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Managing college tuition inflation using a surplus framework methodology

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Abstract

This paper explores prepaid college tuition plans and develops a methodology for managing college tuition inflation. A surplus framework methodology is derived that employs various securities and incorporates both the assets and liabilities associated with prepaid college tuition plans. Although we present a methodology for plan management, the approach is applicable for individuals who manage their own college investment accounts. An interesting result of this analysis is that U.S. Treasury inflation-indexed securities should be included in the asset allocation decision for college tuition inflation management. By incorporating both the assets and liabilities from the plans into a surplus framework methodology, this paper provides a new portfolio management tool for plan administrators and individuals. Our assertion is that better managed plans offer more college financing alternatives for individuals.

Keywords: Portfolio Choice, Computational Techniques, Investment Policy

1. Introduction

College tuition is a subject of concern for families who are saving for their children's education. While consumer prices have been increasing at a relatively modest rate over the past few years, college tuition has been increasing much more rapidly. During the period

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1980–1995, tuition at public universities increased 234%, while median household income rose 82%, and the consumer price index (CPI) increased 74%. Increases in grant aid have not kept up with tuition inflation. Students, and their parents, have absorbed a large portion of the tuition increase through loans. In 1980, the average student loan was $518. By 1995 the average loan was $2,417, an increase of 367%.

With tuition rising faster than household income, an affordability gap has developed. In an effort to reduce the anxiety of meeting college tuition needs, many states have adopted prepaid college tuition plans or variations on the plans. A synopsis of state plans is included in Table 1 and Fig. 1. In general terms, prepaid tuition plans allow investors to pay for college at approximately today's tuition levels for college attendance at a later date. These plans should help mitigate the uncertainty associated with tuition inflation for the individual investor.

The uncertainty, or risk, associated with tuition inflation is shifted from individual investors to states offering the plans or to other guarantors, depending on the structure of the state's plan. The state's ability to manage this risk is essential to the viability of this tuition-financing alternative. Without proper management skills and methods the plans become actuarially unsound and the risk may be transferred back to the individual investor. The state's risk stems from the possibility that plan income from premiums and investment activities will not keep pace with tuition inflation. Two state programs, Michigan and Wyoming, have experienced the effects of this risk. Michigan's plan was suspended when it was deemed actuarially unsound. It has since been reinstated, subject to liquidation if it once again becomes actuarially unsound. Wyoming's plan has also experienced actuarial difficulties. The tuition outlays exceeded the plan's principal and accumulated interest. The state suspended the program, but it honored its obligation and subsidized the shortfall in the contracts.

This paper presents several concepts, but each directly impacts tuition risk-shifting or hedging programs that ultimately affect the individual. The essential elements of prepaid college tuition plans are discussed and a methodology for managing tuition inflation exposure is developed. A relatively new class of securities is introduced that may be beneficial to either states, that are managing prepaid tuition plans, or individuals, who may wish to hedge tuition inflation risk on their own. This paper makes three significant contributions to the existing literature: (1) Prepaid college tuition plans are still in their infancy. This paper explains the mechanics of these plans and discusses the burden of tuition inflation; (2) Surplus framework management is also a relatively new concept. This portfolio management concept has primarily been applied to defined benefits plans. This paper presents a new direction for using this methodology; and (3) U.S. Treasury inflation-indexed securities represent a new asset class. This paper provides a brief background on the new securities and, more importantly, provides a practical application of the securities in a risk management, surplus framework context for prepaid college tuition plan management and tuition inflation hedging.

In section 2, the background for prepaid college tuition plans is discussed. Currently, available plans are presented and are contrasted with other financing alternatives. Section 3 illustrates the transfer of the tuition inflation burden from the individual to the state and the extant surplus framework literature is reviewed. The surplus framework model is developed in section 4. This innovative portfolio management tool is further discussed by means of an example in section 5. Section 6 provides concluding comments regarding the use of U.S.

Table 1
College plans by state

State	Program Name	Program	Year Initiated
Alabama	Prepaid Affordable College Tuition (PACT)	Prepaid Plan	1990
Alaska	University of Alaska Advance College Tuition Payment Plan	Prepaid Plan	1991
Arizona	Arizona Family College Savings Program	Savings Plan	1998
Arkansas	Arkansas College Savings Bond Obligation	Bond Program	1991
California	Golden State Scholarship Trust College Savings Program	Savings Plan	1998
Colorado	Colorado Prepaid Tuition Fund	Prepaid Plan	1997
Connecticut	Connecticut Higher Education Trust (CHET)	Savings Plan	1997
Delaware	Delaware College Investment Plan	Savings Plan	1998
Florida	Florida Prepaid College Program	Prepaid Plan	1988
Georgia	Help Outstanding Pupils Educationally (HOPE) Scholarship Program	Scholarship	1993
Illinois	Illinois Prepaid Tuition Plan	Prepaid Plan	1998
Indiana	Indiana Family College Savings Plan and Save Indiana	Savings Plan	1996
Iowa	College Savings Iowa	Savings Plan	1998
Kentucky	Kentucky Educational Savings Plan Trust	Savings Plan	1990
Louisiana	Louisiana Student Tuition Assistance & Revenue Trust Program	Savings Plan	1997
Maryland	Maryland Prepaid College Trust	Prepaid Plan	1998
Massachusetts	U-Plan The Massachusetts College Savings Program	Prepaid Plan	1995
Michigan	Michigan Education Trust	Prepaid Plan	1988
Mississippi	Mississippi Prepaid Affordable College Tuition Program (MPACT)	Prepaid Plan	1997
Missouri	Missouri Higher Education Savings Program	Savings Plan	1998
Nevada	Nevada Prepaid Tuition Program	Prepaid Plan	1997
New Hampshire	New Hampshire Savings Plan: Unique College Investing Plan	Savings Plan	1998
New Jersey	New Jersey Better Educational Savings Trust	Savings Plan	1997
New York	New York State College Choice Tuition Savings Program	Savings Plan	1997
North Carolina	College Vision Fund	Savings Plan	1996
Ohio	Ohio Prepaid Tuition Program	Prepaid Plan	1989
Oklahoma	Oklahoma College Savings Plan	Savings Plan	1998
Pennsylvania	Pennsylvania Tuition Account Program	Prepaid Plan	1993
Rhode Island	Rhode Island Higher Education Savings Trust	Savings Plan	1998
South Carolina	South Carolina Tuition Prepayment Program	Prepaid Plan	1997
Tennessee	Baccalaureate Education System Trust (BEST)	Prepaid Plan	1996
Texas	Texas Prepaid Higher Education Tuition Program (TOMORROW)	Prepaid Plan	1996
Utah	Utah Educational Savings Plan Trust	Savings Plan	1996
Vermont	Vermont Higher Education Savings Plan	Savings Plan	1999
Virginia	Virginia Prepaid Education Program (VPEP)	Prepaid Plan	1996
Washington	Guaranteed Education Tuition	Prepaid Plan	1997
West Virginia	West Virginia Prepaid College Plan	Prepaid Plan	1998
Wisconsin	EdVest Wisconsin (Wisconsin Education Investment Program)	Prepaid Plan	1997
Wyoming	Advance Payment of Higher Education Costs Program*	Prepaid Plan	1987

Sources: College Savings Plan Network and National Association of State Treasurers (1998).

* The program was suspended in 1995 due to lack of participation. All contracts sold during the program's lifetime are being honored by the state of Wyoming.

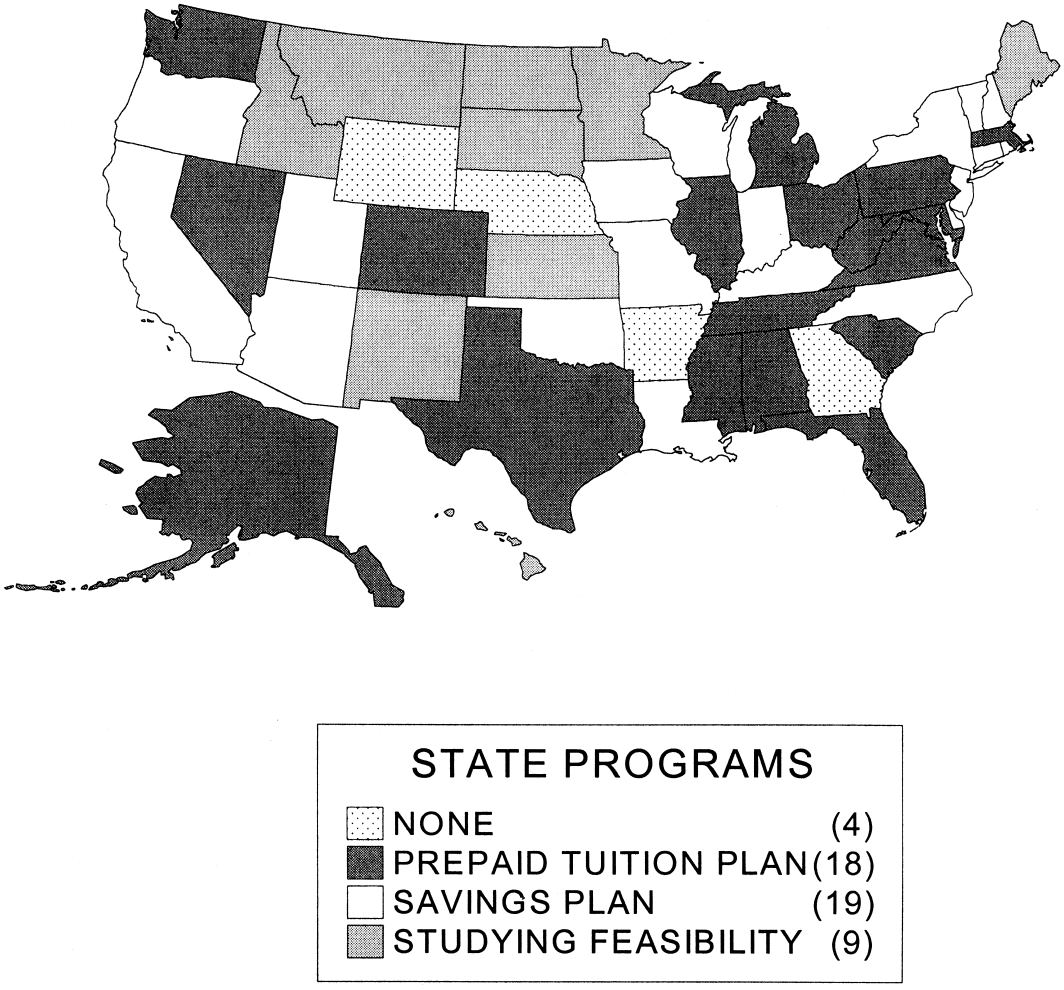

Fig. 1. State College Tuition Plans. Sources: College Savings Plan Network and National Association of State Treasures (1998).

Treasury inflation-indexed securities to assist plan administrators or individuals in the management of tuition inflation.

2. Prepaid college tuition plans

During the past few years, prepaid college tuition plans have been gaining in popularity. Michigan was the first state to initiate a plan, and Florida's is now the largest. The basic idea behind the plan is to allow residents to purchase college tuition for subsequent use at roughly today's price. In this manner, the individual will not be exposed to tuition inflation. States offer the plans to residents and allow for a variety of options and differing degrees of

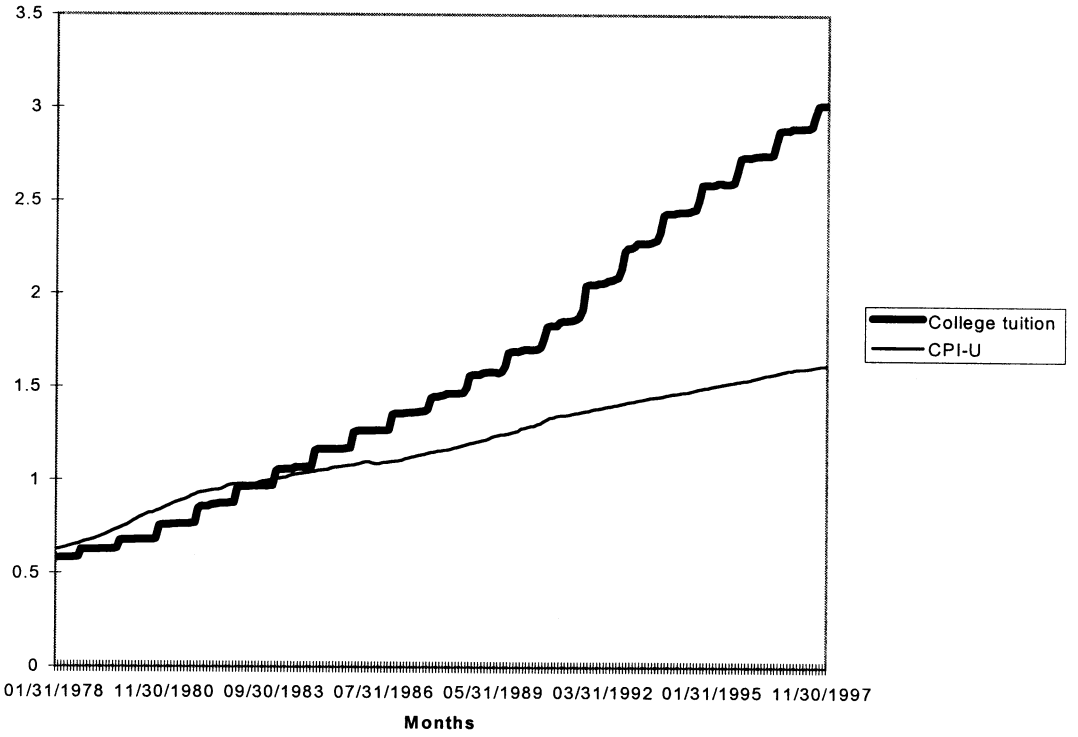

Fig. 2. College Tuition and CPI 1983 = 1. Source: DRI: Standard & Poors.

flexibility. Particular plans are portable and allow the recipient to attend any accredited college in the country while some allow for partial payment at private colleges. Several states allow the plans to be transferred to other members of the family.

There are severe restrictions with a few of the plans. For instance, suppose a child decides not to attend college or does not qualify academically. Some of the money that has been invested may be forfeited. Other plans will refund the invested money, either without interest or with a very modest amount of interest.

Individuals find it appealing to eliminate the uncertainty associated with future college tuition prices. Using the prepaid plans, tuition inflation risk is passed on to states or others parties that ultimately guarantee the plans. Figure 2 illustrates a reason for the plans' popularity. This figure shows that tuition prices have increased at a much higher rate than the general level of prices. Families saving for college realize that tuition costs are escalating and that the prepaid college tuition plans provide more certainty regarding long-term planning. Families can essentially pay for college at today's prices and receive an assurance from the state that tuition will be covered when the child is ready to attend college. A few states have even discussed a prepaid room and board feature to allow for even more certainty regarding the financial obligation of the family. Fowler (1998) examines public school inflation in detail.

As noted in Table 1 and Fig. 1, some states have opted for savings plans rather than prepaid tuition plans. College saving alternatives vary from tax-advantaged bonds, typically

state zero-coupon bonds, to college savings accounts. Unlike prepaid tuition plans, tax-advantaged bonds do not require the funds to be spent on college expenses. To encourage college savings, some states offer a bonus with the tax-advantaged bonds as an incentive to use the funds for higher education at redemption. The zero-coupon bonds are sold at a discount with the difference between purchase price and face value representing the interest on the bonds. The interest is exempt from federal taxes and, for purchasers residing in the issuing state, from state taxes.

College savings accounts allow individuals to invest in funds that are managed by trusts. As an example, the Savings Plan Trust, offered in Kentucky, provides a guaranteed minimum interest rate of 4%, but the earnings vary depending on the manager's selection of investment vehicles. Prepaid tuition plans shift tuition inflation away from the individual while college savings accounts do not shift tuition inflation to other parties. In fact, if the accounts return the guaranteed 4% and tuition continues to increase at historic levels, individuals will notice a significant shortfall between their college savings accounts and the tuition liability they will face.

Prepaid tuition plans come in three main varieties. There are contract, tuition credit, and certificate plans. Contract plans allow the purchaser to enter an agreement for a predetermined amount of education, with the cost calculated as the current tuition level. For instance, if the current cost of four years of tuition is $16,000, an individual may purchase four years of college tuition today and receive a contractual guarantee for four years of tuition in the future. The risk associated with tuition inflation is completely shifted from the individual to the guarantor.

Tuition credit plans are similar to contract plans in that they allow the purchaser to obtain prepaid education. They differ in that the purchaser starts an account and continues to make periodic deposits to purchase prepaid units of education. Certificate plans allow individuals to purchase certificates that are redeemable for a percentage of tuition and mandatory fees. The state commits to pay face value plus annually compounded interest of CPI plus some percent. For instance, Massachusetts' plan allows for interest to compound at CPI plus 2%. If tuition increases faster than CPI plus 2% the *schools* absorb the loss.

In each of these plans the risk of tuition inflation is shifted from the individual to either states, schools, or third-party plan managers. The introductions of prepaid college tuition plans assist students and parents, but risks have been introduced that guarantors must either hedge or absorb.

3. Surplus framework

A relatively new method for viewing the asset allocation decision within portfolio management is the surplus framework. This framework has become popular for defined benefit plan managers. The objective of the plan manager is to maximize the surplus, or the difference between the assets and liabilities. Not only are the defined benefit plan managers concerned with asset returns, they are also acutely aware of the plan's liabilities. The prepaid college tuition plan manager (administrator) faces a similar dilemma. The liabilities are a key concern. The liabilities faced by the prepaid college tuition plan administrator are the tuition outlays that are the responsibility of the guarantor.

Much of the recent literature regarding the inclusion of liabilities in portfolio management optimization stems from the work of Sharpe and Tint (1990). In their study, the authors show that investors may maximize either their asset return or their surplus. Traditionally, fund managers have chosen to maximize asset returns following standard modern portfolio theory. However, situations do arise in which maximizing the surplus is both prudent and appropriate such as pension funds.

Ezra (1991) presents a discussion of liability modeling within the context of defined benefit plans. A key characteristic of defined benefit plans is that pension benefits are defined independent of the value of the plan's assets. The benefits are based on formulas that incorporate employee earnings and, typically, length of service. In essence, the corporation has issued benefit debt to the plan participants. This debt (liability) can be serviced on either a pay-as-you-go basis or a funded basis. A funded basis requires that funds be set aside each year to match the present value of the debt accrued that year. The plan manager needs to be cognizant of the plan's liabilities and not simply focus on asset growth. In his paper, Ezra concludes that the sponsor is better advised to focus on surplus rather than on assets alone when determining asset allocation for defined benefit plans. Fong (1991) incorporates portfolio theory into the surplus management problem.

Leibowitz et al. (1992) present an analysis in which both asset-only performance and surplus control are considered in asset allocation decisions. The authors' "dual-shortfall" approach demonstrates an overlay of the two constraints that were identified by Sharpe and Tint (1990).

Macbeth et al. (1994) reiterate the importance of including the surplus framework when considering asset allocations for defined benefit plans. The authors conclude that a meaningful evaluation of the true risks and rewards for defined benefit plans lies not on a mean-variance analysis of asset returns, but by focusing on future sponsor contributions instead.

Peskin (1997) finds that defined benefit plan investing has evolved from an asset-only methodology to an asset/liability framework. The author concludes that corporations can reduce the present value of future contributions to the plans by more than 20% by incorporating a surplus framework methodology. Further, Peskin finds that focusing on asset-only return maximization leads to financially risky and costly asset allocation decisions. One of the key components of the author's study is the discussion on synchronizing assets and liabilities.

Based on Fig. 1, the reader can see that there are roughly an equivalent number of states offering prepaid plans as savings plans. Reasons offered for the popularity of the college savings plans is that they are less administratively difficult and less risky than prepaid plans which involve tuition inflation risk-shifting. In the next section, a model is developed that builds upon the surplus management literature for defined benefit plans. This model is extended to prepaid college tuition plans, but can be employed by individuals who choose to manage their own college investment account.

4. Surplus framework model

Sharpe and Tint (1990) present a model for surplus optimization in defined benefit plans. Their model is based upon the goal of maximizing the surplus for a plan in the year to come. In this section, this model will be expanded and presented with applications for prepaid

college tuition plans. The basic foundation for the model is the measure of surplus, defined as assets minus liabilities. Sharpe and Tint (1990) further define a variable, k, that captures the importance attached to the liability by the fund manager. This variable can obtain values within the range of zero to one, where zero implies that liabilities are ignored, as in asset-only optimizations, and one implies that a full surplus optimization is utilized. By incorporating this variable, k, the surplus model becomes:

$$S_1 = A_0 + \alpha + \varepsilon_A - k(L_0 + \lambda + \varepsilon_L) \quad (1)$$

where

S_1 = next year's surplus
A_0 = plan assets in period 0
α = net cash for plan. This value is positive if there is a net increase in participation or negative if there is a net outflow of funds, e.g. the child decides to forego college.
ε_A = return on plan assets during period 0 to 1
k = importance attached to liability
L_0 = plan liabilities in period 0
λ = present value of net additions/reductions in liabilities during period
ε_L = return on liabilities due to underlying market factors, i.e. tuition inflation, rather than an addition or paydown in the plan's liabilities.

The liability incurred by the plan, λ, is the present value of the expected future tuition payment. This value may be determined by projecting tuition into the future and then discounting the future value by an appropriate discount factor. The present values of the assets, α, and liabilities, λ may differ due to the recognition of the liability. In this study, it is assumed that the fund recognizes a liability, λ, that is equal to the inflow of assets, α. The present value of the future tuition outlay is equal to the prepaid tuition that is being purchased today. We can relax this assumption without materially impacting the results.

Assuming that $\alpha = k\lambda$ and expressing Eqn. 1 relative to today's asset value we have the following:

$$S_1/A_0 = [A_0 + \varepsilon_A]/A_0 - k[L_0 + \varepsilon_L]/A_0 \quad (2)$$

In order to provide additions to the surplus, the plan would need for the asset investments to exceed the liability return, or $\varepsilon_A > \varepsilon_L$. In other words, the funds invested need to provide a higher return than the change in the liability. The change in the liability is directly impacted by tuition inflation. To maximize the plan surplus, S_1, the manager must make asset allocation decisions that are inclusive of the liability of the plan.

Equation 2 can now be expressed using the more familiar notation of returns. For instance, the term $[A_0 + \varepsilon_A]/A_0$, next year's asset value over this year's value, equals $1 + R_A$. Multiplying the final term by the constant L_0 / L_0, we may express the liability using the notation of returns, i.e., $[L_0 + \varepsilon_L]/L_0 = 1 + R_L$.

$$S_1/A_0 = 1 + R_A - k[L_0/A_0][1 + R_L] \quad (3)$$

Equation 3 can be rearranged into certain components and uncertain components:

$$S_1/A_0 = [1 - k(L_0/A_0)] + [R_A - k(L_0/A_0)R_L] \quad (4)$$

The first bracketed term on the right-hand side of Eqn. 4 is certain, while the second term is uncertain.

The prepaid college tuition plan manager, or individual managing his/her own college investment account, is concerned with maximizing next year's surplus by making appropriate asset allocation choices today. The manager is concerned with the effects of the asset allocation decision on the second term on the right-hand side of Eqn. 4, that is, the uncertain component. For convenience this term can be defined as μ:

$$\mu \equiv [R_A - k(L_0/A_0)R_L] \quad (5)$$

Equation 6 summarizes the objective of surplus optimization using a one-period model, $t = 1$, and the goal of utility maximization where we assume a quadratic utility function:

$$U_{max} \equiv E[\mu] - var[\mu]/\eta \quad (6)$$

where: $E[\mu]$ denotes the expected return of the uncertain component, μ
$var[\mu]$ denotes the variance of the uncertain component, μ
η denotes the fund manager's, or individual's, risk tolerance
With the substitution of μ into the expected return component of Eqn. 6:

$$E[\mu] = E[R_A] - k(L_0/A_0)E[R_L] \quad (7)$$

Notice that Eqn. 7 reduces to $E[R_A]$ when the importance of the liability is zero, $k = 0$. Although the manager is concerned with liabilities, the asset allocation decision only involves the first term on the right hand side of Eqn. 7. Therefore, the utility maximization objective is consistent with traditional asset-only return management with regard to expected return.

The departure from traditional asset-only return management, and the primary contribution of the surplus framework management comes from the treatment of the variance term in Eqn. 6. The variance term can be expanded, as shown in Eqn. 8 below:

$$var[\mu] = var[R_A] - 2k[L_0/A_0]cov[R_A,R_L] + k^2[L_0^2/A_0^2]var[R_L] \quad (8)$$

where

$var[R_A]$ denotes the variance of asset returns $cov[R_A,R_L]$ denotes the covariance of asset and liability returns $var[R_L]$ denotes the variance of liability returns

Traditional asset-only management methodology focused on the first term on the right-hand side of Eqn. 8. The last term on the right-hand side of Eqn. 8 involves constants and variation in the returns on liabilities. This term is not influenced by asset allocation decisions. The second term on the right-hand side of Eqn. 8 is the key contributing factor in a surplus framework. This is the only term that allows for a departure from traditional asset-only portfolio management. Combining Eqns. 7 and 8:

$$U_{max} \equiv E[R_A] - var[R_A]/\eta + 2k/\eta[L_0/A_0]cov[R_A,R_L] \quad (9)$$

The goal of the prepaid college tuition plan manager is to choose a utility maximizing asset allocation. The first two terms on the right-hand side of Eqn. 9 are equivalent to the traditional portfolio maximization goal, that is, to maximize asset return subject to asset return variation. In other words, maximize the risk-adjusted return on assets. These two terms are identified as the expected return and risk penalty, respectively, where the risk penalty is defined as the variance of asset returns divided by the manager's risk tolerance. Without diverting into an exposition on utility theory, risk tolerance can be viewed as the reciprocal of the absolute risk aversion parameter, as developed by Pratt (1964) and others. Following risk aversion parameter values suggested by Friend and Blume (1970) and Grossman and Shiller (1981), this study assumes that the degree of risk aversion for the representative investor ranges from 2.0 to 4.0. This range of values is consistent with studies that take into account a full range of available assets.

The following example will illustrate the risk-adjusted expected return using traditional asset-only portfolio management techniques. Assume that the expected return from a particular asset allocation is 12%, the standard deviation of returns associated with the asset allocation is 10%, and the absolute risk aversion parameter is 2.0. The risk-adjusted expected return is identified below:

Expected return – [variance/risk tolerance], or $12\% - [(10\%)^2/(1/2.0)] = 10\%$ = risk-adjusted expected return

Given the risk aversion measure, this fund manager would be indifferent between the portfolio and 10%, with certainty.

This study expands the utility concept to include the final term in Eqn. 9. Given that the asset and liability have a positive relationship, $\text{cov}[R_A,R_L]$ 0, the final term in Eqn. 9 will increase utility. This final term is referred to as the liability hedging credit. To complete the example above, assume that this liability hedging credit is 2%. The risk-adjusted expected return is shown below:

Expected return – [variance/risk tolerance] + liability hedging credit, or $12\% - [(10\%)^2/(1/2.0)] + 2\% = 12\%$ = risk-adjusted expected return

By including this credit, the fund manager is indifferent between the portfolio asset mix and a portfolio offering 12% with certainty, but with no hedging capabilities against liability fluctuations. The implications of the surplus framework model are that managers may choose a lower expected return or greater asset risk in order to increase the hedging capabilities of the portfolio against increases in liability values.

In order to optimize the portfolio, from a surplus framework, it makes sense to choose assets that have a positive covariance with the plan's liabilities. The liabilities associated with prepaid college tuition plans are driven by tuition inflation. A plan manager should include assets with a positive covariance with tuition inflation.

U.S. Treasury inflation-indexed securities are expected to have a positive relationship with tuition inflation. The degree of correlation may not be perfect; that is, the correlation coefficient may not be 1.0, but the two measures are expected to display positive correlation given the positive correlation between CPI and tuition inflation. This positive relationship is

apparent in Fig. 2 and is calculated to be 0.87 using the College Board's college inflation index as a proxy for tuition inflation (Chicago Board of Trade, 1997).

In the next section, this study develops a comprehensive example using U.S. Treasury inflation-indexed securities to enhance the liability hedging credit component inherent in the surplus framework model.

5. Example of surplus framework model

The trading history of U.S. Treasury inflation-indexed securities is relatively limited. The first note was issued in January of 1997. An important feature of this security is that both the interest payments and principal amount are adjusted for inflation. The principal amount changes, or accretes, based on a predetermined lag and the reporting of CPI to reflect the present price environment. The interest payments are based upon the accreted principal amount. For instance, if the accreted principal is \$1,200 and the note has a 3 3/8% coupon. The semi-annual interest payment is calculated as \$1,200*(.03375/2) = \$20.25. The accreted principal amount changes to reflect the cumulative inflation effect since the security was issued by multiplying the original par value, \$1,000, by the index ratio. This section explores the feasibility of including the inflation-indexed Treasuries in asset allocation decisions for prepaid college tuition plans. The following section will introduce the framework for conducting an empirical investigation after sufficient data has been generated.

The key element of the surplus framework methodology is the covariance term that provides the liability hedging credit. Since college tuition is an annual variable, one observation per year, and the new inflation-indexed Treasuries have a one-year history, an empirical investigation is not possible.

For this study, a comprehensive example will be set forth that will allow managers to adopt a surplus framework in the management of prepaid college tuition plans. The necessary input variables are assumed below:

- Assets today, A_0 = \$1,000,000
- Liabilities today, L_0 = \$1,000,000
- New funds, α = \$250,000
- New liabilities generated, λ = \$250,000
- College tuition inflation = 8%
- Portfolio is limited to investments in S&P 500, U.S. Government bonds, investment grade U.S. corporate bonds, and U.S. Treasury inflation-indexed securities (also referred to as U.S. Treasury inflation-protected securities or TIPS).
- Using the college inflation index (CINF) as the tuition inflation variable and CPI as a proxy for TIPS, we calculate correlation coefficients for each asset with this liability. The results are included in Table 2.

Given the information above, an optimal surplus framework model can be developed that not only considers portfolio return and standard deviation, but also includes the liability hedging credit.

The portfolio return and standard deviation are measured using standard notation. The

Table 2
Example for surplus framework model

$Asset_i$	Source $Return_i$	Std. $Dev._i$	$\rho_{Ri,RL}$	$Cov_{Ri,RL}$	LHC_i
Govt. Bond	6%	8%	0.09	1.8	0.072
Corp. Bond	7%	12%	0.07	2.1	0.084
S&P 500	12%	20%	−0.25	−12.5	−0.5
TIPS	6%	6%	0.87	13.05	0.522

The portfolio is limited to investments in U.S. Government bonds (Govt. Bond), investment grade U.S. corporate bonds (Corp. Bond), S&P 500, and U.S. Treasury inflation-indexed securities (also referred to as U.S. Treasury inflation-protected securities or TIPS). Return, standard deviation, and correlation coefficient measures are historical averages. The correlation coefficient the relationship between asset returns and the college inflation index (CINF). CPI served as a proxy for TIPS in the correlation coefficient calculation.

$\rho_{Ri,RL}$ = correlation coefficient of returns for asset i with the plan liability
$Cov_{Ri,RL}$ = covariance of returns for asset i with the plan liability

$$\text{Liability hedging credit} = LHC_i = \frac{2}{\eta}\frac{L_0}{A_0} Vov_{Ri,RL}$$

$$\text{Liability hedging credit} = LHC_{portfolio} = \sum_{i=1}^{n} X_i LHC_i$$

The table above is based upon the following assumptions:

- Standard deviation for the liability is 2.5 percent. This is the long-term historic volatility for the college inflation index.
- Initial assets equal initial liabilities, i.e., $L_0/A_0 = 1.0$.
- Risk tolerance equals 50, i.e., risk aversion equals 2.
- TIPS real returns are converted to nominal values for comparison purposes.

return is an asset allocation-weighted measure. The portfolio return is the sum of the weighted returns of the individual assets. The standard deviation is measured as the weighted sum of the standard deviations with the corresponding weighted covariance terms, as in traditional portfolio theory.

The surplus framework departs from the traditional portfolio concept in that the liability hedging credit (LHC) is added to the total utility. The following formulas summarize the relationship:

$$\text{Portfolio expected return} = E(R_p) = \sum_{i=1}^{n} X_i R_i, \text{ for asset classes i,. . ., n} \tag{10}$$

$$\text{Portfolio variance} = \sigma_p^2 = \sum_{i=1}^{n} X_i^2 \sigma_i^2 + \sum_{i=1}^{n}\sum_{j=1}^{n} X_i X_j \, Cov_{ij}, \text{ for all i,j} \ni i \neq j \tag{11}$$

$$\text{Portfolio standard deviation} = \sigma_p = \sqrt{\text{portfolio variance}} \tag{12}$$

$$\text{Liability hedging credit} = LHC_i = \frac{2}{\eta}\frac{L_0}{A_0} Cov_{Ri,RL} \tag{13}$$

Table 3
Asset allocation results from surplus framework example
The results below are based on the values in Table 2 and were generated using the surplus framework model and an optimization program. Note that the optimal asset allocations include a significant portion of the portfolio being invested in TIPS. Although the return for TIPS is relatively modest the correlation with the liability makes this security attractive. The implication from this allocation is that managers may choose assets with low returns for their portfolios if the degree of correlation with the liability is strong enough to enhance the liability hedging credit.

$Asset_i$	Allocation
Govt. Bond	4.73%
Corp. Bond	19.82%
S&P 500	34.75%
TIPS	40.69%
Portfolio	
Expected Return	8.28%
Std. Dev.	7.76%
LHC	0.06
Utility	7.14%

The portfolio is limited to investments in U.S. Government bonds (Govt. Bond), investment grade U.S. corporate bonds (Corp. Bond), S&P 500, and U.S. Treasury inflation-indexed securities (also referred to as U.S. Treasury inflation-protected securities or TIPS).

Expected return and standard deviation on the portfolio are calculated in the usual manner.

Liability hedging credit $= LHC_i = \frac{2}{\eta}\frac{L_0}{A_0} Cov_{Ri,RL}$

Liability hedging credit $= LHC_{portfolio} = \sum_{i=1}^{n} X_i LHC_i$

Utility = Portfolio expected return − Risk penalty + Liability hedging credit

Utility $= E(R_p) - (\sigma_p^2/\eta) + LHC_{portfolio}$

$$\text{Liability hedging credit} = LHC_{portfolio} = \sum_{i=1}^{n} X_i LHC_i \tag{14}$$

$$\text{Utility} = \text{Portfolio expected return} - \text{Risk penalty} + \text{Liability Hedging credit} \tag{15}$$

$$\text{Utility} = E(R_p) - (\sigma_p^2/\eta) + LHC_{portfolio} \tag{16}$$

The goal of the college tuition plan manager is to maximize Eqn. 16. This is a departure from the traditional portfolio format, whereby the manager maximized Eqn. 10 subject to Eqn. 12. Using the formulas above and an iterative search for appropriate asset allocations, a simple model is developed to aid in this critical decision analysis.

With the information from Table 2, an asset allocation decision was performed. By maximizing the utility, as defined in Eqn. 16, the optimal asset allocation is presented in Table 3. The prepaid college tuition plan manager should allocate approximately 4.7% to Government bonds, 19.8% to investment grade U.S. corporate bonds, 34.8% to the S&P 500, and 40.7% to U.S. TIPS. These allocations are driven by historic return and risk, the

Table 4
Sensitivity Analysis of Model Parameter Values
The sensitivity analysis allows the keys variables of liability volatility, risk aversion, and correlation between assets and liabilities to vary. In the tables below the liability volatility and risk aversion are chosen and the correlation coefficient, ρ, is allowed to vary. In each table an optimal allocation is presented for the four securities (indices) using the surplus framework model. Note that in all of the allocation decisions, except one, TIPS should be included as a component of the portfolio.

$Asset_i$	$\rho_{Ri,RL}$	Allocation	$\rho_{Ri,RL}$	Allocation	$\rho_{Ri,RL}$	Allocation
Liability Standard Deviation = 6%, Risk Aversion = 4						
Govt. Bond	.1	0%	.1	13%	.1	0%
Corp. Bond	.1	0%	.1	27%	.1	10%
S&P 500	.2	38%	.1	43%	.5	61%
TIPS	.95	62%	.1	17%	.5	29%
Liability Standard Deviation = 20%, Risk Aversion = 2						
Govt. Bond	.1	0%	.1	13%	.1	0%
Corp. Bond	.1	0%	.1	29%	.1	0%
S&P 500	.2	35%	.1	46%	.5	75%
TIPS	.95	65%	.1	13%	.5	25%
Liability Standard Deviation = 20%, Risk Aversion = 4						
Govt. Bond	.1	0%	.1	13%	.1	0%
Corp. Bond	.1	0%	.1	34%	.1	0%
S&P 500	.2	27%	.1	52%	.5	100%
TIPS	.95	73%	.1	2%	.5	0

correlation with the college inflation index, and the risk tolerance of the manager or investor. We allowed the key parameters; liability volatility, asset correlation with tuition inflation, and degree of risk aversion to change and performed sensitivity analyses for these key inputs. The results are included in Table 4.

The key observation for the surplus framework is that a plan manager should consider the risk and return merits of the assets, not on a stand-alone basis, but within the context of the liabilities generated by the plan. To the extent that a relatively low yielding asset has a high degree of positive correlation with the liability, it might warrant consideration from an asset allocation standpoint. The interpretation of the utility value is: A plan manager, with the risk tolerance and asset choices assumed in this example, would be indifferent between receiving the utility value, 7.1%, and an asset mix that provided 7.1% with no uncertainty and no ability to serve as a hedge against fluctuations in liability values. The plan manager can increase his/her risk-adjusted expected return by the value of the liability hedging credit as a result.

6. Conclusion

Individuals have readily accepted prepaid tuition plans and the plans have received strong support in Congress. Given the rapidly escalating costs involved with attending college, individuals are searching for an alternative to indebtedness. Prepaid tuition plans allow

individuals to purchase college tuition today for use at a later time. This reduces the dependency that has been formed between parents, students, and student loans. This paper provides an overview of the plans and suggests a framework for managing the tuition risk that has been shifted from individuals to states or other guarantors. Although the focus of the surplus framework model is for prepaid tuition plan management the methodology may easily be implemented by individuals who manage their own college investment accounts. Additionally, we suggest that U.S. Treasury inflation-indexed securities be included in an asset allocation decision for tuition inflation management. These securities offer new alternatives for inflation-averse investors, corporations, and municipalities. This paper has shown that individuals and states may employ the new securities to facilitate in the management of tuition inflation risk.

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