INFLATION, UP CLOSE AND PERSONAL

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1. ABSTRACT

We suggest that the appropriate measure of inflation for an individual depends on the specific manner in which he ultimately plans to spend his savings. After discussing the use of portfolio theory to calculate such a quantity, we consider the best means of hedging against this personal inflation index in order to preserve wealth.

2. INTRODUCTION

A great deal of research and discussion has been devoted to questions surrounding the construction of an optimal generic measure of inflation. But the effect of inflation on an individual depends on their future spending plans, and it is this consideration that should determine a choice of hedging strategy. However important a generic index of inflation may be for the issuance of bonds and the adjustment of such income streams as social security, the appropriate means of protecting one's portfolio is entirely dependent on an individual's anticipated future disposition of savings. As a simple example, consider two people in identical circumstances – one of whom is saving for the future college education of his children while the other is saving for a holiday villa in France. The change in real value of their savings may differ. If college tuition rises 20% in a given year but the Euro-denominated value of real estate in France decreases by 10%, then one man's savings will have dropped in value while the other's will have risen. This may seem an extreme case. However, most people save money for a small number of anticipated large expenses[1] rather than an indeterminate set of day-to-day costs. Such expenses include real estate, education, travel, and healthcare, among others.

We propose the use of simple portfolio theory[2] to determine the appropriate hedge for each individual, given their expected eventual application of current savings. By treating anticipated large future expenses as instruments, we can measure the historical rate of inflation relevant to that person. While the construction of a suitable replicating portfolio from existing securities may be difficult in

[1] Or would do well to do so.

[2] Though we refer to "portfolio theory" where appropriate, a familiarity with that subject is neither necessary for understanding our approach nor assumed in this paper.

practice, the theoretical means of hedging is straightforward. A variety of predictive models may be constructed along the same lines using the tools of portfolio theory, though we do not pursue this here.

Because we are working with various forms of inflation, all dollar quantities are accompanied by the times at which they are measured. Nor is the use of "present values" applicable except in narrowly defined contexts[3]. We do not have a natural means of connecting dollar values at different times. For this reason, we carefully identify any such implicit connection when present.

3. The Choice of Portfolio

To measure prior inflation we need not consider the timing of future purchases, merely their current cost. The first step is to identify the items toward which savings will be applied. Each of these is treated as an asset in our portfolio, even if no corresponding security exists. The allocation need not be exact; it likely will change anyway as the relative returns of its components differ. The following are some of the assets that could be represented in such a portfolio:

- Real estate. This could include the purchase or upgrade of a primary residence, a desired vacation property, or intended help with a child's future purchase. We ignore investment homes, for reasons that shall be discussed.
- Periodic depreciable expenses. Cars, home repairs that do not add value, and so on.
- Legal costs. These can't be anticipated, but the need to set aside appropriate funds for protection may be.
- Healthcare. Some costs, such as health insurance or orthodontic work, may be predictable. As with legal costs, there may also be the need for a protective allocation.
- Education. Depending on one's inclination and means, this could include anything from preschool childcare to business or medical school.
- Business. If one intends to start a business, the startup costs could be an object of saving. As will be discussed, this depends on the purpose of the business. If it is an end in itself or is imperative, then we include it; however, if it is a mutable means of generating income down the line, it would be considered an investment and ignored.
- Living costs. One may wish to set aside funds to protect against unemployment or defray living costs in retirement.
- Luxuries. These could be depreciable or serve as investments. Ignoring the latter aspect, we consider only purchases.
- Travel.

Although it may seem that the manner in which one intends to pay for a future purchase (such as cash vs mortgage) should affect its treatment, we will see that it does not per se. However, one's current holdings may affect the choice of how to hedge. For example, if someone owns a house and plans to trade up then he must account for the existing home's appreciation relative to that of the intended purchase. We will describe a simple way to deal with this.

We do not include intended future investments in the portfolio. While it may be useful to consider opportunity costs, we assume that any choice of investment portfolio at a future date will be made as dictated by conditions at that time. The purpose of the inflationary portfolio is to measure the loss of purchasing power for those expenses that we anticipate incurring regardless of economic conditions. For example, if we plan on buying a villa in France then we wish to account for the loss (or gain) in value of our savings toward this end. We may be unable to afford to do so or choose not to when the time comes. However, the value of the dollars toward that end is what matters to us now. On

[3]This is an important difference from most financial analyses (including those which deal with inflation). There is no favored mapping from d_t to $d_{t'}$.

the other hand, if we wish to buy the villa as a future investment then our goal is to maximize our risk-adjusted return subsequent to its purchase. We may currently deem the villa a good choice, but be unwilling or unable to invest in it at the moment. At the relevant future time, the villa may or may not remain a suitable investment vehicle. Because we do not care about it other than as an investment, we need not concern ourselves with hedging. Whether the villa will be $500K or $1MM is irrelevant. There are exceptions – for example if the villa is and will be a rare investment opportunity that requires a minimum investment – but in general we can exclude investments from consideration as anticipated expenses. Simply put, inclusion in the inflationary portfolio depends on whether an item is an end in itself (or irreplaceable) rather than a flexible means of achieving some goal.

Note that in anticipating future purchases, any tax implications must be accounted for. If savings are managed in a tax-deferred manner then taxes must be paid on withdrawal. Likewise, we must consider the tax implications of any hedging strategy. We will address this in more detail shortly.

Let us consider a simple example[4]. A family in 1990 consists of two parents, both age 40, an 8-year old boy, and a 10-year girl. The mother and father bring in a joint salary of $150K which they expect will rise with the cost of daily living. They both expect to retire at age 60, purchase an apartment in London and a villa on the Amalfi coast, and split their time between the two. They believe in public education and do not anticipate school or childcare expenses prior to college. However, they have high expectations of their children's scholastic achievements, and plan to send them to top universities. Neither parent has a pension, they assume Social Security no longer will exist when they retire, and they must provide for themselves.

In 1990 dollars, the anticipated expenses could be:

(1) A total of 8 years of college education for their two children at approximately $19K per year[5]. This amounts to $155K in 1990 dollars, and the cost would be spread over 6 years from 1998-2003.
(2) A villa on the Amalfi Coast upon retirement in 2010. A comparable property costs 600MM Lira[6] and the exchange rate is 1371 Lira/USD. This requires around $438K in 1990 dollars.
(3) A flat in London to be acquired upon retirement in 2010. A comparable home in London costs £560K and the exchange rate is 1.784 USD/GBP. This requires a little under $1MM in 1990 dollars.
(4) The monthly healthcare premium for a retired couple is $500 regardless of age (and in 1990 dollars). They anticipate living until age 80, which requires $120K in 1990 dollars.
(5) Their guess at the cost of living (in 1990 dollars) in retirement sans healthcare and travel would be $2K/month for the two of them. Again assuming they live until age 80, this would require $480K in 1990 dollars.
(6) They wish to set aside $500K (in 1990 dollars) for unanticipated legal or health costs. For convenience, let us assume that these change in tandem with healthcare premiums.
(7) They hope to spend about $20K a year on travel after retiring. This requires $400K in 1990 dollars.

The total pie needed is $3.092MM in 1990 dollars. This means that of every dollar saved, a naive planned allocation[7] would involve 5¢ toward education, 14.2¢ toward Lira (or, post-1999, €) denominated Amalfi coast real estate, 32.3¢ toward £-denominated London real estate, 20.1¢ toward healthcare (insurance and protection), 15.5¢ toward living expenses in retirement, and 12.9¢ toward retirement travel.

[4]To be examined in detail in Appendix A.
[5]The total 1990 cost of a year at Harvard, including room, board, and fees.
[6]We use Lira because this was prior to the 1999 Euro transition.
[7]This corresponds to the case where either no inflation is present or inflation is identical across all asset types.

Table 1 displays this portfolio as well as its approximate change in value[8] over the course of a year. Let us suppose that the cost of education rose 6.5%, healthcare premiums rose 15.6%, London real estate fell 5.8% and the $/£ exchange rate dropped 0.9%, Amalfi real estate skyrocketed 15.9% and the Lira/$ exchange rate dropped 12.6%, while food and other daily expenses rose 4.2%.

TABLE 1. Sample Inflation Portfolio

Anticipated Expense	Exposure (h)	Cost $t=0$	Cost $t=1$	$r_{0,1}$
Education of 2 Children	0.050	155160	165240	6.5%
Amalfi Villa	0.142	437537	580197	32.6%
London Home	0.323	999096	932434	-6.7%
Health Insurance in Retirement	0.039	120000	138750	15.6%
Living Expenses in Retirement	0.155	480000	500199	4.2%
Legal and Medical Emergency Fund	0.162	500000	578125	15.6%
Travel in Retirement	0.129	400000	416832	4.2%
Total	1.000	3091793	3311778	7.1%

With an overall inflation rate of 7.1%, a dollar at the end of the year was worth $0.934 (i.e. $\frac{1}{1.071}$) of what it was at the start of the year. As will be discussed, this represents the loss due to inflation for a fully-vested[9] savings portfolio. Specifically, the couple must inject $220K in 1991 dollars in order to remain fully-vested. We will elaborate on this shortly. Later, we will return to this particular portfolio in Appendix A and examine its evolution in greater detail.

4. THE EFFECT OF INFLATION

The appropriate means of hedging against inflation involves a consideration of one's entire portfolio – present investments *and* future purchases. Earlier we mentioned that there was an easy way of accounting for the means by which a future expense will be met. It is through the present investment portfolio that this is accomplished. For example, if one uses cash savings to fund the future purchase of a home then the difference between the inflationary rate of real estate and the risk free rate (or the rate earned on cash savings) is the relevant quantity. However if one is simply exchanging one home for another of equal value then (assuming real estate appreciation is uniform), there is no inflationary cost. Rather than worry about what pays for what, it is best to use simple portfolio theory[10].

Because portfolios behave linearly from the standpoint of returns (and we are not considering variance reduction here), we can consider the asset and inflationary components separately. This simplifies the problem considerably. We must be careful to incorporate only the appropriate assets. Though we are not required to include every asset or anticipated expense in our analysis, those which *are* included must match one another. That is, we should include all assets that will be used toward the eventual purchase of the items in the inflationary portfolio. Of course, the more comprehensive our two portfolios, the greater the utility of the exercise.

We treat the asset portfolio like any other, consider the change in price of each asset, and mark them to market as best we can. As mentioned, we may consider the inflationary portfolio separately[11]. In doing so, its assets can be treated as cash earning no interest. In essence, an individual is short his inflationary portfolio. He can be thought of as having borrowed its contents and sold them for

[8]This is based on the actual historic numbers for 1990-1991 as described in Appendix A. Note that percentages and other calculations are based on higher-precision values that those displayed in Table 3 and may not match exactly.

[9]We refer to an asset portfolio equal in value to the inflationary portfolio as "fully-vested" at that particular time. That is, its owner could acquire the inflationary portfolio (if it is meaningful to do so) but wishes to (or must) defer doing so for some reason.

[10]Again, though we refer to it as such, no knowledge of that subject is needed here.

[11]Bearing in mind that the adoption of a hedge requires inclusion of both portfolios.

cash at their current prices. At some future date he will have to purchase them back to cover his short. The virtual cash position from his initial short sale would be that of a fully-vested saver, an individual who *could* afford to acquire all the assets in the inflationary portfolio at present but does not[12]. If the inflationary portfolio has value V_0 at t_0 and appreciates $x\%$ by t_1, then the following hold:

- The investor requires V_0 at t_0 in order to be fully-vested at t_0.
- The investor requires $V_1 = V_0(1 + \frac{x}{100})$ at t_1 in order to be fully-vested at t_1.
- The investor would have needed $V_1 = V_0(1 + \frac{x}{100})$ in non-interest-earning cash at t_0 in order to be fully-vested at t_1.
- The investor who is fully-vested with V_0 in assets at t_0 would require an $x\%$ after-tax return on his portfolio in order to compensate for the inflationary loss and remain fully-vested at t_1.
- A non-interest-earning cash portfolio that has the fully-vested value V_0 at t_0 would require the injection of $V_0 \cdot (\frac{x}{100})$ dollars at t_1 in order to become fully-vested again. The investor has effectively lost this amount to inflation (in t_1 dollars).

In many cases, the hedging situation is even worse. Other than mature investors seeking to preserve wealth, most individuals are not fully-vested in terms of savings. Rather, they hope to set aside money over the years or achieve sufficient long term investment returns to become fully-vested at some point. However, this can amount to chasing a moving target. The problem is that the individual is always short the *full* inflationary portfolio. If he is fully-vested in savings, then this simply is offset by real assets. The inflationary adjustment to the return on the latter is a factor of $\frac{1}{1+x/100}$.

Consider the inflationary portfolio from Table 1. We would require \$3.092MM in assets to be fully-vested at $t = 0$. Let us solely work in $t = 1$ dollars[13]. We started with a fully-vested portfolio at $t = 0$, which requires \$3.312MM in $t = 1$ dollars (the equivalent of \$3.092MM in $t = 0$ dollars). At $t = 1$ we ended up with \$3.092MM in $t = 1$ dollars. In this sense, our portfolio lost \$220K in $t = 1$ dollars – or 6.6% of its value. This is what would happen to a fully-vested portfolio.

Suppose instead that the couple has only \$1MM in savings. At $t = 1$ they still require \$220K more in savings than they did at $t = 0$. We can think of this in two ways:

- As a proportionate share of a fully-vested savings portfolio, their \$1MM would have declined by a factor of $\frac{1}{1+x/100}$. In our example, this is 6.6%.
- As the totality of their savings, the \$1MM now is worth \$780K. That is, the savings now count less toward their eventual use. In some sense, the \$1MM in savings has experienced a decline of 22%.

Of course, it is rather pointless to think in terms of returns when considering a non-fully-vested portfolio. For example, if there are no savings we would not consider the return to be $-\infty\%$. But the dollar figure *is* meaningful.

One can see the dilemma. If the asset portfolio does not compensate for the entire *dollar* loss in the inflationary portfolio then the saver falls behind. While he still is better off than someone with less or no savings, his goal is outrunning him. Hedging is hard enough for a fully-vested individual; for someone who is not fully-vested, the required return can be impossibly large. Unless the growth in their assets (from saving or investment) keeps pace with their personal rate of inflation,

[12]Obviously, some assets such as four years of college cannot be purchased at present in a meaningful manner. However, their present cost is unambiguous.

[13]As mentioned, when dealing with multiple forms of inflation we have no natural connection between dollar values at different times. Here, we pretend that the mean inflation rate for the start-of-period fully-vested portfolio serves this purpose over short periods.

that goal becomes completely unattainable. Of course, this only is a problem if one's personal rate of inflation[14] is high. If the income inflation experienced by a worker and/or the risk-free returns accessible to him as an investor are greater than the personal rate of inflation then he may not have a problem[15]. It is precisely the point of this paper that these two rates can differ significantly, and often do.

5. HEDGING

Given the leverage required, there may be no meaningful way to hedge a non-fully-vested savings portfolio. What should one do in this case? A good approach would be to hedge against the most problematic form of inflation (if clear) or the most important future expense. Returning to the portfolio in Table 1, the obvious choice is to hedge against a rise in the cost of education. Such inflation almost certainly is irreversible (barring some major change in policy), and the benefit to one's children may outweigh the importance of retirement protection. Once one has selected the most important or most potentially troublesome components, the considerations are the same as those in hedging a fully-vested savings portfolio – so let us consider the latter.

We first note that the structure of future payments is irrelevant. As long as we account for the return of the savings portfolio, we need not make special accommodation. For example, whether one purchases a future house using cash or by taking out a mortgage is irrelevant. While the difference may affect subsequent portfolio behavior, at the time of purchase only the price matters[16]. However, the difference may manifest itself in the manner in which the purchase is represented in the inflationary portfolio. If we anticipate a mortgage, then a downpayment and series of mortgage payments may be included – while a cash purchase would involve a lump sum. However, we treat the choice as an investment decision and – since we only consider present costs anyway – it is of no concern to us.

If our inflationary portfolio is h_I then we may ask how best to allocate h_A, our (fully-vested) asset portfolio, to hedge against inflation. If h_I simply consisted of stocks in a tax-free account, then our solution would be simple: $h_A = h_I$. However, for the items in a real inflationary portfolio h_I we must be creative. Specifically, we need to identify suitable proxies. This may prove considerably more complicated than one would hope. We will not attempt to construct such proxies here, and simply note that the ordinary use of portfolio covariance matrices (with an obvious predictive assumption) may serve toward this end.

Returning to the portfolio in Table 1, let us consider the exposures at $t = 0$. Suppose that the CPI accurately reflects inflation in the cost of living, that gold is a suitable proxy for the cost of education[17], shares in healthcare companies are a proxy for legal and healthcare inflation, oil ETFs are a proxy for travel inflation, 30 year government bonds pay the CPI in both the US and UK, and the real estate markets in NY, London, and Amalfi behave the same. These are ridiculous and inaccurate assumptions, but Table 2 illustrates a possible choice of h_A for illustrative purposes.

6. TAXES

There is a very important and unfortunate asymmetry in the tax treatment of investments. While realized returns are acknowledged by the tax system, effective inflationary losses are not. Suppose one has a portfolio evenly divided between two stocks, one of which experiences a 5% loss and the

[14] i.e. that of the inflationary portfolio.

[15] Nor need the two portfolios keep pace on a year to year basis. For example if the real estate market turns out to be cyclical, then by the time it is necessary to purchase a home prices may have returned to their initial level.

[16] Aside from issues concerning one's ability to secure a loan.

[17] That is, they are highly correlated with scale factor 1.

TABLE 2. Sample Hedge Portfolio

Security	h_A ($K)	Hedges Against
US Residential REIT	1437	London and Amalfi Real Estate
Gold ETF	155	Education
Euro-denominated Oil ETF	400	Travel and Amalfi Home Currency
Sterling-denominated UK Bonds	480	Living and London Home Currency
Sterling-denominated Healthcare ETF	519	Healthcare and Medical/Legal Protection and London Home Currency
US Healthcare ETF	64	Healthcare
Euro-denominated Healthcare ETF	37	Healthcare and Amalfi Home Currency

other a 5% gain over the course of a year. If both are realized, then there is no net tax consequence. This means that one security can be used to hedge the other[18]. With an inflationary portfolio, this is not the case. Let us suppose that we have an inflation hedge using an index. We expect inflation to be positive on average, resulting in a net gain for our hedge. We are not protecting ourselves from volatility or a tail event or an improbable error in outlook. Rather, we do the opposite and expose ourselves to all of these in order to hedge against a necessarily short position in an inflationary portfolio with a large α. If the inflationary portfolio rises by 5% then our hedge (if it works) yields a 5% return. If we started with \$1K, the resulting \$1.05K has the same purchasing power[19] as the original \$1K did a year earlier. We have gained nothing. However, the tax system wouldn't see it that way. If the gain is realized, then taxes would be due. Suppose that one would realize short term annual gains and pay an associated 33% tax. Then the return needed to hedge[20] is 7.46%. In order to realize such a return[21], it is likely that substantial portfolio risk would have to be incurred. Moreover, even a perfect hedge would remain asymmetric. If there were 5% inflation one year, our hedge would make 7.46% pre-tax and 5% post-tax. We would break even (in purchasing power) as intended. On the other hand, if the inflation were -5% our hedge would lose 7.46%. In the absence of any additional real income against which we could deduct the loss, we would not break even[22].

7. CONCLUSIONS

A couple of conclusions may be drawn from our discussion. First, it is impossible to meaningfully hedge against inflation early in a savings regimen. One may at best protect against one's guess at the worst form of inflation or hedge the most important items in the inflationary portfolio.

With fully-vested savings, the goal is wealth preservation rather than accumulation. In this case, it may be possible to construct suitable proxies. These may require a degree of creativity, but would better serve to preserve wealth for its intended future use than would a simple hedge against generic inflation. However, such a hedge may be considerably more difficult when one allows for tax consequences.

Regardless of whether one wishes to hedge as best they can or simply measure the real inflationary depreciation of their assets, the use of a customized inflationary portfolio is critical. A particular

[18]Depending on the situation, there could be some tax damage due to dividends or transactions within a fund. But in theory a proper hedge is possible.

[19]Of course, we may be much worse off because of the leverage issue discussed earlier.

[20]Of course, if the hedge can be accomplished in a tax free manner this isn't an issue. A typical tax-deferred solution would provide some benefit and require only a 6.42% return over 20 years.

[21]This is true even in the absence of the tax issue.

[22]The tax system treats inflation symmetrically, ignoring it whether positive or negative. The asymmetry arises because, in the absence of other offsetting income, we always pay taxes on realized gains but may not recover them on realized losses. This always is a problem, but ordinarily both the investment and hedge are "real". In that case, symmetry is restored because a gain on one side offsets a loss on the other (in theory) and there is no net tax consequence.

individual is likely to experience far different inflation than that represented by any generic index. Only by suitably analyzing this personalized rate of inflation can appropriate planning and investment decisions be made.

APPENDIX A. DETAILED EXAMPLE

An example of a full term portfolio evolution could be illustrative. Let us return to the couple introduced in Section 3. We will use historical data for 1990-2010, so let's begin with that period. We assume that our couple lays its plans in 1990 with the intention of retiring in 2010. All prices used in their planning were appropriate for 1990. We employ a fictitious evolution of prices from 2010-2030. This should not be misconstrued. We do not attempt to predict the future; if we could do that we would not need to hedge against uncertainty. Rather, historical values are used to lend a degree of realism to the possible evolution of a sample inflationary portfolio. The following are our sources:

- Price of Education: We use historical costs[23] at Harvard College as published by that university [1]. We had to make a choice of which school year to associate with a given calendar year, and decided to use the spring semester. For example, we associate the costs from the $1989/1990$ school year with 1990.
- US-Euro Exchange Rate: This was obtained from two sources, one containing Lira-US data prior to the Euro conversion in 1999 and the other containing US-Euro data afterward. In either case, each year's value is the average exchange rate over the previous 12 months[24]. From 1999 onward, we use USD-Euro rates as published by the St. Louis Fed [2]. Prior to 1999 we use Lira-USD rates, also published by the St. Louis Fed [4]. For simplicity, we convert all pre-1999 Lira values to pseudo-Euros using the fixed transition factor (from 1/1/1999) of 1936.27 Lira/Euro [5]. Although this isn't meaningful in any general sense (the Euro is a basket of currencies), it is perfectly reasonable as a comparison mechanism if we solely concern ourselves with Lira-denominated instruments.
- Amalfi Real Estate Prices: Although coastal real estate probably appreciated more rapidly than inland real estate, we could not locate suitable regional historic Italian housing data. Therefore we rely on average prices across the whole of Italy, as reported by the European Central Bank [6].
- US-Sterling Exchange Rate: We use historical data from the St. Louis Fed [3]. Like the Euro and Lira data, it is listed annually as an average over the prior 12 months.
- London Real Estate: We use a regional index for Greater London, published by Lloyds [7].
- Health Insurance Premiums: We use two sources. For 2000-2011 we obtained figures from a publication of the American Hospital Association [8], while for 1990-2000 we use a report from the Kaiser foundation [9]. However, the latter included only a few data points and we extrapolated the rest[25]. Both reports were based on employer health insurance premiums rather than individual (or employee shares), but because we work with percentage changes it is not unreasonable to assume these all move in tandem. For convenience, we choose a base healthcare index value of 1.0 in 1990.
- Emergency Costs: We assume that emergency legal and medical costs move in tandem with health insurance premiums.
- Travel and Living Expenses: These are taken to rise with the CPI, for which we use the US annual average as reported by the US Department of Labor, Bureau of Labor statistics, and published by the St. Louis Fed [10].

[23]The university lists both the tuition and total cost of attendance. We use the latter as a more realistic estimate of the price of education.

[24]For example, the value listed for 2008 is the average from 1/1/2007 - 12/31/2007.

[25]There is no reason to believe this to be correct, but it is a good enough guess for our purposes.

Table 3 lists the source data. Those entries preceded by * were computed from the Lira/USD rate.

TABLE 3. Sample Inflation Portfolio: Source Data

Year	Lira/USD	USD/EUR	USD/GBP	London Real Estate Index	Italian Real Estate Index	Harvard Tuition	Harvard Total	Healthcare Premium Index	CPI
1990	1371	*1.4120	1.7841	236.6	40.1	13085	19395	1.00	130.7
1991	1198	*1.6162	1.7674	222.9	46.4	13960	20655	1.16	136.2
1992	1240	*1.5620	1.7663	202.0	53.3	14860	22080	1.31	140.3
1993	1233	*1.5701	1.5016	192.0	55.9	15870	23514	1.45	144.5
1994	1572	*1.2318	1.5319	195.5	55.2	16856	24880	1.58	148.2
1995	1612	*1.2013	1.5785	194.9	55.6	17851	26230	1.67	152.4
1996	1629	*1.1887	1.5607	212.4	57.8	18838	27575	1.72	156.9
1997	1543	*1.2552	1.6376	246.3	59.7	19770	28896	1.74	160.5
1998	1703	*1.1370	1.6573	272.3	59.7	20600	30080	1.78	163.0
1999	1736	1.0653	1.6172	317.9	60.4	21342	31132	1.84	166.6
2000	1818	0.9232	1.5156	373.6	62.7	22054	32164	1.93	172.2
2001		0.8952	1.4396	428.3	66.4	22694	33110	2.15	177.1
2002		0.9454	1.5025	499.4	74.2	23457	34269	2.36	179.9
2003		1.1321	1.6347	563.3	78.8	24630	35950	2.67	184.0
2004		1.2438	1.8330	608.5	83.6	26066	37928	3.03	188.9
2005		1.2449	1.8204	621.4	90.0	27448	39880	3.32	195.3
2006		1.2563	1.8434	680.9	95.3	28752	41675	3.63	201.6
2007		1.3711	2.0020	777.6	100.0	30275	43655	3.83	207.3
2008		1.4726	1.8545	705.3	102.6	31456	45620	4.04	215.3
2009		1.3935	1.5661	622.0	102.2	32557	47215	4.23	214.5
2010		1.3261	1.5452	659.9	102.3	33696	48868	4.46	218.1

As in Section 3, the couple first initiates its savings plan in 1990 at the age of 40. The children are 8 and 10 at that point. Between 1990 and 2010, the family experiences the 20 years of economic change described in Table 3. We assume that the London and Amalfi homes are purchased on retirement (in 2010), the college expenses arise during the period 1998-2001 for one child and 2000-2003 for the other, and most other relevant costs are incurred annually during 20 years of retirement from 2010-2030. For want of actual data, we create a fictitious scenario for those years. The costs of living and travel grow at the geometric mean of the CPI rate of increase between 1990-2010, computed to be 2.6%. Healthcare premiums and legal/medical expenses rise at the geometric mean of the corresponding rate between 1990-2010, computed to be 7.5%.

For convenience, we assume that monies may be invested risk-free and tax-free at 3% annually. Of course, the actual returns on any investment are unknown in 1990 when the plan is formulated (or, going forward, in 2010 when the anticipated savings are "finalized"). Hedging against the inflationary portfolio from 1990-2010 can help protect savings during that period, while subsequent hedging can ensure a suitable stream of income in retirement.

Note that in 1990, the initial plan speaks only of 1990 dollars. The couple wants a villa, priced in 1990 dollars, and so on. All that differs between the savings targets is their anticipated date of realization. Table 4 lists the set of expenses being saved for and their anticipated dates of realization – all in 1990 dollars.

To properly illustrate the role of legal/medical protection, we assume this is incurred as an expense in the very last year of retirement. This expense is a special one, and we consider scenarios with and without it. On the one hand, maintaining a suitable reserve that rises with actual costs each year is important. Presumably, if the need did not arise these would pass to the couple's children as inheritance. For this reason, we incorporate them as an expense only at the very end. On the other hand, maintaining such a reserve indefinitely is onerous, impractical, and uncommon. Other protection mechanisms such as medicare often exist – and any continuation of the historic rapid rise in medical costs would result in a protection fund that constitutes the vast majority of an inflationary portfolio. This indeed is the case as seen in Table 5. More likely, a reserve would be held up to a point and then allowed to dwindle.

TABLE 4. Sample Inflation Portfolio: Expenses in 1990 Dollars

Year	Education	Amalfi Villa	London Flat	Living Expenses	Travel	Healthcare Premiums	Medical/Legal Protection
1990	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0
1997	0	0	0	0	0	0	0
1998	19395	0	0	0	0	0	0
1999	19395	0	0	0	0	0	0
2000	38790	0	0	0	0	0	0
2001	38790	0	0	0	0	0	0
2002	19395	0	0	0	0	0	0
2003	19395	0	0	0	0	0	0
2004	0	0	0	0	0	0	0
2005	0	0	0	0	0	0	0
2006	0	0	0	0	0	0	0
2007	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0
2010	0	437537	999096	24000	20000	6000	0
2011	0	0	0	24000	20000	6000	0
2012	0	0	0	24000	20000	6000	0
2013	0	0	0	24000	20000	6000	0
2014	0	0	0	24000	20000	6000	0
2015	0	0	0	24000	20000	6000	0
2016	0	0	0	24000	20000	6000	0
2017	0	0	0	24000	20000	6000	0
2018	0	0	0	24000	20000	6000	0
2019	0	0	0	24000	20000	6000	0
2020	0	0	0	24000	20000	6000	0
2021	0	0	0	24000	20000	6000	0
2022	0	0	0	24000	20000	6000	0
2023	0	0	0	24000	20000	6000	0
2024	0	0	0	24000	20000	6000	0
2025	0	0	0	24000	20000	6000	0
2026	0	0	0	24000	20000	6000	0
2027	0	0	0	24000	20000	6000	0
2028	0	0	0	24000	20000	6000	0
2029	0	0	0	24000	20000	6000	500000

Year	BreakEven Added SOY	BreakEven Balance SOY	BreakEven Balance SOY no Medical/Legal	60K Added SOY	60K Balance SOY	60K Balance SOY no Medical/Legal	Education	Amalfi Villa	London Flat	Living Expenses	Travel	Healthcare Premiums	Medical/Legal Protection	Total
1990	169791	169791	169791	60000	60000	60000	0	0	0	0	0	0	0	0
1991	176936	351821	351821	62525	124325	124325	0	0	0	0	0	0	0	0
1992	182263	544639	544639	64407	192462	192462	0	0	0	0	0	0	0	0
1993	187719	748696	748696	66335	264571	264571	0	0	0	0	0	0	0	0
1994	192525	963683	963683	68034	340541	340541	0	0	0	0	0	0	0	0
1995	197982	1190575	1190575	69962	420719	420719	0	0	0	0	0	0	0	0
1996	203828	1430120	1430120	72028	505369	505369	0	0	0	0	0	0	0	0
1997	208504	1681527	1681527	73680	594210	594210	0	0	0	0	0	0	0	0
1998	211752	1913645	1913645	74828	656784	656784	30080	0	0	0	0	0	0	30080
1999	216429	2156351	2156351	76480	721836	721836	31132	0	0	0	0	0	0	31132
2000	223704	2380417	2380417	79051	758214	758214	64328	0	0	0	0	0	0	64328
2001	230069	2615679	2615679	81301	796041	796041	66220	0	0	0	0	0	0	66220
2002	233707	2893587	2893587	82586	868240	868240	34269	0	0	0	0	0	0	34269
2003	239033	3183478	3183478	84468	942805	942805	35950	0	0	0	0	0	0	35950
2004	245398	3524380	3524380	86718	1057807	1057807	0	0	0	0	0	0	0	0
2005	253713	3883824	3883824	89656	1179197	1179197	0	0	0	0	0	0	0	0
2006	261897	4262236	4262236	92548	1307121	1307121	0	0	0	0	0	0	0	0
2007	269302	4659405	4659405	95164	1441499	1441499	0	0	0	0	0	0	0	0
2008	279694	5078882	5078882	98837	1583581	1583581	0	0	0	0	0	0	0	0
2009	278655	5509903	5509903	98470	1729558	1729558	0	0	0	0	0	0	0	0
2010	0	2112293	2112293	0	-1781462	-1781462	0	1049262	2413438	40049	33374	26784	0	3562907
2011	0	2072747	2072747	0	-1937821	-1937821	0	0	0	41088	34240	27588	0	102915
2012	0	2027982	2027982	0	-2102903	-2102903	0	0	0	42153	35128	29667	0	106947
2013	0	1977635	1977635	0	-2277177	-2277177	0	0	0	43246	36039	31902	0	111187
2014	0	1921317	1921317	0	-2461140	-2461140	0	0	0	44368	36973	34306	0	115647
2015	0	1858615	1858615	0	-2655315	-2655315	0	0	0	45518	37932	36891	0	120341
2016	0	1789088	1789088	0	-2860260	-2860260	0	0	0	46699	38916	39671	0	125285
2017	0	1712266	1712266	0	-3076562	-3076562	0	0	0	47910	39925	42660	0	130495
2018	0	1627647	1627647	0	-3304846	-3304846	0	0	0	49152	40960	45875	0	135987
2019	0	1534695	1534695	0	-3545773	-3545773	0	0	0	50427	42022	49332	0	141781
2020	0	1432840	1432840	0	-3800041	-3800041	0	0	0	51735	43112	53049	0	147896
2021	0	1321473	1321473	0	-4068395	-4068395	0	0	0	53076	44230	57046	0	154353
2022	0	1199943	1199943	0	-4351622	-4351622	0	0	0	54453	45377	61345	0	161175
2023	0	1067555	1067555	0	-4650556	-4650556	0	0	0	55865	46554	65967	0	168386
2024	0	923569	923569	0	-4966086	-4966086	0	0	0	57314	47761	70938	0	176013
2025	0	767193	767193	0	-5299152	-5299152	0	0	0	58800	49000	76283	0	184083
2026	0	597582	597582	0	-5650753	-5650753	0	0	0	60325	50271	82031	0	192627
2027	0	413833	413833	0	-6021951	-6021951	0	0	0	61889	51574	88213	0	201676
2028	0	214983	214983	0	-6413876	-6413876	0	0	0	63494	52912	94860	0	211266
2029	0	-8500633	0	0	-15328357	-6827724	0	0	0	65141	54284	102008	8500633	8722065

TABLE 5. Sample Inflation Portfolio: Savings Balance and Expense Outlays (as incurred)

Table 5 illustrates the incurred costs (outlays in dollars at the relevant point in time) along with two sample savings portfolios. Both of the latter accrue interest at the same assumed after-tax risk-free rate of 3%. Both use a fixed contribution in 1990 dollars (which grows with the CPI)[26] for the first twenty years. We arbitrarily assign the deposit of new savings and the withdrawal of expenses to the start of the year, and interest accrual to the end of the year. The "break-even" scenario involves a (1990 dollar) contribution of $169,791 – which guarantees that the couple never experiences a negative balance (when excluding the medical/legal protection). The "60K contribution scenario" assumes a (1990 dollar) contribution of $60,000. In both scenarios we list the portfolio balances with and without the medical/legal protection expense. Of course, the couple would have no way of knowing ahead of time that $169,791 is the break-even savings level.

There are three different dollar amounts that are useful to consider:

- In 1990 dollars, the simple sum of our anticipated expenses is $3,091,793. This is the cost in 1990 if all those expenses were incurred immediately. It also represents the value if there is precisely a 0% rate of inflation in all categories (or averaged across our particular inflationary portfolio). The corresponding quantity without medical/legal protection is $2,591,793.
- The present value in 1990 of all anticipated expenses is $6,018,152. This represents the amount that must be placed in a bank account in 1990 and earn the assumed 3% risk-free after-tax return in order to exactly cover all future expenses (taking into account their timing). The corresponding quantity without medical/legal protection is $3,334,047.
- The as-realized sum of all anticipated expenses is $15,235,010. This is a somewhat meaningless number that represents the sum of all dollars that must be spent at the time the costs are incurred. It is meaningless because we cannot add dollar values at different points in time while in the presence of inflation. The total outlay is independent of any hedge, savings, or assumptions regarding risk-free rates. The corresponding quantity without medical/legal protection is $6,734,377.

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