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THE FINANCIAL STRUCTURE OF PENSIONS PLANS

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LA STRUCTURE FINANCIERE DES REGIMES DE RETRAITE
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RÉSUMÉ

Dans cette contribution, l'auteur discute de la structure financière des régimes de retraite en examinant les types d'actifs utilisés pour leur financement. L'auteur puise dans son expérience des prestations de retraite et des placements disponibles au Canada, aux États-Unis et en Grande-Bretagne.

La contribution se fonde sur le concept de l'"appareillement" en ce qui concerne les régimes de retraite. L'auteur mentionne les difficultés de cette approche, étant donné la nature des régimes de retraite et discute des contributions précédentes. Les points forts et faibles de ces approches sont analysés, sur la base des critères discutés.

Finalement, l'auteur offre quelques solutions à ces problèmes et indique le chemin à suivre en ce qui concerne la recherche dans ce domaine plein de défis.
1. INTRODUCTION

Pension plan assets represent a significant proportion of the savings in many countries. For example, in Canada invested pension plan assets currently amount to about $150 billion, and about $250 billion if we add in pension plans for government employees which are funded through non-negotiable government securities. Clearly, investing such large amounts of money in the most appropriate manner should be a priority. However, the evidence seems to be to the contrary - investment objectives are often set to maximize return on the portfolio with scant regard for the liability structure of the plan, or its immunized positions. If mentioned at all, recognition of the liability structure is often referred to as a "constraint", rather than being recognized as the fundamental building blocks with which the investment strategy should be constructed.

What has brought about this state of affairs and what can be done about it? Hopefully, this paper will add to a growing list of literature (much of it, sad to say, not produced by actuaries) that attempts to remedy this situation.

2. ADVANTAGES TO KNOWING THE APPROPRIATE FINANCIAL STRUCTURE

Since the future is uncertain and we are not able to select beforehand what would turn out to be the best performing assets, we need to be able to find assets that:

- maximize overall return to the pension plan, given the level of risk accepted,
- can be used as a benchmark against which to measure performance,
- are a "safe haven" during uncertain times.

As we go through some of the steps necessary to find the appropriate asset allocation, we will understand why such a seemingly simple and obvious approach is not taken and why for example objectives are framed in terms of maximizing the rate of return on the pension fund, a worse still, simply doing better than everyone else, whether not their pension plan bears any resemblance to one's own.

However, before launching off on this voyage of discovery, it may be as well to discuss briefly the nature of pension plans and the type of assets available to plan investment managers.

3. TYPES OF PENSION PLAN

In Canada, the U.S., the U.K. and many other Western nations the most common type of pension plan will have the following characteristics:

defined benefits - benefits are defined in terms of years of service and salary,

final average - salary to be used to calculate the benefit will be salary at or near retirement, often averaged over a 3 to 5 year period,
indexation - public sector plans are often fully or partially indexed to the cost of living, whereas private sector plans typically are not.

Other types of plans found include:

- defined contribution plans under this type of plan benefits are expressed in terms of the annuity that can be purchased by an accumulation of a predetermined contribution (e.g., 5% of salary from employer and employee). While this type of plan presents some interesting challenges in regard to individual investment strategy, it need concern us no further, since the question of matching assets and liabilities does not arise.

- career average plans under this type of plan benefits are defined in terms of the salary at the date the benefit was earned, i.e., the accrued benefit is not automatically updated for salary increases. However, most plans of this type tend to update benefits to current salary levels from time to time on an ad hoc basis.

- flat benefit plans, benefits are defined as a fixed number of dollars per year of service. These plans are most often found in unionized occupations and are very frequently collectively bargained, again to reflect current day salary levels.

One final point is that while most plans outside the public sector rarely include a contractual indexation provision, it is the practice of most large employers, at least in Canada and the U.K. to grant ad hoc increases to pensioners on account of increases in the cost of living. This would also be the case of public sector plans that are not contractually indexed

The conclusions to be drawn from this discussion are:

- to a large extent benefits are expressed in real terms rather than nominal terms, contractually both pre and post retirement for most public sector plans and up to retirement for most private sector plans,

- there is often a great deal of uncertainty about the realistic, as opposed to the legal, liability structure of pension plans, in view of the tendency to update benefits on an ad hoc basis, where they are not contractually linked to salary or price levels,

- there are a number of different "products" offered, that is immediate pension benefits of more or less fixed amount, either in nominal or real terms; deferred pension benefits generally indexed to wages up to retirement; various other benefits, including vested deferred pensions, survivor's benefits and possibly death and disability benefits in some plans.

It can therefore be seen that the financial structure of a typical pension plan is more difficult to analyse than a life insurance company, or other financial institution. We shall come back to these points later.

4. THE CONCEPT OF IMMUNIZATION

In a pension plan context this term has often been misused to indicate a dedicated portfolio used to match level retirement benefits. In view of the indexed or quasi-
indexed nature of retirement benefits this is not only a misuse of the term, it is a misuse of the concept itself.

Another use of the term "immunization" has been to designate an investment technique designed to achieve a minimum target return over a relatively short horizon (e.g., 5 years). This, too, is a trivial use of the term, since the investment horizon is arbitrarily chosen and has no relationship to the mean term of the liabilities.

However, no discussion of the financial structure of a pension plan, or any other entity with actuarial liabilities for that matter, can take place without starting out with the concept of immunization as introduced by Redington (7). By considering the asset structure that would ensure that a small change in interest rate created neither a deficit nor surplus he concluded that the necessary condition was one where the mean duration of the assets was equal to the mean duration of the liabilities. Fellows (4), by noting the largely indexed or quasi-indexed nature of pension liabilities, concluded that the duration of the liabilities was dead short and therefore Treasury Bills was an appropriate immunizing portfolio. Ilkiw (4), following a somewhat different route came to the same conclusion more recently.

Is this indeed the case, or can we derive another type of portfolio with similar characteristics, but with a higher prospective yield? Given the uncertainties associated with the liability structure of most pension plans it is unlikely that we will be able to come up with a mathematically precise formulation, but it does seem likely that we will be able to improve on the Treasury Bill solution.

Indeed, there is some doubt as to whether an all Treasury Bill (or equivalent short term investment vehicle), portfolio, even for a fully indexed plan, is the most appropriate portfolio, as we shall see.

Instead of using the derivative result of Redington's paper, that is the fact that the mean duration of the assets should equal that of the liabilities, since both can be so uncertain (even on the asset side, if we are considering equities as well as fixed interest securities), we should go back to the underlying premises of immunization. Thus we should seek an asset portfolio that over the long run would be expected to:

- maximize surplus,
- minimize the volatility of surplus.

In addition, we should broaden the independent variable from merely being a change in interest rates to include changes in economic conditions in general, including such variables as inflation and changes in labour income in the economy. Evidently, introducing these additional elements makes it less and less likely that a satisfactory mathematical solution can be found, but does increase the probability of coming up with practical guides pointing towards the appropriate result.

5. ASSET CLASSES

Traditionally, immunization has been discussed in terms of one asset class, namely, fixed interest investments. This has been for two reasons: firstly, liabilities to be immunized
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have generally been of a fixed dollar nature, for which investment in fixed interest securities is appropriate; secondly, asset cash flows are much more certain for this asset class than for any other. In the case of pension plans this selection must be broadened for a number of reasons, not least of which is the fact that pension funds currently invest in a broad spectrum of securities, and a theory which confined itself to fixed interest investments would have very limited practical applications. Another important aspect is "matching by type", as mentioned by Fellows, for instance. It is therefore worthwhile reviewing briefly the types of investments available and their suitability for matching pension plan liabilities in the light of the characteristics of the typical plan discussed above:

Indexed securities

- Given the strong linkage of benefits to the cost of living that we have perceived, these securities would seem to be ideally suited as pension plan assets. Apart from severe lack of availability in some countries they do have some disadvantages:

  - they are not as closely linked to pre-retirement liabilities as compared to post-retirement liabilities;

  - looked at purely from an investment point of view, there may be superior long term investments;

  - they lack equity participation and therefore do not reflect the performance of the economy.

Treasury Bills

- These short-term instruments respond very quickly to changes in interest and inflation rates, and again would be considered good matching assets. They suffer from low long term rates of return.

Long term bonds

- While offering a superior yield to Treasury Bill and other short-term money market instruments, they lock in a particular interest rate and their yields are less sensitive to changes in inflation rates. In fact, sudden changes in inflation which give rise to sympathetic interest rate changes drive short-term bond yields in the wrong direction.

Equities

- Equities are volatile as to both yield and market value. However, historically, they have performed in a superior manner to other asset classes over the long-term and are considered to reflect, at least in the mid to long-term, the performance of the economy. Thus they are considered to be the most closely matched asset by nature to pension plan liabilities. One observation that seldom appears in this type of discussion is that this is a very heterogeneous asset class. It encompasses shares of a very stable nature, such as utilities and financial institutions, shares of a cyclical nature, such as primary resources, speculative shares, such as venture capital, as well as equity investment that have different risk/reward/liquidity characteristics, such as real estate, options, etc.
6. PREVIOUS APPROACHES

Both actuaries and non-actuaries have offered solutions to the problem of matching assets to liabilities in pension plans, and have arrived at different conclusions from Fellows and Ilkiw. Leibowitz (6), for example, uses the "duration" of assets and liabilities to suggest a risk free stance which preserves the amount of surplus irrespective of changes in the interest rate. In his article, he spends much time deriving a "duration" for stocks, a covariance function for the relative movement of stock and bond yields and hence a "total portfolio duration". Unfortunately, the article suffers from a number of inherent flaws. Firstly, Leibowitz uses a "termination" method to determine liability cash flows. He recognizes that the liability framework of a pension plan is complex and chooses this particular liability value since it is "clear-cut". It seems strange to turn one's back on economic reality, that is the going-concern actuarial liability. For the sake of convenience, clearly, to postulate an inappropriate liability target invalidates the whole method, no matter how well articulated the arguments on the assets side are. Ambachtsheer (1) has raised similar objections. A further criticism is lack of resolution of the asset mix problem, although it is mentioned as a portfolio optimization problem in the concluding paragraph of the article.

Wise, in a number of papers (8, 9, 10), has constructed a set of complex mathematical equations which give rise to an efficient frontier type of analysis, but using the liability structure as a benchmark. While the model employs stochastic methods, it does require a close estimate of future liability cash flows. As Wise admits "analytical methods are not able to deal with more realistic stochastic models ..." and suggests that simulation methods are likely to yield more promising results.

A similar "efficient frontier" approach is taken by Arnott and Bernstein (2) in an article for the Harvard Business Review. They modify the conventional risk/reward graph, where risk is defined as the variability over time, to produce a similar graph, but defining risk in terms of the total variability of the asset/liability combination. This causes the various asset classes to shift significantly and interestingly enough Treasury Bills, according to Arnott and Bernstein, change from a low return/low risk asset class to a low return/high risk class. They do however admit that Treasury Bills are a good fit for inflation related liabilities.

Finally Ambachtsheer (1) and Carleton (3) have taken a scenario prediction approach to determining the most likely effect various future economic scenarios would have on each asset class, combined with the effect on the liability side, in order to select a portfolio with the highest prospective yield, given various levels of risk tolerance. This would be considered to be a more practical approach to the simulation techniques suggested by Wise.

7. ANALYSIS

A number of principles are suggested by the review:

- different portions of the liability should be treated separately,
- to the extent possible the solution should not be dependent on future scenarios,
the solution should recognize the economic reality, not just the legal liability, however defined.
- the immunizing asset portfolio should consist of available assets, or those most efficiently traded,
- the solution should encompass variations in economic conditions in general, rather than being confined to simply a change in interest rates, again however defined (e.g. real, nominal).

This is quite a tall order, and indeed it may not be possible to satisfy all criteria at the same time. This may account for the apparently inexplicable behaviour noted at the beginning of this paper, that is, faced with this demanding set of conditions those responsible for investing pension funds have despaired of discovering an appropriate immunized portfolio. Instead, the objective has simply been to maximize returns on assets, either in terms of an absolute objective or even in terms of relative performance, since even setting realistic absolute return objectives has proved daunting. For example, investment literature has identified the actuary's valuation interest rate as the "minimum target" - surely a case of the tail wagging the dog. However, it is clear that a scientific approach, however imperfect, will lead to superior results rather than one that ignores the basic facts of the situation.

The next two sections will suggest approaches for the two main classes of liabilities, namely pensioners' liabilities and active life liabilities (other minor classes of liabilities such as deferred vesteds, death benefits, etc can be found by analogy; in any case they generally account for a very small percentage of total liabilities).

8. PENSIONERS' LIABILITIES

Depending on the pension plan, pensioners' benefits range from fixed dollar benefits, analogous to life annuities in a life insurance company, to fully cost-of-living indexed benefits. For most plans, reality lies somewhere in between. In the private sector benefits are generally increased on an ad hoc basis aiming at some percentage of the consumer price index. In some plans, contractual indexing is limited to a maximum amount. In some cases the cap is in excess of historically experienced rates of inflation, in which case the benefit can be considered to be effectively fully indexed. In other cases the cap is well below the experienced level of inflation - in which case, additional ad hoc increases are often granted.

For truly level annuities the immunizing portfolio is clearly one of long bonds with a mean duration equal to that of the pension. Much has been written about this case and no further description is needed here. However, it is questionable whether a large number of such cases, especially among large sized plans, can be found.

At the other end of the spectrum are fully indexed benefits. If a ready supply of indexed bonds are available, and efficiently traded, an immunizing portfolio of appropriate duration can be found. However, in some countries either indexed bonds are not available in sufficient quantities, or if available are traded in a narrow market and are not truly competitive with non-indexed instruments. In this case, Treasury Bills or other
short-term investments would appear to move most closely in sympathy with changes in liabilities due to changes in the real rate of return. However, in view of the fact that the rate of return of Treasury Bills is not solely a function of the long term real rate of return and observed inflation rates (for example, the yield is heavily influenced by government monetary policy and in fact the observed "real rate of return" may fluctuate widely) a portfolio of short-term government bonds, mortgages and Treasury Bills is likely to be a suitable portfolio giving a significantly higher rate of return. An efficient portfolio, based on observed past behaviour of bonds under various situations, could be constructed by simulation techniques, designed to minimize fluctuation in surplus for this group.

The intermediate case of pensions subject to various levels of ad hoc adjustments is clearly the most difficult, since the actual benefits to be granted in the future are to a large extent unknown, either as a function of current pensions or current pensions and the price index. In some cases a target level of indexation is known, or benefits are linked to some other index (e.g. rate of return of a specified portfolio). Again simulation of the effect of interest rate and inflation rate charges on assets and liabilities will indicate the most appropriate asset mix.

9. ACTIVE LIFE LIABILITIES

In many ways, the same can be said about active life liabilities as has been said about pensioners' liabilities. There are some differences, however. Firstly formal indexation, by way of final earnings pension plans, is almost universal in pension plans in the public and para-public sector and very widespread in private sector plans. Therefore, benefits as a function of future salary levels are less subject to doubt, as compared to pensions in relation to future levels of inflation. However, the problem of updating on a non-contractual basis still exists, since the majority of flat-benefit and career average plans, many of which are subject to some form of collective bargaining, are generally updated to reflect current salary levels, and so the "economic reality" is different from the legal liability.

The other difference is that the mean duration of the liabilities exceeds that of any reasonable matching asset. In addition, even in countries where indexed bonds of long duration are available, they may not be the best immunizing asset, as productivity increases and merit and promotion raises are a significant and variable element of the salary increase, not just increases in price levels.

Again, we have to resort to simulation techniques to find the most appropriate asset mix that will meet the criteria outlined previously.

It is evident that "matching by nature" becomes an important element in these deliberations. Since equities tend to reflect the performance of the economy, as do wage rates over the long run, they will form a significant proportion of the immunizing portfolio. However, since the match will be far from perfect, it is likely that a significant fixed interest component will also be present to reduce volatility, thereby producing the portfolio with the lowest degree of variance of surplus.
10. OTHER CONSIDERATIONS

As mentioned earlier, a simplified approach to the above has been suggested by a number of authors. Under this approach, which we might dub "scenario testing", a number of scenarios are examined, for example "boom-bust", "steady-growth", "stagflation", "recession", etc and the effect that each is likely to have on each component of the liability structure and each asset class is computed. Percentage probabilities are assigned to each scenario and an appropriate asset mix that minimizes variability of surplus is chosen. This is a fairly simple and practical approach. Naturally, it does not meet the requirement of being independent of future scenarios. There may, however, be little alternative, since an exact match of assets and liabilities is clearly not possible in this case. Furthermore, changes in surplus are more than just a function of change in interest rates, other economic parameters being of significant importance as well.

Another thought concerns the variability within asset class. We are used to thinking about different types of fixed interest securities - principally short and long instruments that have differential responses to changes in the economic environment. However, as noted before, the same can be said of the equity class, certainly if we include real estate and other less liquid equity investments in this class. Even within the marketable security class, different industry groups, for example utilities, financial services, primary products, manufacturing and so on, react quite differently to the changes in the environment, although of course the overall market tends to move in concert. This gives the actuary tools to craft an investment policy for pension plans in particular industries that have characteristics peculiar to that industry.

Finally, many financial derivatives such as options, futures, swaps, etc have become increasingly available in recent years. It is possible to use these instruments to fine tune a portfolio, thereby increasing the degree to which assets and liabilities can be expected to move in step for any given change in the economic environment.

11. CONCLUSIONS

This paper has tried to present a framework for determining the financial structure of typical pension plans, by drawing upon analysis in Canada, the U.K. and the U.S. The technique relies on simulating the behaviour of the liabilities and assets of the plan and choosing the asset mix that maximizes surplus while minimizes its variability. A practical approximation to this approach is the "scenario testing" method. Numerical examples of this technique can be found in the sources cited.

While the financial structure of various components of the pension plan may be difficult to identify, it is not an impossible task. Some are relatively straightforward and immunizing assets can be readily identified. For example, fully indexed pensioners' liabilities can be matched with indexed bonds or, when these are not readily available, a suitable mix of Treasury Bills and short term bonds and mortgages. Similarly fixed annuities (rare as these may be) can be matched by an appropriate portfolio of long bonds.
Other components are more difficult to immunize, either because appropriate assets cannot be identified, because the liabilities themselves are not fully Mined, or both. In this case, simulation or scenario testing techniques can be used to identify the portfolio that most closely immunizes the liabilities. These techniques suffer from the drawback that they are dependent on the future economic environment and on our assessment of such an environment, but there are few real alternatives to this.

It is hoped that the paper has drawn together some of the threads of current research on the financial structure of pension plans and pointed the way to future directions in this research.

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