JOURNAL OF FORENSIC ECONOMICS

Discounting Damage Awards Using the Zero Coupon Treasury Curve: Satisfying Legal and Economic Theory While Matching Future Cash Flow Projections

Joseph Irving Rosenberg*

Journal of Forensic Economics 21(2), 2010, pp. 173-194
http://www.JournalofForensicEconomics.com/doi/pdf/10.5085/jfe.21.2.173

Discounting Damage Awards Using the Zero Coupon Treasury Curve: Satisfying Legal and Economic Theory While Matching Future Cash Flow Projections

Joseph Irving Rosenberg*

Abstract

How to calculate damage awards has long been the subject of academic dispute. Much focus has been on what is the appropriate discount rate to convert future lost earnings into a lump sum amount. Conflicting or ambiguous legal guidance by the courts has lead to wide disparities in discount rate methodology. This paper presents a fresh, alternative approach to valuing lost earnings in damage awards using current market data from the zero coupon Treasury bond curve. Unlike many other approaches this approach satisfies legal requirements while offering several theoretical and practical benefits: (a) default free discounting; (b) market-based prices and yields; (c) a fully objective way to recompute awards if market conditions change materially in the course of litigation; (d) satisfaction of the "parity in risk" principal which requires consistent treatment of uncertainty in cash flows and discount rate, which is violated by using an arbitrary average of three-month T-bill rates if inflation is embedded in lost earnings; and (e) a theoretically investible stream of cash flows that can be maturity matched against projected lost earnings. DOI: 10.5085/jfe.21.2.173

I. Introduction

How to calculate an appropriate damage award by discounting future economic losses has been the subject of many conflicting journal articles and academic disputes over the years. Much of the discussion has focused on what is the appropriate level of discount rate used to reduce a series of future cash flows into a lump sum number. However, the concept of discounting future cash flows goes far beyond deriving lump sum damage awards; it applies in all of finance and economics as a way to express the time value of money. To address this issue, it is important to understand the relationship of a discount rate to present value. In cases where the initial investment value or security price is *known* (i.e., present value), the discount rate is solved for and represents the internal rate of return (IRR) or yield to maturity (YTM). In other cases, where the initial investment value or security price is *unknown* (e.g., when valuing a bond, project, or a damage award), the discount rate is assumed and present value is calculated. For either purpose, the discount rate

*Principal, Joseph I. Rosenberg, CFA, LLC (Financial Planning and Investment Advisory Service).

need not be a constant for each period, a topic that is discussed further in this paper (see Section III).

Conflicting or ambiguous legal guidance among the states and the Supreme Court in its *Pfeifer* decision (see Section II) has lead to a wide disparity of discount rate values and the underlying interest rate maturity assumptions employed throughout the forensic economics community. This has been demonstrated via responses to questions in a number of surveys over the last 20 years. In a recently published survey, about 18% of respondents used short term bond interest rates, whereas over 80% used bond rates either of intermediate term, long term, a mix of terms, or some other method (Brookshire, Luthy and Slesnick, 2006). The lack of any clear preferences among forensic economists indicates the range of discretion that courts allow, diversity of jurisdictional requirements, and, most probably, the absence of a convincing single approach to addressing this question.

There is also the question of "parity in risk" argued for by Margulis (1992), Biederman and Basemann (1996), Henderson and Seward (1998), and Brush (2003), while discussed more broadly in Breeden (2003). Simply stated, the proponents of the "parity in risk" principal argue that the correct discount rate to apply in computing a lump sum award should be risk-adjusted to counterbalance the forecast uncertainties from estimating future losses. In other words, only future economic losses that are certain should be discounted with a risk-free discount rate. For instance, mitigating default risk is mandated by the *Pfeifer* decision. Risk parity for default may appear straightforward to achieve by incorporating default risk both in future earnings losses via worklife expectancy and in discounting. However, an academic dispute by Bell and Taub (1999) v. Ireland (1997) showed that agreement on how to eliminate default risk in a way that is consistent with forecasted lost earnings is elusive.

Equally unclear is whether mitigating inflation risk either should be achieved (given that *Pfeifer* does not require it), or even could be achieved without investing lump sum award proceeds entirely in instruments such as Treasury Inflation Protected Securities (TIPS) or three-month T-bills. To those who believe the "parity in risk" principal is sound finance, the current practice of many forensic economists of including inflationary adjustments in forecasting future lost earnings while discounting at some multi-year average of three-month T-bills represents a clear violation of that principal.

The purpose of this paper is to propose an alternative discount rate approach to most of the popular ones in usage. It might be called the Zero Coupon U.S. Treasury Curve Discount method. Rather than have a single, somewhat arbitrary discount rate for discounting all future cash flows, it is proposed instead to use a time series of default-free payments based on a ladder of zero coupon T-Bonds, using independent, widely accepted market prices for these instruments, such as those reported daily in the *Wall Street Journal*. This approach uses observed secondary market prices for a series of zero coupon (ZC) U.S. Treasury bonds that corresponds with the time period of projected economic loss. The sum of each period's ZC bond price multiplied by each period's projected earnings loss would equal the appropriate lump sum amount to be awarded. Since prices are directly translatable into yield, a corresponding series of discount rates also becomes observable, and by solving for the IRR associated with each period's projected cash flow, an implied single discount rate also can be derived.

The benefits obtained by using this approach include:

- Default free discounting, consistent with *Pfeifer*;
- Prices and corresponding interest rates are completely objective, widely accepted, and reflect prevailing market conditions;
- If market conditions change materially during the course of litigation, there is a fully objective way to recompute the lump sum amount via updating the ZC bond prices using the exact same method;
- "Parity in risk" is largely achieved. Since *Pfeifer* does not require that awards be free of inflation risk, and ZC bond values are also not free of inflation risk, parity of inflation risk is achieved by allowing inflation risk in both lost earnings projections and in discounting such projections.[1] Parity in default risk is more problematic to achieve, but it will be argued that this approach addresses most of the concerns involving parity in default risk from the Ireland v. Bell and Taub dispute (See Section II).
- A ladder of ZC bonds can be matched in maturity against projected lost earnings. This provides a theoretically investible, steady stream of periodic (e.g., quarterly or annual) cash flows that could replace lost earnings, with only minimal interpolation for certain out-year observations. Although it may be unlikely that a plaintiff would actually choose to invest his/her award in such a dedicated portfolio, the capability of doing so renders this approach more theoretically correct and internally consistent than alternatives such as selecting a discount rate based arbitrarily on, say, a 20- or 30-year average of three-month T-bills.

A full exposition of this approach is provided in Section III, following a discussion of the legal issues centered on *Pfeifer* and how it has been interpreted.

II. Legal and Economic Issues Related To Discount Rate

In 1983, the U.S. Supreme Court gave its most explicit ruling ever on the topic of discounting and projecting lost earnings, which carries added weight since the opinion was unanimous (*Jones & Laughlin Steel Corp. v. Pfeifer*, 1983). This opinion was most explicit on the subjects of default risk and taxes,

[1]Moreover, this approach allows for the explicit, *time-dependent inclusion of inflationary expectations* in both lost earnings projections and in discounting. This is achieved by deriving future lost wages based on using a real wage growth rate adjusted by the most widely recognized inflationary expectations over time, i.e., by netting the yields on regular coupon-bearing Treasuries and TIPS of equivalent maturities. Since inflationary expectations are seldom constant, especially as at present when it is almost non-existent but expected to rise over time, it is all the more important to recognize the time dependency and variability of inflationary expectations, which can be done with this approach consistently in the numerator and denominator of each discounted cash flow.

whereas it was less so on the subject of inflation. Regarding default risk and taxes, the court said:

> Once it is assumed that the injured worker would definitely have worked for a specific term of years, he is entitled to a risk-free stream of future income to replace his lost wages; therefore, the discount rate should not reflect the market's premium for investors who are willing to accept some risk of default. Moreover, since under *Norfolk & Western R. Co. v. Liepelt,* 444 U. S. 490 (1980), the lost stream of income should be estimated in after-tax terms, the discount rate should also represent the after-tax rate of return to the injured worker.(*Pfeifer*, p. 537).

Clearly the Court intended to protect worker's lost income from "risk of default" and taxes in Federal cases. Since the focus of this paper involves financial/economic issues and theory affecting the discount rate in damage award cases, the separable issue of whether and how to incorporate income taxes in such cases is only discussed here at a high level, rather than being incorporated directly in the numerical examples presented later. First, as Ireland (2004) points out, tax liabilities against lost earnings are not taken into account in most states, being a consideration in only a handful of states plus Federal cases. Second, taking taxes into consideration requires both reducing the initial damage award to be expressed as after-tax lost income and an offsetting if not equal increase to make the plaintiff whole for having to pay taxes on future income earned after investing the award's proceeds. Recognizing the need for consistency in income tax treatment, a U.S Appeals Court ruled that either both offsetting tax effects must be incorporated in the award calculation or else neither one should be incorporated (*Trevino v. United States*, 1986, p. 41). Given the above, and the desire to stay focused on discount rate methodology issues, the two offsetting income tax effects are not incorporated in this paper's examples.

Returning to the *Pfeiffer* decision, while the Court was quite explicit in requiring the use of an after-tax rate of return, its direction on including inflation was less clear, mainly requiring consistency. It said that if inflation is incorporated in the lost earnings estimate, then the discount rate should reflect expected inflation, i.e., it should be a market rate of interest. On the other hand, if inflation is not recognized in the earnings projection, then a below-market rate should be used for discounting, i.e., a real discount rate which only excludes inflation should be used if only real growth and no inflation are incorporated in the earnings estimate. The Court went on to be fairly specific in what range of real interest rate net of inflation would be an appropriate below-market discount rate: "…we do not believe a trial court adopting such an approach in a suit under § 5(b) should be reversed if it adopts a rate between 1% and 3% and explains its choice." (*Pfeifer*, pp. 549-550)

Against this legal backdrop, and with much disagreement remaining in the academic community on discount rate-related issues, it is useful to group the areas of economic dispute into four related but separable issues: (a) "Parity in risk" principal; (b) default risk; (c) inflation risk; and (d) dedicated portfolio v. short-term rollover approach.

A. "Parity in Risk" Principal

This principal was explained most clearly in 1992 by Margulis:

> Parity in risk refers to consistency between the certainty of future lost earnings or profits and the choice of discount rate. It would be inconsistent to discount an expected, but uncertain, stream of future losses by a rate of return earned on investments that are certain, or risk free. (p. 36)

He adds "…the preferred procedure for calculating damages is to discount *actual* future losses to the date of valuation by a *risk-free* rate of return." (p. 38) Noting that future losses are unknown when damages are awarded, he further adds: "To discount expected but uncertain, future sums of money by a risk free rate of return lacks parity in risk." (p. 38)

Margulis describes the language in *Pfeifer* as "contradictory." First he quotes Justice Stevens that "The lost stream (of income's) length cannot be known with certainty….The probability that he would still be working at a given date cannot be known with certainty…" Then, he quotes Stevens again saying "Once it is assumed that the injured worker would definitely have worked for a specific term of years, he is entitled to a risk-free stream of future income to protect his lost wages." (*Pfeifer*, p. 533 & 537, cited by Margulis, p. 36)

A year later, Albrecht (1993) used algebra in an attempt to refute "parity in risk" as described by Margulis' claiming the latter's "contention is not correct." (Albrecht, p. 271) However, the dominant response of forensic economists on "parity in risk" has been expressly in support of Margulis (Biedermann and Basemann, 1996; Henderson and Seward, 1998; Brush, 2003). Other economists, writing before Margulis, also took positions that can be construed as supporting the "parity in risk" principal in concept if not in name, including Jennings and Philips (1989, p. 123) and Levhari and Weiss (1974, p. 950).[2]

While "parity in risk" is a principal that most economists who have discussed the issue appear to support, there is far less agreement on how to apply it to the specific risks raised in damage awards and informed by *Pfeifer*.

B. Default Risk.

Citing *Pfeifer*, Ireland noted somewhat optimistically in 1997:

> There is general agreement among forensic economists that default risk should be virtually eliminated from the discount rate used in per-

[2]Jennings and Philips (1989) argued that actual future labor income will deviate from expected future labor income and thus labor is not a risk-free asset: "To the extent that such deviations may occur, this would call for the stream of expected labor earnings to be discounted at a higher, risk adjusted rate." (p. 123) Levari and Weiss are quoted supporting the position that human capital is probably more risky than physical capital.

> sonal injury and wrongful death damage calculations….Given that damage calculations normally include reductions for probabilities that the individual will not survive, be a labor force participant or be unemployed, it would be inappropriate to use a discount rate with premiums to cover the possibility of nonpayment of the debt securities. To do so would double count the risks that the worker would not have earned projected incomes. (p. 93)

Bell and Taub counter Ireland's treatment of default risk in a 1999 article by asserting:

> …that the risks of not earning projected income in the future and the risk of default on the bonds are not necessarily the same." Although they concede that the two risks are "…superficially equivalent in that they are all downside risks which can only lead to a reduction of the future cash flows, (it is) not necessarily true that the size of the probabilities or states of nature in which they occur are the same (and thus they) should be treated as separate issues." They add that future productivity growth also affects earnings growth but no downward adjustment is typically made for this in earnings projections, unlike for non-survival or non-participation in the labor force. Finally, they make the point cited by Breeden, above, and others, "the well known proposition in finance that only certainty equivalents are discounted with risk free interest rates. (pp. 153-154).

It seems clear that both Ireland and Bell and Taub (B&T) have valid points. As explained in his own reply to B&T, Ireland says that "If you account for all of the risks by probability discounts to the earnings stream itself, you should not also account for them by using a discount rate containing premiums to compensate for those risks." (Ireland, 1999, p. 158) B&T's position is that risk of default and risk of not earning future income are not equivalent. However, while B&T argue that these two risks should be treated as separate issues, they do not suggest any practical way to do so. Ireland's position appears both logical and practical, as when he refers to default risk as "roughly the analog for risks that the worker would not obtain expected future wage benefits because of death, illness or unemployment." (Ireland, 1997, p. 93) Another response might be that even though there is no straightforward way to directly equate default risk on bonds with workforce participation and survival risk on future income, the two downside risks at least offset each other in the same direction through separate numerator and denominator effects, each of which amounts to a reasonable discounting effect. One might add that while "parity in risk" treatment implies theoretical consistency, it doesn't really address how to incorporate dissimilar downside risks in deriving an award, since there is no obvious, precise way to account for worklife expectancy in a discount rate based on financial instrument returns.

B&T also provide two other critiques of Ireland involving default risk. One is that future productivity growth is excluded as a factor in labor force participation and survival and cannot be recognized by reducing projected earnings. They add that no adjustment is typically made to recognize the uncertainty of future productivity growth, and suggest that this is the basis for employing a non-risk free discount rate (B&T, 1999, p.154). Ireland counters that case law requires that such risks be accounted for in the earnings stream, not in the discount rate (Ireland, 1999, p. 158). It should be added that this is exactly the approach taken in this paper, using the Zero Coupon U.S. Treasury Curve Discount Method (ZC T-bond discount method, for short), as explained in detail in Section III. Since most economists would argue that the primary source of real wage growth is productivity gains, it is straightforward to add a "real wage growth" component (separate from an inflationary component) to future earnings projections, as there is no meaningful way to reflect productivity growth in a discount rate based on financial instruments.

B&T's final critique is that only certainty equivalents should be discounted with risk free interest rates. Since Ireland himself limited his response by saying that B&T did not understand his distinction between default risk and inflation risk, and since inflation risk is addressed separately in the next section, it is only worth adding that the ZC T-bond discount approach presented in this paper includes inflation risk and thus does not employ a totally risk free interest rate.

C. Inflation Risk

Inflation risk is usually viewed as the difference between expected inflation and actual inflation. The mitigation of this risk is achieved in many labor contracts via cost-of-living allowances or COLAs. Although *Pfeifer* was clear in requiring the exclusion of default risk in damage awards, as noted above, it only required consistency pertaining to the treatment of inflation risk. One way to achieve consistency is to offset projected inflation in lost wages (whether or not in COLAs) by a discount rate that reflects the same projected rate of inflation.

Several economists argue that *Pfeifer* requires exclusion of inflation risk as well as default risk (Yandell, 1991; Romans and Floss, 1992; Albrecht and Wood, 1998). However, Ireland, 1997, Brush, 1993, and others convincingly reject this interpretation since only the exclusion of default risk is explicitly required by the *Pfeifer* decision. For fixed income investors, inflation risk is a key factor in the term premium that usually results in longer maturity bonds exhibiting higher yields than comparable ones with shorter maturities, and Brush (1993) uses this maturity distinction in his analysis. He goes further in suggesting that award bias results from the exclusion of inflation risk such as by discounting lost earnings at short term T-bill rates: "If use of a risk-adjusted discount rate is considered appropriate, then discounting with Treasury bills will result in overcompensation of the plaintiff." (p. 271) Brush estimated a wide degree of overcompensation based on length of future loss period, the historical period used, and selection of alternative non-risk free instruments, ranging from a low of 10% for shorter, 10-year loss periods, to almost double the compensation or 97% higher using corporate bonds and the period 1982-2001 (Brush, p. 271). Without quantifying its magnitude, Margolis also pointed out the danger of overcompensation resulting from violating the "parity in risk" by failing to remove elements of uncertainty in the projection of future losses (Margulis, p. 33).

The issue of discounting at a risk free rate in which neither inflation nor default risk is incurred requires consideration of an important related question: Should either Treasury Inflation Protected Securities (TIPS) or short-term T-bill rates be used for discounting damage awards, and if so, under what circumstances?

The *JFE* April 1989 issue was devoted entirely to the question of "Selecting a Discount Rate." Several economists said they used short term T-bill rate either for short term valuations or as one of many rate indices. Ray suggested that because over 70% of cases settle before trial, he advocates use of "a twenty-year average for ninety-day treasury bills (as)… more appropriate in many cases." (Ray, p. 95) Others have also advocated a preference for short term risk free rates specifically to negate inflation risk, based on the idea that an average of such short rates smooths out fluctuations (Romans and Floss, p. 265) or based simply on an individual's desire to minimize inflation risk (Houldsworth and McKinnon, p. 209).

By discounting awards to exclude inflation as permitted but not required by *Pfeifer*, using three-month T-bill rates as the discount rate results in the present value of awards as likely to be higher than by using almost any other type of financial instrument.

Ireland has long made the case for using TIPS as preferable to T-bills for discounting future earnings streams if the economist wishes to eliminate inflation risk. The issue for him is:

> …whether there should be a reduction in the value of the discount rate to eliminate a risk premium for a risk that may produce either more or less purchasing power than forecast. Economists who do not feel that damage awards need to be free of an inflation risk would not necessarily use a discount rate based on inflation-adjusted bonds, regardless of (various) problems with the fit of the bonds… However, such economists might still want to use the rates on TIPS bonds to determine the appropriate real rate of interest and the current expected rate of inflation. (1997, p. 95)

There is a lengthy back and forth between Bell and Taub and Ireland as to whether the two-sided risk of inflation (positive and negative variance) means that an increase in variance must result in a change in the present value calculation. (B&T, p. 155; Ireland, 1999, p. 158). Rather than sorting out the relative merits in this fairly arcane dispute, the position held in this paper is that damage awards do not need to be free of inflation risk because *Pfeifer* was explicit in only requiring awards to be free of default risk. If *Pfeifer* did require inflation free discounting, this might have forced more explicit thinking of how to resolve the "parity in risk" problem (i.e., zeroing out both inflation and default risk would make the discount rate truly risk free and thus force the issue of making projected earnings losses a "certainty equivalent"). Ignoring the "parity in risk" problem for the moment, if *Pfeifer did* require inflation free discounting, the TIPS yield curve would be a far preferable source for excluding both inflation and default risk than would the three-month T-bill, the other leading contender for eliminating inflation risk via discounting.[3]

Use of TIPS for discounting to negate inflation risk would certainly complicate the analytics of compensating for earnings loss. This is due to the fact that coupon interest is only a portion of TIPS return; this creates a timing mismatch between taxes due on accreted value and actual cash flow (a timing problem even more pronounced with ZC T-bonds). However, T-bills are also highly unsuitable as a discount rate for backing out inflation accurately, due largely to their extremely high near-term volatility and the impact of arbitrarily selecting a given time period for averaging. For example, the *arbitrary* time period selection of a 10-, 20- or 30-year average of T-bill yield yields (through September 2009) would result in discount rates of 2.82%, 3.87% and 5.55%, respectively. Clearly, all three cannot be said to all offset inflation with any accuracy. In addition, using observable T-bill yields at any one point in time, such as virtually any time from late 2008 through late 2009, would have resulted in near zero discounting of future lost earnings.

D. Dedicated Portfolio v. Short Term Rollover Approach

A dichotomy that economists have often used in describing alternative discount rate approaches is to lump them into either "dedicated portfolios" or "short term rollover." Three-month T-bills are the quintessential short term rollover instrument offered as a totally risk-free discount rate. The frequency that an investor can roll over any lump sum to adjust to changing rates is what negates inflation risk, and is the main argument used by short term rollover proponents (Harris, 1995, p.131; Houldsworth and McKinnon, 1994, p. 209). However, the only way that inflation risk can truly be avoided, ex post an award, would be to invest that award in an inflation-protected asset. Although this could be done with TIPS or T-bills, neither would likely be used exclusively for investing the actual award.

Dedicated portfolios also have been in use for damage cases for some time. As far back as 1977, this method has been favored by some, among other reasons, because (a) its results are more easily understood by jurors, who can be shown a specific investment plan that will produce the desired income stream, and (b) it doesn't require an estimate of future average interest rates, precisely because it relies on known yields at the time of valuation (Hickman, 1997, p. 132).

As Brush puts it, "It is often argued that there should be no connection between the determination of an appropriate discount rate and an appropriate investment allocation of a damage award." (Brush, p. 265, citing Ireland, 1998,

---

[3]Ireland makes the cogent point that the three-month T-bill has a significant negative liquidity premium. This is evinced by the wide difference between the two instruments in their *real* rates of return, TIPS being over 1% higher in 1998, when he wrote his paper, and over 1.5% higher at the TIPS auction in July 2009. T-bills are only used as temporary stores of value, as when portfolio managers are willing to accept lower than market rate interest in exchange for their liquidity advantage. As Ireland (1997) states, "…there is no basis in either legal requirements or in economic theory for arguing that the loss replacement fund should have the liquidity advantages available in Three Month Treasury Bills." (pp. 10-11)

p. 269; and Romans and Floss, 1992, p. 266). Brush goes on to argue instead, that an appropriate discount rate should reflect the degree of risk associated with the future earnings stream that is to be discounted, i.e., "parity in risk." By this logic, unless there is zero inflation risk in future earnings, there should not be zero inflation risk in discounting.

To summarize, it is recognized that whether the instrument is ZC T-bonds, three-month T-bills, or any other combination used for discounting damage awards, there need be no connection between the discount rate and the instrument(s) in which the award is actually invested. Therefore, there is no reason why an effective discount rate based on a dedicated portfolio approach shouldn't be used in award valuation, even if the award is not being so invested, as long as the dedicated portfolio and the future earnings stream have comparable risks, i.e., risk parity. The same cannot be said of an award based on 90-day T-bill rate, which lacks risk parity with any lost earnings stream that includes future inflation. It will be argued in the next section that the ZC T-bond discount method accomplishes parity in risk in the form of a dedicated portfolio that need not be actually invested, and that is objectively derived, theoretically correct and internally consistent. *This approach offers a straightforward way to provide default risk free (but not inflation risk free) cash flows that match the future earnings stream in timing and amounts based on the same inflation assumptions, and avoids having to choose an average discount rate based on an arbitrary selection of past time periods.*

III. Explanation and Example of Zero Coupon Treasury Bond Approach

The ZC-T-bond approach, if followed fully, requires the observed yield curves of three types of Treasury bonds: Zero Coupon Treasuries, Coupon Bearing Treasuries, and Treasury Inflation Protected Securities, or TIPS. Daily yield and price data from dealer quotes are available for outstanding securities for all three Treasury bonds types via the on-line *Wall Street Journal* (*WSJ*). As an alternative data source, a series of daily interpolated yield curves have been constructed by a research division within the Federal Reserve Board, and are available online, with the first data sets and creation methodologies explained in two papers (Gurkaynak, et al., 2006 and Gurkaynak, et al., 2008).[4] Appendix I compares these two data sources, and explains that the difference in results obtained when used in the same hypothetical damage award are extremely small (averaging less than 1 basis point in yield difference) over all future years in common,

Figure 1 shows the three Treasury yield curves used to illustrate this method based on the November 2, 2009 closing yields obtained from the next business day's *WSJ*. As may be seen, while each of the three Treasury yield

[4]The first paper produced a smoothed off-the-run daily Treasury yield curve expressed in par yields, zero coupon yields and various forward rates. The second paper is a sequel to the first, and produced the same yield curve statistics for Treasury Inflation Protected Securities or TIPS. Both papers reference how researchers can access both data sets online, with the links provided in Appendix I.

curves is positively sloped, consistent with current market conditions, the yield hierarchy across curve type reflects the relative riskiness to a change in interest rates for a given maturity (given that all three have the same default risk, which is considered essentially nil). For instance, zero coupon Treasuries typically will exhibit the highest yields for a given maturity (subject to rare anomalies, especially in short remaining maturities). This is mainly due to the fact that all ZC bonds have a "duration" equal to their maturities, unlike regular coupon-bearing Treasuries that for the same final maturity, always have a shorter duration.[5] Since duration is a key measure of interest rate risk, the yield hierarchy between ZC and coupon-bearing bonds (higher yields required for higher risk Treasuries) is to be expected. A secondary factor contributing to higher yields for ZC T-bonds is the income tax liability owed by investors for imputed interest when ZC bonds are held in non-tax deferred accounts. TIPS have the lowest interest rate risk of the three types, since by design they carry no inflation risk which is the primary source of interest rate risk to the value of bonds, although they too have a similar tax liability issue as ZC T-bonds for their non-coupon based imputed interest.

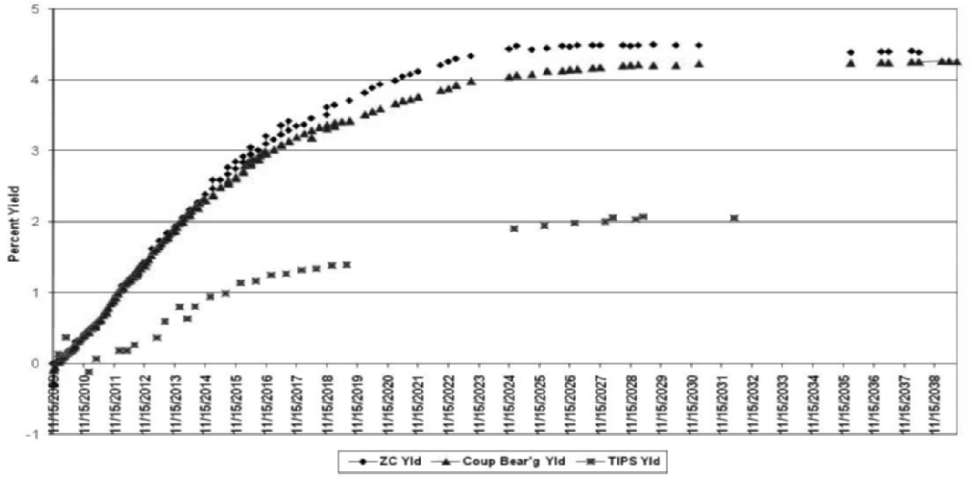

Figure 1. US Treasury Yields, by Type, as of 11-2-09
(Secondary market offer yields, *Wall Street Journal*)

The basic idea behind the ZC T-bond approach to valuing the loss of future earnings is this: A dedicated portfolio of ZC T-bonds, with objectively observed market prices, can be used in theory to fully fund the projected future earnings losses of a plaintiff. While it is recognized that lump sum awards do not have to be invested in the same instrument that is used to derive the discount rate,

[5]Duration is a measure of the sensitivity of a financial instrument's price to interest rate movements. It often is measured in units of time (e.g., duration in months or years), and represents the weighted average maturity of the present value of cash flows. Mathematically, it also can be expressed as the first derivative of price with respect to changes in yield.

using observed prices for ZC bonds allows for basic consistency and "parity in risk" between earnings loss estimates and discounting:

- Having *no default risk* on the ZC T-bonds effectively if not perfectly corresponds with the one-way downside risk that Ireland explained (above) in terms of earnings and survival uncertainty built into worklife expectancy tables;
- Having *inflation risk* still embedded in the ZC bonds yields fully corresponds with the inflation assumptions that will be built into the lost earnings projections, and are in fact the same in both ZC bond yield and future earnings projections. Since inflation expectations are not constant, a curve of inflation expectations by year is derived for both purposes from the same source: the difference between coupon-bearing Treasury yields and TIPS yields for each year of remaining maturity, based on the data in Figure 1 and shown in Figure 2. (Appendix II explains how these inflation expectations and ZC T-bond price data by years to maturity were derived, as well as how all of the raw data used in this paper were extracted).

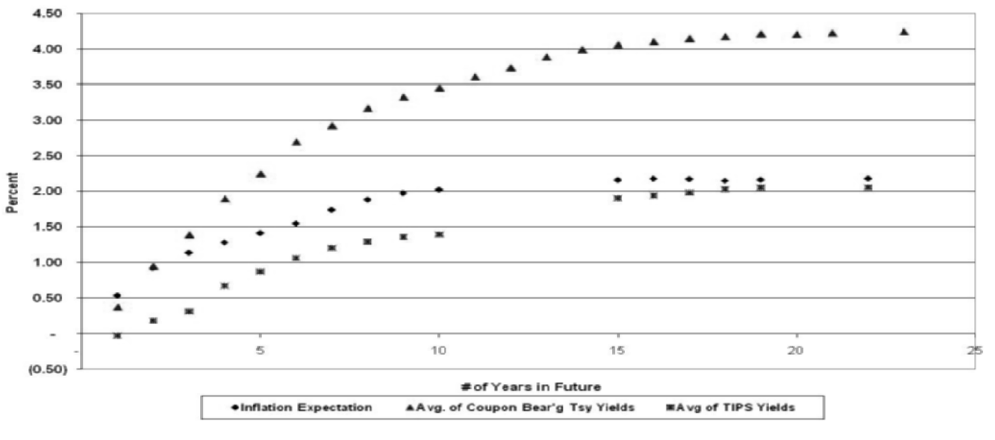

Figure 2. Inflation Expectations: Derived as Yield Difference between Coupon-Bearing Treasuries and TIPS, at Equivalent Remaining Maturities
(Data from *Wall Street Journal* 11-2-2009)

The best way to further explain and illustrate the ZC T-bond approach to valuing the loss of future earnings is by a detailed example. This is shown in Table 1. The steps taken to produce the lump sum present value of $1,089,171 shown in Table 1 for a hypothetical plaintiff's lost earnings are as follows:

- Step 1: Based on the Ciecka, Skoog and Krueger Markov Worklife Expectancy Model, a hypothetical white male plaintiff with a high school diploma has a worklife expectancy (remaining years in the labor force) of 26.1 years (Ciecka, Skoog and Krueger, 2007). This is shown in columns A and B of Table 1;

- Step 2: Yearly inflation expectations are derived as described above and shown in column C of Table 1. They are based on the difference between coupon-bearing Treasury yields and TIPS, averaged among available securities for each year of forecast. (Appendix II explains this in more detail, including how interpolation and extrapolation were preformed where needed).

Table 1
Hypothetical Valuation of Lost Wages Using Zero Coupon U.S. Treasury Curve Discount Method

Assumptions:

Hypothetical Earnings Losses for Totally Disabled Plaintiff

Current Salary of Plaintiff: $50,000 (for simplified explanation, tax adjustment excluded)

Current Age of Plaintiff: 30

Estimated Worklife Expectancy of 26.1 years (Ciecka, Skoog & Kruger, 2007)

Annual Average **Real** Wage Increase = 1.1 % (SSA-OASDI, 2009)

Annual Expected Inflation Derived from TIPS and Coupon-Bearing Treasury Yield Curves

Solve for "r":		**Solve for "g":**
nominal annual compund return "r" = IRR = **4.164%** Where NPV= 0	Implied net discount rate = (1+r)/(1+g) - 1 = **1.344%**	Single "g" requires IRR = **2.783%** Where NPV= 0

A	B	C	D	E	F	G	H	I = E*H/100	Cash flows= J [see (1)]	K = D	Cash Flows L [see (2)]
Year	Years in future	Inflation Expectation	Annual Wage Increases (real + infl)	Estimated Future Gross Earnings	Avg # of yrs in future of actual ZC bonds O/S	Average Quoted "Ask" Yield (%)	Average Quoted "Ask" Price	PV of Cash Flows discounted at "Ask Price"	(1,089,171)	Annual Wage Increases (real + infl)	(1,300,000)
2010	1	0.53%	1.63%	50,816	0.83	0.315	99.708	50,668	49,130	50,816	49,675
2011	2	0.92%	2.02%	51,844	2.04	0.915	98.125	50,872	47,712	51,844	49,027
2012	3	1.14%	2.24%	53,003	3.04	1.443	95.705	50,727	46,830	53,003	48,766
2013	4	1.28%	2.38%	54,264	3.91	1.890	92.886	50,403	46,262	54,264	48,741
2014	5	1.41%	2.51%	55,626	4.99	2.378	88.861	49,430	45,389	55,626	48,512
2015	6	1.55%	2.65%	57,098	5.96	2.770	84.858	48,452	44,766	57,098	48,476
2016	7	1.74%	2.84%	58,718	6.87	3.080	81.059	47,597	44,369	58,718	48,629
2017	8	1.88%	2.98%	60,469	7.83	3.337	77.193	46,678	43,940	60,469	48,779
2018	9	1.97%	3.07%	62,328	8.97	3.560	72.883	45,427	43,222	62,328	48,722
2019	10	2.02%	3.12%	64,275	10.04	3.765	68.784	44,211	42,681	64,275	48,799
2020	11	*2.05%*	3.15%	66,299	10.87	3.940	65.454	43,396	42,554	66,299	49,198
2021	12	*2.08%*	3.18%	68,405	11.79	4.083	62.118	42,492	42,294	68,405	49,500
2022	13	*2.10%*	3.20%	70,597	13.04	4.257	57.773	40,786	41,479	70,597	49,363
2023	14	*2.13%*	3.23%	72,878	13.79	4.340	55.369	40,352	41,530	72,878	49,919
2024	15	2.16%	3.26%	75,253	15.16	4.460	51.249	38,567	40,544	75,253	49,637
2025	16	2.18%	3.28%	77,720	16.04	4.440	49.466	38,445	40,404	77,720	50,048
2026	17	2.17%	3.27%	80,262	17.04	4.480	47.009	37,731	40,058	80,262	50,286
2027	18	2.15%	3.25%	82,869	17.91	4.490	45.148	37,413	39,909	82,869	50,687
2028	19	2.16%	3.26%	85,573	19.04	4.487	42.995	36,792	39,362	85,573	50,749
2029	20	*2.17%*	3.27%	88,369	19.79	4.500	41.480	36,656	39,424	88,369	51,340
2030	21	*2.17%*	3.27%	91,262	20.91	4.490	39.531	36,077	38,888	91,262	51,408
2031	22	2.18%	3.28%	94,255	22.00	*4.470*	*37.987*	35,805	38,417	94,255	51,530
2032	23	*2.18%*	3.28%	97,345	23.00	*4.451*	*36.570*	35,600	38,091	97,345	51,779
2033	24	*2.18%*	3.28%	100,538	24.00	*4.433*	*35.154*	35,343	37,768	100,538	52,029
2034	25	*2.18%*	3.28%	103,834	25.00	*4.414*	*33.737*	35,030	37,447	103,834	52,280
2035	26	*2.18%*	3.28%	107,239	26.29	4.390	31.915	34,225	36,699	107,239	52,122
Sum of PV of Annual Cash Flows:								**1,089,171**			

(1) Solving for *r*, such that the Initial Investment (i.e., the award) = PV of cash flows at "ask price" of all ZC bonds. Thus, *r* = the internal rate of return (IRR), which is the single nominal annual compound discount rate implied by all ZC bond prices if the award were invested solely in ZC bonds in order to avoid any default risk .

(2) Here, the initial investment (excluding wage growth) = initial wage times the number of years of earnings loss. Then *g* is solved for as the IRR, resulting in a single discount rate that accounts for variable wage growth over all future years based on each year's specific inflation assumption (derived from Treasuries) + 1.1% constant real wage growth assumption (from OASDI).

- Step 3: In column D, the OASDI's 2009 long run forecast of 1.1 % in real wage growth (OASDI, 2009) is compounded with the time dependent inflation forecast from column C and used to generate future gross earnings forecasts for each year in column E.

- Step 4: Using the *WSJ*'s actual outstanding ZC bond prices, average maturities were calculated for bonds maturing in each whole year of the forecast. For each future year, the corresponding averages of bond "ask" yields and prices (i.e., those available to investors, unlike the "bid" yields and prices) were also calculated. The results are shown in columns F, G, and H.
- Step 5: The Present Value of future cash flows is obtained by summing up the discounted value of each year's estimated future earnings by the corresponding "ask" price for that year, i.e.,

$$(\text{Price}_i/100)(\text{Estimated Future Gross Earnings}_i)$$

where i is each corresponding future year.[6]

In other words, in order to buy $100 of ZC T-bonds due on average in forecast year 1, a lump sum investment of $99.708 is required. The same procedure is done for each forecast year, so for example, in order to buy $100 of ZC T-bonds due in year 26, a lump sum of 31.915 is required. Applying this series of average ZC T-bond prices to each year's forecasted lost earnings over the estimated 26 years of worklife gives a PV total of $1,089,171, shown in column I.

This captures the full procedure for deriving a lump sum PV of lost earnings. This method is consistent with the well-established practice in finance that "…a bond can be viewed as a package of zero coupon securities (each coupon being a unique bond, with one principal payment at the end), in which case a unique discount rate should be used to determine the present value of each cash flow." (Fabozzi, 1996, p.26) This concept of having a separate discount rate for each cash flow is in fact

[6]While i represents each corresponding future year for earnings, for ZC bond prices and corresponding maturities, each i is the *average* remaining maturity for outstanding ZC bonds closest to each year in the future, such that the average maturity corresponds with the average price of those same bonds that mature each future year. For example, there are six ZC bonds that mature from 5/15/2010 to 2/15/2011, all of which are closer to one year of remaining maturity than to two years. The average maturity of these six "year one" bonds (i = 1) is .83 year after 11/9/2009, which is time zero, when the bond prices were observed. Those six bonds with an average maturity of .83 year have a corresponding average price of 99.708. Similarly, there are two ZC bonds that have remaining maturities closer to two years after time zero 11/9/2009 (i.e., 8/15/2011 and 2/15/2012). The average maturity and average price of these "year two" bonds (i = 2) are 2.04 years and 98.125, respectively. These values are shown in Table 1 (column F) as the average number of years in the future of the actual ZC bonds that will mature each year in the future and the corresponding average price of those bonds (column H). These average prices of bonds maturing each year are then applied to each year's gross future earnings to obtain present values (column I). The same procedure is done to obtain bond average maturities and average prices for years 3 through year 26. Note for four of the out years, years 22 -25, no ZC bonds were maturing, so interpolation of prices was required from the year 21 and 26 average maturities (20.91 years and 26.29) and average prices (4.49 and 4.39). It is understood that there is a very slight imprecision in employing non-integer yearly periods for discounting each future year's lost earnings, but the effect on the annualized return and hence, present value of the award, is negligible. This was confirmed by comparing these results with those from a series of derived ZC bond yields and implied prices based on a series of exact yearly remaining maturity intervals obtained from another procedure developed at the Federal Reserve. See Appendix I for details. It should be added that a similar type of imprecision results from any damage award based on future annual earnings estimates and annual discounting, given that most people are paid at least monthly.

the basis for most bond pricing models. However, it doesn't directly answer what some people will want to know: What is the *single* net discount rate implied by this procedure with multiple effective discount rates? To answer that question, two more steps are required.

- Step 6: Based on a lump sum investment of $1,089,171 at time zero, solve for the single discount rate, i.e., the internal rate of return (IRR), that equates the PV of lost earnings to that investment. Each year Price × Estimated Gross Earnings is discounted at the IRR until the *net* present value or NPV = 0:

$$\text{NPV} = -\text{ Investment} + \sum_{i=1}^{n} (\text{Price}_i)(\text{Estimated Gross Earnings}_i)\, /\, \left(1+ \text{ IRR}\right)^i = 0$$

  where *i,* as explained in footnote 6, is the average maturity in years closest to each integer future year of the actual ZC T-bonds outstanding, e.g., .83 years in year 1, 2.04 years in year 2, 3.04 in year 3, etc., and with the price being the average price corresponding with each future year's maturating ZC T-bonds. This procedure solves for the single discount rate equivalent embedded in the series of ZC T-bond prices of r = 4.164%, shown at the top of column J.

- Step 7: Finally, a single earnings growth rate, g, is needed to calculate the implied net discount rate, which is $(1+r)/(1+g)-1$. The g is similarly derived as an IRR, only this time it is calculated by equating the present value of the estimated future gross earnings to the total earnings without any growth, i.e., (26 years) (50,000) in lost earnings today is $1,300,000

$$\text{NPV} = -\text{Investment} + \sum_{i=1}^{n} \text{Estimated Gross Earnings}_i \,/\left(1+\text{IRR}\right)^i = 0$$

  This IRR formula is similar to the one above, except that the estimated yearly gross earnings are not discounted by ZC T-bond prices. That is because since we are only trying to see what is the single earnings growth rate implied by the average real wage growth (constant at 1.1%/yr) plus the expected inflation rate that varies each year. The result is g = 2.783%, shown at the top of column L (column K repeats D). Taken together, the implied net discount rate is $(1+r)/(1+g)-1 = .0134$ or 1.34%.

It is asserted that the ZC T-bond method presented here is preferable in terms of sound finance theory to many of the alternative discount methods employed, mainly because it is internally consistent in terms of inclusion of both default risk and inflation risk, it does not violate the "parity in risk" principal, nor does it rely on an arbitrarily selected historical period for averaging of short term T-bill rates that causes wide variations in present value results.

Table 2 compares the results from using this method with results calculated using the same underlying assumptions of Table 1 but based on selected alternative net discount methods. Seven alternative cases are shown in Table 2. The first four cases use nominal wage growth from OASDI, which includes its own long run inflation assumptions. However, for nominal annual compound return, only case 1 is also taken from OASDI, using its average nominal interest rate assumption for future funding of the social security trust fund. The other cases, 2-4, use short-term T-bill rates averaged over the last 30-year, 20-year and 10-year periods. As may be seen, the full ZC T-bond approach results are very close to the OASDI long range forecast, but it is only close to case 2 among the ones using an average of T-bill rates for discounting (30-year average).

Table 2
Comparison of PV of Lost Earnings Using Different
Sets of Assumptions for Net Discount Rate

		Cases	Nominal Wage Growth from OASDI				Expectations Derived from TIPS/Treasury Curves		
			OASDI 2009 Long Range Forcast	30 yr avg., 3-Month T-Bill	20 yr avg., 3-Month T-Bill	10 yr avg., 3-Month T-Bill	30 yr avg., 3-Month T-Bill	20 yr avg., 3-Month T-Bill	10 yr avg., 3-Month T-Bill
		Source of r & g	1	2	3	4	5	6	7
		r (nominal annual compound return)	5.70%	5.55%	3.87%	2.82%	5.55%	3.87%	2.82%
		g (nominal wage growth)	3.90%	3.90%	3.90%	3.90%	3.00%	3.00%	3.00%
		Net Disc. Rate: [(1+r)/(1+g)]-1	1.732%	1.588%	-0.029%	-1.039%	2.476%	0.845%	-0.175%
Year	Years in future	Gross Earnings, No Inflation	PV of Future Lost Earnings at Net Discount Rate				PV of Future Lost Earnings at Net Discount Rate		
2010	1	50,000	49,149	49,218	50,014	50,525	48,792	49,581	50,087
2011	2	50,000	48,312	48,449	50,029	51,056	47,613	49,166	50,175
2012	3	50,000	47,489	47,692	50,043	51,592	46,463	48,754	50,263
2013	4	50,000	46,680	46,946	50,058	52,134	45,340	48,346	50,351
2014	5	50,000	45,885	46,212	50,072	52,682	44,245	47,941	50,439
2015	6	50,000	45,104	45,490	50,087	53,235	43,176	47,539	50,527
2016	7	50,000	44,336	44,779	50,101	53,794	42,133	47,141	50,616
2017	8	50,000	43,581	44,079	50,116	54,359	41,115	46,746	50,704
2018	9	50,000	42,839	43,390	50,130	54,930	40,122	46,354	50,793
2019	10	50,000	42,109	42,711	50,145	55,507	39,152	45,966	50,882
2020	11	50,000	41,392	42,044	50,159	56,090	38,206	45,581	50,971
2021	12	50,000	40,687	41,386	50,174	56,679	37,283	45,199	51,060
2022	13	50,000	39,994	40,739	50,188	57,275	36,382	44,821	51,149
2023	14	50,000	39,313	40,103	50,203	57,876	35,503	44,445	51,239
2024	15	50,000	38,644	39,476	50,217	58,484	34,646	44,073	51,329
2025	16	50,000	37,986	38,859	50,232	59,099	33,809	43,704	51,418
2026	17	50,000	37,339	38,251	50,246	59,719	32,992	43,338	51,508
2027	18	50,000	36,703	37,653	50,261	60,347	32,195	42,975	51,598
2028	19	50,000	36,078	37,065	50,275	60,981	31,417	42,615	51,689
2029	20	50,000	35,463	36,485	50,290	61,621	30,658	42,258	51,779
2030	21	50,000	34,860	35,915	50,304	62,268	29,917	41,904	51,870
2031	22	50,000	34,266	35,353	50,319	62,922	29,194	41,553	51,961
2032	23	50,000	33,682	34,801	50,333	63,583	28,489	41,204	52,051
2033	24	50,000	33,109	34,257	50,348	64,251	27,801	40,859	52,143
2034	25	50,000	32,545	33,721	50,362	64,926	27,129	40,517	52,234
2035	26	50,000	31,991	33,194	50,377	65,608	26,474	40,178	52,325
PV at alternative net discount rates:			**1,039,533**	**1,058,266**	**1,305,081**	**1,501,545**	**950,246**	**1,162,754**	**1,331,161**
PV from Table 1, ZC T-bond method			**1,089,171**	**1,089,171**	**1,089,171**	**1,089,171**	**1,089,171**	**1,089,171**	**1,089,171**
% Difference			**-4.56%**	**-2.84%**	**19.82%**	**37.86%**	**-12.76%**	**6.76%**	**22.22%**

This is not surprising because the longer the historical period for averaging T-bill rates, the more muted is the effect of the recent aberrantly low T-bill rates embedded in the *r* part of the net discount rate, giving less inflated PV results. It is argued that due to greater weighting of recent T-bill rates in cases

3 and 4, the PV results are increasingly distorted relative to those resulting from the full ZC T-bond approach of Table 1 (almost 20% and 40% higher respectively). Similarly, cases 3 and 4 result in much higher PVs relative to the OASDI assumptions embedded in case 1. The thing that the ZC T-bond method and the OASDI methods both have in common is that neither one unduly weights today's extremely low inflation over time. The ZC method does incorporate extremely low inflation expectations but, appropriately, only for the near forecast years, consistent with investor expectations embedded in the various Treasury yield curves. The same cannot be said for cases 3 and 4, which overweight the impact of today's immediate inflation expectations in the shorter period (20- and 10-year) historical averages of T-bill rates.

Cases 5-7 are designed to be closest to the ZC T-bond method on earnings growth and inflation while showing how the arbitrary choice of different T-bill rates for discounting give widely varying award results. Cases 5-7 use the same 30-yr, 20-yr and 10-yr averages of T-bill rates for r respectively, as did cases 2-4. For "g," which is a nominal annual growth measure, cases 5-7 all use the same 1.1% real wage growth from OASDI used in the ZC T-bond example, and the same average inflation expectation embedded in the Treasury yield curves used in the ZC T-bond example, i.e., 1.88%. Combining the OASDI real wage growth of 1.1% and the average inflation rate of 1.88%, together they give an implied nominal annual wage growth of 3.00% (= $(1+.011)\times(1+.0188)-1$). Thus, cases 5-7 are as close in comparison with the ZC T-bond discount method as possible, given that the r portion of the net discount rate must remain different. As may be seen, case 5-7 results are more symmetric and generally closer to those of the ZC T-bond method. However, having a PV range that varies by 40% depending on whether one selects a 10-yr T-bill average or a 30-yr T-bill average underscores the arbitrariness of results based on the particular period selected for historical T-bill yields.

IV. Conclusion

The Zero Coupon Treasury bond discount approach to valuing lost future earnings offers a theoretically sound and internally consistent alternative to many existing approaches, especially ones based on discounting future earnings at a rather arbitrarily-selected historical period of three-month T-bill yields. Using three-month T-bill yields as a discount rate effectively eliminates both default risk and inflation risk, resulting in a truly risk-free rate that is appropriate only for discounting cash flows that are a "certainty equivalent." Unless both default and inflation risks also are removed from a projected lost future earnings stream, the "parity in risk" principal of finance is violated. Although Treasury bonds being free of default risk is not a perfect analogy to adjusting future earnings losses for worklife expectancy, both reflect the downside risks of curtailing future cash flows. As Ireland argued in 1997 (and cited above), bond default risk is "roughly the analog for risks that the worker would not obtain expected future wage benefits because of death, illness or unemployment." Considering these as satisfactorily offsetting is the only practical way to achieve default risk parity in valuing lost earnings. And the uncertainty of future wage increases due to productivity gains is best addressed separately and directly, via incorporating a factor to represent real wage growth which in the long run can only spring from productivity gains.

Achieving parity of inflation risk is another matter. Unless one removes inflation risk from both the discount rate and from future lost earnings by voiding COLAs and related assumptions embedded in earnings projections, then the parity principal is violated. Only if future earnings can be presented somehow as a certainty equivalent cash flow stream can one really justify reducing this to a lump sum by using a fully risk free discount rate, which means negating both inflation and default risk. On this score, while the ZC T-bond discount approach eliminates default risk, it explicitly allows for inflation risk, which is objectively derived from the Treasury bond market, and applied consistently as a time-dependent variable in both the discount rate and in projected future lost earnings. Finally, by offering a market based approach that can be readily updated based on a well documented procedure, in the event that initial results based on it change materially by the time of a later court ruling, the ZC T-bond discount method is also robust, in addition to being objective, internally consistent, and sound in finance theory.

References

Albrecht, Gary R., "Compensatory Damages and the Appropriate Discount Rate, A Comment," *Journal of Forensic Economics*, 1993, 6(3), 271 –272.

___________, and John Wood, "Risk and Damage Awards: Short-Term Bonds vs. Long-Term Bonds," *Journal of Legal Economics*, 1998, 7(1), 48-59.

Bell, Edward and Allan Taub, "Some Issues Concerning Risk Adjustments in Damage Calculations," *Litigation Economics Digest*, Fall 1999, 4(2), 153-155.

Biedermann, Daniel K. and Robert C. Basemann, "Risk Free vs. Risk-Adjusted Discount Rates: A Comment," *Journal of Forensic Economics*, 1996, 9(1), 45-47

Brookshire, Michael L., Michael R. Luthy and Frank L. Slesnick, "2006 Survey of Forensic Economists: Their Methods, Estimates, and Perspectives," *Journal of Forensic Economics*, 2006, 19(1), 29-59.

Breeden, Charles H., "The „Income-Variance" Risk Factor and *Jones & Laughlin v. Pfeifer* Guidelines for the Calculation of Present Value," *Journal of Forensic Economics*, 2003, 15 (1), 19-29.

Brush, Brian C., "Risk, Discounting, and the Present Value of Future Earnings, *Journal of Forensic Economics*, 2003, 16(3), 263-274

Ciecka, James E, Gary R. Skoog and Kurt V. Krueger, "New Tabulations of the Markov Worklife Expectancy Model," presented at the 19th Annual Meeting of the Academy of Economic and Financial Experts, March 29, 2007, Las Vegas, Nevada.

Fabozzi, Frank J., *Bond Markets, Analysis and Strategies*, Upper Saddle River, NJ: Prentice Hall, Third Edition, 1996.

Gurkaynak, Refet S., Brian Sack, and Jonathan H. Wright, "The U.S. Treasury Yield Curve: 1961 to the Present," Finance and Economics Discussion Series, Divisions of Research and Statistics and Monetary Affairs Federal Reserve Board, Washington, DC, 2006-28.

___________, "The TIPS Yield Curve and Inflation Compensation," Finance and Economics Discussion Series, Divisions of Research and Statistics and Monetary Affairs Federal Reserve Board, Washington, DC, 2008-05.

Harris, William G., "Do Tax-Exempt Discount Rates Eliminate Tax-Induced Errors," *Journal of Forensic Economics*, 1995, 8(2), 131-138.

Henderson, James W., and J. Allen Seward, "Risk Aversion and Overcompensation from the Risk Free Discount Rate," *Journal of Legal Economics*, 1998, 8(2), 25-32.
Hickman, E. P., "Selecting Income Growth and Discount Rates in Wrongful Death and Injury Cases," *Journal of Risk and Insurance*, 1997, 44(1), 129-132.
Houldsworth, Mark A. and Tom D. McKinnon, "Dedicated Portfolios And The Present Value Of Lost Earnings: A Comment," *Journal of Forensic Economics*, 1994, 7(2), 209-210.
Ireland, Thomas, "The *Pfeifer* Decision, Risk and Damage Awards: An Extended Response to Albrecht and Wood," *Journal of Legal Economics*, 1997a, 7(3), 23-34.
___________, "Forensic Implications of Inflation-Adjusted Bonds," *Litigation Economics Digest*, 2(2), 1997b, 92-102
___________, "Why Inflation-Indexed Securities Are Not Poorly Suited For Discounting A Future Earnings Stream," *Journal of Forensic Economics*, 1998, 11(3), 269-270.
___________, "Response to Bell and Taub: „Some Issues Concerning Risk Adjustments in Damage Calculations," *Litigation Economics Digest*, 1999, 4(2), 157-158.
___________, "The Role of a Forensic Economist in a Damage Assessment for Personal Injuries," *The Earnings Analyst*, 2004, 6, 15-46.
Jennings, William P., and G. Michael Phillips, "Risk as a Discount Rate Determinant in Wrongful Death and Injury Cases," *The Journal of Risk and Insurance*, 1989, 56(1), 122-127.
Levhari, David, and Yoran Weiss, "The Effect of Risk on the Investment in Human Capital," *American Economic Review*, 1974, 64(6), 950-963.
Margulis, Marc S., "Compensatory Damages and the Appropriate Discount Rate," *Journal of Forensic Economics*, 1992, 6(1), 33-41
Ray, Clarence G., "A Case Against the use of the *Wall Street Journal* Method of Selecting a Discount Rate," *Journal of Forensic Economics*, 1989, 2(2), 94-95.
Romans, Thomas J., and Frederick G. Floss, "Four Guidelines for Selecting a Discount Rate," *Journal of Forensic Economics*, 1992, 5(3), 265-266.
Yandell, Dirk, "The Value of Lost Future Earnings: Methodology, the Discount Rate and Economic Theory," *Journal of Legal Economics*, 1991, 1(3), 54-67.
2009 OASDI Trustees Report, officially called "The 2009 Annual Report of the Board of Trustees of the Federal Old-Age and Survivors Insurance and Federal Disability Insurance Trust Funds," 2009.

Cases

Jones & Laughlin Steel Corp. v. Pfeifer, 462 U.S. 523 (1983)
Trevino v. United States, 804 F2d 1512 (9th Cir. 1986)

Appendix I
Comparison of Treasury Data Sources Available Online from the *Wall Street Journal* and the Divisions of Research and Statistics and Monetary Affairs of the Federal Reserve Board

(hereafter referred to as Fed R&S and MA Divisions)

All required data for use in the ZC-T-bond approach to valuing damage awards can be obtained by either of the above two sources. The *Wall Street Journal* (*WSJ*) publishes dealer-provided price and ask-yield quotes for actual securities that are tradable at 3 pm each day the market is open. The second source of such data is the Fed R&S and MA Divisions. Like the *WSJ*, it produces a number of valuable daily yields and related measures that also are based on a large set of observable Treasury coupon-bearing securities (including TIPS) as described in two separate articles. (Although published by the Fed, these data are labeled "not an official Federal Reserve statistical release"). Where this data series stands out is that off-the-run Treasuries (rather than on-the-run) are used precisely to minimize security-specific liquidity and demand issues exhibited in dealer quotes, such as those in the *WSJ* that its authors believe would detract from pure yield-curve related insights. The combined dataset explained in both Fed R&S and MA Divisions articles is particularly useful to researchers who need internally consistent data series for studies involving macroeconomic concepts such as term premia and inflation compensation over time.

By using dealer quotes for actually tradable T-bonds, especially for ZC T-bonds, the *WSJ* data capture technical price and yield effects in terms of security-specific demand and liquidity issues. This has some added value if ones wishes to derive a damage award based on a dedicated portfolio valuation method. It is argued here that this is useful for award valuation purposes even if the plaintiff isn't expected to actually invest only in such zero-coupon securities, just as proponents of using an arbitrary multi-year average of 90-day T-bill rates wouldn't expect a plaintiff to actually invest only in 90-day T-bills, continuously rolling over the unused award proceeds into more such T-bills. The Fed R&S and MA Division, in contrast, derive data in the form of continuously compounded zero coupon yields from the smoothed par yield curve generated from off-the-run coupon bearing T-bonds. It does this by effectively "view(ing) coupon-bearing bonds as baskets of zero-coupon securities, one for each coupon payment and the principal payment." (Gurkaynak, 2006, p. 11)

In the second Fed R&S and MA paper published in 2008, a series of breakeven inflation rates is derived as the difference between nominal coupon-bearing Treasuries and TIPS. These breakeven rates are defined as "…the inflation rates which, if realized, would leave an investor indifferent between holding a TIPS and a nominal Treasury security." (Gurkaynak, 2008, p. 9) While an extensive review of both Fed R&S and MA papers is beyond the scope of this paper, it is worth noting that this breakeven rate series is described as representing inflation compensation, which includes not only inflation expectations but also an inflation risk premium (a plus) and a TIPS liquidity premium (a minus). While recognizing this conflation of factors, the authors conclude that inflation compensation as they measure it "… is nonetheless a very useful indicator of investors" inflation concerns. Moreover, it is the only inflation indicator which is available over a high frequency, which makes it quite useful in a range of applications. (Gurkaynak, 2008, p. 20) Academics may debate how much of "true" inflation expectations are embedded in the yield curve difference between coupon-bearing Treasuries and TIPS, however derived; but given some unavoidable subjectivity in separating these factors, and the inherent liquidity difference between the two instruments, it remains unclear whether a more objective, universally accepted, and meaningful way of deriving future inflation expectations can be found.

Although both data sources should be considered appropriate for use with the ZC T-bond method proposed in this paper, the *WSJ* data were selected due to the fact that they represent real tradable securities with published ask-prices and may be viewed as closer to what a dedicated portfolio would provide. Despite the methodological differences between the two sources and varying differences by year of observation, the results from both data sources observed on November 2, 2009 differed by a net amount of < 1 basis point when averaged over all future years in the example. Thus, the choice of source would have had only a negligible effect on the present value of the hypothetical award.

For interested readers, the two Fed R&S and MA Divisions data are available via the links below:

http://www.federalreserve.gov/pubs/feds/2006/
http://www.federalreserve.gov/pubs/feds/2008/

Extraction of *WSJ* data and required derivations are discussed next in Appendix II.

Appendix II
Data Extraction and Derivation of ZC T-Bond Prices and Inflation Expectations by Year to Maturity

Since daily data are available with a one-business day lag, information from the *Wall Street Journal* on November 3, 2009 were extracted to obtain the desired November 2 closing Treasury prices and yield data. These data may be extracted by anyone with a subscription to the online *WSJ* at www.wsj.com. Once at the home page, follow these links: /Markets/Market Data/Bonds, Rates and Credit Markets. Holding the cursor over "Bonds, Rates and Credit Markets," a pop-up screen appears labeled "Quotes and Trading Statistics." In the lower left side of that screen, the last three selections produce the prior day's closing prices and yields by maturity date for the three types of Treasuries used in this paper:

- Treasury Inflation-Protected Securities (TIPS)
- Treasury Quotes
- Treasury Strips

Note that the Treasury Quotes link displays data separately for Treasury Notes and Bonds at the top and for Treasury Bills at the bottom. For this paper, only Treasury Notes and Bonds were used since, as coupon bearing instruments, their yields were more appropriate to use with TIPS in order to produce the inflation expectations by maturity data series. The Treasury Strips link displays data separately for, Treasury Bond and Note Stripped Principal, which are combined and used in this paper interchangeably since they both are zero coupon Treasuries that only pay principal at maturity. A third section with stripped coupon interest is ignored.

After copying to a spreadsheet the day's raw prices, yields and maturity dates for all ZC T-bonds and notes (hereafter referred to collectively as "bonds") listed in the *WSJ*, each bond's ask price and a calculated number of fractional years of remaining maturity were grouped and averaged by nearest future year to maturity. (Similar to coupon-bearing Treasuries, in a rare number of cases, more than one ZC T-bond matures on the same date, in which case an average price and yield for that maturity date was first obtained). Interpolation was then used to derive missing prices and yields for ZC T-bonds for years 22-25, using the fractional number of years to maturity of the observations for years 21 and 26. It should be noted that the *WSJ* published yields are in bond-equivalent (i.e., semi-annual yield * 2), and will differ slightly from any calculation based on annual yields, as in this paper.

To derive inflation expectations, raw data from the *WSJ* on yields for ordinary coupon-bearing Treasuries (notes and bonds) as well as for TIPS were similarly extracted from the *WSJ* and sorted by maturity date, Where the coupon-bearing Treasury security and a TIPS security of the same maturity date were both available, the latter is subtracted from the former to obtain a presumed inflation expectation for that future period. (In a rare number of cases, more than one Treasury security matures on the same date, in which case an average yield for that maturity date was obtained). If there was no corresponding coupon-bearing Treasury for the same maturity date as a TIPS, then interpolation based on the fractional number of years in the future was performed in order to obtain an estimate of the coupon-bearing Treasury yield for the maturity date needed to match the TIPS. The results were then aggregated by years to maturity (rounded to an integer). Finally, for those years where no TIPS yields were available and were needed for an earnings forecast year, interpolation and extrapolation were performed. For example, TIPS were missing for future years 11-14, and thus were interpolated from the year 10 observation of 2.02% and the year 15 observation of 2.16%. Similarly, for years 23-26, the last four future valuation years where no existing TIPS would be outstanding, the derived expected inflation rate for year 22 (the final TIPS observation) was extrapolated as a constant, a seemingly reasonable assumption, given the flatness of derived future inflation rates from the last two yearly observations (e.g., 2.16% in year 19, and 2.18% in year 22). Finally, it should be noted that extrapolation would have been required regardless of data source, since the last year of derived breakeven inflation compensation rates from the Fed R&S and MA Divisions was year 20.