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# Falling into a Trap of Your Own Making: Asset Allocation and Portfolio Construction for Pension Funds Experiencing Cash Outflows

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# Introduction

- Due to demographic trends, the lack of expected contributions from plan sponsors, and low expectations of future portfolio returns, many pension funds are now concerned that they will be experiencing cash outflows for many years to come.

- This situation raises grave concerns about "sequencing risk" in terms of how the interaction of negative cash flows and the order of realized returns may impact solvency. This is particularly true for many defined benefit pension plans that are materially underfunded or are otherwise susceptible to failure due to optimistic return expectations.

- Unfortunately, many pension funds have dramatically increased their exposure to illiquid assets (e.g. private equity, commercial real estate) in the hope of increased returns, which poses a material problem for the subject organizations during periods of cash outflows.

# Practical Considerations of the Illiquidity "Game"

- An immediate question for these organizations is whether it is better to incur the high transaction costs of liquidating some part of the illiquid assets so as to maintain portfolio allocations in their desired state, or fund outflows by liquidating liquid assets only.
  - By allowing the portfolio to become more and more illiquid, expected returns may actually rise as most plans assume that illiquid assets produce higher returns than illiquid assets.

- This second course of action minimizes short term costs but forces the portfolio allocation to drift into an increasingly illiquid state over time. If the negative cashflows were to be compounded by a concurrent market decline *it is conceivable that many large pension schemes could exhaust the entire value of the liquid assets, forcing a costly "fire sale" of illiquid assets.*

- The practical problem issue is how to explicitly model the tradeoffs of returns, risk and costs associated with this increasingly common situation to identify sensible courses of action.

# A Broader Theoretical Problem

- A secondary but very important consideration of negative cash flow investing is whether the traditional mechanisms of a mean-variance asset allocation objective function (Markowitz and Levy, 1979) are even relevant.
- The mean-variance objective is a Taylor series representation of a log wealth utility function, where the key feature is the compounding of returns over time.
- This objective may be inappropriate when investment returns are paid out as benefits rather than compounded to generate greater future wealth.
- For example, $1 compounded at 8% annually for 50 years yields a terminal wealth of $46.90. Of that total, $1 is the original investment, $4 is summation of the annual returns, and $41.90 (89% of the total) is from compounding.
  - If the full annual returns (and more) are being immediately distributed, the basic economics of portfolio theory come into question.

# Let's Review DB Pensions in General

- Every defined benefit pension scheme has an explicit guarantee of funding from the sponsoring organization
  - If the plan becomes underfunded by virtue of poor investment results, the sponsoring entity must increase contributions in future years to make shortfalls

- One conceptual way to view this situation is to assume that a pension plan is always fully funded
  - Any underfunding is made up by an implicit asset which is similar to a perpetual call option on a bond from the sponsor. Alternatively, the fund has a put option on the fund surplus. The sponsor is short that put.
  - Under this framework, both the asset allocation and risk profile of a underfunded pension scheme is quite different from the conventional perspective, as a large portion of the fund is now concentrated in a bond-like security of a single issuer.

- Actuarial and accounting standards (e.g. FASB 87, GASB, IFRS) have key differences across countries and between corporate and public sponsor entities

# Ownership and Economic Incentives

- The key question with respect to any defined benefit pension scheme is to whom does the money in the plan belong?
  - The obvious answer is the pensioners but it's not that simple
  - Some organizations (e.g. State of California) treat pension liabilities as general obligations like bonds.
    - In that view the investment portfolio is an unrelated "piggy bank".
- The sponsoring entity is responsible for shortfalls so they have an economic stake in investment performance
  - The better the investment performance the lower the expense of future contributions will be
  - This is good for shareholders, existing employees and tax payers
- The pensioners only concern about investment performance is that it not be so horrible that the sponsor is strained to the point of default on funding obligations
  - Under US law, smaller units of government like towns can declare bankruptcy but states cannot.

# Pension Liabilities in Brief

- Accumulated Benefit Obligation
  - The present value of promised pension benefits assuming the plan was terminated immediately
- Pension Benefit Obligation
  - The present value of promised pension benefits assuming the plan is ongoing and staff continue to receive pay increases until normal retirement
- The promised pensioner payments included in ABO and PBO are discounted to present value
  - In most countries the discount rate is the *assumed rate of return on investment for the plan assets*
- Corporate plans in the US follow FASB 87
  - Specifies that the yield on high quality corporate bonds be used and is subject to periodic reset
  - Multiple discount rates conforming to an observable yield curve are rarely used

# A Simplistic View

- Running a defined benefit pension scheme is just being long a diverse set of assets (equities, diverse fixed interest, property) and being short a portfolio of risk-free fixed interest securities

  *If the plan is supposed to be riskless to the pensioners, why not discount the liabilities at risk free yields?*

  - We assume that the sponsor will continue to exist to act as a guarantor of the benefit payments through additional contributions if needed
  - Discounting at the *expected* return on assets makes volatility of annual contributions smaller which is helpful for corporate operational planning
  - This fine as long as the amount of additional benefit payments potentially required are not too large for the sponsor to handle
- Secondary guarantors may also exist
  - In the UK there are private pension insurers (e.g. Brighton Rock)
  - For US corporate plans there is the PBGC (80% coverage)

# Status of Defined Benefit Plan Funding

- Most corporate plans subject to FASB 87 are in OK shape
  - Oddly, the big risk for these plans is if credit market conditions improve. Government bond yields in many countries are close to all time low values.
  - If credit spreads decline, corporate bond yields will also drop resulting in a decrease in the pension liability discount rate which will increase the present value of the liabilities
- Public entity pension plans are another story
  - In the US, the aggregate underfunding of state and local pension schemes is acknowledged to be up to $4 TRILLION (Pew Foundation Study, 2015)
  - If you put US public funds on the corporate accounting standard, the underfunding has to go up a couple TRILLION more.
  - In 2012, GASB Statements 67 and 68, which tightened up the rules a little.
  - Non US corporate pensions are usually on the IFRS standard which is close to US public plans.

# The Meaning of a "Fully Funded" Plan

- Many people assume that if a plan is in "fully funded" status it will not require unexpected additional contributions from the sponsor
  - For most plans where the liability discount rate is the expected rate of return on assets, there is a 50% chance that the realized investment returns will be less than assumed, so there is a 50% probability that additional funding of some size will be needed
  - For FASB 87 compliant plans, the probability of needing additional sponsor funding is less but can still be substantial depending on the volatility of the asset portfolio, the volatility of bond yields and the duration of the liability payment streams
- For underfunded plans, the dependence on additional contributions from the sponsor is obvious
  - Under FASB 87 the sponsoring firm shows pension scheme underfunding as a liability on the corporate balance sheet
  - FASB 106 does the same for health care costs

# An Alternative View of Pension Funding

- Every defined benefit pension scheme has sufficient asset value at all times such that the probability of not meeting a required payment is nil.

- A significant part of the asset portfolio is a implicit asset which is a portfolio of call options on bonds (i.e. a fixed stream of cash flows) from the sponsoring entity
  - The value of this implicit asset is not only large enough to bring the plan to full funding, but is large enough to bring the plan to a sufficient surplus as to virtually guarantee all obligations
  - Even for a fully funded plan, the notional exposure is real
  - If a plan was really funded to this level of surplus, it would be subject to tax penalties in some countries (e.g. USA)
- From the standpoint of the plan, the implicit asset adds a lot of specific risk since it is a call on bonds from one issuer.
- In some cases, public entities have actually issued bonds and contributed the cash to make up shortfalls, or made contributions of their own bonds.

# A Rough Example - Stylized

- We have a "fully funded" pension scheme
  - 50% in the FTSE All World Index in US$,
  - 50% in FTSE 15+ Maturity UK Gilt Index
  - Expected returns are 9% and 7% respectively
  - Historic volatilities are 15.88% and 11.34% respectively
  - Historic correlation is .18
  - Liabilities are level payments for 25 years
- Portfolio expected return is 8% with a volatility of 10.55%
  - We know the likelihood of realizing 8% is 50%
  - To get a 99% chance of meeting our return target over a 25 year horizon, we have to go all the way down to 3%
- If we discounted our liabilities at 3% instead of 8%, we would be far below full funding.
  - We need to have a 62.27% surplus that is the difference is the value of the implicit call option on additional funding from the sponsor

# Rough Example II

- To reduce the likelihood of needing additional funding from the sponsor to below 1% we need a 62.27% surplus
  - Our portfolio now consists of 50 units of FTSE equity, 50 units of FTSE fixed income (gilts) and 62.27 units of value in the implied call option on a bond from the sponsor
- Our asset allocation has shifted to 30.8% equity, 30.8% conventional fixed income and 38.4% implicit fixed income.
  - Is it prudent to put 38.4% of a large pension scheme into a call option on the bonds of a single issuer?
- Let's consider the same case but with the plan only 70% funded
  - We still need to have a 62% surplus given the volatility of the portfolio and our capital market expectations
  - Our implicit asset now makes up the difference between 70% funding and 162% funding, or *92% which is bigger than the actual funding.*

# How about a more aggressive fund?

- Let's assume we started with a 50% allocation to equities, 30% allocation to fixed income and *a 20% allocation to real estate with the same capital market assumptions as equities.*
  - The expected return for the fund is now up to 8.40%
  - The volatility of the fund is up to 12.19%
  - With the higher expected return, our plan is now about 103% funded
- As both the mean and standard deviation of the return distribution have increased, the tail probabilities don't change very much
  - Over the 25 year horizon, we still need to have a discount rate down around 3% per annum to make the probability of requiring sponsor funding less than 1%
- This suggests that sponsors cannot substantially reduce the economic value of the implicit guarantees by taking a more aggressive investment posture to increase the expected returns

# Lets Add Outflows to Our Example

- We'll keep our existing assumptions for a $125 Billion plan
  - $125 Billion in present value of liabilities discounted at the 8.4% rate.
  - $100 Billion in investment assets, of which 20% is illiquid real estate, so we have $80 Billion in liquid assets
  - The expectation of the geometric mean return is 7.66%
- We expect to have net outflows of $9 Billion at the end of each year for the indefinite future
  - Expectation of the a net outflow of about $1.34 Billion the first year which grows with time, as investable assets decline
  - We fund the outflows by selling liquid assets only
- In a "fire sale" of real estate, the expected transaction cost is 40% for the first two years and 6% thereafter.

# Base Case Outcomes

- If the plan experiences the geometric return rate of 7.66% and $9 Billion a year in outflows.
- The plan runs out of liquid assets in 15 years.
- The plan has zero assets after 24 years
- The total transaction costs to liquidate real estate in the future is about $9 Billion (out of a peak RE value of $66 Billion)
- The present value of the real estate transaction costs is $1.8 Billion

# Now Let's Assume A "Bear" Market

- We will assume only a 2% return for all asset classes the first 10 years of the process.
  - This corresponds roughly to the 95% confidence interval for the expected portfolio return over a 10 year horizon
  - After the first 10 years we assume that returns go back to the base case assumptions, or an expected geometric mean of 7.66%
  - The situation could be worse if there were a single sharp decline rather than a prolonged period of low returns.
- The fund runs out of liquid assets in year 10
- The fund has zero assets in year 13
- Estimated transaction costs are $5.2 Billion out of a peak RE value of $32 Billion. The present value of the transaction costs is $2.1 Billion

# Keeping Asset Allocation Fixed

- What if we sell off a little bit of real estate each year of outflows to keep the asset allocation fixed?
  - Assuming the base case capital market assumptions the fund has zero value by year 25
  - Assuming the "bear market" scenario the fund still has zero assets in year 13
  - At least from this simple stylized example, there doesn't seem to be a strong benefit either way.

- Obviously we could do bootstrap simulations to take into account all possible return sequences. See our June 2013 newsletter, https://www.northinfo.com/documents/554.pdf.

- We could also use a heuristic simplification of game theory such as Markowitz and Van Dijk (FAJ, 2003).

# A Discretionary Wealth Approach

- A sensible approach to this problem is to utilize the Discretionary Wealth Hypothesis (Wilcox, JPM, 2003).
- We have our existing asset mix because we have chosen it from what we believe is the "efficient frontier" (Markowitz, JOF, 1952).
- The particular portfolio we hold is consistent with some tangency slope along that efficient frontier, which exhibits an explicit risk aversion usually defined as $\lambda$
- Wilcox shows that the ideal $\lambda$ is a function of the value of the assets and liabilities of a plan.
  - As the assets (including the value of sponsor guarantees) and liabilities decline through outflows, the portfolio asset mix may move to a more conservative position on the efficient frontier in order to reduce the potential of further low returns and the eventual need to liquidate illiquid assets.
  - In essence we are revising the asset mix from time to time in order to keep the value of the assets above a "floor" value equal to the value of the illiquid assets.

# Another Move in the Right Direction

- The return distribution of many illiquid asset classes can be reasonably replicated with portfolios of liquid instruments.
- This has already been fairly broadly adapted with hedge fund separate accounts (e.g. without lockups).
- Northfield has done extensive research in the replication of various real estate assets including both commercial and residential property.
  - https://www.northinfo.com/documents/735.pdf
  - https://www.northinfo.com/documents/813.pdf
- There is a fairly extensive literature on replicating venture capital and private equity returns with public equities
  - Cochrane (2001)
  - Kinlaw, Kritzman and Mao (2014)

# Economic Stress on the Guarantor

- Many public plan sponsors (e.g. states) may be more reticent to make good on guarantees (e.g. make extra contributions) in periods when they expect poor economic conditions and hence low tax receipts.

- We can easily make our capital market expectations dependent on economic scenarios in order to better position the portfolio to potentially need contributions when the sponsor is best able to provide them.

- In essence we are treating the power to tax the economy as a contingent asset of the plan under the DWH. At least in the US states cannot go bankrupt so there is an implicit Federal guarantee.

- The potential for a sovereign government to default it's obligations is covered in Bodie, Gray and Merton (2007) and Belev and diBartolomeo (2013, 2019).

# Canadian Plan : Base Case from Historical Data

| Null Scenario | | | | | |
|---|---|---|---|---|---|
| | | Mean | StDev | Skew | Kurtosis |
| | S&P TSX Composite | 3.87 | 18.07 | 0.31 | 3.29 |
| | S&P 500 | 6.01 | 14.23 | 0.06 | 2.97 |
| | MSCI EAFE | 7.46 | 17.59 | -0.05 | 3.02 |
| | S&P 600 | 6.68 | 19.08 | 0.23 | 3.1 |
| | MSCI EM | 10.07 | 20.46 | -0.05 | 3.02 |
| | JPM Global Bond Index | -0.21 | 17.27 | 0.17 | 3.7 |
| | BAFI US Govt Inflation Linked | 1.8 | 10.32 | 0.2 | 4.43 |
| | Portfolio | 4.34 | 11.19 | -0.02 | 3.02 |

# An Example: Inflation Moves 2-3% in Two Years

| | | | | | |
|---|---|---|---|---|---|
| Inflation Up | | | | | |
| | | Mean | StDev | Skew | Kurtosis |
| | S&P TSX Composite | 3.2 | 17.8 | 0.27 | 3.26 |
| | S&P 500 | 5.68 | 14.56 | 0.07 | 2.98 |
| | MSCI EAFE | 7.34 | 17.41 | -0.04 | 3.02 |
| | S&P 600 | 6.76 | 19.18 | 0.22 | 3.01 |
| | MSCI EM | 9.86 | 20.53 | 0.06 | 3.06 |
| | JPM Global Bond Index | 0 | 17.59 | 0.34 | 4.23 |
| | BAFI US Govt Inflation Linked | 1.96 | 10.36 | 0.27 | 4.81 |
| | Portfolio | 4.44 | 11.39 | -0.04 | 3.12 |
| Inflation Down | | | | | |
| | | Mean | StDev | Skew | Kurtosis |
| | S&P TSX Composite | -18.68 | 23.02 | 0.21 | 2.72 |
| | S&P 500 | -9.41 | 18.52 | 0.04 | 2.67 |
| | MSCI EAFE | -15.68 | 23.29 | 0.15 | 2.56 |
| | S&P 600 | -11.81 | 22.86 | 0.27 | 2.94 |
| | MSCI EM | -16.94 | 26.51 | 0.24 | 2.56 |
| | JPM Global Bond Index | -7.66 | 16.28 | 0.48 | 4.13 |
| | BAFI US Govt Inflation Linked | -10.28 | 15.9 | -0.05 | 2.56 |
| | Portfolio | -9.82 | 15.69 | -0.04 | 2.72 |
| | | | | | |

# Mixture Distributions

When dealing with capital market assumptions which are conditional on multiple economic scenarios, the resultant distributions will be “mixture distributions” which will result in the presence of skew and kurtosis.

The resulting four moment distribution can then be converted back to the economically equivalent normal distribution using the method of Cornish and Fisher (1937).

$$\mu = \sum_{i=1}^{n} p_i \mu_i$$

$$\sigma^2 = \sum_{i=1}^{n} p_i(\sigma_i^2 + \mu_i^2) - \mu^2$$

$$skew = \frac{1}{\sigma^3} \sum_{i=1}^{n} p_i(\mu_i - \mu)[3\sigma_i^2 + (\mu_i - \mu)^2]$$

$$kurtosis = \frac{1}{\sigma^4} \sum_{i=1}^{n} p_i[3\sigma_i^4 + 6(\mu_i - \mu)^2\sigma_i^2 + (\mu_i - \mu)^4]$$

# Is a Mean-Variance Objective Still OK?

- For decades asset allocations have been based on concept of efficient frontiers from Markowitz (1952) and a mean-variance objective function from Markowitz and Levy (1979).
  - The mean-variance objective is also the basis of Wilcox's DWH
  - The mean-variance objective is just the first two terms of the Taylor series approximation of log-wealth utility, which implies compounding of investment returns.
  - If a plan has negative outflows it isn't compounding returns
- However, it should still be true that plans should want to maximize returns and minimize the likelihood low returns.
  - This kind of objective is commonly describes as maximizing the Sharpe Ratio
  - DeGroot and Plantinga (2001) show the circumstances where mean/variance and Sharpe Ratio methods do or do not align.
  - They align when the investor is highly leveraged, which is the circumstance of underfunded DB pension plan under the DWH

# Conclusions

- Many public and corporate entities around the world have materially underfunded defined benefit pension plans.
  - For US public plans alone the aggregate underfunding is in the range of $5,000,000,000,000. Not a trifling sum.
  - The implicit value of plan sponsor guarantees dominate many plans
- To improve return expectations many plans have increased their commitments to illiquid assets, creating the potential for serious liquidity problems when plans are experiencing net outflows.
- The detailed circumstances of a particular plan may be modeled by simulation or via a game theoretic solution.
  - Plans should be well prepared to revise asset allocations for greater "downside" in order to reduce the potential for "fire sale" liquidations of illiquid assets.