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Disaggregated TIPS: The case for disaggregating inflation-linked bonds into bonds linked to narrower CPI components

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Inspiration for the article

This financial innovation, like most, is driven by market incompleteness and risk-shifting needs. I had recently established a consulting relationship with one of the largest pensions in the U.S. As part of the trustees' normal review of the actuarial assumptions, I learned that pensioners' future health care costs were more than 1/3 of the total benefit obligation. Thus, the liability was tied to future medical inflation.

Since their introduction, inflation-linked bonds have served a useful asset allocation role for pensions—particularly pensions that operate in a liability-aware way. Inflation-linked bonds have some basis risk—insofar as a company's pension inflation might differ from national inflation. The problem with liabilities linked to retirees' medical costs is greater. The question, then, was how to match the medical-cost liability.

I was aware of (little utilized) possibility of decomposing inflation-linked bonds into zero coupon inflation-linked bonds. The obvious solution was to use that precedent, but disaggregate the bonds by inflation component, rather than by time.

Notes for non-US readers

Because I wanted to examine the mechanics of implementing my idea, I needed a specific national laboratory in which to work. Familiarity meant I focused on US inflation (CPI) and inflation-linked bonds (TIPS).

The paper could be readily generalized to other national markets. For example, applying the ideas to RPI and UK linkers is a natural extension.

But would the idea be useful in other countries? For example, pensions in countries with national health systems would be significantly less concerned about medical-care inflation. Because individuals' consumption baskets change over time, I believe the answer is "yes". Breaking inflation-linked bonds into components then reassembling them into packages that align with investors' liabilities makes sense—whatever the nationality.

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Slicing and Dicing TIPS

COMMENTS WELCOMED

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The author is Associate Professor of Finance and Investments at the U.S. Air Force Academy, but this paper was written in a private capacity. The opinions included are those of the author only and not necessarily those of the any organization with which the author is affiliated. Related materials will be maintained at *www.williamjennings.com*.

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Abstract

Investors generally face inflation-linked obligations—a fact contributing to the popularity of TIPS and other inflation-linked bonds. With TIPS, one characterization of inflation, the Consumer Price Index, applies to all investors. Investors, however, face different flavors of inflation. To date, these heterogeneous needs have not been addressed by the inflation-linked marketplace. The paper describes the case for and mechanics of splitting TIPS into disaggregated TIPS matched to components of the Consumer Price Index. Disaggregated TIPS better address investors' specific real liabilities.

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Slicing and Dicing TIPS

Inflation-linked (real) bonds have been an extraordinary success for both the U.S. Treasury and investors since their 1997 introduction. Real bonds have several advantages, but the fundamental characteristic—being a true inflation hedge—is the most attractive feature. Real bonds' inflation-hedging feature has attracted a wide array of investors, including pensions, foundations, endowments, pre-paid tuition plans and individuals.

In the United States, the inflation hedge on Treasury Inflation Protection Securities (TIPS) is tied to CPI-U, the Consumer Price Index for All Urban Consumers. One characterization of inflation applies to all TIPS investors.

This is the problem and opportunity that this paper addresses. My inflation is not your inflation. Retirees and retirement plans, for example, might be more sensitive to inflation in medical costs. Parents care about the cost of college tuition. A local foundation cares more about local inflation.

To date, the inflation-linked bond marketplace has not addressed this diversity of inflation-hedging needs. The marketplace has, however, addressed time-specific inflation-hedging needs by stripping TIPS into zero-coupon real bonds. This paper investigates whether the precedent of *slicing* TIPS into time-specific components can, and should, be extended to *dicing* TIPS into CPI-component disaggregated TIPS. (For readability, I use "disaggregated TIPS" hereafter as shorthand for the more descriptive, but cumbersome, "CPI-component disaggregated TIPS".) Such disaggregated TIPS could then be combined (by either investors or intermediaries) in new ways that reflect investor-specific inflation-hedging needs.

I begin by elaborating on several instances where individual and institutional investors care about inflation tied to their personal basket of consumption goods. After briefly reviewing TIPS, CPI and the stripping process, I demonstrate the mechanics of how TIPS could be "diced" into components. In an appendix, I show the asset-liability efficiency gain for an institutional pension fund facing a liability mix dependent on retirement and retiree health benefits as well as for an individual investor with heavier medical expenses.

Whose inflation?

Kneafsey [2003] and Bernstein [2003] represent a back-to-basics approach to investing. Kneafsey poses and answers the question: "What is the investor's problem?" The answer is to fund a stream of liabilities. For most investors, these liabilities are linked, in greater or lesser degree, to inflation. Moore [1999] characterized this as "ubiquitous real liabilities."

It is a natural extension to think of ubiquitous *but heterogeneous* real liabilities. Individuals, pensions, foundations and endowments face different flavors of inflation. More narrowly, people living in Boston or San Francisco face different housing inflation than those living in Houston or Kansas City. Idiosyncratic inflation experiences are so prevalent that the Bureau of Labor Statistics website prominently displays a link to a fact sheet [2002] on why published averages do not match an individual's inflation experience. Further, the idea of investor-specific inflation mattering is embedded in the asset-liability optimization literature of Sharpe and Tint [1993]; Leibowitz, Bader and Kogelman [1996]; Ryan [1999] and Waring [2004]. I discuss different types of inflation mattering to different investors below.

College inflation, for example, captures many investors' attention. College endowments, among the most sophisticated institutional investors, care crucially about their specific inflation; for example, the 2003 *Yale Endowment Report* specifies that Yale measures real returns relative to college inflation. The state-managed investment pools backing §529 prepaid-tuition plans should be focused on asset-liability optimization where the liability is state-specific college inflation. Many prepaid plans use TIPS in recognition of this liability, but the hedge is imperfect. Disaggregated TIPS linked to the college cost component of CPI would be a better hedge.

Rampant inflation in college costs certainly captures parents' attention. Both the size of the tuition bill and the rate of growth can seem staggering. In response, institutions developed products like the CollegeSure CD, which offers a terminal value linked to college inflation. State college tuition inflation is particularly pernicious because it generally accelerates when a slowing economy hurts many asset classes. The demand for state §529 prepaid-tuition plans is a case of individual investors favoring a product with *specific* inflation immunization—often state-specific college inflation immunization. Merton [2003] discusses the college-inflation-linked liability at length, but points out that providers of college savings products, rather than investors, now bear the liability risk. The investors, however, acquire counterparty risk. As I discuss below, disaggregated TIPS can avoid counterparty risk.

Similarly, charitable foundations have liabilities in a conceptual rather than a contractual sense. These liabilities—payments to grantees and operating expenses—are tied to inflation because trustees generally seek to preserve intergenerational equity.[1] Because of varied eleemosynary goals, however, the inflation faced by specific charities differs. Salem and Barnes claim it is possible for charities to specify "any institution-specific sensitivities that might logically affect investment policy choices (*e.g.*, material linkages between an institution's overall financial condition and the evolving fortunes of particular industries, companies, political jurisdictions, or the like)" (TIFF [2004]). Although they make this claim in the context of "off-balance sheet assets" (like prospective donations), the insight applies to liabilities as well. Food banks face volatile food inflation, community-housing initiatives face local housing inflation, and hospital conversion foundations generally focus on health care and face medical inflation. Foundation scholarship programs are like college endowments in facing education inflation.

Pension providers should care about surplus risk. Surplus is a function of the investment pool and two contractual liabilities—a retirement benefit linked to general inflation and a retiree health-care benefit linked to medical inflation. Retiree medical liabilities are nontrivial relative to pension liabilities. The medical liability component alone represents 40% of General Motor's total postretirement benefit liabilities. Medical inflation can be even more important because it is substantially higher than overall inflation. In the twenty years ending January 2004, medical care costs increased 186 percent while non-medical inflation increased only 75 percent. Many companies expect medical inflation to continue to outpace other inflation; IBM, for one, uses actuarial assumptions of 8½% health care cost inflation and 4% compensation inflation.[2]

Many pensions use TIPS in recognition of their inflation-linked liability, but the hedge is imperfect given the importance of postretirement health benefits. Disaggregated TIPS linked to the medical care cost component of CPI provide more explicit immunization/collateral and would be a better hedge.[3] We investigate this scenario in detail in the Appendix.

Merton [2003] also introduces the idea of "condo value insurance." He states:

> Suppose you are a futures trader who moves to a condo in Chicago. If you are always going to live in Chicago, then whether the price of housing increases or decreases, ownership is a hedge to maintain the same standard of living in housing. But you recognize that you are at some risk of having to move to find work if the futures industry does poorly. If you and others like you have to move at the same time, housing prices are likely to be depressed when you have to make the sale. Ownership is no longer a hedge. Such risk might be better borne, rather than by you, by local institutions that are always going to be located in Chicago and thus have something of a hedge in the form of lower compensation to pay if the real estate market goes down. Perhaps, then, especially for people who are not going to be there permanently, the idea of some kind of floor or insurance of value, like a put option, on the condo might make sense.

In addition to a hedge on current consumption, housing value insurance could serve as a hedge on future consumption. Suppose I have a strong desire to retire to the coast, or suppose an investment banker knows he must return to New York or London after assignment to a regional office. Without exposure to a particular housing market, there is a risk that individuals cannot maintain the same standard of living when they return or retire. Disaggregated TIPS linked to housing inflation could help hedge general housing inflation. This might be of particular interest for expatriates or missionaries who do not know where they will live when they return. They avoid the costs of keeping their house and becoming a landlord. Second-order disaggregated TIPS linked to specific regions' or cities' housing costs, could help support a market for Merton's "condo value insurance" or direct hedging by individuals.

More generally, different individuals have different consumption baskets. Garner, Johnson and Kokoski [1996] analyze an experimental CPI for the poor (who consume proportionally more food and fuel, but less education). At the other extreme, *Forbes* publishes a tongue-in-cheek Cost of Living Extremely Well (featuring Dom Perignon, Rolexes, diamonds, *etc.*) Arrow [1958] felt there should be separate CPIs for every income level. Amble and Stewart [1994] analyze an experimental CPI for the elderly (who consume proportionally more medical care and less education). (I discuss homeowner retirees in more detail in the Appendix.) Regionally, housing is 48% of CPI-U for Boston, but only 37% for Houston and St. Louis. In each case (income, age, or region), the consumption basket and price index differs from the national CPI-U. Disaggregated TIPS—reassembled in customized packages—would be a better hedge than generic TIPS.[4]

Given heterogeneous real liabilities, generic TIPS provide only a partial solution. Without greater customization, investors bear more risk. Specifically, they bear basis risk—the risk that their CPI-linked hedge and their own inflation liabilities differ. Disaggregated TIPS address this risk.

The idea of component-specific inflation-linked bonds is not new. Williams [1997] highlights grain-denominated lending and borrowing in ancient Mesopotamia. Shiller [2003] documents 18th century Massachusetts bonds linked to a four-item basket of goods. Tom Wolfe memorably highlighted the gold-price Giscard bonds in *Bonfire of the Vanities*. Austria issued bonds indexed to electricity in 1953.

These approaches, however, are one-off attempts at market completeness. Disaggregated TIPS offer a much fuller menu of choices for hedging investors' ubiquitous but heterogeneous real liabilities.

TIPS

I prepare for our discussion of disaggregated TIPS with an inflation-linked bond refresher—why governments issue them, why investors buy them, how they work and the current state of the market. (For more detail, see Bynjolfsson and Fabozzi [1999] and Deacon, Derry and Mirfendereski [2004].) For simplicity, I focus on the U.S. TIPS market, but the discussion is generalizable to other inflation-linked bond markets—particularly ones where inflation-linked bonds are strippable (like Canada currently and France and South Africa prospectively).

Governments find the inflation-linked bond market attractive for many reasons. First, central bankers gain more direct insight into inflation expectations. Market-based inflation expectations derived from the TIPS-*versus*-nominal differential are necessarily superior to prior reliance on surveys of economists. Beyond just providing higher quality information about inflation expectations, there is a greater quantity of information because there is a complete and continuous term structure of inflation expectations. Second, governments can credibly signal their inflation-limiting intensions. Absent TIPS, governments have an incentive to debase their currency thus expropriating wealth from nominal Treasury owners. These owners wisely demand an inflation premium in nominal yields. A robust TIPS market mitigates some of this cost in the nominal market. Furthermore, a robust TIPS market can lower borrowing costs if uncertainty about inflation creates a positive inflation-hedging cost (see Hammond [2003]). Fourth, offering TIPS diversifies the government's liability portfolio. If investors have habitat preferences, such diversification of debt offerings may lower borrowing costs by diversifying the creditor pool. Fifth, offering TIPS may enhance a government's mean-variance efficiency in asset-liability space because future government revenues are likely correlated with inflation in the long run. Shorter term, TIPS may help budget smoothing if inflation is negatively correlated with revenues. Finally, governments may want a robust TIPS market because it creates a public good.

How does issuing TIPS create a public good? Consider the reasons investors benefit from a TIPS market.

First, it is an explicitly inflation-linked asset. The damage inflation can do to portfolios is obvious to anyone that experienced it in the 1970s and early '80s. Even low inflation can hurt spending power over long horizons. Second, unexpected inflation represents a transfer from creditors to debtors. Third, TIPS low correlation pushes out the mean-variance efficient frontier. Also, TIPS have low volatility. For more risk averse investors, TIPS substantially displace nominal bonds in efficient portfolios. Finally, many investors appreciate TIPS ability to match their liabilities and find they expand their hedging opportunities. This holds in both single period asset-liability optimization and multi-period portfolio survival simulations.

Since introduction in 1997, the TIPS market has expanded to $200 billion, or about 7 percent of the long-term public debt. There are currently 12 issues outstanding with maturities of 2 to 28 years. TIPS experience reasonable demand at auction (bid-to-cover around 2) and liquidity in the dealer market (average daily volumes approaching $3½ billion).[5] Although a global inflation-linked bond market does exist with at least 30 sovereign issuers, the market is dominated by the US and UK.

TIPS pay semiannual interest that depends on the coupon rate and inflation from the bond's "dated date". For example, the 3 5/8 4/15/28s have a reference CPI-U of 161.74000. CPI-U is the non-seasonally adjusted US City Average All Items Consumer Price Index for All Urban Consumers. For the coupon payment on 4/15/04, the reference CPI-U was a linear interpolation between the January and February 2004 CPIs of 185.2 and 186.2. Since April has 30 days, the Index Ratio was 1.14793 [{185.2 + (14/30)*(186.2-185.2)} / 161.74000]. Accordingly, the 3 5/8 4/15/28s paid $20,806.23 per million face value on 4/15/2004 [$1m · .03625 · 1.14793 / 2]. TIPS final par value also depends on inflation from the bond's dated date. So, if inflation is 3% a year for the next 24 years, CPI-U will be 377.42, and the Index Ratio will be 2.33350, so the bond will pay $2,333,500 per million of initial par value. In short, both coupons and principal payments on TIPS are linked to inflation. In formulas, the value of coupon and final payments are as follows.

$$\text{CouponPmt}_{\text{date}} = \frac{\text{CouponRate}}{200} \times \text{IndexRatio}_{\text{date}} \times \text{Par} \tag{1}$$

$$\text{PrincipalPmt}_{\text{maturity}} = \text{Par} \times \text{Max}\left[1, \text{IndexRatio}_{\text{date}}\right] \tag{2}$$

where the variable names are as described above. The $\text{Max}(1,\text{IndexRatio}_{\text{date}})$ reflects the guarantee that deflation will not reduce the final payment below par value.

STRIPS is an acronym for Separate Trading of Registered Interest and Principal of Securities. From inception, TIPS were strippable (see Grieves and Sunner [1999]) and Barclays Capital did so, calling the components iSTRIPS. This product helps institutional investors build a customized inflation-indexed cash flow stream. Consider, for example, a company with a young workforce and a defined benefit pension plan implicitly linked to inflation. The surplus-optimal asset allocation for a fund with such an inflation-linked liability would likely include long-dated iSTRIPS. Consistent with the Ryan [1999] concept of a custom liability index, iSTRIPS help match the pension liability better than even long-dated TIPS because of the intervening cash flows. In the "slicing and dicing" of my subtitle, iSTRIPS could be seen as slicing (in the time dimension) and serve as a useful model for disaggregating TIPS (in the CPI component dimension), or the dicing of my subtitle. We turn now to CPI to understand how that dicing might work.

The CPI-U is a Laspeyres price index. Roughly, this means it measures price changes over some period for a basket of consumption goods chosen at the beginning of the period. The Bureau of Labor Statistics [BLS] first determines the proportion of consumption spent on apples, for example. The BLS then determines how prices of apples have changed since the initial basket of goods was determined.

Consider a detailed example now because of the importance of index construction to understanding disaggregated TIPS. Imagine a world with only two kinds of goods—medical care and everything else. Assume medical care is five percent of the initial basket of goods with non-medical goods the remainder. Table 1 calculates the Laspeyres price index if medical inflation is 11 percent and non-medical inflation is 3 percent. Again, the Laspeyres formula multiplies initial weights by ending prices to compute the price index. In Table 1, this gives an ending price index value of 103.4. Aggregate inflation is 3.4%. Note that if the consumption basket does not change, as Laspeyres assumes, then the proportion spent on the higher-inflation medical goods is more than the initial five percent (0.0555/1.0340, or 5.4%).

Table 1

	Basket Weight at t=1	Price Index at t=1	Inflation level	Price Index at t=2	Multiplied Value
	W_1	P_1		P_2	$W_1 \cdot P_2$
Medical Care	5%	100	11%	111.0	0.0555
Non Medical	95%	100	3%	103.0	0.9785
Aggregate CPI	100%	100		103.4	1.0340

Disaggregated TIPS

In Table 1, aggregate inflation is 3.4%. Consider how this affects a hypothetical 3% coupon TIPS. Before inflation (at time t=1), it pays $15,000.00 per million face value. For simplicity, assume the coupon is due exactly at time t=2 and this bond's reference CPI-U is 100. Accordingly, the Index Ratio is 1.03400. The hypothetical 3% TIPS will pay a semiannual coupon payment of $15,510.00 per million face value [$1m · .03 · 1.03400 / 2].

Now consider how this 3% TIPS could be "diced" into two disaggregated TIPS—one linked to medical care inflation and the other linked to non-medical inflation. Table 1 assumed medical care was five percent of the initial basket of goods. Accordingly, TIPS with $1 million face value could be diced into $50,000 in medical care and $950,000 in non-medical disaggregated TIPS. Before inflation (at time t=1), the medical care disaggregated TIPS would receive a $750.00 coupon payment [$50,000 · .03 · 1.00000 / 2] and the non-medical disaggregated TIPS would receive $14,250.00 [$950,000 · .03 · 1.00000 / 2]. The two coupons sum to the original $15,000.00 per million face value. See Table 2.

Table 2

	Basket Weight at t=1	Par Value	Index Ratio	Coupon at t=1	Coupon Proportion
Medical Care	5%	$50,000.00	1.00000	$750.00	0.0500
Non Medical	95%	$950,000.00	1.00000	$14,250.00	0.9500
Aggregate CPI	100%	$1,000,000.00	1.00000	$15,000.00	1.0000

Now consider the inflated coupon payments at t=2. The medical care disaggregated TIPS would receive an $832.50 coupon payment [$50,000 · .03 · 1.11000 / 2] reflecting the medical care price index of 111.0. Similarly, the non-medical disaggregated TIPS would receive a $14,677.50 coupon payment [$950,000 · .03 · 1.03000 / 2]. The two coupons sum to $15,510.00, the time t=2 semiannual coupon of the aggregate TIPS—there is no frictional gain or loss from disaggregating TIPS. See Table 3.

Table 3

	Basket Weight at t=1	Par Value	Index Ratio	Coupon at t=2	Coupon Proportion
Medical Care	5%	$50,000.00	1.11000	$832.50	0.0537
Non Medical	95%	$950,000.00	1.03000	$14,677.50	0.9463
Aggregate CPI	100%	$1,000,000.00	1.03400	$15,510.00	1.0000

Recall that Table 1 assumed medical care was 5.0 percent of the initial basket of goods but that the higher (11%) medical inflation caused it to grow to approximately 5.4 percent of consumption at time t=2. Which of these is most relevant to dicing TIPS? Because CPI-U is a Laspeyres price index, initial basket weights are crucial. Note that the $1 million TIPS was disaggregated into $50,000 in medical care and $950,000 in non-medical disaggregated TIPS—*and these par values did not change when computing time t=2 coupons*. The disaggregated par value weights must remain proportional to original basket weighting, not the new weighted value. (Of course, the $832.50 medical disaggregated TIPS coupon tracks the price index and is approximately 5.4 percent of the $15,000.00 aggregate TIPS coupon.)

Below, I give more-general formulas for disaggregated TIPS. They accommodate different Index Ratios for the CPI components and different break-ups of CPI. The value of coupon and final payments are as follows.

$$CouponPmt_{date} = \frac{CouponRate}{200} \times SubIndexRatio_{date} \times Par \times Weight_{initial} \quad (3)$$

$$PrincipalPmt_{maturity} = Par \times Weight_{initial} \times SubIndexRatio_{date} \quad (4)$$

SubIndexRatio is the Index Ratio for the CPI component; $Weight_{initial}$ is the percentage of the overall CPI basket the CPI component represents at the time of disaggregation. The term ($Par \times Weight_{initial}$) is the par value of the disaggregated TIPS.

Extended example

Note for the journal editor: If space is a constraint, the extended example could either be deleted or moved to an appendix or a www-based supplement.

We will now step through a more realistic example. This should provide a more comprehensive proof of concept.

Assume the 3 5/8% 2028 TIPS described above were disaggregated immediately after the April 15, 2003, coupon payment. The price is 123-26 and the Index Ratio (reflecting accumulated inflation) is 1.12745. One million face value costs $1,395,924.03 [$1m · 123.8125 / 100 · 1.12745].

From $1 million in TIPS, nine disaggregated TIPS are created. (This is one for each of the eight main CPI components; note that it excludes energy, which is in more than one category but which might make an attractive disaggregated TIPS.)

Obviously, it is crucial that the rules for determining basket weights be clearly articulated. The BLS regularly publishes data on the relative importance of different CPI components; care should be taken with these since they reflect both original basket weights and subsequent inflation. In equation (4), $Weight_{initial}$ is relative the overall CPI basket at the time of CPI "re-basketing" date immediately before the reference date for the aggregate TIPS. For this bond, weights from 1993-1995 were in use in 1998 when the bond was issued. These weights are multiplied by the $1 million par value of the TIPS to be disaggregated to get the component s' par values.

Reference CPI-Us are computed for each component in the same way as they were for the aggregate TIPS. (For the 4/15/2028 bond, it is a 7/30 interpolation between the January and February 1998 CPI-Us.)

Table 4

	Original Basket Wgt.	Par Value	Reference CPI-U	Index Ratio	Coupon at 4/15/04
Housing	39.560%	$395,600	158.53333	1.17721	$8,440.89
Food & Bev.	16.310	163,100	160.06667	1.15198	3,405.47
Apparel	4.944	49,440	130.78000	0.89545	802.41
Transport	17.578	175,780	142.42000	1.10827	3,530.96
Medical	5.614	56,140	238.66000	1.27680	1,299.19
Recreation	6.145	61,450	100.48667	1.07610	1,198.54
Education & Communication	5.528	55,280	99.85333	1.11310	1,115.27
Other	4.321	43,210	232.14000	1.30016	1,018.26
Aggregate CPI	100.000%	$1,000,000	161.74000	1.14793	$20,811.00

Move forward one year. How is the April 15, 2004, TIPS coupon allocated? Like aggregate TIPS, one must compute an Index Ratio using the reference CPI and the January and February 2004 component CPIs. (Again, since April has 30 days and the coupon pays on the 15th, the index ratio uses 14/30 interpolation between January and February 2004 CPIs.) This Index Ratio gives the cumulative inflation in the component since the TIPS was issued. Coupons are computed using the coupon rate (3 5/8%), component par values and component index ratios.

For example, medical care represented 5.614% of the consumption basket when the TIPS was issued, so the medical TIPS that is created from disaggregating $1 million in regular TIPS has a par value of $56,140. (See Operational Issues in the next section.) The reference CPI for medical care, related to the bonds' "dated date", is 238.66. The CPI interpolated from January and February 2004 is 304.72, so the Index Ratio is 1.27680. Accordingly, the medical care disaggregated TIPS pays a coupon of $1,299.19 on April 15, 2004 [$56,140 · .03625 · 1.27680 / 2].

Technicalities

While I hope the notion of disaggregated TIPS appears intuitive, the process of actually implementing such securities might be somewhat problematic. Below, I consider a range of potential complications for the idea of disaggregated TIPS:

Operational issues: Book-entry systems at the Federal Reserve and dealers would need to be modified to accommodate disaggregated TIPS. Each disaggregated TIPS created would require its own CUSIP.

To separate a conventional book-entry TIPS into CPI-specific component with par values of $1000, the normal minimum, could require a significant initial position. Bureau of Labor Statistics data on the relative importance of CPI components are normally presented to the hundred-thousandths place (*e.g.*, 6.019%). This would require $100 million up front—a nontrivial sum. Alternatively, a less granular rounding scheme could be agreed to; for example, rounding to the thousandths place (*e.g.*, 6.0%) would only require $1 million—an amount comparable to that necessary for stripping TIPS (see Grieves and Sunner [1999]). The less granular approach could be combined with a norm that the residual accrues to a particular CPI component (*e.g.*, other goods and services). This approach could also be used when, due to rounding, the component weights do not sum exactly to 100%.

Granularity: There is an additional granularity issue. Notice that Table 4 shows $20,811.00 in total coupons. This compares to the $20,806.23 we computed earlier in the paper for the full TIPS. The difference is small—less than one-twentieth of a basis point. Part of this difference is discussed in the next section on reweighting the CPI, but part of the difference is attributable to granularity in reported CPI numbers. Price indices are reported to one decimal place. The difficulty arises when this level of rounding is used for large dollars of disaggregated TIPS. Again, the solution to this problem could be to assign the residual to a particular CPI component.

Reweighting the CPI: While an investor might desire bonds exactly linked to a specific CPI-of-interest, changes to the basket of goods making up the aggregate CPI complicate the approach recommended here. Regular TIPS are linked to CPI-U with its changing basket weights. If the disaggregation process depends on a non-governmental intermediary that intermediary would bear some "re-basketing" risk. Such a process introduces counterparty risk. These risks, although presumably compensated, hurt the fundamental attractiveness of disaggregated-CPI TIPS.

The way around these two risks is to assure that the CPI guarantees in TIPS pass unabated to disaggregated-CPI TIPS. This means any changes to the weighting of a CPI component will affect the payoff of the related disaggregated TIPS. For example, health care's weight declined from 6.387% in 1990 to 5.768% in 1999, but rose to 6.074% in 2003.

Below, I give more-general formulas for disaggregated TIPS. They accommodate different Index Ratios for the CPI components and different break-ups of CPI. The value of coupon and final payments are as follows.

$$CouponPmt_{date} = \frac{CouponRate}{200} \times SubIndexRatio_{date} \times Par \times Weight_{initial} \times Ratio_{most\text{-}recent} \quad (5)$$

$$PrincipalPmt_{maturity} = Par \times Weight_{initial} \times Ratio_{most\text{-}recent} \times SubIndexRatio_{date} \quad (6)$$

where

$$Ratio_{most\text{-}recent} = \frac{Weight_{most\text{-}recent}}{Weight_{initial}} \quad (7)$$

Equation (7) makes the adjustment for "re-basketing" the CPI.[6] The consequence of this approach is reduced counterparty risk but increased basis risk—investors receive good, but incomplete, hedging of their specific inflation.

The TIPS deflation hedge: Regular TIPS contain a promise that the final principal payment will be at least $1000—even if there is deflation from reference CPI-U of the bond's "dated date". The Max(1,$IndexRatio_{date}$) term in equation (2) reflects this guarantee.

Note that this is an aggregate promise, not a component-by-component promise. Even if some goods experience deflation, inflation in other goods may offset that and vitiate the aggregate deflation guarantee. Effectively, the Treasury gains from holding a "portfolio" of commitments tied to different types of inflation. Inflation offsets component deflation.

The fact that the TIPS deflation guarantee is not component-by-component explains why equations (4) and (6) do not have a no-deflation Max(1,$SubIndexRatio_{date}$) term like equation (1). Resolving this proposition (a low-likelihood one, in my view) is beyond the scope of this paper.[7]

Variable inflation risk premium: Simple analysis assumes that TIPS yield-to-maturity plus expected inflation equals nominal Treasuries' YTM. A more sophisticated approach recognizes that the nominal YTM includes an inflation risk premium that compensates investors for uncertainty about future inflation. See Hammond *et al*. [1999]. Working backward from the nominal YTM, this implies TIPS pricing reflects an inflation risk premium.

If TIPS were disaggregated, it is reasonable to expect cross-sectional differentials in both inflation expectations and inflation risk premiums. Uncertainty about medical inflation, for example, might lead to bigger inflation risk premiums for medical disaggregated TIPS. But like supply and demand differentials, this is not a problem. If TIPS can be freely disaggregated and reassembled, arbitrage opportunities suggest that we can expect that disaggregated TIPS prices will reflect the market's aggregate judgment and that variable inflation risk premiums won't create imbalances. In fact, we might expect the regular TIPS market to be more efficient. Disaggregated TIPS provide a market-driven price for inflation; component-specific inflation risk premiums are incorporated.

Taxation: Under the Internal Revenue Code, capital gains are generally taxed without adjusting for inflation. With TIPS, the inflation-adjustment to principal is treated as if it were a zero coupon bond. Although the principal payment may be years away, the increase in the Index Ratio and future principal payment is treated as current income and taxed each year. For this reason, many advise individuals to hold TIPS in tax-advantaged accounts. There is nothing in the design of disaggregated TIPS that should preclude them from being treated the same way as regular TIPS under the tax code.

Conclusion

Earlier, I mentioned the grain-priced lending of ancient Mesopotamia. My paper is effectively a call for a return to the commodity-specific nature of the Mesopotamian receipts. Doing so will help complete financial markets by allowing more-specific inflation hedging. This article is in the spirit of Bach and Musgrave [1941], an early call for creating inflation-linked Treasuries, in both describing both the benefits and technical details of the proposed product—CPI-component disaggregated TIPS.

Investors gain from having an inflation-linked asset that is tied to the inflation that they most directly face. As I show in the Appendix, the risk-return-correlation attributes of disaggregated TIPS push out the efficient frontier—particularly in an asset-liability context. Restated, disaggregated TIPS expand the hedging opportunities of heterogeneous private investors. The government gains by creating a private good that benefits investors. It further gains by having market-based measures of specific types of inflation.

The concept advanced here is not without limitations—notably the potential for acceptance. Acceptance and understanding of TIPS themselves has been slow and limited (see Arnott [2003]). Adoption of more-specialized inflation products like TIPS futures, CPI futures, iSTRIPS and inflation-linked swaps is not encouraging. Inflation futures have been unpopular, and less than one percent of TIPS have been stripped. Inflation-linked swaps, the most successful of the specialized products, are a small but growing part of the investment landscape; like inflation-linked swaps, disaggregated TIPS compliment the main TIPS market by adding flexibility and creating opportunities for financial engineering to meet investment objectives unavailable in the native TIPS market. My hope in proposing disaggregated TIPS is that these capabilities induce acceptance.

Why shouldn't this idea of bonds linked to custom CPI baskets be handled in the OTC derivatives market? The quick answer is liquidity and counterparty risk. While there is a well-developed global interest rate swap market and a growing inflation-swap market, a disaggregated TIPS market of the sort described above would enhance liquidity because of the government endorsement and standardization. Inflation purchasers (investors) gain by knowing a standardized marketplace exists for them to unwind their custom-inflation position.[8] They also avoid the risk of counterparty default. Inflation payers (issuers) gain the benefit of a disaggregated inflation market without the risks and logistical difficulties associated with creating it themselves. The order matching process is much more continuous with disaggregated TIPS than in a one-off swaps market.

While various commodity futures contracts exist and are certainly real assets, there are at least two problems that prevent them serving as substitute for disaggregated TIPS. First, they offer an incomplete menu of hedging opportunities (both in scope and time horizon). Second, they are imperfect—generally too volatile—hedge (Kaplan and Lummer [1998] and Strongin and Petsch [1997]).

This paper describes both a problem and a solution. Even if the mechanics of the solution require further refinement, the problem of ubiquitous but heterogeneous real liabilities (*i.e.*, non-standard inflation hedging needs) remains, and I hope the financial marketplace moves to address them.

> *If the market had invented CPI-component disaggregated TIPS first, who would bother to invent ordinary CPI-U TIPS? Provided the markets are liquid, everyone would prefer a customized basket of goods.*[9]

Appendix—Applying disaggregated TIPS to pensions

Below I introduce two scenarios—for an institutional investor and an individual one. In the scenarios, I motivate why they care crucially about particular baskets of inflation-indexed liabilities.

Institutional case: Most public pensions have explicit or implicit inflation-adjusted retirement benefits. As discussed in the body of the paper, postretirement health benefits are a significant portion of the overall pension promise to retirees. In 2003, a number of states (*e.g.*, California, Texas) modified their plans to reflect the growing realization of this issue.

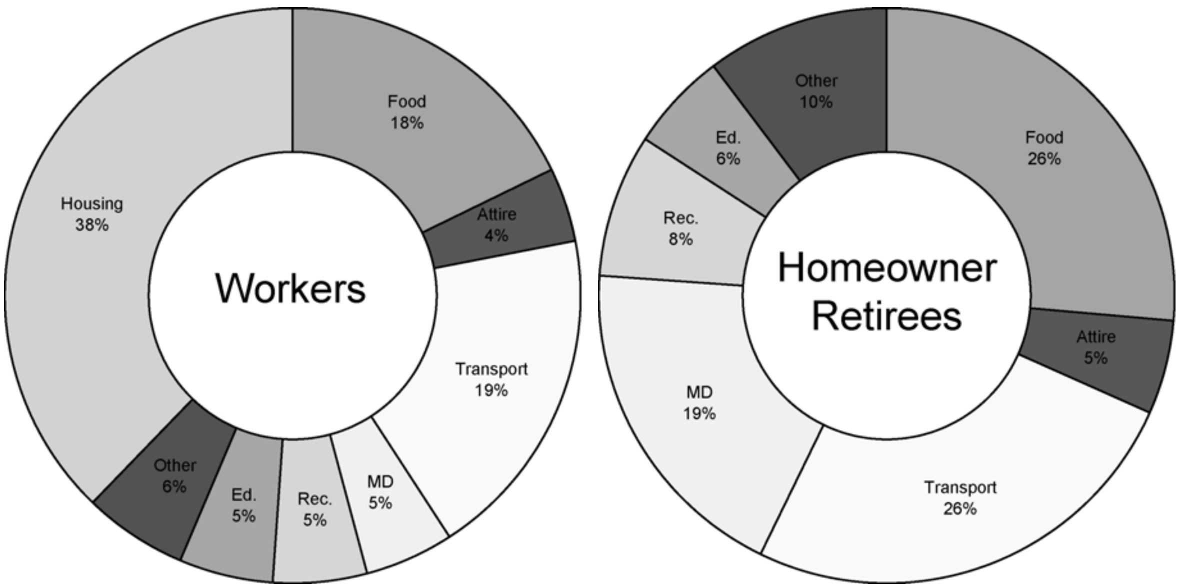
These liabilities are large and increasing. IBM's inflation assumptions (8½% health care cost inflation and 4% compensation inflation) make a nice case study. If these differentials persist for only five years, health care costs will be up more than twice (2.32×) the broader-based compensation inflation (50% *versus* 22%). (The author is familiar with actuarial assumptions showing both much higher medical inflation and differentials lasting much longer.) With statistics like these, it is easy to see why pensions are concerned; further, it is intuitive to see why pensions might gravitate to financial products that help meet these inflation-linked liabilities.

Individual case: The purchasing pattern of retirees differs from workers. Typical retirees, for example, spend significantly more on medical care. Because of this upweight on rapidly growing medical costs, retirees' inflation is almost always higher than general inflation. This discrepancy has led to arguments for linking Social Security to a custom consumer price index for the elderly [CPI-E]. See Amble and Stewart [1994].

In constructing an experimental CPI-E, the U.S. Bureau of Labor Statistics found the consumption basket of the typical retiree had twice (2.02×) the medical care expense of the typical worker. Housing costs comprised almost 46% of the CPI-E.

The BLS uses an imputed rent approach to housing inflation. Many retirees, however, own their homes, so housing inflation is not a significant part of their "felt" inflation. If we jack-knife housing costs out of the CPI-E, to obtain a measure of the inflation felt by homeowner retirees (and financed by their investment portfolios), medical care grows to almost one-fifth of the index. See Figure A1 for the respective consumption baskets.

Figure A1



Analysis: This is the situation I analyze. A retiree is optimizing in asset-liability space. The liability is inflation-linked with a 20/80 split between medical and non-medical inflation.

Similarly, a hypothetical Teachers' Retirement System must fund an overall-inflation retirement benefit liability and a medical-inflation retiree health benefit liability. I assume the 20/80 split between medical and non-medical inflation holds to allow us to merge the individual and institutional examples. Below, I simply refer to the "investor."

Table A1 presents the investor's optimization inputs. The less-than-historical equity risk premium is conservative. Recent experience in medical inflation supports the medical versus non-medical disaggregated TIPS premium.[10]

Table A1

	Asset Class	Expected Return	Standard Deviation	Correlation 1	2	3	4	5
1	Stocks	8.0%	20.0%	1.00	0.60	-0.20	-0.20	-0.20
2	Bonds	5.0%	8.0%		1.00	0.00	0.00	0.00
3	Ordinary CPI-U TIPS	4.5%	3.0%			1.00	0.75	0.95
4	Medical Inflation TIPS	6.4%	4.0%				1.00	0.70
5	Non-Med Inflation TIPS	4.4%	3.0%					1.00

I assume the investor currently has a surplus[11]—the asset-liability ratio is 1.2 to 1. After optimizing in asset-liability space, one obtains the results in Table A2. Because many people find moves "north" and "west" in risk-return space (return-enhancing and risk-reducing moves, respectively) more intuitive, I focus on them rather than on maintaining a constant risk aversion coefficient.

Table A2

TIPS Environment	Portfolio Description	Stocks	Bonds	TIPS	Medical Inflation TIPS	Expected Surplus Return	Expected Standard Deviation
		Asset Class					
No TIPS	Baseline Portfolio	60%	40%	na	na	2.80%	14.81%
TIPS	Risk ⇓ Portfolio	66%	0%	34%	na	2.80%	13.75%
	Return ⇑ Portfolio	72%	0%	28%	na	3.01%	14.80%
Disaggregated TIPS	Risk ⇓ Portfolio	25%	0%	0%	75%	2.81%	5.31%
	Return ⇑ Portfolio	72%	0%	0%	28%	3.55%	14.82%

As expected, adding TIPS to the asset-liability space shifts the efficient frontier northwest. Many researchers find that adding TIPS to stock/bond portfolios enhances portfolio efficiency and that TIPS displace ordinary bonds along much of the efficient frontier.[12] My results, in asset-liability space, are consistent with the earlier research. With Table A1 optimization inputs, adding TIPS to the investment opportunity set leads to either 7% less risk or a dramatic 21 basis point increase in expected surplus returns.

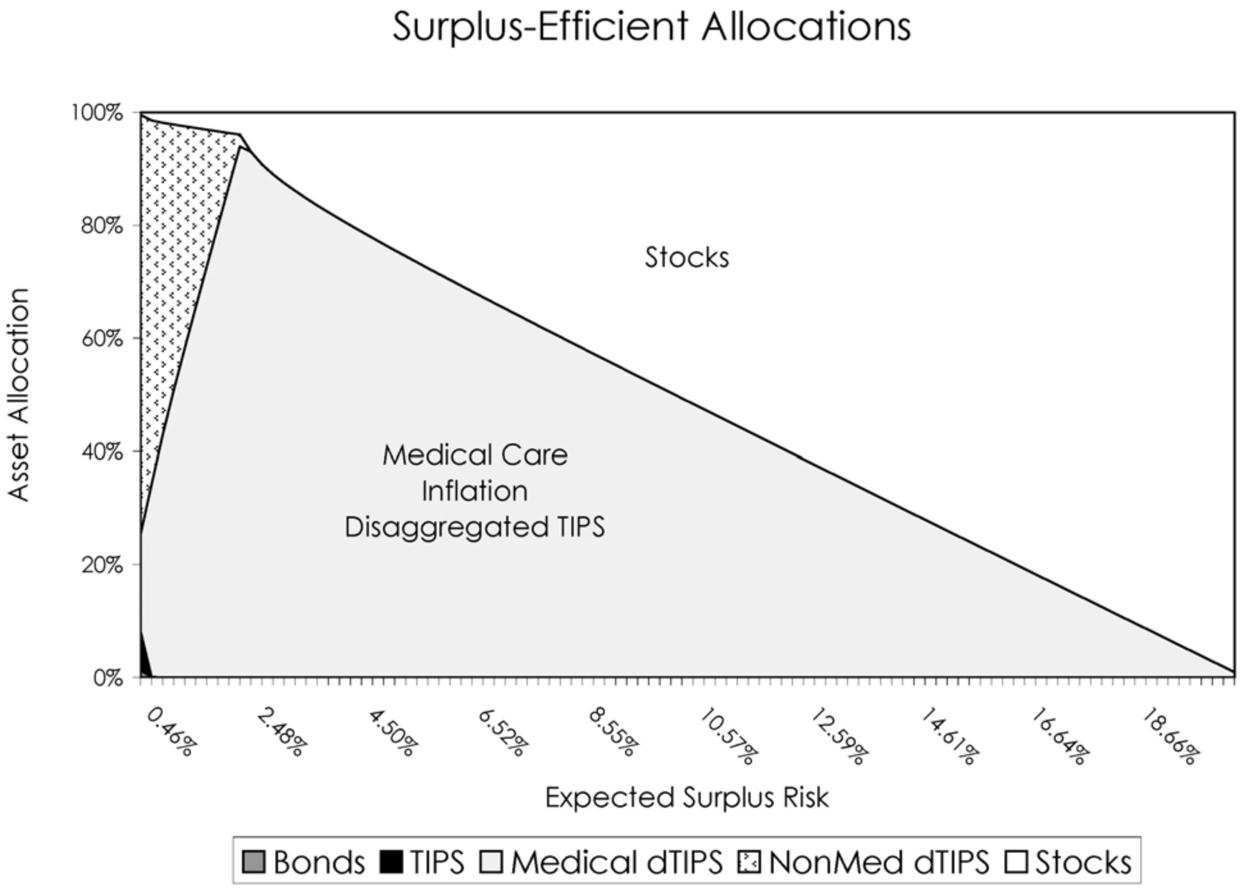
The results for disaggregated TIPS are striking. With Table A1 optimization inputs, adding disaggregated TIPS leads to either 64% less risk or a 75 basis point increase in expected surplus return. These are astounding efficiency gains. The results are an artifact of the dramatic, but plausible, inputs for medical inflation.

Note that the efficient portfolios listed hold only stocks and medical-inflation disaggregated TIPS with no nominal bonds, ordinary TIPS or non-medical disaggregated TIPS. This is true across much of the efficient frontier; at lower risk aversions, a combination of medical and non-medical disaggregated TIPS forms the bulk of the portfolio. See Figure A2. Except in the lowest risk aversion region, TIPS and nominal bonds are totally displaced and play no part in the efficient portfolio. For individuals and pensions facing high and uncertain medical care inflation, the medical inflation disaggregated TIPS are extremely attractive. They are both a liability hedge and a high return-per-unit-risk asset.

The case study considered in this Appendix is a joint one pertaining to both individual pensioners and institutional pension funds. In it we demonstrate that because investors should care about customized inflation, disaggregating the CPI-U inflation-adjustment component of TIPS helps improve portfolio efficiency.

Generally, more complete financial markets enhance efficiency; the increased granularity of disaggregated TIPS makes markets more complete. Particularly, disaggregated TIPS help solve the pension investor's problem of ubiquitous but heterogeneous real liabilities.

Figure A2



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Endnotes

[1] See Tobin [1974] on trustees serving as guardians of the future against the claims of the present. Private foundations face an Internal Revenue Code requirement to pay out five percent of assets. While TIPS real yields have always been inadequate to completely meet this goal, TIPS can play an important role in asset mixes designed to meet the joint goals of intergenerational equity and paying out five percent. TIPS attractiveness holds even for charities not subject to the five percent payout rule. The hedge, however, is imperfect.

[2] Most government pension benefits are explicitly linked to inflation; while this benefit-linking is less prevalent in private pensions, there is an indirect link since benefits are tied to some function of final compensation. Since SFAS 106 in 1990, companies must address postretirement medical liabilities in their financial statements. The statistics on GM and IBM are from their 2003 annual reports.

[3] After 2008, CalPERS will link agencies and municipalities' contributions for retiree health care to the medical care component of the Consumer Price Index. This is partial recognition of the need to respond to a specific type of inflation.

[4] I would not necessarily expect the poor or elderly to trade in a highly evolved financial product. Instead, non-profits and social service organizations that support the poor, for example, have implicit liabilities tied to "CPI-Poor" and could reasonably benefit from a custom basket of disaggregated TIPS. Similarly, financial intermediaries might create annuity packages for the elderly linked to CPI-E (see Bodie [2004], for example).

[5] Sack and Elsasser [2004] note this volume is comparable with off-the-run Treasuries. Spreads, however, are significantly higher—up to $6/32^{nds}$.

[6] Combining equations (6) and (7), the two $Weight_{initial}$ terms appear to cancel out. Recall however, that *Par* is the par value of the aggregate TIPS and ($Par \times Weight_{initial}$) is the par value of the disaggregated TIPS. Since the actual par value of disaggregated TIPS would not really change, the ratio in equation (7) is necessary to adjust the coupon and final payments.

[7] The aggregate TIPS deflation hedge is effectively a European put. There are several alternatives: i) Each disaggregated TIPS should only benefit from the deflation hedge if there is aggregate deflation. This would create a conditional version of equation (6) that included a no-deflation term only when there is aggregate deflation. (It is effectively a European dual-factor barrier knock-in put.) ii) Upon formation, disaggregated TIPS lose the aggregate deflation hedge. Unfortunately, this makes reconstituting them into regular TIPS difficult or impossible, which would hurt the attractiveness of the disaggregated TIPS market. This makes this option clearly unattractive. iii) The aggregate deflation hedge could attach to a particular disaggregated TIPS. Under this option, my bias is toward attaching it to Other Goods or Services, a rump sector for which I have difficulty imaging significant demand. At the extreme, that disaggregated TIPS could benefit from aggregate deflation even when its CPI component inflated. iv) The deflation promise could trade separately. Doing so might allow stripped TIPS principal components to be further split into the deflation promise and a cash flow promise (which would then be fungible with stripped TIPS coupons of the same date).

[8] At the time of writing, the author is unaware of any ISDA- or equivalently-standardized inflation-linked swap terms.

[9] Deacon *et al.* [2004] report that Barclays [2002] makes a similar claim for TIPS vis-à-vis nominal bonds.

[10] Historical optimizer inputs are specious. History can, however, inform prospective asset class risk and return assumptions. In using history-based inputs, it is vital to remember that, to paraphrase Mark Twain, history is more likely to rhyme than repeat.

[11] Longevity risk and bequest motives are justification for the individual acting as if she has a surplus (rather than just increasing consumption). Even after several years of declining assets and soaring liabilities, Wilshire [2003] reports 29 of 123 state pension funds have surpluses. In 2000, almost 70% of state funds had surpluses.

[12] See, among others, Siegel [1998], Bodie [1990], Brynjolfsson and Rennie [1999], Chen and Terrien [1999], Dalio and Bernstein [1999], Lamm [1998], Phoa [1999], Rudolph-Shabinsky [2000], and Kothari and Shanken [2004].