

CONTRIBUTION N° 01

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 **f a 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 f **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 harbour" 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 **a** 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 **we** 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** or surplus he concluded that **the** necessary condition was one where the mean duration of **the assets** equalled 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**

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 the expected 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 Bemstein** (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 Bemstein**, 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-&-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 changes 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 UK, 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, **and** 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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