TIPS, the Triple Duration, and the OPEB Liability: Hedging Medical Care Inflation in OPEB Plans

By Michael Ashton, CFA
Managing Principal
Enduring Investments LLC
Morristown, New Jersey
ph: 973-457-4602
m.ashton@enduringinvestments.com

Abstract

The adoption of FAS 158 forces sponsors of post-employment health benefit plans to consider how to manage the volatility that changes in medical care inflation create in the other postemployment benefits (OPEB) liability. By choosing carefully how the nominal discount rate used for the liability is decomposed into real rates and inflation, I illustrate that the true exposure to an OPEB plan is to the spread of medical care inflation above (or below) the overall inflation rate. The implication is that an effective immunization strategy exists that can eliminate most of the volatility in the OPEB account.

Introduction

One of the more critical dilemmas facing sponsors of post-employment health benefit plans is the question of how to manage the volatility that changes in medical care inflation create in the other postemployment benefits (OPEB) liability. This dilemma has grown more acute since FAS 158 required that OPEB funding surpluses or deficits be brought on-balance-sheet by year-end 2007. GASB 43 and 45, the equivalent guidance for public plans, have less-onerous provisions that nonetheless are leading to considerable energy being spent on structuring the liability accounts so as to make the impact on public sector finances (and on the financial statements of public sector entities) less dramatic. However, if public sector plans only act to immunize themselves against the accounting impact and not the economic impact of fluctuations in medical care inflation, they are not addressing the full problem; and so the conclusions drawn herein are applicable as well to sponsors of public sector plans.

In 2004, Siegel and Waring published a landmark paper titled "TIPS, the Dual Duration, and the Pension Plan." The authors argued that the main sources of volatility in the funding status of pension plans—changes in the interest rate used to discount future liabilities, coupled with fluctuations in the asset portfolio designed to provide the means to pay those liabilities—can be addressed by reallocating the pension assets to Treasury Inflation-Protected Securities (TIPS) and Treasuries.[1] It may seem that the facts that medical care inflation is not currently tradable and that OPEBs are generally poorly funded or unfunded offer little hope of a similarly optimistic outcome, but this is not the case.

This paper discusses some notional approaches to addressing the problem of open-ended medical care inflation exposure, and proposes some practical steps that can be taken to ameliorate this risk. It leverages off the work of Siegel and Waring in doing so. Prior to that, though, I will discuss medical care inflation generally and how it affects the OPEB liability.

1. Trends in and Possible Causes of Medical Care Inflation

What is most striking about medical care inflation is its durability. Over the last 20 years ending in December 2010, the broad category of Medical Care consumer price index (CPI) has outpaced "headline" CPI[2] by 1.79 percent per annum.[3] Over a 40-year period, this subindex has exceeded headline inflation by 1.87 percent per annum. Putting this in perspective, one dollar today, broadly speaking, buys between *one-fifth* and *one-sixth* as much as it did in 1970, but only *one-eleventh* as much when used to purchase medical care (more poignantly, two-elevenths versus one-eleventh). Expressed another way, $1 invested in the one-year Constant Maturity Treasury (CMT) rate at the end of

[1] Siegel and Waring. 2004. "TIPS, the Dual Duration, and the Pension Plan." *Financial Analysts' Journal* September/October, pp. 52–64.
[2] Headline CPI is typically represented by the year-on-year percentage change in the Non-Seasonally Adjusted Consumer Price Index for All Urban Consumers.
[3] All CPI price index data is sourced from the Bureau of Labor Statistics; these data may be accessed at http://www.bls.gov/cpi/home.htm.

1970 and rolled annually would have nearly doubled in real terms[4] broadly, but in terms of medical care that investment would today buy almost exactly as much medical care as it did previously—the risk-free *real return*, in terms of units of medical care, was essentially zero over the last 40 years because medical care prices have outpaced overall inflation so handily.

The Bureau of Labor Statistics breaks Medical Care CPI into various subindices. Here is how those subindices have grown over the last 20 years, outright and in real terms. Column 3 is merely Column 2 minus aggregate headline inflation.

	% of Headline CPI (Dec. 2010)	*1990-2010 Compounded Inflation Rate*	*1990-2010 Excess Inflation Rate*
All Items	**100.000**	2.50%	
Medical care	6.627	4.29%	1.79%
Medical care commodities	1.633	3.20%	0.70%
Medicinal drugs***	1.554		
Prescription drugs	1.253	3.98%	1.48%
Nonprescription drugs***	.300		
Medical equipment and supplies***	.080		
Medical care services	4.994	4.59%	2.09%
Professional services	2.830	3.70%	1.20%
Physicians' services	1.477	3.59%	1.09%
Dental services	.723	4.72%	2.22%
Eyeglasses and eye care	.246	1.99%	-0.50%
Services by other medical professionals	.384	2.86%	0.36%
Hospital and related services	1.703	6.19%	3.69%
Hospital services*	1.440	6.23%	3.89%
Nursing home and adult day care services*	.150	4.23%	1.89%
Care of invalids and elderly at home**	.113	2.22%	0.04%
Health insurance**	.461	0.79%	-1.38%

*Figures are 14-year compounded rates as the series begins in 1986.
**Figures are five-year compounded rates as the series begins in 2005.
***Category is newly defined; no more than one year of data is available for the series.

Confronted with these figures, one's first reaction is to ask, "Why?" Why has inflation in medical care so consistently beaten generic headline inflation? An explanation tied to the demographic bulge associated with the baby boomer generation is enticing, since it is reasonable to postulate that effect as an important one now as the boomers start to retire, but this is clearly insufficient. The boomers could not have been pushing on the system for the last 40 years, and as noted above the premium to medical care inflation has been that durable.

Obviously, the state of medicine and the quality of medical care has increased exponentially over the last few decades, but the BLS indices are supposed to "hedonically" adjust for this tendency of goods to cost more simply because they have improved. However, the possibility exists that the hedonic adjustments made for medical care are insufficient.[5]

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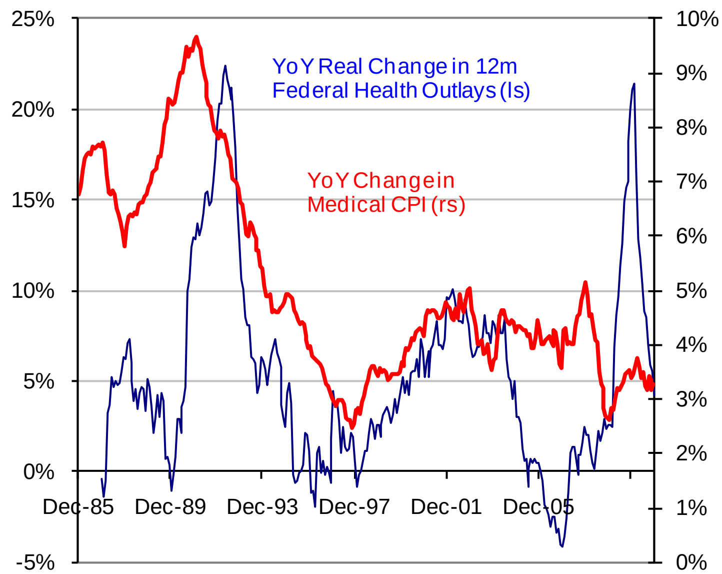
[4] Source for year-end one-year CMT rates is the Federal Reserve H15 report. Actually the increase is 85 percent.

[5] One way to test this hypothesis might be to examine how the *weighting* of Medical Care CPI in the overall CPI has changed over time, and thus measure the rate of substitution between medical care and other goods (if the demand for medical care is perfectly inelastic, the increase in weighting would match the relative price change). By comparing this elasticity measure with other measures of the demand elasticity of health care, it may be possible to test the hypothesis that the hedonic adjustments are adequate.

Two other possibilities suggest themselves. The first is that, as with so many goods, the increasing involvement of government as a purchaser of medical care might work to increase prices in the sector. A monopsonistic purchaser should work to push inflation *lower*, but this is much less likely when the purchaser is not driven by anything approximating a profit motive. More significantly, some important parts of what the government buys are excluded from Medical Care CPI since the government is not, after all, a "consumer" in the usual sense of the word. Medicare expenditures, for example, are excluded from CPI. It may be that health care providers raise prices in the part of the market not dominated by a monopsonist (the U.S. government) in order to compensate for the lower price demanded by the monopsonist.



Another possibility is supply-side in nature. The increasing cost of malpractice insurance and of tort and patent defense, driven by the ballooning tort-lawsuit industry, may have shifted the supply curve for medical care to the left, resulting in higher prices. The fact that one of the biggest drivers of medical care inflation (as in Table 1) is Hospital Services is suggestive.

The purpose of this paper is not to answer the question of why medical care inflation has been such a problem in the past, nor whether it is destined to remain so in the future. The purpose here is to address the problem, given that medical care inflation has been historically high (and variable), that such a phenomenon poses for sponsors of OPEB plans that include health benefits.

2. Medical Care Inflation in the OPEB

Pension and OPEB plans accumulate liabilities on the basis of promises they have made to covered employees. In the case of a pension plan, the promise is in the form of a cash flow or series of cash flows: "We will pay you 60 percent of your final salary." The present value of such a promise, ignoring the possibility that the benefit may be frozen or reneged upon, can be arrived at by calculating (a) the expected final salary, which is a function of the expected time to retirement, the current salary, and the rate of wage inflation[6]; (b) the payout schedule given a retirement date, which is a function of expected mortality and the particulars of the plan (employee or employee plus spouse, nominal or inflation-adjusted, etc.); and (c) the discount rate curve, which may be a risk-free or more typically a corporate (aka "risky") curve.[7] Siegel and Waring demonstrated that a "typical" plan had certain exposures to real rates and nominal rates that flow naturally from the modeling of sensitivities of this sort of plan.

In the case of medical care inflation, the promise is in the form of services: "We will provide you with health care coverage at a certain level." The process for figuring the present value of future health care liabilities is reasonably similar except that the actuary must consider medical care inflation rather than wage inflation and also model how a retiree's consumption of health care might vary over time, since benefits are not promised in terms of a certain dollar value of health care but in terms of a certain breadth of coverage or quality of care. For example, an employer might offer to extend the employee's preretirement health care plan into retirement, perhaps with modifications to co-payment and out-of-pocket maximums. For any given employee, this could result in a wide range of actual expenditures based on the retiree's health, his/her family's health, disincentives (or a lack of disincentives) to consume medical care, and so on. Unlike a pension claim, which is reasonably estimable for any employee expected to reach retirement age with the company, the OPEB claim for a given employee is frighteningly unpredictable. It is only when these claims are aggregated for large numbers of employees that the resulting distribution becomes passingly actionable.

Consider the following hypothetical plan covering 10,000 retirees and with 10,000 current employees eligible to participate upon retirement:

[6] The wage inflation of the company in question, that is, for employees who will still be employed as they reach retirement. This is a conditional rate of inflation that is subject to many biases. For example, it will tend to be higher for high-productivity industries and for companies that are successful at retaining quality employees; it will tend to be lower for companies subject to adverse employee selection (ones that get poached a lot or that offer early retirement plans that tend to favor the re-employable). Et cetera.

[7] Technically, if the pension fund is a liability of the company and secured with the general resources of the firm, the discount rate should be a rate reflecting the riskiness of the sponsor's credit. However, this would lead to the curious effect that a firm could reduce its pension fund (and OPEB) burden by becoming less creditworthy (which reduced burden, in turn, could increase its creditworthiness!). With pension funds, which are required to be secured by actual funding, a "market" corporate credit curve is generally used but with the typically unfunded OPEB plan, this is a more poignant question. Public plans under the Governmental Accounting Standards Board (GASB) actually are supposed to use a discount rate linked to the expected return of the *assets*, which produces the perversity that the more crazy the risk the plan takes, the lower are the liabilities.

Covered retirees

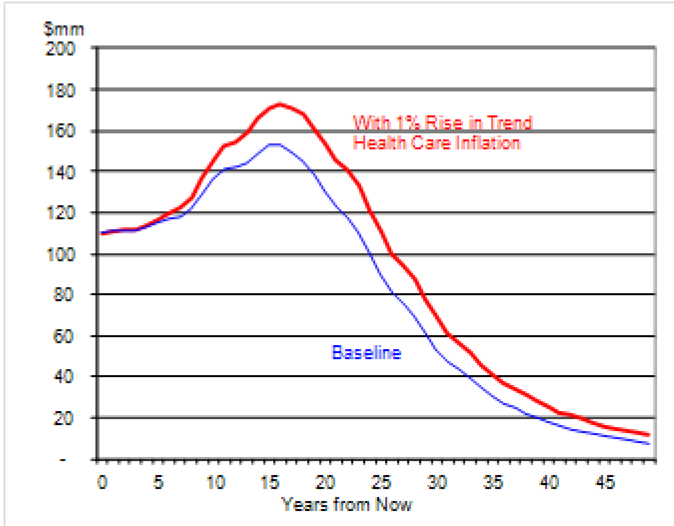
Age	*Number of Retirees*
60-64	3,267
65-69	2,323
70-74	1,539
75-79	1,292
80-84	978
85-89	631
90+	260
Avg: 70.0 yrs	10,000

Eligible employees

Age	*Number of Employees*
20-24	400
25-29	675
30-34	875
35-39	1,300
40-44	1,950
45-49	1,950
50-54	1,300
55-59	875
60-64	675
Avg: 46.3 yrs	10,000

For simplicity, we will assume the plan closes to new employees at this point, but no one ever quits or is fired. The plan therefore runs down only as employees exit the plan by dying, and the entire plan has roughly a 50-year average life.[8] In the base case, I assume somewhat typical costs and distributions of plans between Employee Only, Employee plus Spouse, etc., retirement age at 65, normal mortality experience, and medical care inflation that declines from 8 percent to 5 percent in four years (and then remains at 5 percent indefinitely). Under these assumptions, as the chart below shows, total medical care costs rise for about 16 years before finally declining; a 1 percent rise in the trend rate of medical care inflation, assuming no other change in the inputs, increases the peak by about $22mm *per year*. Even in present-value terms, this is an adverse change of $186mm in the OPEB liability—and this assumes the plan is no longer available to new employees.

[8] Obviously, considerable actuarial critique can be leveled at this model, but I make these assumptions merely to illustrate the scale of the OPEB liability and its sensitivity to health care inflation.



If, instead, the plan is made available to new employees, then the effect of an increase in trend medical care inflation is far larger, and indeed can actually diverge as the calculation horizon extends without bound. Of course, this economic liability will not show up as an accounting liability, since to do so would recognize a liability to employees not yet hired. But corporate plan sponsors and their boards, and public plan sponsors as well, should be aware of the size of the problem they are effectively confronting if they decide to continue providing the same benefit to future hires. The analysis of any balance sheet that includes an infinite liability is pretty simple: the firm that possesses such a liability cannot remain as a going concern and the plan (or the firm) will ultimately be terminated. The benefit scheme will need to be modified so as to make the liability finite and manageable in an economic sense—regardless of whether in the short term the plan can be made manageable in an accounting sense.

3. Notional Approaches to, and Problems with, Hedging Medical Care Inflation Risk[9]

The implication of the Fisher equation decomposing nominal rates into real rates, inflation, and a risk premium is what gives rise to the possibility of treating cash flows as having multiple durations. The Fisher equation[10] is generally

$$\left(1+\frac{n}{f}\right)=\left(1+\frac{r}{f}\right)*\left(1+\frac{i}{f}\right)*\left(1+\frac{p}{f}\right)$$

Where

n = nominal rate of interest
r = real interest rate,
i = inflation rate expected by investors over the life of the bond

[9] This paper is not meant to be a paean to the Siegel/Waring treatise, but the framework presented by those authors is intentionally paralleled in parts here.
[10] Fisher, Irving. 1930. *The Theory of Interest*. New York: The Macmillan Company.

p = risk premium representing the premium demanded by investors for bearing inflation risk, and
f = compounding frequency in terms of payments per year.

Since real rates are now observable directly, in the form of TIPS,[11] the expected inflation rate and risk premiums are often bundled in the i term and the p term ignored. For the sake of expositional simplicity, I follow this practice. Moreover, further analytical simplicity is also usually sought by linearly approximating this relationship as:

$$n = r + i$$

Since nominal rates are composed of the real interest rate, or inflation-free cost of money, plus[12] a premium for expected inflation, it is mathematically obvious that changes in the nominal rate are driven by changes in the real rate or changes in inflation expectations. While this is intuitive, the team of Leibowitz, Sorensen, Arnott and Hanson (1989) deserve credit for making this explicit.[13]

There is an unstated, but important, assumption in this construction and it will come into play later. The "real rate" and the "inflation rate" in this formula, represented as r and i respectively, relate to the overall "market basket" of goods and services in the economy. That is, i is the consumption-weighted average rate of rise of all goods and services, and r can be thought of as a return in terms of an increased (or decreased, in the case of negative real rates) quantity of that market basket. It can be useful to think of the real rate as the investor's return in terms of units of "stuff" while the nominal rate is the investor's return in terms of dollars. Then what we reflexively call "*the* real rate" becomes just the most-general of all real rates: for any particular basket of "stuff" there will be a real rate specific to it, and an inflation rate specific to it.

The non-risky *nominal* rate to a date, representing a return in terms of dollars, is not affected by the market basket in question. If 5 percent is the nominal interest rate for one year, that has a very simple meaning: if you invest $1 today, you will receive $1.05 in one year. It doesn't matter what you plan to buy with that $1.05.

Thus, where I have previously written $n = r + i$, in fact a more *general* equation would be

$$n = r_x + i_x, \quad \text{for all baskets } x.$$

In an idealized world, every investor could buy a bond with a yield that paid in terms of the "stuff" he or she cared about, reflecting that investor's particular experience

[11] This is approximately the case. The lags inherent in the structure imply that the yield of a TIPS bond does not represent a pure real rate corresponding to the holding period, but it is near enough. For further discussion of the two main structures of U.S. inflation-linked bonds, see Ashton, Michael, "iApples and iOranges: Comparing CIPS with TIPS," Working paper, 2006.

[12] Or minus, of course.

[13] There is no reason that nominal rates may not be otherwise decomposed and other durations considered. For example, it is also true that nominal risk-free rates equal nominal risky rates less a discount because of their lesser risk. So we could say a Treasury bill has LIBOR duration and (negative) TED spread duration if we wished. This particular decomposition would not help in our current exploration, but it is important to remember that Fisher's exposition is not the *only* way to decompose risks but has value in this case mainly because of the existence of relevant hedge instruments.

of inflation. Practical finance is moving in that direction, and it will eventually be possible to trade certain inflation subcomponents separately from “overall” inflation, but as of mid-2011 only the general real rate represented by TIPS, and the corresponding inflation rate, are accessible. This is not a sufficient reason to gloss over this increase in the generality of the Fisher equation, however: after all, when Fisher wrote that equation, it was not possible to hedge real rates distinctly from nominal rates at all. The importance of this extension will become apparent later in this article; for now, however, we will temporarily return to the generic formula $n = r + i$ to develop the argument with a minimum of clutter.

Multiple Durations

The percentage change in a nominal bond’s value for a unit change in the nominal yield to maturity is called its modified duration and is given as:

$$D_n = -\left(\frac{1}{P}\right)\left(\frac{\partial P}{\partial n}\right)$$

The percentage change in a bond’s value for a unit change in the real yield is:

$$D_r = -\left(\frac{1}{P}\right)\left(\frac{\partial P}{\partial r}\right)$$

And the percentage change in a bond’s value for a unit change in expected inflation[14] is:

$$D_i = -\left(\frac{1}{P}\right)\left(\frac{\partial P}{\partial i}\right)$$

These durations are not precisely equal. If $n = r + i$ exactly, then a unit change in either r or i produces exactly a unit change in n. However, the Fisher equation is multiplicative, so a unit change in r in fact causes a $(1 + i)$ movement in n and a unit change in i causes a $(1 + r)$ movement in n. For $r = i$, $D_i = D_r$, and if $i, r > 0$ then $D_n < D_i , D_r$. While i, r, and n are small, though, it is expedient to treat

$D_n = D_i = D_r$ and to pretend that $n = r + i$.

[14] In this paper, and in others, this is sometimes called “inflation duration,” which can be confusing because this is not the change in the price of a bond due to changes in *realized* inflation but due to changes in inflation *expectations*. This distinction is worth noting because the value of a TIPS bond does change over time with *realized* inflation (the bond’s principal accretes) but does *not* change with changes in inflation *expectations*.

Partial Duration Hedges

This construction is sufficient for most vanilla single-currency bonds. The exciting development over the last nine or 10 years is that each of these partial durations can be traded separately.[15]

Real rate exposure can be hedged using TIPS, which are (nearly) pure real rate instruments. That is, for TIPS $D_i = 0$. The price of a TIPS bond is affected only by changes in real rates.

Exposure to changes in inflation expectations can be hedged using zero-coupon inflation swaps, which are (nearly) pure expected-inflation instruments. That is, for zero-coupon (ZC) CPI swaps $D_r = 0$.

Nominal duration exposures can be hedged with nominal bonds, but except for the expediency and extra liquidity of doing so there is no reason to use nominal bonds since the same exposures can be created with ZC inflation swaps and TIPS, weighted so $D_r = D_i = D_n$. That is, the nominal bond market is redundant. So, while Siegel and Waring illustrated that any point on the Inflation Duration-Real Interest Rate Duration plane can be achieved with long and short leveraged portfolios of nominal bonds and TIPS, in fact any point on that plane can be reached without even using nominal bonds.

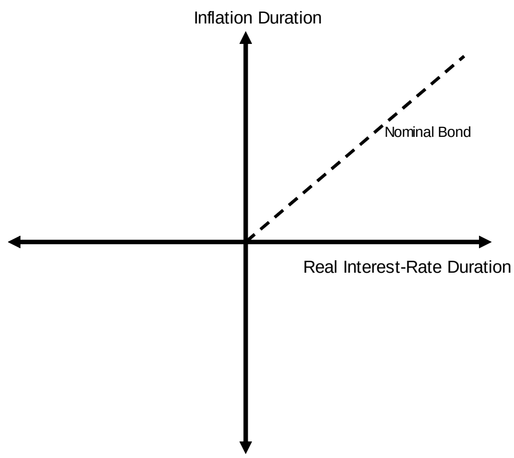


Figure 1: The Dual Duration

All nominal and inflation-linked bonds (and liabilities modeled as portfolios of nominal or inflation-linked bonds) have (at least) two durations, which can be visualized as an ordered pair on the plane shown in Figure 1. Nominal bonds are represented by the set of points on the line extending from the origin and including all $D_r = D_i$ where $D_r, D_i > 0$. TIPS are represented by the set of points on the x axis, where $D_r > 0$ and $D_i = 0$ (short positions in nominal bonds or TIPS extend the graph to the negative side). ZC inflation swaps are represented by all points on the y axis where $D_r = 0$.

[15] Siegel and Waring (2004) observed: "Finally, Figure 3 shows that short selling of nominal bonds or TIPS or both when combined with the use of leverage makes any desired combination of D_i and D_r achievable … of course, nobody really invests this way, but the conclusion is too appealing to pass over without mentioning." At the time, the CPI swaps market was fledgling, but now investors *really can* invest this way.

The Triple Duration

We can also extend this framework further and bifurcate inflation duration more finely.

In speaking of inflation duration, we have essentially defaulted to the use of a generic inflation index, such as the Non-Seasonally Adjusted CPI-U (henceforth "NSA CPI") on which TIPS are indexed. There is nothing wrong with this, although as I noted previously the choice of index affects the definition of the real rate—that is, the "real rate" on which TIPS values fluctuate is only the *true* real rate for investors whose actual inflation experience is identical to the measure described by NSA CPI. If an investor's personal market basket inflates faster than the NSA CPI, then the *de facto* real rate received from TIPS will be less—in other words, if an investor buys a 1y TIPS with a 2 percent real yield, expecting to be able to buy 2 percent more "stuff" with the proceeds (whatever nominal amount that turns out to be), but the stuff the investor wants to buy actually inflates 2 percent faster than NSA CPI, then this investor has realized a 0 percent *de facto* real rate and is no better off in *de facto* real terms.

For many purposes, and for long horizons, it is probably sufficient to believe that an institution is not derelict in assuming that NSA CPI is a reasonable approximation of the inflation it faces.[16] However, this is demonstrably false in the case of an OPEB medical care liability, which is sensitive very specifically to medical care inflation. In principle, what an OPEB plan needs are bonds that pay off not in dollars, and not in "real" terms adjusted by a *generic* inflation basket, but in "real" terms adjusted by a *specific* basket indexed to medical care inflation.

In fact, OPEB plans explicitly recognize this exposure, and report the medical-care-inflation duration in a footnote that describes the effect on the Accumulated Postretirement Benefit Obligation (APBO) of a 1 percent change in the trend rate of medical care inflation. For example, Caterpillar Inc.[17] reported in their 2010 10K (Note 12):

> "Assumed health care cost trend rates have a significant effect on the amounts reported for the health care plans. A one-percentage-point change in assumed health care cost trend rates would have the following effects:"

(Millions of dollars)	*One-percentage-point increase*	*One-percentage-point decrease*
Effect on 2010 service and interest cost components of other postretirement benefit cost	$19	$(15)
Effect on accumulated postretirement benefit obligation	$311	$(266)

In the context of the simplified model described above, $n = r + i$, we can make the following notational adjustment:

[16] … especially considering that NSA CPI is generally thought to overstate inflation—see, for example, "The Advisory Commission To Study The Consumer Price Index," also known as the Boskin Commission report and available at http://www.ssa.gov/history/reports/boskinrpt.html, which concluded the CPI overstates inflation by about 1.1 percent. But some special-purpose institutions should consider whether the proper reference index is not NSA CPI but, say, Education CPI (for a university endowment, for example) or some other component or mix of components. The concepts presented in this paper can also help these institutions manage non-headline-inflation risk such as this.

[17] The author has no relationship to Caterpillar Inc. and the company is used only as an illustration.

$$n_m = r_m + i_m \qquad (1)$$

Where i_m is the expected rate of medical care inflation and r_m is the real rate of interest in medical care inflation space. That is, r_m represents the additional *medical care services* that investors need to receive to compensate them for the interim use of their money.

Note that it is reasonable to declare that $r_m < r$ if $i_m > i$, and specifically, $r_m = n_m - i_m$. First recognize that n (without a subscript) describes the expected relationship between nominal dollars today and nominal dollars at maturity. That is, n describes an "exchange rate" between spot dollars and future dollars. As I pointed out earlier, this rate should be independent of the particular goods the investor plans to purchase in the future. However, r_m (by construction) very explicitly describes the real return (in units of medical care) the investor demands, and this may be more or less than some r_A, a real return in units of good A. In fact, the relationship of some r_B, a real return in units of good B, and r_A is driven by the expected relative forward prices of good B and good A.

An illustration may be illuminating. Consider an investor who has $100 to invest. (Suppose that, today, $100 buys 100 units of good B or 100 units of good A). The investor's options are to buy a one-year bond that pays 20 percent, to buy a one-year bond that pays 110 units of good B, or to buy a one-year bond that pays 110 units of good A. Assume that good A is expected to rise in price by 5 percent and the value of good B is expected to rise 20 percent. Which will the investor choose?

Regardless of the investor's personal preferences, because of the 20 percent rise in price expected from good B, then plainly an investor seeking to maximize his nominal return will buy the bond denominated in terms of good B. At maturity, if the expected inflation has been realized, then he can sell 110 units of good B, which are now worth $132, and buy the 110 units of good A (for $115.50) that his heart truly desired, or merely keep the cash and be better off than if he had invested in the nominal bond (which would have paid $120).

Rationally, the yield of the B-bond will be bid down and the yield of the A-bond offered up until both bonds offer as expected returns essentially $120 worth of their respective goods, eliminating the temporal arbitrage.

The 100 initial units in each case grow into $1+r_x$ units at $1+i_x$ dollars/unit, where x designates the type of unit.

$$100(1 + r_B)(1 + i_B) = 100(1 + r_A)(1 + i_A)$$

$$\left(\frac{1 + r_B}{1 + r_A}\right) = \left(\frac{1 + i_A}{1 + i_B}\right)$$

$$1 + r_B = \left(\frac{1 + i_A}{1 + i_B}\right)(1 + r_A) \qquad (2)$$

The real return in units of B demanded for bond B is the real return demanded in units of A for bond A, times the ratio of expected future price indices (compared to today) given by $(1+i_A)/(1+i_B)$. The non-compounded simplification is:

$$100(1+r_B+i_B)=100(1+r_A+i_A)$$

$$(r_B+i_B)=(r_A+i_A)$$

$$r_B=r_A+(i_A-i_B) \tag{3}$$

and the commonsensical conclusion is that the real return demanded in units of B for bond B is equal to the real return demanded in units of A for bond A plus the difference in their relative rates of inflation. Thus, if bond A is priced to have a real yield of 10 percent (recall that it pays 110 in one year), then bond B in this example should yield 10% + (5% - 20%) = -5%. This is tolerably close to the -3.75 percent answer done the correct way, but do observe that the simplification works best if r_A, r_B, i_A, and i_B are low and similar.

So there is triangular arbitrage of sorts going on here. Nominal rates define the exchange rate of *current dollars for future dollars*. The array of expected inflation rates for the universe of goods defines the exchange rates of *future goods for each other*, and the array of real returns for bonds paying in units of various goods ties those *future values back to spot prices in dollars*.

The implication is that when we specify a bond's **payout** by indexing to a particular subcomponent of inflation, we are simultaneously specifying the bond's **relative real return** as relating to the expected inflation differential between this subcomponent and other subcomponents, or headline inflation.

Because the nominal rate of interest is not defined with respect to any goods, we can lose the subscript attached to *n* and simplify equation (1) as

$$n = r_m + i_m, \tag{4}$$

which is the medical care version of the general equation I highlighted on page 9.

This means that *every* bond, even if not indexed to medical care, also has a

$$D_{i_m} = -\frac{1}{P}\frac{\partial P}{\partial i_m} \quad \text{and a} \quad D_{r_m} = -\frac{1}{P}\frac{\partial P}{\partial r_m},$$

although in most cases we don't care what a Treasury bond's medical-care-inflation duration is!

Unfortunately, we cannot reach every point on the ordered pair (r_m, i_m), because there is no instrument linked to medical care inflation.[18] How, then, is this insight useful?

[18] That is, as of this writing. William Jennings discussed in 2004 how TIPS flows could be technically disaggregated in "Disaggregated TIPS: The Case for Disaggregating Inflation-linked Bonds into Bonds Linked to Narrower CPI Components." Various practitioners, including the author, have discussed slicing

4. Practical Control of OPEB Medical Care Inflation Exposure

Analysis of OPEB Liability

As is frequently the case with the confusion of real and nominal risks, the analysis of the OPEB liability in nominal space obfuscates the nature of the problem and, frankly, the obviousness of the solution. For the purposes of illustration, we will address a $1bln OPEB liability that has the following sensitivities reported by the actuaries:

Sensitivity to a 1% change in nominal discount rate curve:	$85mm
Sensitivity to a 1% change in the medical care trend rate:	$90mm

That is, this hypothetical OPEB liability increases by $85mm (8.5 percent) if the nominal discount rate declines 1 percent, and increases by $90mm (9.0 percent) if the medical care cost trend rate rises 1 percent. These figures describe something similar to, but not precisely, the plan's modified duration with respect to nominal rates and the medical care cost trend rate.

An important theoretical point needs to be inserted at this juncture. What actuaries are calculating is not really the modified duration of the liability with respect to medical care inflation. The sensitivity is calculated as the change in the liability that occurs if medical care inflation rises (or declines) due to the change in the expected future medical care expenses *but assuming the nominal discount rate is held constant.* With this approach, the relationship between the nominal discount rate and the rate of medical care inflation is ignored. A one-period liability thus looks something like this:

$$L = \frac{U(1+i_m)}{1+n}$$

where U is the future consumption of medical care in today's dollars. The future nominal consumption is then U compounded by the medical care inflation rate; the present value is found by discounting this amount by a nominal interest rate.

That expression of the liability is technically incomplete. Expanding the denominator as well we can see:

$$L = \frac{U(1+i_m)}{(1+r)(1+i)}, \text{ and rearranging,}$$

TIPS into component CPIs inside a trust that then issued receipts for the disaggregated pieces. The technical hurdles are low, but the marketing hurdles (who buys "Other CPI"?) have henceforth been too high for such a structure to be successfully built. In 2008, French bank Natixis (for whom the author worked at the time), in conjunction with MacroMarkets LLC, developed, but never issued, a pair of securities linked to Medical Care CPI. The dormant prospectus can be found at http://edgar.sec.gov/Archives/edgar/data/1420012/000114420408004174/0001144204-08-004174-index.htm. Eventually, there will be traded instruments linked to inflation subcomponents.

$$= \frac{U}{\frac{(1+i)}{(1+i_m)}(1+r)} \qquad (5)$$

But the denominator here has a special interpretation. We earlier presented the relationship between the real rates applicable to two different goods as a function of the expected relative inflation rates experienced by the two goods. Equation (2) becomes (if good "A" is the general market basket and good "B" is medical care:

$$1+r_m = \frac{(1+i)}{(1+i_m)}(1+r) \qquad (6)$$

Recall that the fractional term is the ratio of expected future price indices between (in this case) overall inflation (1+i) and medical care inflation (1+i_m)—a measure of how much faster or slower medical care inflation is than headline inflation over the relevant horizon.

Plainly, equation (6) is the denominator of equation (5), which shows that:

$$L = \frac{U}{(1+r_m)} \qquad (7)$$

Actuaries then *can't* really be finding the medical care inflation duration, which clearly is zero for this type of liability since the medical care inflation cancels—the liability actually only has real duration (in medical care space).[19]

Now, if bonds existed that paid like TIPS but on medical care inflation rather than headline inflation—that is, if there were a **real yield curve in medical care inflation space**—then the OPEB plan sponsor's job would be fairly easy: project the real quantities of medical care expected to be consumed in the future, without guessing at the price of that medical care, and hedge those amounts by buying real bonds maturing on or around the consumption date.

If such bonds don't exist, then equation (5) is still very useful, and in fact contains an exciting result. The plan described by that equation has **real** duration, but the **inflation** duration isn't to medical care inflation *or* to "broad" inflation. Instead, the plan is exposed to the *relative* inflation between medical care and broad inflation. The liability's value clearly rises in the event of

(a) A decline in broadly defined real rates (1+r), and/or
(b) A decrease in the ratio (1+i)/(1+i_m).

Instead of having three durations (real rates, overall inflation and medical inflation), we are back to only two that really matter (real rates and the relative spread

[19] What they are doing, though, is something very close to this, and I demonstrate in the Appendix that actuarial estimates produce a result similar to that which I will describe in a moment. Actuaries' estimates, while incorrect, have the advantage of (a) being available and (b) being unlikely to deviate drastically after correction from the theoretically correct durations.

between headline and medical care inflation)! So what does the asset portfolio[20] look like that hedges this liability, this exotic medical care exposure? It will be mostly composed of a long position in TIPS with a collective duration of about 8.5.

With this matched asset/liability portfolio, the remaining risk is the medical-care-headline spread. This exposure cannot presently be hedged with conventional instruments. However, notice several salient features of this residual:

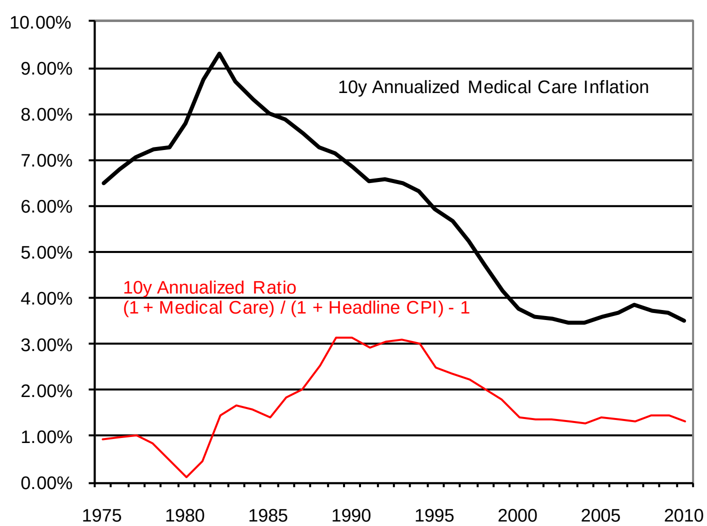
(1) The volatility of the spread is dramatically lower than the volatility of medical care inflation itself, and

(2) The institution likely already has valued this spread implicitly in their actuarial projections as disclosed in the footnotes to the financial statements.

Lower Volatility

We began this discussion with a concern about not only the level of medical care inflation but also its volatility. FAS 158 causes this volatility to move on-balance-sheet and ultimately through the income statement, and there seemed no reasonable alternative.

We have converted this problem to one where the level of medical care inflation essentially *doesn't matter*, and the volatility of the spread is significantly less than the volatility of the rates (see chart below). Notice that the range on the long-term *rate* of Medical Care CPI ranged from 3.45 percent to 9.31 percent, while the *spread* between headline inflation and medical care inflation spanned only the range from 0.10 to 3.26 percent.[21]



[20] …or *shadow* asset portfolio. While most OPEB liabilities are not fully funded, they can still be hedged with derivative equivalents of this solution—using total return swaps on TIPS, for example.

[21] Here I illustrate $(1+i_m)/(1+i)$ rather than $(1+i)/(1+i_m)$ to represent a more intuitive positive spread of medical care inflation *over* headline inflation rather than the reciprocal as it appears in the formulas.

Conservative Valuation

Most entities that have OPEB liabilities at present have fairly conservative estimates of the trend rate of future medical care inflation. For example, in the footnotes of Caterpillar the medical care inflation trend rate assumption is 5.0 percent by 2019.[22] For GE, it is 6.0 percent by 2025.[23] For Alcoa, it is 5.0 percent by 2015.[24] Meanwhile, the CPI swaps market implies long-term inflation expectations at between 2.80 percent (for 10-year swaps) and 2.92 percent (for 30-year swaps).[25] This suggests that companies are valuing the spread of medical care to headline inflation around 2 to 3 percent. In Section 1, I pointed out that over a very long period of time the actual spread has been a bit less than 2 percent. While future experience may have medical care inflation run at faster or slower rates relative to NSA CPI, it is fair to say that at least presently for public companies the OPEB liability is not likely to be aggressively lowballed through the inflation assumption. Moreover, over the long run the law of large numbers probably plays a role—if medical care cost increases continue to run 2 percent higher than inflation for the next 40 years, at some point the NSA CPI will essentially *be* medical care inflation.[26]

So the good news is that there is unlikely to be any important transition cost if plans move to use the hedging methodology I describe.

The Risks of the Inflation Spread Exposure

Of course, any OPEB plan will have idiosyncratic risks particular to the pool of employees/retirees covered by the plan. This is where reinsurance comes into play. The plan sponsor often obtains reinsurance against catastrophic spikes in health care costs—but, using the methodology described herein, the insurance is likely to be cheaper. As noted above, the headline-medical-care spread, over time, has reasonably low volatility. If the reinsurer is asked to hedge not against a *general* rise in medical care inflation, but rather only against an adverse movement in the spread, the cost should reasonably be lower.

Moreover, this also increases the feasibility of self-insuring this small risk, at least until such time as a medical-care-inflation market germinates. To some extent, OPEB plan sponsors already assume some of the risk of rising medical costs, since a long-term, at-the-money reinsurance solution is much too expensive. Some plans may choose to accept the inflation basis risk as a part of the reasonable cost of having a plan … especially if they believe they can contain costs through behavior modification and incentive strategies.

Finally, the fact that future medical care inflation is very hard to estimate argues that instead of exhaustive actuarial analysis it might be reasonable to simply assume that

[22] 2010 10K. Caterpillar also notes, interestingly, "This rate represents 3.0% general inflation plus 2.0% additional health care inflation," which makes the point very explicit.

[23] 2010 10K. The author has no relationship to GE and the company is used only as an illustration.

[24] 2010 Annual Report. The author has no relationship to Alcoa and the company is used only as an illustration.

[25] Source: Enduring Investments (May 10, 2011). Enduring Investments is a boutique consulting and investment management firm specializing in customized inflation solutions.

[26] This assumes that the demand for health care is somewhat inelastic, which it may not be in the long run.

in the long run medical care inflation will run 2 percent faster than NSA CPI and be done with it. This means that the estimate of the long-run trend rate of medical care inflation, which appears in the financial statements, will change every year to reflect changes in the general level of inflation expectations—but the sponsor who implements this strategy no longer cares about this number. All that matters is the spread. If the spread of medical care inflation over headline inflation is simply set at 2 percent, then the main remaining source of balance sheet and income statement volatility resulting from the OPEB liability disappears. Especially if backstop reinsurance is obtained and, perhaps, the actuarial estimate of the spread is updated every five to 10 years, such a practice is eminently defensible.

5. Conclusion

It is natural that financial analysts and actuaries look at balance sheet risks in nominal terms, and consider the sensitivities in nominal terms—after all, it is the way fixed income has been taught for generations. But this perspective is limiting. Fisher observed that nominal rates can be thought of as consisting of a real cost of money and a premium for the expected loss of purchasing power; Leibowitz, Sorensen, Arnott and Hanson extended the thought, but Siegel and Waring made the key breakthrough by arguing that securities that pay a stream of nominal flows have a dual duration: either a change in real rates or changes in expected inflation may drive a price change in a bond.

The notion of "inflation" as a single number or concept, however, is also archaic. There are as many measures of inflation as there are goods and services whose prices fluctuate. I demonstrated that this implies an equal number of distinct real rates, although that is mainly a point of academic interest.

More importantly, these inflations are hierarchal. That is, the rate of inflation of a basket of goods consists of the weighted average of the rates of inflation of the individual components. And it is this observation that leads to a useful insight: one can think of a nominal security as having durations with respect to a particular component of inflation, say i_m, and also having duration to the inverse.[27]

An OPEB liability, as it turns out, often has a natural offset to a large part of the perceived medical care inflation risk. The *positive* duration of the liability with respect to medical care inflation partly offsets the *negative* duration of the liability with respect to overall inflation; this latter comes about because the plan has negative duration with respect to nominal rates and we can creatively decompose a nominal rate into its elemental pieces of real rates and expected inflation. By examining these partial durations, I was able to demonstrate that for most OPEB plans, the salient risk is not to medical care inflation, but to the spread between medical care inflation and overall inflation. This suggested a reasonable and basic portfolio which, when combined with a defensible strategy for valuing the spread, defeases the major risks of the OPEB liability and virtually eliminates the balance sheet and income statement volatility caused by changes in medical care inflation expectations over time.

This same approach might be applied to other such problems where the size of a future cash flow varies positively with a component inflation and the present value of those cash flows varies inversely (of course) with nominal interest rates. Even the

[27] This observation is used in the Appendix to arrive at our conclusion via a different route.

original approach that Siegel and Waring suggested as a solution to the pension liability hedging problem might be improved, for living plans, by considering that the pension liability grows not just with inflation but with *wage* inflation; this introduces a term of $(1+i)/(1+ i_{wages})$. I leave it to other writers and practitioners to come up with additional creative implementations of this approach to attack previously intractable problems.

APPENDIX

Here is a different way to reach approximately the same conclusion as we reach more elegantly in the main body of the paper. We began with the following sensitivities reported by the actuaries analyzing a $1 billion OPEB liability:

Sensitivity to a 1% change in nominal discount rate curve:	$85mm
Sensitivity to a 1% change in the medical care trend rate:	$90mm

Since we do not want to confuse the issue by using the redundancy of nominal rates, and since for nominal rates $D_n=D_r=D_i$, the postulated durations can be separated like so:

	D_r	D_i
Nominal Discount Rate Effect	-8.5	-8.5

These signs are negative because a higher discount rate lowers the OPEB liability. Also,

	D_{i_m}
Medical Care Inflation Effect	9.0

This sign is positive because a rise in expected medical care inflation increases the OPEB liability. So, here is our "bond" for which its medical care duration matters—but, alas, the medical care inflation is not tradeable.

We decomposed the nominal discount rate effect into $n = r + i$. However, we can think of overall inflation as consisting of two parts: medical care inflation, and the inflation of everything else *except* medical care.

$$n = r + (i - i_m) + i_m,$$

But this means the OPEB plan's problem now looks like this:

	D_r	D_{i-i_m}	D_{i_m}
Nominal Discount Rate Effect	-8.5	-8.5	-8.5
Medical Care Inflation Effect			9.0
Aggregate Portfolio Exposure	-8.5	-8.5	0.5

This says that the OPEB plan's exposure to medical care inflation, which is very real, can be offset against a similar exposure, *which is embedded in its nominal discount rate exposure.* The residual terms show that the portfolio has:

(1) Exposure to a decline in real rates of D_r = -8.5,

(2) Exposure to a widening of the spread of medical care inflation over broad inflation (which makes i-i_m more negative) of D_{i-i_m} = -8.5, and

(3) Small exposure to a rise in medical care inflation of D_{i_m} = 0.5.

This is very close to the result we found in the main body of the paper, and the hedge would be very close to the one described there if we made no further corrections. However, there is still a slight exposure to medical care inflation, because the medical care inflation duration doesn't quite match the broad inflation duration. Why this difference?

Remember our one-period liability model.

$$L = \frac{U(1+i_m)}{1+n}$$

The actuarial approach essentially finds the reported durations by moving i_m while holding n constant, and then doing the opposite. But in yet another way to arrange this equation, we can split the denominator thus:

$$L = \frac{U(1+i_m)}{(1+r_m)(1+i_m)}$$

Obviously, canceling (1+i_m) in this equation gets us expediently to equation (7), but if we refrain from this cancellation then we can see the source of the actuarial error.

When the actuaries move (1+i_m) in the numerator while holding the denominator constant, they introduce an error in the following way. If (1+i_m) is rising, then (1+r_m) must be declining so that (1+n) remains constant. In fact, if i_m is above r_m, which is a fairly typical situation, then a 1 percent increase in i_m implies that r_m decreases by slightly less than 1 percent, and a 1 percent decrease in i_m implies that r_m increases by slightly less than 1 percent. This result follows from merely rearranging the Fisher equation as follows, and recognizing that (1+n) in this context is taken to be constant:

$$r_m = \frac{(1+n)}{(1+i_m)} - 1$$

The mismatch in the reported nominal and inflation durations is in fact almost entirely illusory. Suppose that actuaries are estimating a 6 percent long-term rate of medical care inflation at a time when nominal rates are also at 6 percent (implying a long-term real rate, in medical care space, of 0 percent). Then if the calculated nominal duration is 8.5, the reported medical care inflation duration will be 9.1 for a 1 percent increase in medical care inflation, and 8.9 for a decrease. Not only are the durations incorrect altogether since the liability has only real duration, but the misspecification produces an apparent convexity in the actuarial estimates that should be suspicious, considering that (1+i_m) doesn't appear in the denominator of the equation the actuaries are using!

Practically speaking, these errors do not imply that the entire actuarial report is bunkum. The reported nominal duration will be quite close to the actual real duration of the liabilities, especially if inflation is fairly low. The inflation duration we already know to be zero, so to use the argument presented here in the appendix, it should be taken as equal to the nominal duration (which will result after the cancellation in the correct result: the liability will have exposure to general real rates and to the spread of medical care inflation over general inflation).

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