

# RET RPIRM Model Solutions

## Spring 2021

### 1. Learning Objectives:

3. The candidate will understand how to evaluate the stakeholders' financial goals and risk management with respect to their plan.

### Learning Outcomes:

- (3d) Understand and apply the principles of financial economics with respect to pension plan investing.
- (3e) Provide advice and analysis to stakeholders regarding the economic assumptions used in the valuation of their retirement plans.
- (3f) Provide advice and analysis to plan sponsors and other stakeholders regarding the mitigation of pension plan risks.

### Sources:

RPIRM-120-13: The Case Against Stock in Public Pension Plans Pages 60-61

RPIRM 121-13 The Case for Stock in pension funds Page 44-45

Pension Actuary's Guide to Financial Economics pages 6-7, section 4 p. 14-21, p.24

### Commentary on Question:

*Commentary listed underneath question component.*

### Solution:

- (a) Critique the following statement made by the CFO of ABC Company: "The only true representation of the liability of a pension plan is calculated by discounting its cash flows using the risk-free interest rate."

### Commentary on Question:

*Candidates were expected to recognize that plan cashflows should be discounted relative to a cash-flow matching portfolio and also comment on multiple shortfalls of the CFO's proposed approach. Candidates performed reasonably well on this question. The answer below includes more detail than would be needed for full credit.*

## 1. Continued

Pension plan liability cashflows should be discounted with respect to the expected rate of return of the plan's assets in a cash-flow matching portfolio. This portfolio could include a variety of asset classes in addition to risk-free bonds, including corporate bonds, equities, or other asset classes. Risk-free interest rates alone may not capture all of the risk inherent in a liability; for example, if the liability contains economic risk (i.e., salary growth), the risk-free rate would not represent the cost of the future accrual. Typically, discounting using the risk-free interest rate would give the solvency liability, which includes all risk premium.

- (b) Describe the advantages and disadvantages of this investment strategy.

### **Commentary on Question:**

*In order to receive full credit for this question, candidates were expected to provide multiple advantages and disadvantages to a 100% bond portfolio. Candidates performed reasonably well on this question. The answer below includes more advantages and disadvantages than would be needed for full credit.*

### **Advantages**

- Investing 100% in bonds increases interest rate protection, which can reduce both contribution volatility and funded status volatility
- By gaining fixed income exposure through the pension plan, shareholders can experience a tax arbitrage opportunity, which may drive the attractiveness of the stock
- Bonds have similar characteristics to pension liabilities, reducing risk through improving the liability match
- Government bonds have low default risk

### **Disadvantages**

- There is a scarcity of long-term Treasuries, which contributes to lower yields for Treasuries relative to other bonds
- Because the plan is not fully funded, investing 100% in bonds requires the plan to forgo the potential for growth assets to help reduce the plan deficit
- Bonds may introduce a large amount of credit spread and yield curve risk
- Typically, bonds do not help with hedging the economic risk in the liability, such as future accruals
- A 100% bond portfolio may not be appropriately diversified
- Bonds typically do not protect against inflation

## 2. Learning Objectives:

2. The candidate will recognize and appropriately reflect the role of plan investments in managing plan sponsor risk.

### Learning Outcomes:

- (2c) Evaluate how factors including cash flow requirements, various plan designs and various economic environments affect setting investment strategy.

### Sources:

RPIRM 111-13

### Commentary on Question:

*Commentary listed underneath question component.*

### Solution:

- (a) Calculate the interest-rate hedge ratio of the current asset mix.

#### Commentary on Question:

*Points were awarded to candidates who calculated liability duration using other data points shown in the question, and also where duration was derived using exponential interpolation instead of linear.*

$$\text{Interest rate hedge ratio} = \text{Fixed income allocation} * \text{Fixed income duration} * \frac{\text{Funded ratio}}{\text{Liability duration}}$$

$$\text{Funded ratio} = \text{market assets} / \text{liabilities} = 750 / 850 = 88.2\%$$

$$\text{Liability duration} = - (V_- - V_+) / (n_- - n_+) * (1/V), \text{ where } V = \text{value, } n = \text{interest rate, subscript } - \text{ means lower interest rate, subscript } + \text{ means higher interest rate}$$

$$\text{Liability duration} = - ((925-775) / (.03-.05)) * (1/850)$$

$$\text{Interest rate hedge ratio} = 40\% * 5 * 88.2\% / 8.82 = 20\%$$

- (b) For a 50 basis-point drop in interest rates, Company XYZ would like to limit its deficit to \$120 million. Calculate the minimum face value of the available interest-rate swap that would achieve Company XYZ's goal.

#### Commentary on Question:

*Points were awarded to candidates who used an alternative approach to solve the problem. Errors that occurred in part a) were carried forward by graders to assess if candidates would have solved the problem, and points were awarded when applicable.*

## 2. Continued

$$\text{Effective duration for liability} = - ((925-775) / (.03-.05)) * (1/850) = 8.82$$

$$\text{Asset duration} = 40\% * 5 + 60\% * 0 = 2.0$$

$$50 \text{ bp drop in interest rates results in Liability} = 850 + 850 * 8.82 * 0.5\% = 887.50$$

$$50 \text{ bp drop in interest rates results in Assets} = 750 + 750 * 2.0 * 0.5\% = 757.5$$

$$\text{Deficit with no action} = 887.50 - 757.5 = 130 \text{ which exceeds the goal of } 120$$

$$\text{Instead we need plan assets to be at least } 887.50 - 120 \text{ goal} = 767.50$$

$$\text{To achieve goal using duration management need asset duration based on } 767.50 = 750 + 750 * \text{New duration} * 0.5\%$$

$$\text{New duration} = (767.50 - 750) / (750 * 0.5\%) = 4.67$$

$$\text{Notional principal} = \text{Market value} * (\text{Target duration} - \text{Portfolio duration}) / \text{Swap duration}$$

$$\text{For receive-fixed swap, minimum notional principal to limit deficit to } \$120\text{m is } 750 * (4.67 - 2.0) / 15.0 = \$133.5$$

- (c) Critique the strategy of constructing an asset portfolio where assets and liabilities are matched only based on total duration for the purpose of managing interest rate risk.

### **Commentary on Question:**

*Most candidate did not perform well in part c) as opposed to part a) and b).*

### **Strengths of the strategy**

- Sensitivity to changes in interest rates is the main cause of variability in pension liabilities.
- To hedge this interest-rate sensitivity, we must make the duration of assets similar to that of the liabilities.
- Effective duration is perhaps the most commonly used measure of interest rate risk exposure of an interest rate contingent claim.

## 2. Continued

### **Weaknesses of the strategy**

- Duration based models of risk assume parallel shifts in the yield curve; in practice, yield curves regularly steepen and flatten.
- Plans continue to maintain low hedge ratios due to concern over rising interest rates that would “lock-in” a high cost for the hedging of this risk.
- Could consider a glide path strategy to gradually reduce asset and liability mismatch over time according to predefined triggers.
- Effective duration is often inadequate in measuring a security’s interest rate risk exposure.
- Key rate durations have several advantages over existing measures of interest rate risk exposure.
- Two portfolios can have the same effective duration but completely different interest rate risk exposure.
- Immunization (matching duration all along the curve) is required for non-parallel yield curve shifts.
- It does not take into account the convexity.

### 3. **Learning Objectives:**

2. The candidate will recognize and appropriately reflect the role of plan investments in managing plan sponsor risk.

#### **Learning Outcomes:**

- (2c) Evaluate how factors including cash flow requirements, various plan designs and various economic environments affect setting investment strategy.

#### **Sources:**

RPIRM-103-15, RPIRM-132-14, RPIRM 108-13, Litterman Chapter 2, Litterman Chapter 24

#### **Commentary on Question:**

*Commentary listed underneath question component.*

#### **Solution:**

- (a) Describe the considerations for adhering to prudent investment principles for co-trustees.

#### **Commentary on Question:**

*Candidates that did well on this question focused on considerations specifically related to having co-trustees. Most candidates that did not do well only provided the list of prudent investment principles.*

Each trustee should be aware of the investments of the other, so that the various parts fit together to form an appropriately balanced fund.

The trustee is also under a duty to take whatever actions are reasonably necessary and appropriate to prevent co-trustees from breaching their duties.

The trustee is also under a duty to take whatever actions are reasonably necessary and appropriate to cause the co-trustee to compensate the fund for the loss if a breach does occur.

- (b) Explain how the strategy may or may not be violating prudent investment practices.

#### **Commentary on Question:**

*Candidates that did well needed to recognize that solely investing in bonds is not an issue, so long as the investment makes sense for the fund.*

### 3. Continued

Requires the exercise of reasonable care, skill, and caution, and is to be applied to investments not in isolation but in the context of the trust portfolio and as a part of an overall investment strategy, which should incorporate risk and return objectives reasonably suitable to the trust.

In making and implementing investment decisions, the trustee has a duty to diversity the investments of the trust unless, under the circumstances, it is prudent not to do so.

The selection of bonds may be appropriate but may be a violation if the maturity dates are not staggered.

Asset allocation should reflect the pension plan's risk tolerances. Decision makers should consider a full range of possible investment opportunities.

Risks of only investing in corporate bonds of the retail sector include:

- Single investment represents a significant fraction of an investment portfolio; there is an avoidable concentration of risk
- Sector risk
- Default risk

#### 4. Learning Objectives:

3. The candidate will understand how to evaluate the stakeholders' financial goals and risk management with respect to their plan.

#### Learning Outcomes:

- (3d) Understand and apply the principles of financial economics with respect to pension plan investing.
- (3e) Provide advice and analysis to stakeholders regarding the economic assumptions used in the valuation of their retirement plans.
- (3f) Provide advice and analysis to plan sponsors and other stakeholders regarding the mitigation of pension plan risks.

#### Sources:

RPIRM 112-13 and RPIRM 123-13

#### Commentary on Question:

*Commentary listed underneath question component.*

#### Solution:

- (a) Calculate the standard approximation of the expected geometric average return of the portfolio above.

#### Commentary on Question:

*Most candidates were able to determine the mean and variance of the portfolio, however not all candidates were able to correctly calculate the expected geometric average.*

$$\text{Expected Geometric Average Return} = \text{Expected Arithmetic Average Return} - 50\% * \text{Variance of Average Returns}$$

$$\text{Expected Arithmetic Average Return} = 5.82\%$$

$$\text{Standard Deviation} = 8.38\%$$

$$\text{Variance of Average Returns} = (\text{Standard Deviation})^2 = 0.70\%$$

$$\text{Expected Geometric Average Return} = 5.82\% - .5 * 0.70\% = 5.47\%$$

- (b) Describe the process and considerations for constructing an efficient frontier for optimizing the asset return and risk of an investment portfolio.



## 4. Continued

### **Commentary on Question:**

*Most candidates incorrectly provided the definition of the efficient frontier rather than describing the processes and methodologies to construct an efficient frontier. Candidates who did describe the process, were able to identify the first 2 steps of the process (1 – calculate returns/volatility, 2 – determine the efficient frontier) but missed consideration of constraints. Most candidates did not identify the various methods used to determine the efficient frontier.*

There are three steps in the process for constructing an efficient frontier:

1. Calculate the expected returns, standard deviations and correlation for the included asset class
  2. Determine the efficient frontier methodology to be implemented, options include:
    - a. Quadratic programming (Mean-variance frontier, Single-period frontier (i.e., one year))
    - b. Non-linear programming (Mean-variance, multiple period, downside risk, and asset/liability frontiers, Characteristics are versatility, parameterization, and approximate solutions)
  3. Determine the model constraints amongst the following categories:
    - a. Liquidity – Illiquid assets classes maybe restricted
    - b. Fiduciary issues – some assets classes may have limitations
    - c. Accuracy of estimates – uncertainty around the assumptions for expected return and other statistics for an asset class
    - d. Investment policy – Portfolio allocations are restricted by external or internal requirements
- (c) Recommend variations to the efficient frontier that you would derive for the purpose of advising Company XYZ on their investment strategy, in light of the goal stated above.

### **Commentary on Question:**

*Most candidates were not able to identify other variations of the efficient frontier that could be used, instead providing proposed asset allocations or glide paths. Most candidates were able to identify that a key consideration in any model used should be the funded ratio.*

The goal of Company XYZ is to minimize downside risk and improve the funded ratio. A surplus efficient frontier (also known as an asset/liability frontier) would allow XYZ to:

- optimize portfolio returns relative to plan liabilities; and
- define risk/reward statistics in term of the funding deficit.

Company XYZ could also implement a multi-period efficient frontier that looks at the funded status at the end of 10 years. This model allows for serial correlation and other relationships between years to be modeled.

## 5. Learning Objectives:

1. The candidate will understand how to analyze the issues facing retirement plan sponsors regarding investment of fund assets and make recommendations.

### Learning Outcomes:

- (1g) Solve for a measure of investment performance relevant to a given benchmark.

### Sources:

Modern Investment Management, Litterman, Robert, 2003 p. 268, 273-275

RPIRM-104-15, p. 749-753

### Commentary on Question:

*Commentary listed underneath question component.*

### Solution:

- (a) Describe the key objectives of performance measurement tools.

#### Commentary on Question:

*Most candidates were able to identify one or two objectives. Candidates were expected to indicate that the objectives focus on risk-adjusted returns, not just absolute returns.*

- To determine whether returns achieved are sufficient to compensate for the level of risk taken
  - To determine whether a manager generates consistent excess risk-adjusted performance compared to a benchmark
  - To determine whether a manager generates superior risk-adjusted performance compared to a peer group
  - To provide a basis for identifying managers whose processes generate high-quality excess risk-adjusted returns.
    - High-quality meaning that their processes and therefore returns can be repeated in the future.
- (b) Describe the strengths and weaknesses of the following performance measurement tools:
- (i) Attribution Analysis
  - (ii) Information Ratio

#### Commentary on Question:

*Many candidates resorted to defining attribution analysis and information ratio, for which no points were rewarded. And those who did answer the question directly were able to provide a couple strengths of each, but struggled with identifying weaknesses.*

## 5. Continued

### (i) Attribution analysis

#### Strengths

- Can be performed on a micro, macro and factor basis
- [Relatively easy to calculate and split out returns to different securities and sectors
- Allows returns to be separated out into the same risk buckets used for budgeting
- Test whether a manager has generated excess returns purely due to their risk factors

#### Weaknesses

- Can only compare managers that use the same risk/return factors to select investments

### (ii) Information Ratio

#### Strengths

- Can be used at the individual security, sector, country or fund level
- Focuses on active returns and active risks by using tracking error which reflects only risk taken to achieve excess returns
- Can be used to measure relative performance against a benchmark or peer group
- Test whether a manager has generated sufficient returns to compensate for risk taken

#### Weaknesses

- Relies on benchmark data that may not be readily available for either managers or peer group
- The measure is calculated using actual realized results which may not produce the same relative ranking when using estimates to forecast the future
- Cannot distinguish between different manager styles

- (c) Calculate the incremental return contribution and incremental value contribution of the six levels of investment policy decision-making for the fund by filling out the table in Excel.

## 5. Continued

Decision-Making Level (Investment Alternative)	Fund Value	Incremental Return Contribution	Incremental Value Contribution
Beginning value	\$132,685,956		
<b>Total Fund</b>	<b>\$133,269,850</b>		

### Commentary on Question:

*Almost all candidates were able to identify the various decision-making level category names and incremental return contributions. Many candidates were slightly off in their calculations of the incremental value contribution, however, as a result of failing to recognize the cash flows in the calculation. Regardless, the majority of points were awarded and this section of the question was done quite well.*

*Rubric shown uses simple interest but candidates who used compound interest received full credit. Also, the return on 90-Day Treasury Bills of 0.52% in the question was not sufficiently clear as to whether this represented a monthly return or 90-day, so candidates who used 0.52% or 0.17% (i.e.,  $0.52\% \times 30/90$ ) were given full credit.*

Decision-Making Level (Investment Alternative)	Fund Value	Incremental Return Contribution	Incremental Value Contribution
Beginning value	\$ 132,685,956		
Net contributions	\$ 131,002,541	0.00%	\$ (1,683,415)
Risk Free Asset	\$ 131,231,071	0.17%	\$ 228,530
Asset Categories	\$ 130,012,391	-0.92%	\$ (1,218,680)
Benchmarks	\$ 132,099,485	1.58%	\$ 2,087,094
Investment Managers	\$ 132,760,025	0.50%	\$ 660,540
Allocation Effects	\$ 133,269,850	0.39%	\$ 509,825
<b>Total Fund</b>	<b>\$ 133,269,850</b>	<b>1.72%</b>	<b>\$ 583,894</b>

## 5. Continued

### Net contribution

- Incremental Value
  - = contributions – benefit payments
  - = \$2,530,120 - \$4,213,535
  - = **\$(1,683,415)**
- Incremental return = **0.00%**

### Risk Free Asset

- Incremental Value
  - = Risk free return on beginning assets + risk free return on net contributions
  - = \$132,685,956 \* 0.52%/3 + \$(1,683,415) \* 0.52%/3 \* 0.5
  - = **\$228,530**
- Incremental Return: 0.52% / 3 = **0.17%**

### Asset Categories

- Incremental Value
  - = Asset category incremental return on beginning assets + asset category incremental return on net cash flows
  - = \$132,685,956 \* -0.92% + \$(1,683,415) \* -0.92% \* 0.5
  - = **\$(1,218,680)**
- Incremental Return:
  - = weighted average of index returns in excess of risk free return, weighted on policy weights
  - = 30% \* (3.52% - 0.52%/3) + 50% \* (-4.03% - 0.52%/3) + 20% \* (1.04% - 0.52%/3)
  - = **-0.92%**

### Benchmark

- Incremental Value
  - = benchmark incremental return on beginning assets + benchmark incremental return on net cash flows
  - = \$132,685,956 \* 1.58% + \$(1,683,415) \* 1.58% \* 0.5
  - = **\$2,087,094**
- Incremental Return:
  - = weighted average of manager benchmark returns in excess of index returns, weighted on policy weights
  - = 30% \* (3.52% - 3.52%) + 50% \* (-1.26% - -4.03%) + 20% \* (2.03% - 1.04%)
  - = **1.58%**

## 5. Continued

### Investment Managers

- Incremental Value
  - = investment manager incremental return on beginning assets + investment manager incremental return on net cash flows
  - =  $\$132,685,956 * 0.50\% + \$(1,683,415) * 0.50\% * 0.5$
  - = **\$660,540**
- Incremental Return:
  - = weighted average of actual returns in excess of manager benchmark returns, weighted on policy weights
  - =  $30\% * (4.02\% - 3.52\%) + 50\% * (-1.35\% - -1.26\%) + 20\% * (4.01\% - 2.03\%)$
  - = **0.50%**

### Allocation effects

- Incremental Value
  - = residual from increase in market value from beginning to end of month, not accounted by the impacts calculated above
  - =  $(\$133,269,850 - \$132,685,956) - -\$1,683,415 - \$228,530 - -\$1,218,680 - \$2,087,094 - \$660,540$
  - = **\$509,825**
- Incremental Return:
  - = residual from total fund return, not accounted by the impacts calculated above
  - =  $1.72\% - 0.00\% - 0.17\% - -0.92\% - 1.58\% - 0.50\%$
  - = **0.39%**

### Total fund

- Incremental Value
  - = end of month assets – beginning of month assets
  - =  $\$133,269,850 - \$132,685,956$
  - = **\$583,894**
- Incremental Return:
  - =  $(\$133,269,850 - \$132,685,956 - -\$1,683,415) / (\$132,685,956 + 0.5 * -\$1,683,415)$
  - = **1.72%**

## 6. Learning Objectives:

3. The candidate will understand how to evaluate the stakeholders' financial goals and risk management with respect to their plan.

### Learning Outcomes:

- (3a) Compare the interests of plan sponsors, employees, shareholders, taxpayers and other stakeholders related to the financial management of a retirement plan.
- (3f) Provide advice and analysis to plan sponsors and other stakeholders regarding the mitigation of pension plan risks.

### Sources:

RPIRM 115-13

### Commentary on Question:

*Commentary listed underneath question component.*

### Solution:

- (a) Describe the objectives of the following stakeholders with respect to a public defined benefit pension plan:
  - (i) Taxpayers;
  - (ii) Elected officials; and
  - (iii) Plan participants.

### Commentary on Question:

*Most candidates did well on this question. Full credit was given to candidates who named at least four objectives for each stakeholder.*

- (i) Taxpayers
  - Pay the lowest taxes for the public services that taxpayers require
  - Expect state and local governments to hire and retain the best public sector employees
  - Tax money should be used wisely, i.e. public pension plan surplus should be minimized
  - Reduce future tax burden by keeping assets in the plan instead of paying out for benefits enhancement or other purposes
  - Cost for public pension plan is predictable and does not impinge on other public services

## 6. Continued

- (ii) Elected officials
  - Re-election is often the primary goal
  - Provide rich benefits to public servants
  - Deliver the best public services at the lowest cost
  - Elected officials want to raid pension assets to use for other projects
- (iii) Plan participants
  - Desire robust and adequate retirement benefits because many are not covered by social security system
  - They do not want any negative surprises with regards to benefit levels as they approach retirement
  - Want to make the least contributions for the greatest pension benefits
  - Maximize overall compensation package
- (b) Explain how an asset liability management framework would affect the stakeholders from part (a) in terms of their objectives.

### **Commentary on Question:**

*Most candidates did well on this question. Full credit was given to candidates who provided at least two objectives and described how asset liability management framework would affect these objectives. The answer below provides more objectives than would be needed for full credit.*

- (i) Taxpayers
  - As part of asset liability management framework, better asset liability matching helps taxpayers achieve the objective of paying the lowest and predictable taxes
  - Designing assets to move in tandem with liabilities can maintain the funded status of the plan at the same level, regardless of what occurs with capital markets. Thus, no contributions would be required from taxpayers to finance the public pension plan
  - Although riskier assets investment could generate higher expected returns in a long-term, funded ratio of the plan could also be substantially lower in many scenarios. If an actuarial funding valuation was performed during the years where funded ratio drops, taxpayers will likely be called on to make contributions
  - Public pension plan surplus is minimized with the asset liability management framework. No potential surplus to be used for benefit enhancement or other purposes, and thus reduce future tax burden



## 6. Continued

- (ii) Elected officials
  - Asset liability management framework prevents elected officials from raiding pension assets to use for other projects for the purpose of re-election
  - Elected officials are no longer able to defer cost recognition on public pension plan. More transparent transfer of risks and costs to future generations through comprehensive stochastic modeling of investment, funding and benefit policies to project the plan going forward many years
  - Elected officials are not able to enhance public plan benefits using temporary surplus in the plan
  
- (iii) Plan participants
  - Asset liability management framework helps employees achieve the objective of having secured benefit at retirement
  - Pension benefits are unlikely reduced or enhanced because more stable funded status of the plan
  - Plan participants will be required to make contributions at a stable level and no intergenerational inequity concerns