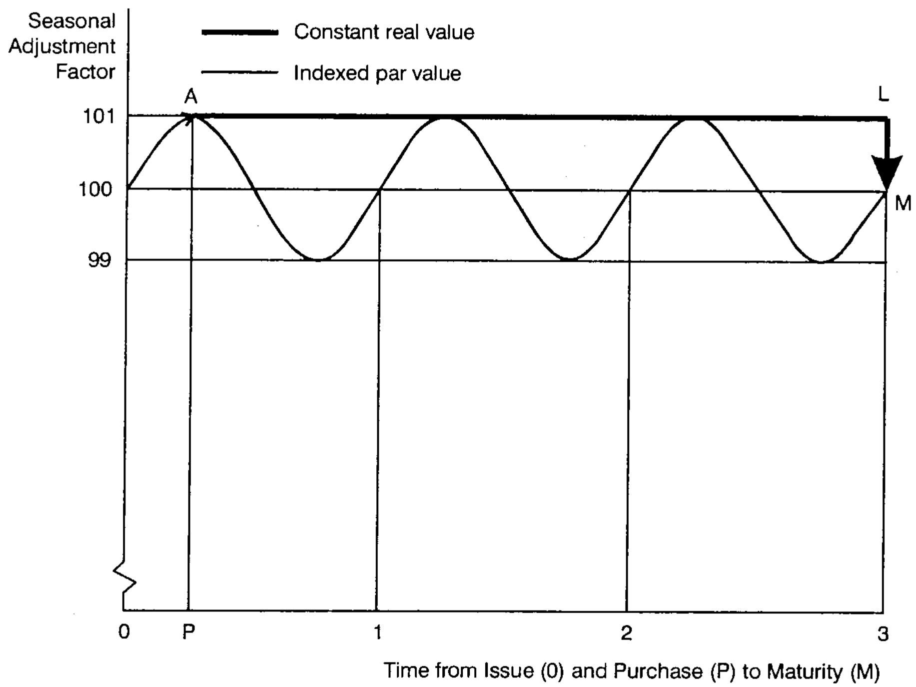
5. Biases Arising From a Predictable Seasonal Component in Monthly Price Movements

Before deriving the seasonal bias factors mathematically, it is useful to picture this bias with the help of the stylized seasonal pattern of a trendless par value shown in Figure 1. Consider an inflation protection security which was issued at time (0) when the seasonal adjustment factor was at a neutral level of 100. To illustrate a case of conditional underindexation, investors buy the security at a later time (P) when the seasonal contribution to the price level, identified by the seasonal adjustment factor reported by the Bureau of Labor Statistics (BLS) for the CPI-U — U. S. City Average — All Items, is at a peak.[10]

Rather than being a data plot, the scaling and pattern shown in Figure 1 are therefore grossly simplified and made continuous to illustrate the basic point that the relation of the seasonal position reflected in the par value at time of purchase to that expected for all remaining (coupon and principal) pay-out dates determines whether overindexation or underindexation is in prospect. Specifically, the figure shows that if the inflation-protection security is bought at a time when its par value, determined by the past momentum of the seasonal adjustment factor, reaches a seasonal high of 101, the interest to be earned on that security, in relation to this seasonally-elevated par value, will fall short of the stated real coupon rate in 11 out of 12 months in which seasonal adjustment factors reflected in the price-adjusted par value are below 101. In all these "grey" months, the security would be earning on less than 101 — on no more in fact than before — and this would require a compensatory price reduction in the real price to 100/101 = 0.9901 in relation to a par value of 1. This price decline, viewed independently of the imperfections in the indexation process that caused it, would lead to a rise in the reported real yield, thereby imparting a seasonal pattern to that yield, even though its required level has not changed at all.

[10] The 1996 values of the seasonal adjustment factor which have also been applied in 1997, before revisions are made in each of 5 later years, are, from January to December (BLS, 1997, p. 7): 99.806, 99.871, 100.064, 100.128, 100.064, 100.000, 99.936, 99.936, 99.937, 100.000, 99.874, 99.623. The average of these 12 monthly factors is 99.937. The average actual value of these seasonal adjustment factors is below 100 on account of Jensen's inequality, and their amplitude from peak to trough is less than 0.6, with a low in December and a high in April in most recent years. The new seasonal factors for 1997 (with the 1997 values applied also to 1998), released February 20, 1998, were little changed from the above: 99.812, 99.937, 100.125, 100.125, 100.000, 99.938, 99.938, 99.938, 99.938, 100.000, 98.815, 99.629.

Figure 1. Predictable Adverse Seasonal Indexation Bias.
Par value curve to maturity (M) undulates with seasonal factors below line of constant real value



The shortfall in the base on which interest is paid is indicated by comparison with the peak-to-peak line, AL, at level 101, which maintains constancy of the real value of A. In all but one of 12 months, this line is above the undulating curve representing the path of the seasonal adjustment factor and indexed par value. In addition, if maturity falls into a month with a seasonal factor lower than the one reflected in the current par value, there is an anticipated shortfall of indexation in the repayment of principal. In Figure 1, those paying the par amount of 101 at time P would know that the pay-back of principal will be only 100 at maturity of this three-year security so that there is an anticipated loss in real value of LM. The reason is that the seasonal pattern, and hence the seasonally unadjusted CPI used for the price adjustment of the par value, suggests seasonal deflation from 101 to 100, while the underlying inflation trend that concerns the investor is perfectly flat. That investor is interested in real wealth

accumulation and consumption smoothing rather than immediate consumption. Clearly buying the same security at a par value reflecting a seasonal high can not afford as high a real yield as buying it at a par value reflecting a seasonal low.

5.1. Calculation of the Seasonal Bias on TIPS

The seasonal bias factors, specified below, adjust the expected real value of future pay-outs on a daily basis for any expected seasonal indexation bias. The purpose of this adjustment is to eliminate measurement errors in the yield arising from the use of seasonally unadjusted data in indexation.

Leaving the conceptual illustration with arbitrary numbers aside, we now focus concretely on seasonal distortions of the indexation factor that arise in connection with the semiannual coupon payments and eventual repayment of inflation-adjusted principal on the first ten-year TIPS issue. On this issue, the first payment and all other odd-numbered coupon payments are due on July 15, six months from the issue date or dated date, if different. The even-numbered coupon payment dates, including the maturity date, fall on January 15, the dated date. The seasonal adjustment factors applied to all future coupon and principal payments to calculate adjusted real yields for 1997 are those first reported for 1997 in January of that year because any revisions in these factors that will be announced in subsequent years are viewed as unexpected.[11]

To compare the relative seasonal position of the indexed par value used to determine the size of the coupon payments and of the principal payment with the seasonal position embodied in the same security purchased on day d of month t, we first construct three geometrically interpolated seasonal adjustment factors that make reference to the dated date (t^*, d^*) or the current date (t, d). The first such seasonal adjustment factor (SAF) applies to the odd-numbered coupon payments due in month $t^* + 6$, the second to the even-numbered semiannual coupon payments and the principal payment due in month t^*, and the

[11] More precisely, the seasonal adjustment factors are recalculated in January (*e.g.*, 1998) of each year for the past five years (1993-1997). The seasonal factors obtained for the most recent year (1997) then first are applied throughout the next year (1998) until the first revision early the following year (in January 1999). With the seasonal pattern for 1997 subject to three more revisions, the last revision applying to 1997 is scheduled for January 2002.

third applies to the current date. D^*, D^{**}, and D are equal, in order, to the number of days in either the coupon payment month — $t^* + 6$ in formula (9) and t^* in formula (10) — or in the current month, t, as in (11). Daily dates are needed because the seasonal component that applies two to three months earlier is interpolated over the payment month to the payment date, as are all other elements of the seasonally unadjusted CPI. We also need daily dates because we are comparing the seasonal component of the future coupon or principal payment relative to the seasonal factor at the time of purchase to determine whether underindexation or overindexation is in store.

The seasonal adjustment factor that applies to odd-numbered coupon payment dates is:

$$\text{(odd)}SAF_{t^*+6,\,d^*} = SAF_{t^*+3}\,(SAF_{t^*+4}/SAF_{t^*+3})^{(d^*-1)/D^*}. \tag{9}$$

Since the first 10-year TIPS issue was in January, $t^* + 3$ refers to April and $t^* + 4$ to May in the formula above. Hence, using the factors given in footnote 11, the seasonal adjustment factor reflected in the odd-numbered coupon payments on July 15[12] is $100.128(100.064/100.128)^{14/31} = 100.099092$.

The seasonal factor that applies to even-numbered payment dates, including principal repayment, is:

$$\text{(even)}SAF_{t^*,\,d^*} = SAF_{t^*-3}\,(SAF_{t^*-2}/SAF_{t^*-3})^{(d^*-1)/D^{**}}. \tag{10}$$

Since $t^* - 3$ is October and $t^* - 2$ November in the scheme above, the seasonal adjustment factor reflected in the even-numbered coupon payments and in the principal balance due at maturity is $100.000(99.874/100.000)^{14/31} = 99.943077$.

The seasonal factors applying to the various components of payout must be related to the factor applying on a given (investment) date, d, of interest in month t which is:

$$\text{(current)}SAF_{t,\,d} = SAF_{t-3}\,(SAF_{t-2}/SAF_{t-3})^{(d-1)/D}. \tag{11}$$

The respective seasonal indexation bias factors, SBF that apply

[12] The actual auction date of the first 10-year TIPS note was January 29, 1997, dated January 15, 1997, with regular coupon payment dates of January 15 and July 15, and maturity of January 15, 2007.

to odd-numbered and even-numbered coupon payments together with principal repayment for an investor at time (t, d) then are:

$$\text{(odd)}SBF_{t^*+6,\,d^*|t,\,d} = SAF_{t^*+3}\,(SAF_{t^*+4}/SAF_{t^*+3})^{(d^*-1)/D^*} / SAF_{t-3}\,(SAF_{t-2}/SAF_{t-3})^{(d-1)/D} \tag{12}$$

$$\text{(even)}SBF_{t^*,\,d^*|t,\,d} = SAF_{t^*-3}\,(SAF_{t^*-2}/SAF_{t^*-3})^{(d^*-1)/D^{**}} / SAF_{t-3}\,(SAF_{t-2}/SAF_{t-3})^{(d-1)/D}. \tag{13}$$

To illustrate, this time a seasonal *over*indexation bias, assume (t, d) is February 1, 1997 (ignoring that this was a Saturday and thus not an actual trade date). With d = 1, formula (11) directs us to the seasonal adjustment factor three months earlier, which is 99.874 for November. To find out the seasonal adjustment factor for the date of the first coupon payment, July 15, formula (9) requires the seasonal adjustment factors three and two months earlier. These are 100.128 for April and 100.064 for May. Because d^* is 15 and $D^* = 31$ days, the geometric average of these two values with exponent 17/31 for April and 14/31 for May yields 100.099092 as already deduced. Hence the seasonal bias factor from formula (12) is 100.099092/99.874 = 1.002254. This means simply that because prices in November tend to be seasonally depressed compared with March-April, an investor on February 1 who knows the seasonal pattern conveyed through lagged-momentum indexation can look forward to the coupon payments due each July 15 as being 0.2254% larger in relation to the seasonally depressed par amount invested, than the real yield calculation subsuming perfect simultaneous indexation without predictable bias would suggest. Clearly if the 10-year note were always available at par, the seasonal bias from lagged-momentum indexation would cause the real yield to fluctuate. Conversely, the price of the security, in percent of par, would have to fluctuate for the real yield to be constant.

The value of the seasonal bias factor from formula (13) for the same February 1 purchase is 99.943077/99.874 = 1.000692. Because this value applies both to even-numbered coupon payments and to repayment of principal at maturity, it carries progressively more weight as the maturity date comes closer, compared with the factor applicable to odd-numbered coupon payments. Hence the composite seasonal bias factor does not have a constant annual pattern even if the monthly seasonal adjustment factors of the CPI do not change from year to year.

We now turn to the calculation of present values adjusted for seasonal bias factors. Taking account of seasonal indexation bias on the evaluation date (t, d), and using $(1 + hR)^{-2}$ as the discount factor for every other (odd-numbered or even-numbered) half-yearly coupon payment, the sum of the discounted coupon payments from equation (2) is:

$$SDCS_{t,d} = \{hC + (C/[R(2 + hR)])\,[1 - (1 + hR)^{-(n-2)}]\}SBF_{t^*+6,d^*|t,d} \quad (2a)$$

$$+ \{(1 + hR)(C/[R(2 + hR)])\,[1 - (1 + hR)^{-n}]\}SBF_{t^*,d^*|t,d}$$

This calculation discounts the coupon payments to the next coupon payment date, such as July 15, 1997 and then January 15, 1998, and accounts for all odd- and even-numbered coupons. Next taking account of the seasonal indexation bias shared with even-numbered coupon payments, and discounting to the time of the next coupon payment, as before, the present value of principal repayment from equation (3) is:

$$DPS_{t,d} = (1 + hR)^{-(n-1)}SBF_{t^*,d^*|t,d}. \quad (3a)$$

Using the exponential formula for ADF that is given in equation (7) for discounting from the date of the next coupon payment back to the evaluation date, and substituting U. S. parameters in expression (8) for accrued interest, AI, the appropriate calculation of the real yield on TIPS, R, now requires solution of the equation:

$$MV_{t,d} = [(SDCS + DPS)/ADF - AI]_{t,d} \quad (1a)$$

With seasonal indexation bias now recognized on the right side of equation (1a), the observed real market value or purchase price, MV, on the left-hand side, is expected to depend in a predictable manner on the valuation or purchase date as well as on the issue date of TIPS.

6. Indexation Bias from Largely Transitory Disturbances in Seasonally-Adjusted Inflation

Let lagged-momentum indexation, as practiced with TIPS, be indicated by rates of price change being calculated with price indexes applying

up to three months before the time of issue in month t. Taking the nominal stream of coupon payments discounted at a nominal factor and the discounted value of principal due n semiannual coupon periods from the time of issue and then canceling out overlapping segments of the respective price ratios yields:

$$MV_t = [(E_tP_t/P_{t-3})(E_tP_{t+3}/E_tP_t)C/2]/[(1 + R/2)(E_tP_{t+6}/E_tP_t)] +$$
$$[(E_tP_t/P_{t-3})(E_tP_{t+9}/E_tP_t)(C/2)]/[(1 + R/2)^2(E_tP_{t+12}/E_tP_t)] + \ldots$$
$$(E_tP_t/P_{t-3})(E_tP_{t+6n-3}/E_tP_t)/[(1 + R/2)^n(E_tP_{t+6n}/E_tP_t)]\text{ , or}$$

$$MV_t = [(E_tP_t/P_{t-3})/(E_tP_{t+6}/E_tP_{t+3})] \quad (14)$$
$$\{(C/2)[(1 + R/2)^{-1} + [(E_tP_{t+6}/E_tP_{t+3})/(E_tP_{t+12}/E_tP_{t+9})]\,(1 + R/2)^{-2} + \ldots]$$
$$+ [(E_tP_{t+6}/E_tP_{t+3})/(E_tP_{t+6n}/E_tP_{t+6n-3})](1 + R/2)^{-n}\}.$$

Hence even if there is no reason to think that the three-month inflation rate for any distant future period will be different from that for another such period (*cf.* Mussa, 1976), so that the expected price ratios in the last two lines above are identical, MV, with R = C, will not be 1 but:

$$MV_{t,R=C} = [(E_tP_t/P_{t-3})/(E_tP_{t+6}/E_tP_{t+3})] \equiv IBF_t. \quad (15)$$

IBF_t thus represents the Inflation Bias Factor reflected in the market value at time t relative to 1.

For the first half of each month, the quarterly gross inflation rates appearing in equation (15) are separated into known and expected gross monthly inflation rates as shown below:

$$IBF_t = (E_tP_t/P_{t-3}) / (E_tP_{t+6}/E_tP_{t+3}) =$$

$$\{[E_t(P_t/P_{t-1})](E_tP_{t-1}/P_{t-2})(P_{t-2}/P_{t-3})\} / (E_tP_{t+6}/E_tP_{t+3}) \quad (15a)$$

In the first half of any month t, before the monthly CPI release date, only the ratio P_{t-2}/P_{t-3} is known in the numerator of IBF_t. We will assume that all *expected* seasonally adjusted monthly inflation rates are the same, so that $E_t[P_{t-1}/P_{t-2}] = E_t[P_t/P_{t-1}] = (E_tP_{t+6}/E_tP_{t+3})^{1/3}$ and that the term structure of the expected inflation rate was flat in the United States in 1997. Nevertheless, the level of that expected rate of inflation is informed to a degree (1-λ) — later consistently assumed to be 0.2857 — by current observations of the preceding gross inflation rate that may differ from the rate previously expected, so that

$E_t(P_{t-1}/P_{t-2}) = \lambda E_{t-1}(P_{t-2}/P_{t-3}) + (1-\lambda)(P_{t-2}/P_{t-3})$. Now the value of IBF for the first day, d = 1, of any month, t, when information on the CPI for the previous month is not as yet available, is:

$$IBF_{t, d\, d=1} = (P_{t-2}/P_{t-3})/(E_t P_{t+6}/E_t P_{t+3})^{1/3} =$$

$$[\lambda E_{t-1}(P_{t-2}/P_{t-3})/(P_{t-2}/P_{t-3}) + (1 - \lambda)]^{-1}. \qquad (15b)$$

As the CPI release date in month t approaches, the relevance of the more distant monthly rate, (P_{t-2}/P_{t-3}), begins to diminish since this gross rate of inflation will continue to contribute to the indexation process only until the first of the upcoming month. From the 8:30 a.m. release date to the first of the next month, the day at which P_{t-3} ceases to contribute to the momentum of indexation, 1 plus the inflation rate over 2 months, P_{t-1}/P_{t-3}, rather than 1 month, P_{t-2}/P_{t-3}, is known in the numerator of equation (15a) within the indexation horizon. After the first of month t + 1 and until the next CPI release date in that month, the gross inflation rate P_{t-1}/P_{t-2} remains as the only known rate still relevant for the imminent application of the index.

Only *prospective*, and not past, indexation gains or losses can bias the current yield reported on TIPS and call for a correction of that yield. From the first day of any month t to the day before release of P_{t-1} around the middle of month t, there is relatively little advance information available for identifying any temporary disturbance that may be contained in each successive monthly report of inflation that will still affect indexation. For this first part of each month, the formula for IBF is:

$$IBF_{t, d\, d < \text{release date in month } t} = [\lambda E_{t-1}(P_{t-2}/P_{t-3})/(P_{t-2}/P_{t-3}) +$$

$$(1 - \lambda)]^{-[D-(d-1)]/D}. \qquad (15c)$$

As advance information is used up, the exponent in the above equation declines daily during the first half of that month from the first day (d = 1) to the last day prior to that CPI release date. From the release date on and for the rest of the month, *two* monthly deviations from the underlying rate of inflation can be identified that may cause a predictable change in the real value of principal on account of lagged-momentum indexation. The value of IBF from the release date around the middle of each month to the first day of the next month is:

$$IBF_{t, d\, d \geq \text{release date}} = [\lambda E_{t-1}(P_{t-2}/P_{t-3})/(P_{t-2}/P_{t-3}) + (1-\lambda)]^{-[D-(d-1)]/D}$$

$$[\lambda E_t(P_{t-1}/P_{t-2})/(P_{t-1}/P_{t-2}) + (1 - \lambda)]^{-1}. \qquad (15d)$$

To illustrate: If a month has D = 30 days and the release date of the CPI for the previous month falls on the 16th so that d = 16, the exponent is 15/30 = 0.5 because exactly half of the monthly indexation remains to be applied over the second half of the current month. By the first of the next month the exponent on the first factor on the right of equation (15d) has fallen to 0. As this factor moves beyond the indexation horizon on the first day of the new month, the second factor moves up within the indexation range. Thus on the first day of the new month the exponent on the second factor, which is now the first and sole surviving factor, is 1 for the last time. It then starts to decline as the number of days remaining in the new month (in the numerator) falls below D' = 31 (in the denominator). The formula for the remaining dates of the new month, t + 1, before the next CPI release date, thus is an update of (15c) with D' replacing D:

$$IBF_{t+1, d\, d < \text{release date in month } t+1} = [\lambda E_t(P_{t-1}/P_{t-2})/$$

$$(P_{t-1}/P_{t-2}) + (1-\lambda)]^{-[D'-(d-1)]/D'}. \qquad (15e)$$

As already pointed out in Section 2, lagged momentum indexation allows the investor to know the indexation for varying lengths of time ahead. Lead time shrinks from 1-½ months on the release date to ½ month on the day before the next release date. This variable amount of foreknowledge of the consequences for future indexation applies also to any inflation outliers.

Both equations (15c) and (15d) involve $E_{t-1}[P_{t-2}/P_{t-3}]$, and (15d) and (15e) involve $E_t[P_{t-1}/P_{t-2}]$. We now estimate these terms by taking the gross inflation rate of the six months just prior to the indexation horizon. Hence the pattern, shown for these two expressions, is:

$$E_{t-1}[P_{t-2}/P_{t-3}] = [(P_{t-3}/P_{t-9})]^{\alpha/6};\ E_t[P_{t-1}/P_{t-2}] = [(P_{t-2}/P_{t-8})]^{\alpha/6}. \qquad (16)$$

Concretely this means that to estimate the inflation rate expected, say in March 1997, to have prevailed from January to February of that year, we use information for July 1996 through January 1997 before the price index for February 1997 is released. Once it is released, we can then compare expected and actual outcomes for inflation and what to make of any difference.

If a country is known to be taking growing inflation risks, $\alpha > 1$ would be an appropriate choice, while $\alpha < 1$ would be suitable for a country engaged in a credible program to reduce inflation or if surveys of informed opinion indicate that inflation is expected to decline. For 1997-1998, however, we take $\alpha = 1$ and substitute $[(P_{t-3}/P_{t-9})]^{1/6}$ for $E_{t-1}[P_{t-2}/P_{t-3}]$ and $[(P_{t-2}/P_{t-8})]^{1/6}$ for $E_t[P_{t-1}/P_{t-2}]$ in equations of type (15c) or (15d) to obtain actual measures of $IBF_{t,d}$.[13]

Translated into forecasts of the net inflation rate, the persistence implications of the six-month moving average process assumed above are these: The retrospective forecast of the most recently revealed monthly net rate of inflation, $\pi_{t-1} \equiv \ln(P_{t-1}/P_{t-2})$, is used to identify the innovation or error term, ε_{t-1}, in that rate. Based on a six-month average of immediately prior inflation, the underlying rate of inflation, $E_t(\pi_{t-1})$, was estimated as $\ln\{(P_{t-2}/P_{t-8})^{1/6}\}$ before the price index P_{t-1} was reported, so that:

$$E_t(\pi_{t-1}) = (1/6)\,\Sigma_{i=2\to 7}\,\pi_{t-i} = \pi_{t-2} - (5/6)\,\Delta\pi_{t-2}$$

$$-(4/6)\,\Delta\pi_{t-3} - (3/6)\,\Delta\pi_{t-4} - (2/6)\,\Delta\pi_{t-5} - (1/6)\,\Delta\pi_{t-6}. \qquad (17)$$

Hence, the largely transitory innovation is:

$$\varepsilon_{t-1} = \pi_{t-1} - E_t(\pi_{t-1}) = \Delta\pi_{t-1} + (5/6)\,\Delta\pi_{t-2} +$$

$$(4/6)\,\Delta\pi_{t-3} + (3/6)\,\Delta\pi_{t-4} + (2/6)\,\Delta\pi_{t-5} + (1/6)\,\Delta\pi_{t-6}. \qquad (18)$$

As expression (18) makes clear through the unitary coefficient on π_{t-2}, the expectations process contains a unit root though the permanently active component of a one-time disturbance, previously identi-

[13] The derivation of inputs for this calculation is shown in Table 1 available upon request. In its last column it is convenient to present $(P_{t-2}/P_{t-3})/E_{t-1}(P_{t-2}/P_{t-3}) = (P_{t-2}/P_{t-3})/[(P_{t-3}/P_{t-9})]^{1/6}$ as $P_{t-2}/\{P_{t-3}(P_{t-3}/P_{t-9})^{1/6}\}$, where the denominator (in braces) of P_{t-2} represents the expected value of P_{t-2}, which is obtained by applying the average monthly gross inflation factor for the prior six months to P_{t-3}. Similarly, the second factor in equation (15d) is estimated as $P_{t-1}/\{P_{t-2}(P_{t-2}/P_{t-8})^{1/6}\}$ as soon as P_{t-1} has been released in month t, so that only updating is involved.

fied as $(1 - \lambda)$, is low. The effect of any single-pulse disturbance eventually stabilizes at between 28% and 29%[14] of the size of that disturbance in the present scheme. This percentage broadly conforms to the Fama and Gibbons' (1984, p. 329) finding that only about 20 percent of the unexpected inflation rate in any one month is incorporated into the inflation rate expected for the next month. Lastly, although it could be consistent with a recommendation earlier in this report to use the seasonally adjusted CPI as first reported for 1996 and not as reported with the first retroactive revision of the seasonal adjustment factors in 1997, we use the best data available at the inception of TIPS to estimate IBF. This means recourse to the data reported from January 1997 on.

The adjustment of the real yield by means of the indexation bias factor is simpler to apply than with the seasonal bias factor. IBF, unlike SBF, corrects for an expected percentage change in the real par value which is the same for all future payments of coupons and principal. It therefore appears simply as a multiplicative factor in the basic market value formula:

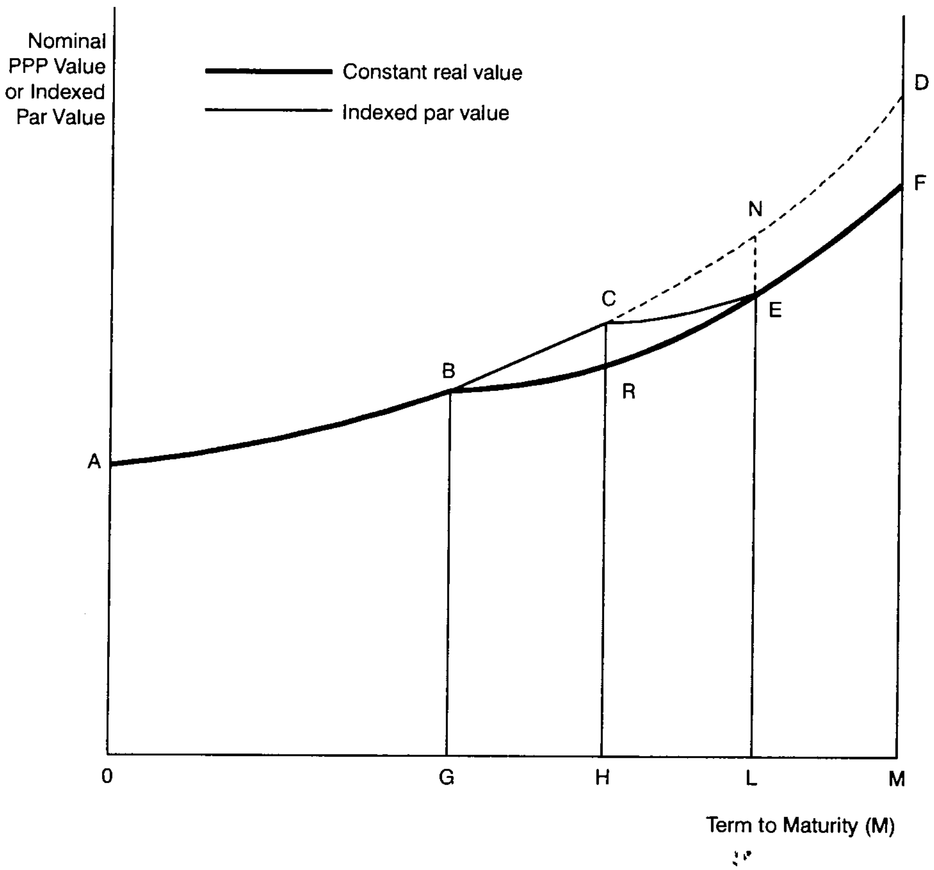
$$MV_{t,d} = [IBF(SDCS + DPS)/ADF \; - \; AI]_{t,d}. \qquad (1b)$$

6.1. Illustration of Indexation Bias from a Dip in Recently-Reported Inflation

An illustration may help visualize how and when there may be prospective indexation bias. When the *price level* is expected to be a random walk with steady drift, the underlying inflation rate can be treated as a constant to which actual month-by-month inflation, when disturbed by unpredictable temporary factors, soon will return. Even if the inflation rate also contains a small element of random walk so that the return to the *status quo ante* is incomplete as here assumed, indexation bias in the calculation of the reported real rate of yield may be predicted by the extent to which the most recently reported rate of inflation differs from the underlying rate. Any such occurrence would bias prospective indexation on account of lags in that process away

[14] Since the sum of the coefficients in equation (19) is 3.5, the exact percentage is 1/3.5 = 28.57 percent.

Figure 2. Adverse Nonseasonal Indexation Bias.
Bias occurs, on account of lagged-momentum indexation, as soon as a temporary unexpected dip in inflation has been recognized.



from the maintenance of the real value of investments but only for as long as the new information affects *prospective* indexation.

Figure 2 helps explain exactly how the bias arises and for how long it is operative after a particular event. It shows a temporary slowing of the inflation rate that causes the price path to follow the trajectory ABRF, instead of continuing from B to C and D along the nominal-value curve that rises at a constant rate of inflation. Curve segment RF reflects almost the same underlying inflation rate as the curve with constant price level growth, AD, as the observed dip in the inflation rate will have only a small impact of (1-λ) times the

inflation surprise on the expected permanent future rate of inflation. If GH, which is equal to HL, is the length of lag in the inflation rate applied to adjust the nominal par value, that value follows the path ACEF. Thus lagged-momentum indexation would cause the par value of a security to continue to follow the upwards curving path reflecting the original inflation rate right up to point C.

If any temporary change in the inflation rate is unanticipated until fully reported at time H, there is no predictable indexation bias for or during the episode, of length GH, of unusually low inflation. There is only an ex post gain in the real par value of the security since that value goes from GB to HC, rather than to HR which is all that would be required to maintain the real value of an investment of GB ex post. If the deviation of the inflation rate from the underlying inflation rate is expected to be end as soon as it is fully reported at time H, then there is an expected real indexation loss at that time as the par value of HC is expected to rise only to LE rather than to LN, the value required to keep real value intact in view of the return of inflation to its (slightly modified) underlying rate. Hence the loss of real value in prospect on account of lagged momentum indexation on an investment of HC at time H is equal to EN, yielding an indexation bias factor as an adjustment to principal equal to (LE/LN) < 1.

What is the story behind the prospective underindexation in this instance? An investor purchasing the security at a par value of HC at time H will have observed a temporary reduction in the rate of inflation by that time but conclude correctly that the previously established inflation trend, in large part (λ = 0.7143), with resume. Hence the investor will realize that instead of heading from C in the direction of D, as would be required to keep up with correctly anticipated inflation, lagged indexation will make the par value follow the jagged course to F via point E. Interest will not be earned on the underindexation indicated by the vertical difference between curve segments CD and CEF, and repayment of principal at maturity will be underindexed by the amount FD in this example.

Once any temporary fluctuation in the inflation rate that causes a permanent change in the price level has aged beyond the reach of lagged indexation, there is no indexation bias in the measurement of the real yield until a new fluctuation is reported that affects the indexation in prospect. In Figure 2, for instance, the investor purchasing the security at time L at the par amount LE will get complete prospective indexation and an unbiased measure of the real yield on the amount invested. Only the investor paying par (of HC) at time H would be misinformed by the way in which reported real yields are calculated as if they were independent of the imperfect indexation procedure actually applied rather than compensating for predictable effects of imperfections that have been activated by events.

7. Indexation Biases Arising from Anticipated Future Changes in the Measured Inflation Rate

Because of lagged-momentum indexation, predictable changes in real value can also arise from deviations in the rate of basis adjustment from that required to maintain constancy of real value on a current basis. Such deviations can be anticipated whenever future rates of inflation are expected to differ from current rates.

Surveys of inflation expectations taken in 1996-1997 did not indicate that the rate of inflation expected for the future differs appreciably from the then current level of 2 to 3 percent per annum at either long or short forecasting horizons.[15] Particularly in developing countries with mixed stabilization success, however, changes in fiscal and political control and in the monetary-policy and exchange-rate regime can sometimes be anticipated. Mexico, for instance, has pursued a determined policy of getting the inflation rate down to single digits to levels at least as low as the 7 percent last observed during 1994. Lagged momentum indexation will leave the real value of principal permanently elevated when the underlying rate of inflation is expected to fall and to remain lower than before. Aware of this impending benefit, reported yields would fall when such an expectation arises even when the required real rate of return is unchanged.

Of course if the fall in the reported rate of inflation, as now in the United States, is due in part to formula and sampling revisions

[15] For instance, the 1-year (10-year) ahead forecast of CPI inflation obtained quarterly (I through IV) from the survey of professional forecasters by the Federal Reserve Bank of Philadelphia (phil.frb.org/econ/spf/cpie1.dat and cpie10.dat) for 1996-I through 1997-III is: 2.78 (3.00), 2.88 (3.00), 3.00 (3.00), 3.03 (3.00), 3.08 (3.00), 3.00 (2.85), 2.85 (3.00). All of these estimates fall into a range barely more than a quarter percent wide. For an evaluation of the Survey of Professional Forecasters see Croushore (1993). Even if intended as forecasts of measured rather than "true" inflation, these forecasts are unlikely to reflect that scheduled changes in statistical procedures alone had served to depress measured inflation by 0.4 percentage point per annum by 1998 compared with the status of statistical procedures applied prior to 1997.

lowering the inflation deduced from any given change in the economy's set of prices, rather than to genuinely lower rates of increase in these prices, there is a continuing effect, beyond lagged-momentum indexation, that works the other way. Any expected systematic underindexation in comparison with current CPI estimation methods would lead to a compensating rise in the reported real yield as soon as the prospect of BLS-produced underindexation, relative to the status quo, becomes firm. Since there would be no appreciable BLS effect on the nominal interest rate, those who interpret the difference between an otherwise comparable nominal interest rate and the real rate on TIPS as the expected inflation rate could erroneously conclude that expected inflation, and not just reported inflation, has "really" fallen.[16]

While the indexation bias of the previous section was developed against a background of steady underlying inflation, that rate may itself be expected to change. Of course if *the inflation rate* were a random walk without drift, no change in the future inflation rate could ever be anticipated at the time of an investment in TIPS. Because the inflation rate expected for the future would then always be equal to the latest reading, predictable underindexation or overindexation could not arise. However, if there were reasons to expect, for instance, that future inflation rates generally will be lower than the most recent rates of inflation, perhaps because the new government, say of a developing country, has announced a credible stabilization program of monetary and fiscal restraint or adopted a currency-board arrangement, predictable overindexation would arise. Conversely, if the gov-

[16] Inferences derived from interest-rate comparisons themselves beg many questions and have no proof-value in this regard. Emmons (1997) has inferred from a decline in the spread between the 10-year conventional U. S. Treasury yield and the 10-year TIPS yield and from a similar decline in the term-structure spread between the 10-year and the 3-month conventional Treasury yield that could be observed from late April to late July 1997 that the average annual rate of inflation expected over a 10-year horizon declined by as much as 75 basis points over such a short period. However, interest-rate based models have had rather limited success in forecasting inflation (Hafer and Hein, 1985; Mishkin, 1990). For example, if nominal interest rates rise and real interest rates fall when there is increased uncertainty about inflation but no change in its expected level (see Lahiri, Teigland, and Zaporowski, 1988), the Irving Fisher procedure erroneously registers an increase in the expected rate of inflation by falsely attributing the action of the second moment under risk aversion to the first.

Barr and Campbell (1997) find that the levels of real rates and expected inflation start out correlating negatively at short horizons, with the correlation becoming zero and then positive as the horizon increases. They show that extraction of the term structure of expected inflation rates from the term structure of nominal interest rates is not as comparatively simple as it would be if a liquidity premium and an otherwise constant, or at least inflation-independent, real interest rate could be subsumed. Tzavalis and Wickens (1996) also found that the forecasting ability of the term spread for future inflation is very poor.

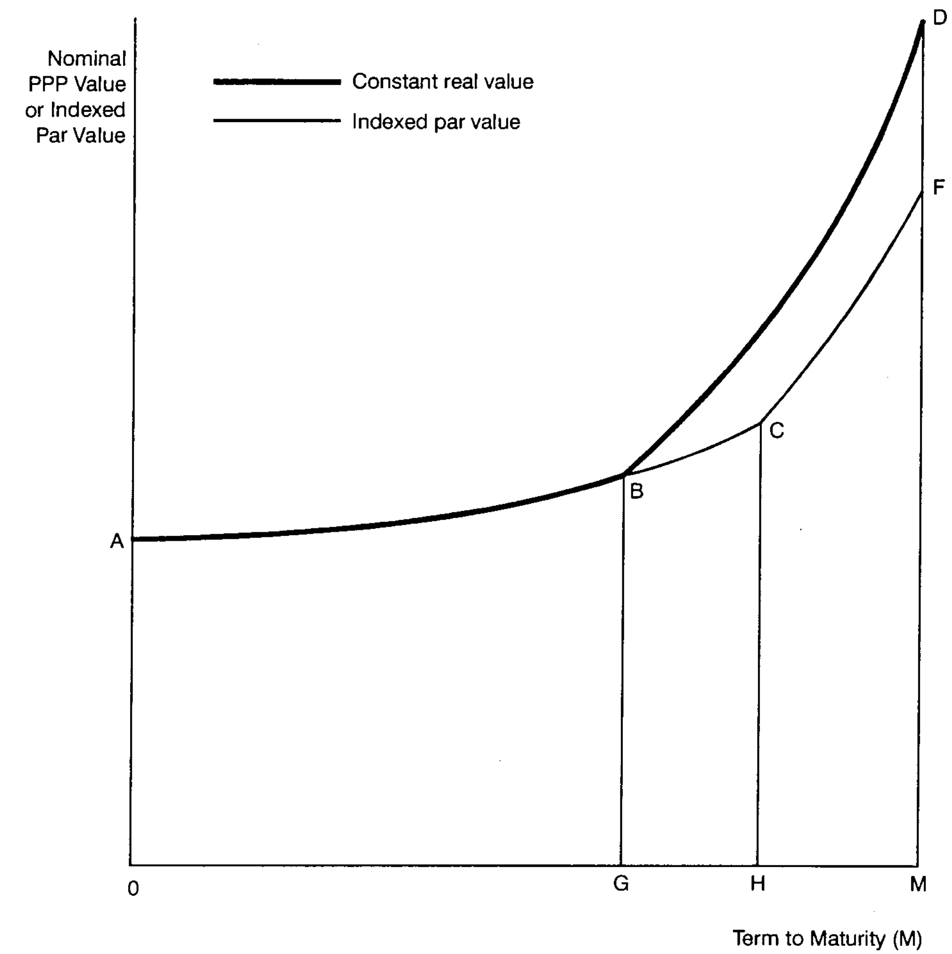
ernment were losing fiscal control and a rise in the monetization of deficits loomed ahead, the expected inflation rate would, at some point, be expected to rise well above the current rate. Because the starting date of this adverse dynamic would be uncertain, a "peso problem" would arise. The mere prospect of such a regime change would result in expected underindexation on account of the lagged inflation momentum in the indexation factor used to update the par value of inflation-protection securities.

Because constancy of the underlying inflation rate is never guaranteed, categorical statements to the effect that "TIPS entail no inflation risk" (*e.g.*, Sargent and Taylor, 1997), are too strong. Similarly, Hetzel's (1992, p. 13) statement that "because holders of the indexed bonds are guaranteed payment representing a known amount of purchasing power, they do not have to forecast inflation" is misleading. Since perfectly simultaneous indexation is unobtainable, such holders can not in fact know what amount of purchasing power indexed instrument will deliver without reference to forecasted inflation rates compared with the current rate. Furthermore, expected and unexpected inflation and the factors that produce them can, of course, be correlated either positively or negatively with the real yield required on TIPS and hence with their market price.

Figure 3 illustrates the real-value effects of a permanent inflation shock by introducing a regime break characterized by a maintained increase in the rate of inflation at time G. If the break is fully anticipated at time G, before the higher inflation rate is actually revealed in faster advance of the price level, there is anticipated underindexation from the prospect of following the indexation path BCF instead of the constant-real value path BD from point B. If the regime change was a known possibility but not a certainty, the degree of anticipated underindexation is less. In either case, however, the market price of TIPS would fall below the indexed par value in the span of the line segment BC, only to rejoin the solid line representing that value at point C.

Once again, only *prospective* overindexation or underindexation can affect the real price of TIPS relative to its real par value and with it the correct calculation of the real yield from current price quotations. Because curve segment CF embodies the same inflation rate as segment BD, the investor at time H will get exact real-value maintenance in the par value from time H on. Thus there is no conditional indexation bias at that point provided that the inflation rate continues

Figure 3. Underindexation Due to a Coming Inflationary Regime Change.
Underindexation results from an expected increase in inflation to a permanently higher level.



without further change at the higher level, as presented in Figure 3. Yet the investor who has held the security since time G and who bought at a price that did not allow for the impending regime change will have experienced a real indexation loss between time G and H that is not recouped.

8. Conclusions and Assessment

The risk-free real interest rate is an important anchor for portfolio valuation models. It is often assumed implicitly that the long-term real interest rate appearing as part of the user cost of capital in models of private investment, for instance in the IS sector of the economy, is free of default risk. Hence it is easy to seize on the real yield on TIPS as finally providing a more certain revelation of "the" real interest rate than hitherto available.

A number of studies have already pointed out that the information benefits of having such a market series of real yields available are not as great as crude identifications might have led us to suppose. Fisher (1997) has explained why it is impermissible to interpret the yield that remains after subtracting the expected rate of inflation — a residual which is Irving Fisher's ex ante real rate — as the same as the yield on a real bond and why, conversely, subtracting the yield on a real bond from the yield on a nominal bond is not sufficient to identify the expected rate of inflation. Greenspan (1992) and researchers from the Bank of Canada (Côté *et al.*, 1997) have provided useful cautions in this regard. Fisher (1997) has shown that expected inflation can not, in general, be extracted from real and nominal bond prices alone just as expected exchange-rate depreciation can not, in general, be extracted from foreign or domestic bond prices or international interest rate differentials (see Engel, 1996; Kamin, 1997).[17] Garrison and White (1997), Söderlind and Svensson (1997), and Bernanke and Woodford (1997) have developed insightful models and appraisals.

The yield on TIPS clearly does not define "the real interest rate" pervading the economy as it does the "IS" schedule of undergraduate textbooks. Instead it is the yield on a particular, imprecisely indexed government financing instrument whose relation to "the" riskless real rate, in any of its possible manifestations and derivations, remains to be examined. In addition, the real yields reported are calculated with the assumption of perfect simultaneous indexation as if that the real value of the inflation-adjusted principal could always be *expected* to be fixed when on a current basis. This, however, is not the case because predictable indexation biases exist.

Our study has suggested adjustments that would make the reported real yield that is subject to economic analysis more accurate so that it is, in fact, the internal rate of return afforded by a real stream of expected payouts. Those payouts may be affected by predictable changes in the real value of principal which reported yield calculations have ignored. We therefore conceptualized and quanified imperfections in indexation and some of their expected effects on reported yields. These yields must be expected to have a seasonal component because they are calculated without allowing for predictable seasonal changes in the real value of a principal that is indexed to the lagged rate of change in the seasonally *un*adjusted CPI. Each monthly report of the seasonally adjusted CPI also is liable to affect the reported yield to the extent changes in the last reported monthly inflation rate from its earlier average level contain more noise than signal about future inflation rates. For in that case the latest report of inflation may contribute to an identifiable prospect of lagged-momentum indexation differing from the expected value of the currently ongoing, but not as yet observable, inflation rate. Finally, news about long-term inflation trends and targets or about the procedures used to measure inflation will have an immediate impact on the level of reported yields.

The effects quantified daily over the first trading year of the first TIPS issue were:[18]

i) Over the first year of trading, adjustment for predictable seasonal bias changes the yield by varying amounts ranging from *+ 4 basis points* in late February and early March to *– 3 basis points* in early November on the first TIPS issue examined.

ii) The adjustment for the inflation bias factor at first raises the yield very slightly and then *lowers* it by a maximum of *3 basis points* later in the first coupon period, because temporary surprises in the seasonally adjusted inflation rate were mainly on the downside. Lagged-momentum indexation then produces predictable underindexation because the current rate of inflation is expected to be higher

[17] Even ignoring the heterogeneity of instrument construction, tax status, and indexation in the real bonds issued by different central governments around the world, we therefore doubt that comparison of their real yields will do much to "shed light on the market's expectations as to the future course of various bilateral real exchange rates" (Summers, 1997, p. 4). Nevertheless we favor international standardization of real bonds using the best available design features to lower information costs and to minimize various sources of indexation bias and the attendant risks to the real par value.

[18] The daily reported yield rates and the adjustments thereto are given in Table 2 available upon request (6 pages). The adjustments to the daily yields reported in the *Wall Street Journal* were calculated with the closing prices of the first issue of TIPS also reported daily in that source, and with the monthly seasonal adjustment factors and seasonally adjusted and not seasonally adjusted monthly CPI-U data releases from the BLS.

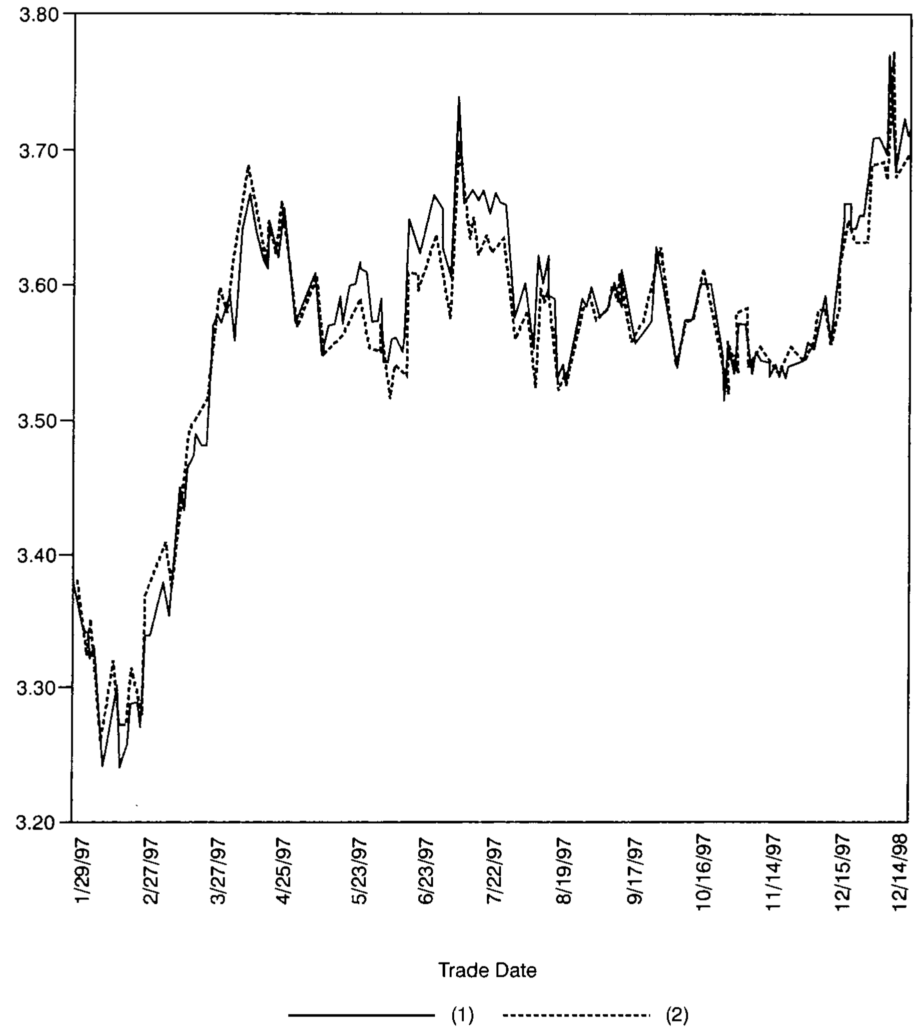
than the rate at which the par value will be adjusted. During the second coupon period, the adjustment for the inflation bias factor alternates between lowering and raising the yield with a maximum change of *1 basis point* in either direction. The reason was that the inflation rate was extremely low and steady over this stretch.

As shown in Figure 4, all these adjustments combined happen to be largely offsetting for the first TIPS issue. Over its first trading year, from the first trading date on January 29, 1997 to January 14, 1998, the reported rate rises on balance, but with some ups and downs that widen the range, from 3.37 to 3.71 percent, or by 34 basis points, while the real yield with all the adjustments increases from 3.38 to 3.69 percent, or by 31 basis points. The absolute difference between corresponding entries of the two series is never more than 5 basis points, or less than 1.5 percent of their value. The range of variation of the revised series is 49 basis points compared with 53 basis points in the reported series, or 8 percent less.

Although the adjustments suggest that, over the first trading year, the first TIPS issue could be expected to yield about what the reported yield had suggested, the reporting bias, for other coupon periods, or issues in other months, could be more pronounced and one-sided. It could also be appreciably larger in developing countries. There monthly inflation rates tend to be choppy on account of discrete adjustments in administered prices and minimum wages. Also, regime changes are more dramatic and speculations about them are reflected in the capital and exchange markets, and seasonally sensitive prices, particularly food prices, have a greater weight in the CPI than in the United States.

Like all debt instruments, TIPS are valued by forward-looking investors so as to afford the yield they require from the stream of payments expected on the instrument until maturity. To know what stream to expect, large institutional investors and market makers can not ignore the operation of seasonal factors, the outlook for inflation compared with recent experience, or the prospect of statistical revisions in the CPI. Because imperfections in the indexation procedure actually applied to TIPS follow predictably from known events or conditions, these events must be monitored by TIPS-market specialists. Details of statistical and indexation practice matter because the indexation procedure actually applied and the correct calculation of the real yield are inextricably linked and can not safely be separated.

Figure 4. Real Yield on TIPS with (1) Private Sector Formula and (2) Complete Set of Formula and Economic Adjustments



8.1. Risks of Definitional and Procedural Changes Affecting the Movement of the Price-Index

This lack of independence is contrary to what is assumed in the calculation of reported real yields. It also runs counter to Shiller's (1997, p. 210) advice that the public should be encouraged to write contracts in terms of a "real dollar" or a "contract dollar," rather like the UF in Chile or the UDI in Mexico, "thereby cutting out the math anxiety issue induced by index numbers, reframing the discussion solidly in real terms". Our advice, instead, would be to worry greatly about the index numbers and real-to-nominal exchange rates put out by government and the exact manner in which they are applied to generate some measure of real-value maintenance.

In the United States, the Bureau of Labor Statistics (BLS) in effect administers the TIPS exchange rate whose course yields the lagged momentum in the seasonally unadjusted CPI. At the same time, the Secretary of the Treasury is the U. S. President's, and the nation's, chief advisor on economic policy. Viewed in conjunction also with the independent monetary authorities, the government as a whole thus not only "makes" inflation but also its measure.

While we do not have any doubt that the BLS is interested only in improving the accuracy of measuring inflation, the consequences of doing so in a way that yields systematically lower reports of a given rate of inflation are nevertheless harmful to TIPS investors to the extent they did not anticipate such a change in statistical procedures. The 1996 Economic Report of the President (U. S. Council of Economic Advisers, 1996, p. 73) already noted that "although true inflation is expected to remain constant from 1996 onward, inflation measured by the CPI is expected to edge lower as revised procedures gradually remove the upward biases in current CPI inflation figures. CPI inflation is likely to slow by 0.2 percentage point in 1997 ... and by another 0.1 percentage point [estimate since raised to 0.2 percentage point] in 1998" as the BLS implements new procedures. Hence a good part of the decline in reported inflation from 1996 to 1998 will be statistical and not "real".

Because the Boskin (1996) Commission Report recommended changes in statistical procedure that would reduce the rate of inflation reported annually by as much as 1.1 percentage points a year, a "peso" problem has arisen. New investors in TIPS will require higher yields than warranted by current statistical procedures until it is clear which

further statistical measures will be implemented. Hence the real yield reported on TIPS may be quite far removed from the economic concept of "the" real rate and specifics can not safely be ignored.

For example, if measures close to those recommended by the Boskin Commission were adopted at the start of the year 2000 when the first TIPS issue still has seven years to run, the exact same set of price increases as would otherwise occur could be evidenced by a reported inflation rate of 2 rather than 3 percent per annum merely by changing the statistical looking glass. The effect would be the same as imposing a capital levy of about 6.6 percent at maturity (5 to 6 percent in present value terms, including the growing levy on coupon payments after January 2000). If such a levy would break into full consciousness of TIPS investors all of a sudden, say around New Year 1999, the market price of TIPS on the next trading day would fall by 5 or 6 percent and the reported yield would rise instantly from, say, 3.5 percent by about 70 basis points, or by 20 percent in round numbers, as progressive depreciation of the exchange rate between "real" and nominal claims, starting in the year 2000, would now be anticipated. The reason, however, would not be that the required real rate of return on TIPS has changed, but that a prospect of underindexation relative to the previously expected maintenance of the statistical status quo has opened up. Changes in that prospect would contribute to variations in reported yields and may have contributed both to the level and the variability of those yields already.

The point of this example, as of the earlier calculations, is that investors in TIPS can not rely on changes in real yields calculated without reference to the indexation procedure as correctly identifying the real yields they should expect to obtain unless they can afford errors which may at times be large. We also provide the first quantification of the measurement errors that can result from imperfections or time-inconsistency in the indexation process, hoping thereby to contribute to the intellectual seasoning of the issue.

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Conditional Transfers to Promote Local Government Participation in Mexico

Rafael Gamboa*

Abstract: Mexico is a very centralized country mainly as a result of the involvement of the federal government (FG) in functions that would be more efficiently provided by subnational governments (SG). The concentration of activities in the FG is the result of two institutional features: the unclear legal assignment of expenditure functions across levels of government, and the assignment of sources of revenue that concentrates a larger share of revenues in hands of the FG. In the presence of multiple uses of federal transfers, and in the absence of information on the costs of providing SG services, the FG has been reasonably reluctant to decentralize more functions. As long as the FG remains in control of most of government revenues, it is important to ensure that the benefits from decentralization also accrue to it. The transfer of functions should avoid SG neglect of those functions that generate benefits to the rest of the country and keep control over the size of transfers. One instrument that can achieve both objectives is a widespread use of conditional grants.

Resumen: Las decisiones de la administración pública mexicana están relativamente centralizadas a causa de la participación del gobierno federal (GF) en funciones que proveerían más eficientemente los gobiernos locales (GL); esta situación se ha generado ante la poco clara asignación de funciones entre niveles de gobierno y la concentración de fuentes de ingreso en el ámbito federal. Al existir múltiples usos de las transferencias federales, y poca información sobre los costos de realizar funciones locales, es razonable que el GF se muestre renuente a descentralizar funciones, aunque reconoce la ventaja informativa que tienen los GL. Mientras el GF mantenga el control

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