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SUBTASK 4.9 REPORT

EVALUATION OF MODEL OUTPUT

One of Three Six-Month Reports

IN-DEPTH TECHNICAL REVIEW OF THE PENSION BENEFIT GUARANTY CORPORATION'S
MULTIEMPLOYER AND SINGLE-EMPLOYER PENSION MODELS

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Introduction

In July 2015, the Social Security Administration (SSA) engaged the FTI Consulting team (FTI) to conduct an 18-month, in-depth technical review of the Pension Benefit Guaranty Corporation's (PBGC) single-employer (SE) and multiemployer (ME) Pension Insurance Modeling System (PIMS). Task 4 of the Statement of Work (SOW) consists of 10 subtasks required for this in depth review - nine specific areas of review and a final report.¹ Three of the subtask reports are due at the end of each of the six-, 12- and 18-month periods. This report for Subtask 4.9, along with those for Subtasks 4.1 and 4.5, are due at the end of six-month period. As a part of our comprehensive review of PIMS, this report documents our evaluation of the presentation of PIMS's model output as shown in the annual Projections Report and other documents (see Subtask 4.9: Evaluate the Presentation of Model Output).²

The presentation of PIMS's model output is important because "the audience for these reports, including policymakers, plan sponsors, and plan participants, needs to have confidence that the reported results accurately reflect the models' outputs and reasonably depicts the uncertainties the models are designed to estimate."³ Confidence in the system and clarity in the presentations are paramount to the proper message being received by a diverse group of readers. Our review of the technical inner workings of PIMS will be presented in the 12-month, 18-month and final reports. This report presents FTI's review of the current PBGC output, the tools used to prepare the output, and recommendations of enhancements to the overall projection message. The primary publication where the results from PIMS simulations are presented and explained is the PBGC's 2014 Projections Report, which in keeping with its status as a report to the Congress, is reviewed and cleared by all three Board agencies and the Executive Office of the President. PIMS simulations are also employed as the basis for various technical assistance requests, in estimating the agency's future budget needs. Finally, the agency has put up a page on its web site, where it displays results of sensitivity tests as well as other documentation. Sensitivity tests are reviewed at the agency level.

Both the presentation of PIMS's output for multiemployer plans (ME-PIMS) and single-employer plans (SE-PIMS) are evaluated in this report.

As part of documenting our evaluation of the presentation of PIMS's model output presented in the 2014 Projections Report, this report also addresses the following key questions raised in Subtask 4.9:⁴

- a. Are procedures in place to ensure that the presentation of results accurately reflects the model output?
- b. Is the transfer from raw model output to presentation sufficiently automated that new errors are not introduced?
- c. Has the challenging task of presenting the possibility of rare but catastrophic events been adequately met?

¹ Social Security Administration, Evaluation of the Pension Benefit Guaranty Corporation's Pension Models, Description/Specification/Work Statement, p. 14.

² Ibid., p. 19.

³ Ibid., p. 20.

⁴ Ibid., p. 20.

- d. Can indications be given of how the results might differ if fatter risk tails were modeled?
- e. What should PBGC learn from presentation of results of comparable models?

Altogether, the SOW prescribed that FTI would produce three reports for each of the three six-month periods during the contract. Our team recognized that, due to the tasks necessary for the project start-up, the time to complete the reports during the first six months would be compressed. The start-up tasks included the initial kick-off meeting with the PBGC and SSA, creating the final workplan, installing the servers at the FTI Consulting Data Center, reviewing initial documentation and gaining an understanding of the system. Due to the tighter window to complete reports, we chose the three subtasks that were not solely dependent on the system being fully operational. Subtasks 4.1 (Evaluation of PIMS Modeling of Macroeconomic Variables) and 4.9 were identified by our team as ones for which a significant amount of work could be completed without access to PIMS software. We expected Subtask 4.5 (Evaluate PIMS Documentation) would be challenging to complete in the first six months, but also considered that a review of the documentation would be necessary in order to help our team understand the system. Although our team has produced comprehensive reports for this first six-month period, we also recognize that during the next 12 months there will be significant added insight gained that will enhance our understanding of PIMS and could potentially change some of our views. Additional information and findings will be included in the future as either an addendum to this report or in the Subtask 4.10 final report, or both.

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Findings

Based on our analysis, we recommend that PBGC consider making the following changes or additions in the output produced by PIMS:

Level I recommendations - Changes we believe are important and will greatly enhance the presentation and evaluation of PIMS output

- Recommendations for the Projections Report
 - Provide a detailed explanation of the purpose of the Projections Report
 - Provide explanations for the main drivers of uncertainty and extreme losses
 - Present PBGC liabilities using alternate discount rates, such as a risk-free rate of return, to accommodate certain readers of the report
- Other recommendations
 - Identify and eliminate inconsistencies between PIMS documentation and disclosures in the Projections Report
 - Publish on PBGC's website deterministic scenarios based on historical financial experience or other stress-testing scenarios to provide context for rare but catastrophic events
 - Enhance documentation for completing the output from PIMS for the Projections Report

Level II recommendations – Changes that are less critical than Level I but will be helpful for the presentation and evaluation of PIMS output

- Recommendations for the Projections Report
 - Include a general discussion of how the distribution of outcomes is skewed by stochastic volatility of asset returns, non-normal distribution of certain variables and increased volatility and correlation at unfavorable scenarios
 - Expand explanations of the driving forces behind the uncertainties that affect projected deficits
- Other recommendations
 - Break out the assets and liabilities that make up the projected deficits
 - Split the liabilities for single-employer plans already under PBGC control and the liabilities expected from future takeovers; Similarly, for ME, split the liabilities for those plans currently receiving financial assistance and those expected to receive financial assistance in the future
 - Expand disclosures in the Appendix so that an independent evaluation of PBGC's pension insurance programs can be performed
 - Perform exploratory data analysis on the output from PIMS for reasonableness tests

Other findings from our evaluation of the PIMS output are as follows:

- The Projections Report provides appropriate and effective descriptions that are understandable to the many stakeholders who will likely be interested in the results.
- The output data from PIMS are correctly transferred to the Statistical Analysis Software (SAS) coding to produce the charts and information for the Projections Report. A checklist guides the PBGC staff through the process, and the results are checked by preparing the same information independently in a spreadsheet.
- Although other pension protection programs exist in other countries, none have the unique characteristics of the PBGC. Studying the reports from other countries provides insight into structures that would be helpful to the PBGC (assuming Congress would implement), but due to the underlying differences, we have so far found little of their output that either is not already produced by or applicable to the PBGC. We will further explore comparable systems as we work on Subtask 4.2 and Subtask 4.4.

Scope and Methodology of Evaluation

This report addresses the accuracy and effectiveness of the presentation of PIMS's model output. Our recommendations of additional displays, disclosures or analyses are for the readers of PBGC's Projections Report to better understand how the projected results are created and what the projected results mean. The effectiveness of a presentation depends on the level of understanding of the intended audiences and the goals of the presentation. Our evaluation studies the intended audiences and provides recommendations to enhance the presentation. Our report also looks at the quality assurance aspect of producing the results, provides examples of how better to analyze the results for reasonableness and discusses the risk and occurrences of extreme outcomes.

This report does not address the adequacy of PIMS's modeling techniques, model assumptions, model documentations and model implementations, which will be covered in other reports in our in-depth technical review over the remainder of the 18 months. For example, the 2014 Projections Report shows and gives an explanation for the \$13.7 billion reduction in the projected net deficit for the multiemployer program due to changes to the ME-PIMS model from 2013 to 2014.⁵ This Subtask 4.9 report does not evaluate whether the \$13.7 billion amount is reasonable, or whether the model changes that caused this reduction in projected net deficit are based on sound modeling principles. However, this report looks at the explanation of these changes and evaluates if the reduction in projected net deficit has been communicated appropriately and effectively, in the context of the overall reconciliation presented in the 2014 Projections Report.

Our approach for reviewing the presentation of PIMS's output has two components. First, we take the ME-PIMS's and SE-PIMS's model output as given, and review the tools⁶ and procedures PBGC's Policy Research and Analysis Department (PRAD) uses to process the PIMS's model output into the exhibits in the 2014 Projections Report. We review the appropriateness of the tools and procedures as well as PRAD's quality control policy⁷ governing the use of PIMS in published reports to ensure the model output are presented accurately. Next, we review the content of the 2014 Projections Report and suggest steps PBGC may consider to improve its communication of PIMS's model output to its readers.

Due to certain funding and accounting requirements, a typical pension report is often compliance-based, backward looking, and focuses primarily on contribution and disclosure calculations. PIMS's model is different as output consists of simulations of plan sponsor behavior and their impact on a unique national pension insurance system. PIMS is forward looking, showing a range of possible outcomes. Thus the communication of PIMS's model output has its own unique challenges. Despite the differences between PIMS and traditional pension modeling, we have observed a number of trends in the presentation of actuarial projections by pension professionals that may be helpful in projecting PIMS output:

- a. Increasingly, more disclosures are made available so that different stakeholders can assess the health of a pension system. For example, liabilities are calculated with different discount rates; sensitivities of the actuarial projections to key assumptions are presented; and benefit payments or cash flows of a pension system are provided so that

⁵ Pension Benefit Guaranty Corporation, FY 2014 PBGC Projections Report, p. 22.

⁶ The spreadsheets are "Report #'s with MRPA (#23) MortFix.xlsx" for ME-PIMS and "pbf_postprocess_fy14.sas" and "FY14_Post_processing_report_numbers 20150601(E).xlsx" for SE-PIMS

⁷ The document titled "Quality Assurance Procedures for Formal PRAD Reports Utilizing the Pension Insurance Modeling System (PIMS)", version 5.0, issued on August 25, 2015

interested parties can perform their own independent analyses.⁸ In a similar fashion, PRAD has published sensitivity analysis in PBGC's PIMS website.

- b. Online and interactive tools have been developed to communicate pension benefits and to manage risk. For example, interactive pension risk management tools have been developed so that plan sponsors can see a daily update of their pension risk exposures;⁹ online pension calculators are available to individuals so that they can understand the present value and the accrual pattern of their pension benefits over their careers, enabling them to assess the impact of potential pension formula changes.¹⁰ Generally speaking, online and interactive tools are effective means for users to understand a range of possible outcomes and the drivers behind the variability of the results. It may be possible to construct similar tools based on PIMS output and have them available on PBGC website.

The usefulness of these ideas is considered as we review the presentation of PIMS's model output.

General Review of 2014 Projections Report Content

Intended Audiences

The private pension system in the United States has many stakeholders, all of which are potential readers of the Projections Report. Subtask 4.9 identifies three classes of readers of the PBGC's Projections Report as: policymakers, plan sponsors, and plan participants.¹¹ Additionally, pension practitioners, plan trustees, taxpayers, and the public in general are important parties with great interest in the well-being of the nation's pension insurance program.¹² These stakeholders and interested parties have a wide-range of backgrounds, expertise, and perspectives, as well as potentially conflicting interests in the private pension system of the United States.

With such a diverse audience, it is difficult to have a report that fully meets the needs of every interested party. To this end, PBGC's Projections Report has a narrative that discusses the projection

⁸ As an example of more disclosures, Statement No. 68 of the Governmental Accounting Standards Board, Accounting and Financial Reporting for Pensions, which is applicable for pension plans sponsored by state and local governments, but not to PBGC's projections, requires the disclosure of the sensitivity of the net pension liabilities to the discount rate.

⁹ For example, RiskFirst has developed a real-time analytics and reporting platform that allows users to monitor and review defined benefit pension plan funding position on a daily basis. It also allows the calculation of value-at-risk (VaR), what-if analysis, and stress-testing against historic market events.

¹⁰ As an example of online pension calculation tools, the tool provided by Urban Institute allows state and local government employees to experiment with different pension formulas and accrual patterns. Available: <http://apps.urban.org/features/build-your-own-pension/>

¹¹ *ibid.*, p. 20.

¹² In 2012, PBGC's Office of Inspector General published a Management Advisory Report, "Ensuring the Integrity of Policy Research and Analysis Department's Actuarial Calculations." In this report, the importance of PIMS results to different stakeholders are stated on page 2, "PBGC uses PIMS to produce reports that provide influential information for stakeholders, to include PBGC management, PBGC's Board, the Executive and Legislative branch staff, Congressional Budget Office, Joint Committee on Taxation, Office of Management and Budget (OMB), Department of Labor (DOL), Government Accountability Office (GAO), and private sector employee benefit organizations.

results in laymen’s language, and an appendix that provides technical details of the data, methods, and assumptions used in the PIMS modeling.

General Content

We find such organization of the Projections Report to be appropriate and effective. Further, efforts are made in the narrative to explain every concept and term used in the report to make the material accessible to non-specialists. Similarly, the appendix discusses the data, methods, and assumptions in a comprehensive manner. The information in the appendix is not intended for a pension practitioner to replicate results, however, it is enough for a pension practitioner to understand PIMS’s model output and is an improvement to past disclosures where the assumptions and methodology descriptions were very limited.

We have noted some inconsistencies between the Projections Report and other documentations provided by PBGC. For example, the assumption of plan asset returns is presented differently in the Projections Report as compared to other documentations.¹³ However, where inconsistencies exist, the Projections Report appears to have the most up-to-date information consistent with the operation of PIMS.

Purpose of the Projections Report

Determination of the appropriate level of detail that should be included in the Projections Report requires an examination of the purposes of the Projections Report. Purpose of the Projections Report means what the report is intended to accomplish, including how the results are interpreted by its intended users. Without a clear understanding of what the report is intended to accomplish, there is a risk to include a large wish list to the report, with many items on the list lacking value with respect to the report’s intended goals.

The 2014 Projections Report states, “This report is an actuarial evaluation.”¹⁴ However, there does not appear to be further explanation as to what an “actuarial evaluation” means nor a clear statement on what the Projections Report is intended to accomplish. Typically, the term “actuarial evaluation” means an evaluation, based on actuarial principles, of the pension insurance programs’ ability to pay its obligations when due. In actuarial literature, this may be referred to as an evaluation of the “actuarial soundness” of the pension insurance system.

The PBGC’s 2015 Annual Report describes the 2014 Projections Report as providing “information on the condition of both insurance programs.”¹⁵ The Projections Report is prepared by PRAD who “conducts its forecasting and modeling work using PIMS. The annual Projections Report outlines the direction of PBGC’s single-employer and multiemployer programs based on projections from PIMS.”¹⁶

The statutory language in ERISA 4008 states that the PBGC is required to submit a report that, among other things, “shall include an actuarial evaluation of the expected operations and status of the funds established under section 1305 of this title for the next five years (including a detailed statement of the

¹³ The appendix in the 2014 Projections Report appears to have more update-to-date discussion on plan asset returns than the description in the document, “Pension Insurance Modeling System” by PBGC.

¹⁴ Ibid., p. 4.

¹⁵ Pension Benefit Guaranty Corporation, 2015 Annual Report, p. 3.

¹⁶ Ibid., p. 17.

actuarial assumptions and methods used in making such evaluation).”¹⁷ The statute further describes information from PIMS that should be included in the report. For example, the report should include “a summary of the Pension Insurance Modeling System microsimulation model, including the specific simulation parameters, specific initial values, temporal parameters, and policy parameters used to calculate the financial statements for the corporation.”¹⁸

In this report we do not attempt to evaluate whether the statutory obligations under ERISA 4008 are met by the various reports published by PBGC. We reviewed the statutory language to gain insights into the purposes of the Projections Report. It is evident from above that one of the Projections Report’s intended uses is to fulfill ERISA 4008 reporting requirements.

Synthesizing all the references to the Projections Report, we can now summarize the purpose of the Projections Report as follows:

The Projections Report should provide relevant information that allows its readers to evaluate the financial health of PBGC’s pension insurance programs. This is done through a projection of assets, liabilities, claims, and cash flows so that an evaluation can be made as to whether PBGC’s pension insurance programs can pay its obligations when due.

An integral part to understanding the financial health of PBGC’s pension insurance programs is to understand its risks. In order to gain this understanding of risks, below is what we feel the goals should be in explaining the purpose of the Projections Report:

- a. The readers should be able to understand the projected financial results;
- b. The readers should be able to understand the uncertainty of the financial projections;
- c. The readers should be able to understand the main drivers of these uncertainties, especially in cases of extreme losses;
- d. Pension professionals should be able to perform an independent evaluation of the financial health of the pension insurance programs based on PIMS’s output and other information released by PBGC.

Our evaluation of the presentation of PIMS’s model output is based on the purpose and goals stated above.

Evaluation of the 2014 Projections Report

The 2014 Projections Report does well with respect to communicating the financial results and uncertainty (goals (a) and (b)). However, the report is mostly absent in providing explanations for the main drivers of uncertainty and extreme losses (goal (c)). With respect to goal (d), we find that the Appendix has useful information that allows pension professionals to understand what PIMS does, but in order for an independent evaluation of PBGC’s pension insurance programs to be performed, additional information provided by PBGC would be required.

¹⁷ ERISA sec. 4008.

¹⁸ Ibid. See also Joint Committee on Taxation, Technical Explanation of H.R. 4, the “Pension Protection Act or 2006,” as Passed by the House on July 28, 2006, and as Considered by the Senate on August 3, 2006.

Following are specific comments regarding the 2014 Projections Report.

1. The main measures of financial health presented in the Projections Report are the projected insolvency date and the projected net position for the multiemployer and single-employer programs.¹⁹ The net position is based on the accounting balance sheet from PBGC's annual reports, and is not necessarily an economic balance sheet.²⁰ The 2014 Projections Report adequately explains the modeling of PBGC's ME and SE liabilities, including the concepts of "booking" and "unbooking" for multiemployer plans. Prior reviewers suggest that liabilities should be calculated on a different interest rate basis, in part because they believe using a more economic or market-consistent measure of PBGC's liabilities gives a better indication of PBGC's financial health.²¹ Further, risk management is usually done on the basis of an economic balance sheet. We believe both perspectives are important, and PBGC should accommodate the needs of its readers by providing liabilities at risk-free rates in its Projections Report.
2. The 2014 Projections Report shows the change in the net position of PBGC's multiemployer and single-employer programs if the market price of annuities were 50 basis points higher or lower than the baseline projection.²² We suggest that future Projections Reports also disclose the spread between this discount rate and the simulated 30-year Treasury rate, so that interested readers can estimate, based on 50 basis point discount rate sensitivity, what the liabilities would be if risk-free rates were used.
3. The 2014 Projections Report states, "These are the present values of PBGC's deficit (i.e., negative net position), assuming that PBGC had been able to borrow any amounts needed in previous years to meet its financial assistance obligations at current guarantee levels if assets and premiums are insufficient to provide the guarantees."²³ The notion of borrowing cost is used to explain the concept of present value. An alternate explanation for the concept of present value could be that this is the amount of money needed today so that if it earns interest at the discount rate, it would be sufficient to provide the guaranteed benefits. The choice of discount rate is discussed fully in our other reports;²⁴ here we simply point out this description

¹⁹ Ibid., p. 9 – 13, 26 – 27.

²⁰ The basic principle of an economic balance sheet is that both assets and liabilities should be valued on a market-consistent basis. Thus, liabilities are generally valued by constructing hypothetical asset portfolios whose cash flows match those of the liabilities. The economic deficit is the difference between the assets and liabilities on the economic balance sheet. A ten year window (or any time frame without economic justification) for the "booking" and "unbooking" of liabilities is a convention essentially inconsistent with market valuation, as it excludes information analysts would consider economically relevant, i.e., "catastrophic" events that are foreseeable, if of uncertain likelihood. .

²¹ Numerous prior reviewers have argued for a more economic or market-consistent measure of PBGC's liabilities. For example, Novy-Marx, R., "Economic and Financial Approaches to Valuing Pension Liabilities", 2013, Maurer, R., "Integrated Risk Management for Defined Benefit Pensions: Models and Metrics, 2013, Fabozzi, F., "Measuring and Explaining Pension System Risk", 2013, Lucas, D., "Joint Risk of DB Pension Underfunding and Sponsor Termination: Incorporating Option-Based Projections and Valuations into PIMS", 2013, Babbel, D., "Evaluating Pension Insurance Pricing", Brown, J. et al, "A Review of the Pension Benefit Guaranty Corporation Pension Insurance Modeling System", 2013. For a discussion of market-consistent valuation of public pension obligation, see Biggs, A. and Smetters, K., "Understanding the Argument for Market Valuation of Public Pension Liabilities", 2013.

²² Ibid., p. 24 – 25, 36 – 37.

²³ Ibid., p. 11.

²⁴ See the report for Subtask 4.1, "Evaluation of PIMS Modeling of Macroeconomic Variables."

in the 2014 Projections Report and that the process of discounting net positions 10 years out to the present is done in the post-processing spreadsheets, not as part of PIMS processing. PBGC may want to consider rewording this explanation.

4. The 2014 Projections Report discusses changes due to the Multiemployer Pension Reform Act of 2015 (MPRA) and how the projected results change due to the utilization of suspensions and partitions provisions of MPRA. The graphs showing the effects of MPRA are informative and well done, and the explanations of modeling approaches and assumptions are adequate. The presentation of net position using alternate MPRA assumptions is also very helpful for readers to understand the preliminary nature of MPRA assumptions.²⁵
5. The 2014 Projections Report shows the full distribution of PIMS simulated net positions (see Figures 5, 6, 8, 9, 14, 15 of the 2014 Projections Report). These graphs are well laid-out and well annotated and allow the readers to see the full range of possible outcomes. However, the graphs are based on 500 simulations for the multiemployer program and 5,000 simulations for the single-employer program.²⁶ The number of scenarios may be sufficient for the calculation of median and mean to be stable, but it is not clear whether the number of scenarios allows for an accurate depiction of the entire distribution of net positions. An estimate of the number of scenarios that will be adequate for depicting the entire distribution may be provided in future reports.
6. The 2014 Projections Report goes into great detail discussing the sources of uncertainties in the multiemployer and single-employer programs. Three major sources of uncertainty are identified for the multiemployer program: (1) probability of new claims, (2) variability in the timing and amount of financial assistance payments, and (3) extent to which plans will use suspensions and partitions under MPRA.²⁷ For the single-employer program, five sources of uncertainty are discussed: (1) the bankruptcy of plan sponsors, (2) the size of benefit payment payments and new claims, (3) projected liabilities in 2024, (4) the investment return on PBGC-trusted assets, and (5) the amount of premium income from 2015 – 2024.²⁸ For each source of uncertainty, the 2014 Projections Report shows the mean, high (85th percentile) and low (15th percentile) results. The Projections Report identifies and displays the range of values for each source of uncertainty in an understandable manner. However, there appears to be little discussion on the macroeconomic or demographic forces that give rise to these uncertainties. That is, the Projections Report describes the ranges of uncertainties (what the range of outcomes are), but does not discuss the main drivers of these uncertainties (how do they arise).

Apart from idiosyncratic factors²⁹ that impact individual plans, there appear to be three systematic factors that would impact the performance of the pension insurance programs: asset returns, interest rates, and the total number of covered participants (including both active

²⁵ Ibid., p. 18 – 20.

²⁶ Ibid, p. 8, 51. The number of simulation needed depends on modeling assumptions and methodologies, and may be discussed in the report for Subtask 4.4.

²⁷ Ibid., p. 13.

²⁸ Ibid., p. 27 – 32.

²⁹ Following PBGC's 1998 Databook, we define idiosyncratic risk as "the risk that some plan sponsors (or industries) that have lots of pension underfunding incur severe financial difficulties." They are simulated as the firm-specific variables in PIMS simulation. See section 5.2.5 of PBGC's "Pension Insurance Modeling System", 2010.

and retired participants)³⁰ in each pension insurance program. We believe readers will benefit from a discussion of how each systematic factor impacts the pension insurance programs. For example, persistently low equity returns will increase plan underfunding and cause some multiemployer plans to be insolvent. It will also accelerate the timing of financial assistance payments. For single-employer plans, low equity returns will increase the size of the claims and the probability of bankruptcy. Due to the complexity of PIMS, the readers will benefit from a discussion of how equity returns impact different components of the pension insurance system, resulting in an increase in net deficit. PBGC should consider describing the scenarios that lead to unfavorable results in the Projections Report.

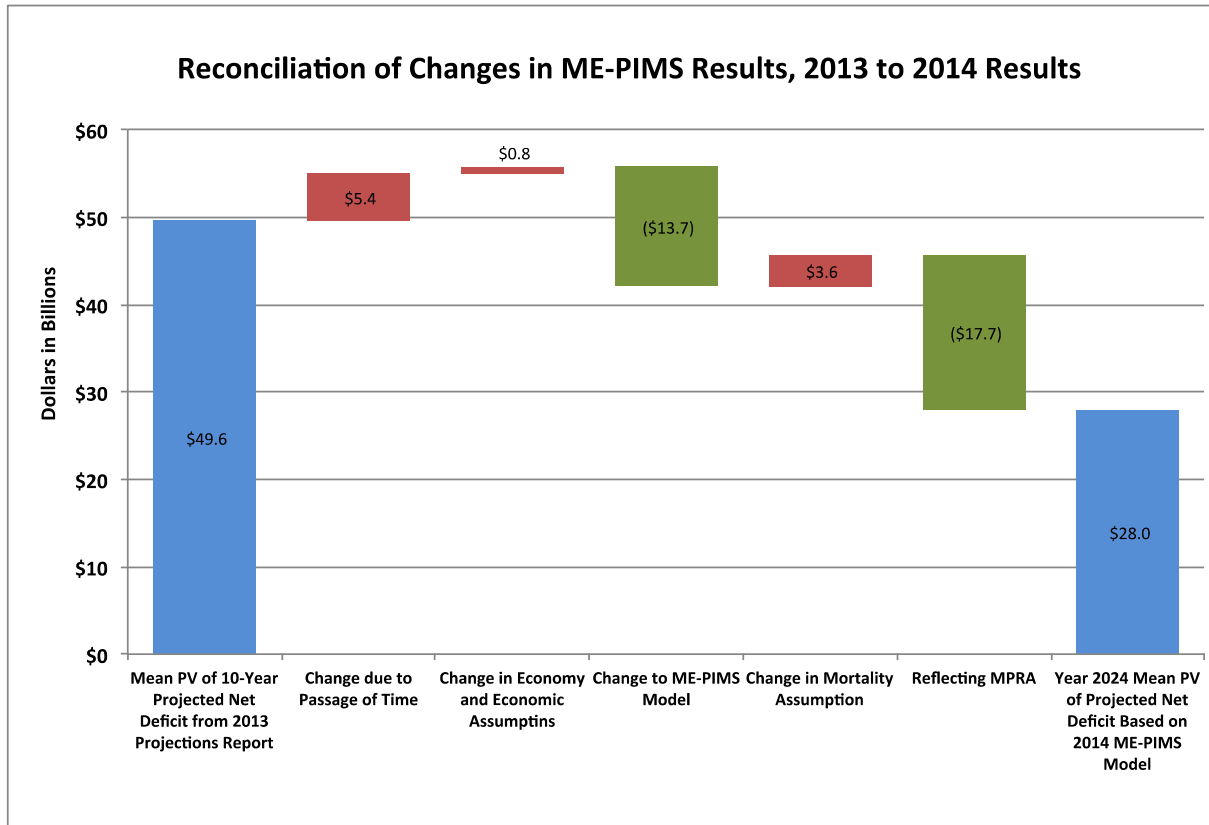
Various displays can be used to illustrate the impact of equity returns on pension insurance programs. For example, the Compound Annual Growth Rate (CAGR) can be calculated for each scenario, and the scenarios can be grouped or ranked by compounded average annual equity returns. Then, the net positions and new claims for scenarios with different CAGR can be compared and displayed. In the section titled “Exploratory Data Analysis for PIMS’s Output,” we suggest other ways to illustrate the relationship between these systematic factors and the pension insurance programs’ net positions. These charts may be useful for internal analysis or incorporated into special studies.

7. The 2014 Projections Report shows a reconciliation of forecast results from 2013 to 2014 for both ME-PIMS and SE-PIMS, followed by a discussion of each item.³¹ These exhibits are helpful for readers to understand year-over-year change and the explanation for each item appears to be adequate. PBGC should consider using a “waterfall chart” to depict the reconciliation of the current and previous year forecast results as this is an effective tool to depict sources of year-over-year change.

³⁰ This risk includes the systematic decline of the defined benefit pension plans for plan sponsors, and the risk of underestimating mortality improvement.

³¹ Ibid., p. 22 – 24, 35 – 36.

Figure R: “Waterfall chart” depicting the reconciliation of changes in ME-PIMS results from 2013 to 2014 results



Additional Recommendations

Following is additional information that we believe will help readers of the Projections Report better understand the main drivers of pension insurance programs’ financial results. It will also help pension professionals create their own evaluation of the financial health of the pension insurance programs.

1. PBGC should consider adding supplemental information on its website that shows the projected assets and liabilities separately in addition to net positions. This information is readily available from PIMS’s output. Breaking out the projected assets and liabilities allows the readers to understand each component’s uncertainties, inter-related relationships and systematic factors and other sources of uncertainties. For example, if an analysis calls for an interest rate change, then examining how projected assets and liabilities change with interest rates can help readers better understand the interest rate risk in the pension insurance programs. Also, the total balance sheet assets and liabilities can be used as an indication of risk exposure.
2. For single-employer programs, PBGC should consider splitting current and future costs in its projections and publish them as supplemental information on its website. The projection of current costs would consist of a projection of assets and liabilities that are already recorded in PBGC’s annual report. The projection of future costs would consist of a projection of assets and liabilities associated with future claims. The projection of PBGC premiums, together with their earnings, can be separated as well. This split would be helpful for policy makers as policy

options and PBGC's Risk Mitigation Program usually impact future costs only.³² This split will also be helpful for technical readers to understand the PBGC risks as the current cost and future cost may have different risk characteristics and require different risk management procedures. For example, the asset allocation can be different between PBGC's assets and the assets of PBGC's insured plans. Thus, the current costs and future costs would have different risk characteristics. PBGC may want to investigate how PIMS can be configured to output these items.

3. PBGC may consider showing certain deterministic forecast scenarios as supplemental information on its website. It is fairly common in risk management software to provide a forecast of financial positions based on conditions existing in a certain historical period.³³ For example, a deterministic forecast scenario might show the financial position if the Asian Debt Crises of 1998 were to reoccur, or if our economy returns to a high inflation regime of the 1970s. In addition, PBGC could determine what its financial position would look like if we have another industry failure with a high concentration of PBGC-insured plans similar to the failure of steel industry or airline industry. PBGC could also perform a projection assuming a large decline in PBGC-insured plans and covered participants as corporate pension sponsors de-risk their pension plans.

Another example comes from the Society of Actuary's Blue Ribbon Panel Report on Public Pension Plan Funding regarding pre-defined stress-testing scenarios.³⁴ Pre-defined scenarios are useful in demonstrating how certain risk factors impact the financial position of a financial entity. Allowing these risk factors to change one at a time, the projections show how these risk factors impact the various components of a complex financial system. Another reason for using pre-defined scenarios is that one can allow the risk factors to correlate in certain ways that are not available from the stochastic scenario set. In order for the forecasts to not detract from the stochastic results presented in the Projections Report, PBGC can publish them separately from the Projections Report, or with an online tool.

4. Some pension practitioners may wish to perform their own independent analysis of the financial health of the pension insurance programs. In order to accommodate this group, PBGC could show benefit payments, financial assistance payments, premiums, expenses and other cash flows that are associated with the liabilities PIMS generates for a baseline scenario.³⁵ This can be published as supplemental information on PBGC's website and would give the pension practitioners a starting point for their analysis.

³² For a discussion of going-forward costs versus legacy costs, see American Academy of Actuaries Issue Brief, "Examining the PBGC Premium Structure", 2012.

³³ For a treatment of scenario analysis, see International Actuarial Association, "Stress Testing and Scenario Analysis", July 2013.

³⁴ Society of Actuaries, "Report of the Blue Ribbon Panel on Public Pension Plan Funding", February 2014, p. 52.

³⁵ Generally speaking, a baseline scenario is a scenario where the economic and demographic experiences are assumed to follow current assumptions with no change in current level of plan benefits. The cash flows are not restricted to 10 years of forecast, but are projected for all future time periods so that the discounted value of the benefit payments gives the benefit obligation. Sensitivities in cash flows, that is, changes in cash flows associated with small changes in certain inputs, such as equity returns, interest rates, or bankruptcy rates, should also be provided.

Comparison to Other Pension Protection Systems

One of the questions asked in the SOW for Subtask 4.9 was whether or not there is output from comparable models from which the PBGC could learn. PBGC is very unique, even within the pension protection realm. Although helpful information can be learned from the other systems, at this point of our evaluation, we have not found output that pertains to PBGC from other systems' reports. Our future reports will include addendums that will include any additional information we find over the next 12 months, especially during our work on Subtask 4.2 and Subtask 4.4. Please note that in Subtask 4.1 our team members provide a summary and commentary of many of the pension protection systems in Canada and Europe.

Quality Assurance and Automation of Output

The first question asked in the SOW for Subtask 4.9 is "Are procedures in place to ensure that the presentation of results accurately reflects the model output?" In answering this question our team looked at existing documentation relating to the PIMS model. This documentation consists of standalone documents and comments embedded within the PIMS and SAS coding.³⁶ One of the documents is a quality control manual that was created after a Management Advisory Report by the Office of Inspector General was published.³⁷ The quality control document summarizes the procedures used to produce the Projections Report and references checklists used in the output process. The projection results are prepared by exporting the PIMS output to a SAS program. The PIMS output is also exported to a spreadsheet. Within the spreadsheet, parallel operations are performed and the results are then compared to the SAS post-processing results. Although there are multiple tools that can be used to check the model output, the spreadsheet created by PBGC staff is appropriate. Managing the changes necessary to the spreadsheet on a year-to-year basis requires a high level of understanding of the system. Although there is documentation within the SAS coding, there does not seem to be adequate documentation on how to modify the spreadsheet to create the current year's Projections Report results. It is our recommendation that one of the tabs in spreadsheet include step-by-step instructions on how to update the spreadsheet. An alternative would be to create a macro that once the PIMS data are imported would make all the necessary modifications to produce the output.

Quality assurance procedures are in place to make sure the output from PIMS is correctly transferred from PIMS to the Projections Report. A quality assurance manual and checklists are used to guide and track the procedures.

Explanation of Reasonable but not Predictive

On page 4 of the 2014 Projections Report, readers are cautioned not to take financial estimates as predictions. The Report also states that the estimates are reasonable and states, "The resulting evaluation represents a reasonable estimate of the possible distribution of projected outcomes relative to the operation and status of these programs."³⁸ Brown's review of PIMS observed that "PBGC clearly states every year in their annual reports that the 'PIMS model is not predictive' and that 'PIMS provides

³⁶ Post-processing SAS codes are in the file "pbf_postprocess_fy14"

³⁷ The document titled "Quality Assurance Procedures for Formal PRAD Reports Utilizing the Pension Insurance Modeling System (PIMS)", version 5.0, issued on August 25, 2015

³⁸ Ibid., p. 38.

a range of possible future outcome.’ However, it seems clear that many readers – both inside and outside government – are treating the projections as predictions, particularly in the absence of any other estimates that have truly detailed quantitative analysis underlying them.”³⁹ How should the readers understand an estimate that is reasonable, but not predictive? What analysis has PRAD performed to assess the reasonableness of the distribution of projected outcomes? If an estimate is reasonable, does it have any predictive value?

To understand reasonable but not predictive estimates, the Projections Report may want to clarify that reasonableness refers to the entire range of outcomes (i.e., the distribution of outcomes) being reasonable, and that there is no prediction as to where on the range of outcomes the actual results may fall. The average, median, and percentiles are attributes of the entire range of outcomes and do not represent any specific outcome. However, when the annual averages are plotted on a graph, for example, on Figure 3 and 4, the tendency is to “connect the dots” and treat it as an outcome. To combat this tendency, especially when the exhibit is meant to convey risks or uncertainties, PBGC may want to consider showing only the range of results, without plotting the mean.

It is not clear from the documentation provided by PBGC what checks of PIMS output are made to back up the claim of reasonableness. While it is important to assess the reasonableness of the input and the processing algorithms of PIMS, we believe it is also helpful to assess the reasonableness of PIMS’s output. As the Inspector General’s report indicated, “The process of dotting does not involve verification of underlying calculations or supporting documentations,” and therefore is not sufficient as a quality control.⁴⁰ Since a complex simulation system may produce unexpected results, PRAD may need to investigate outliers and unexpected results. After PIMS finishes running, is there more analysis performed on PIMS’s output beyond “dotting the numbers”? We suggest that PBGC may want to perform exploratory data analysis on PIMS’s output to assess the reasonableness of the range of outcomes. The use of exploratory data analysis on PIMS’s output is also useful in understanding the main driver of PBGC’s financial results and extreme events. The next section describes some examples of exploratory data analysis on PIMS’s output.

Exploratory Data Analysis on PIMS’s Output

The following discussion shows an example of how the PBGC can further educate the interested parties and build additional confidence into their messages. The following examples are only to show how to build enhanced credibility in the output. Additional analysis of this type will be discussed further in future reports, after the system is better understood by our team.

Our exploratory data analysis of PIMS’s output plots the quantity of interest against other factors to observe relationships and correlations. Each relationship is plotted two times for ME-PIMS, with all scenarios and the worst 5% net position scenarios. The relationships for SE-PIMS are plotted three times as the worst 1% net position scenarios are also included.

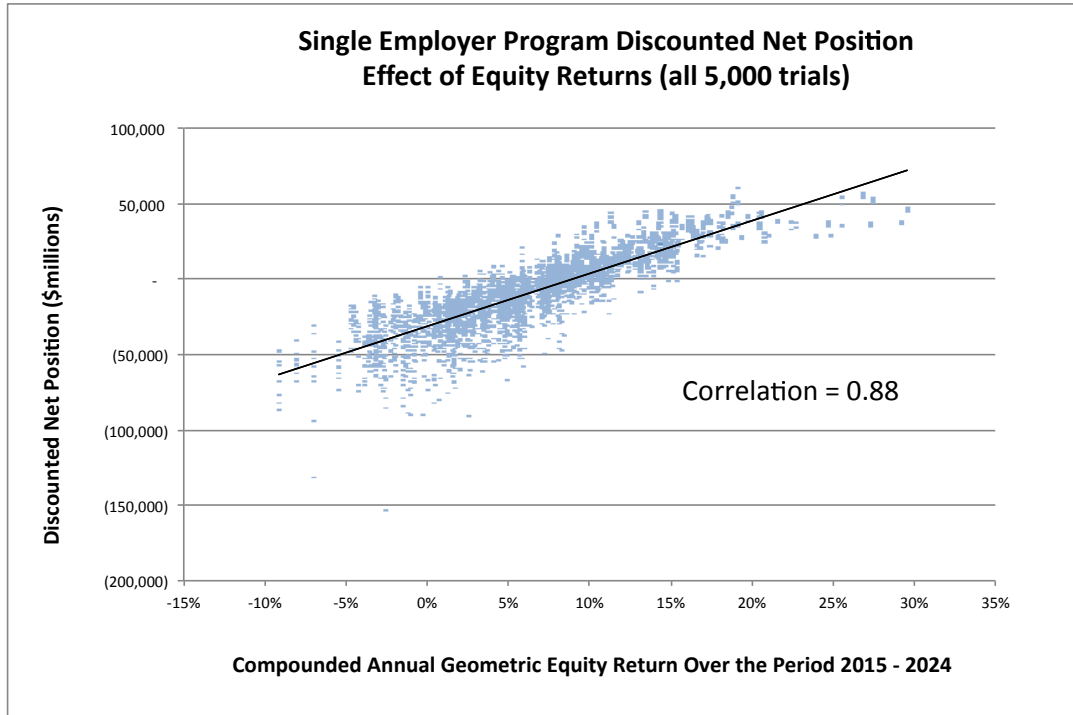
³⁹ Brown, J. et al, “A Review of the Pension Benefit Guaranty Corporation Pension Insurance Modeling System”, 2013, p. 49.

⁴⁰ Pension Benefit Guaranty Corporation, Office of Inspector General, “Ensuring the Integrity of Policy Research and Analysis Department’s Actuarial Calculations”, 2012, p. 8. For this report, a checklist of PIMS post-processing reviews was provided by PBGC.

The Impact of Equity Returns

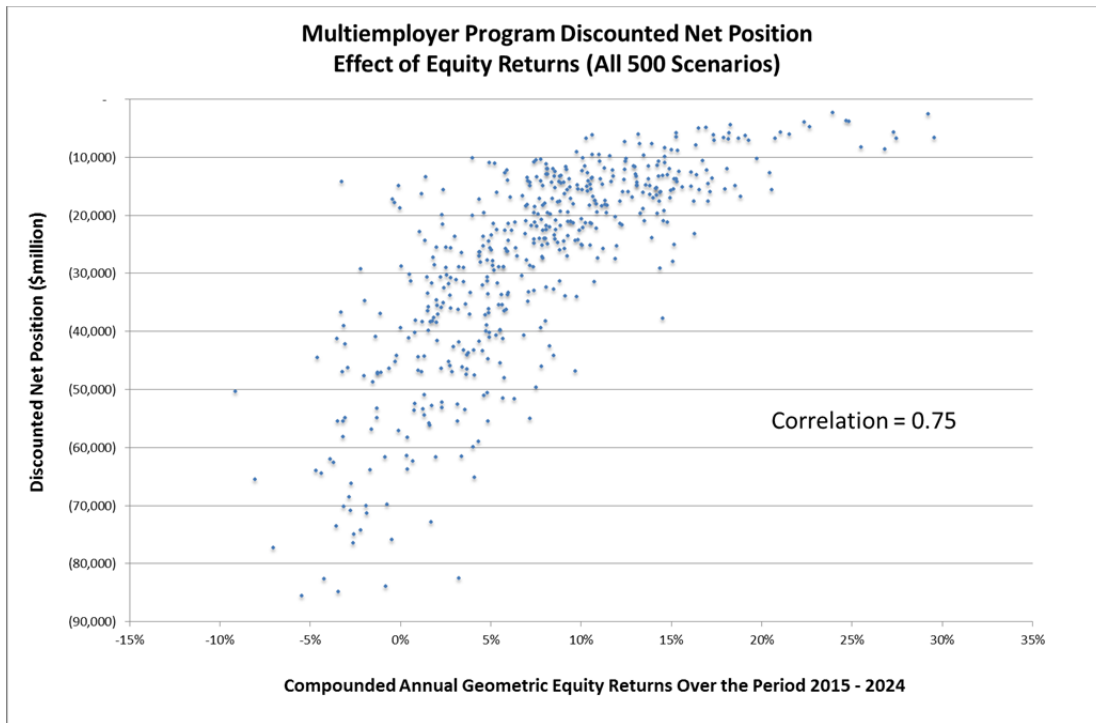
The first series of graphs plot the present value of 2024 net positions of SE programs and post-MPRA ME programs against the compounded annual geometric equity returns of each scenario.

Figure SE – 1: Single-employer program’s net position is strongly correlated with equity returns (the higher the returns, the better the funded position), but volatility increases at the lower end of the return spectrum as there is a wider range of potential deficit outcomes.



Source: Authors’ compilation based on PIMS output for 2014 Projections Report

Figure ME – 1: Multiemployer program’s net position is strongly correlated with equity returns, but the relationship appears to be non-linear and volatility increases at the lower end of the return spectrum.



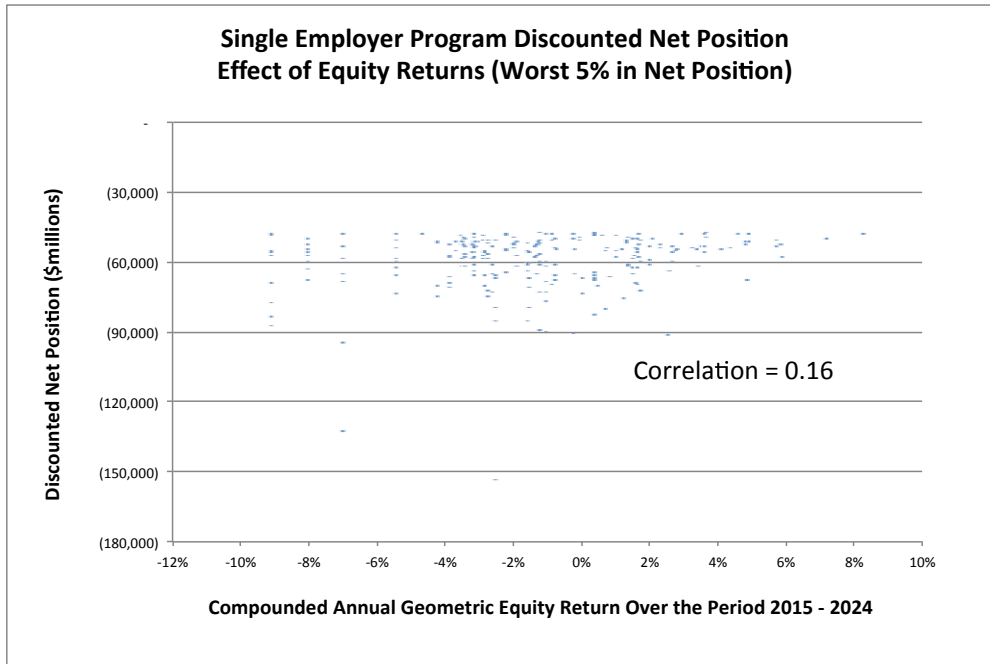
Source: Authors’ compilation based on PIMS output for 2014 Projections Report

As Figures SE-1 and ME-1 show, there is a strong positive relationship between equity returns and the programs’ present value of projected 2024 funded position. Moreover, there is considerable volatility around the trend line with increasing volatility towards the lower return area.

Although the ME graphs show a strong positive relationship, the relationship appears to be nonlinear. Because the ME program only offers financial assistance upon plan insolvency (and does not take over assets to pay benefits), and the level of PBGC premiums and existing assets are low and not invested in equities, high equity returns do not eliminate all of ME deficits. This is shown by the flattening of the net funded positions as equity return increases. Since the assumption of MPRA implementation of suspensions and partitions, and mass withdrawals probability are dependent, in part, on the funded ratio of the plan, it is possible that this is the main cause of non-linearity

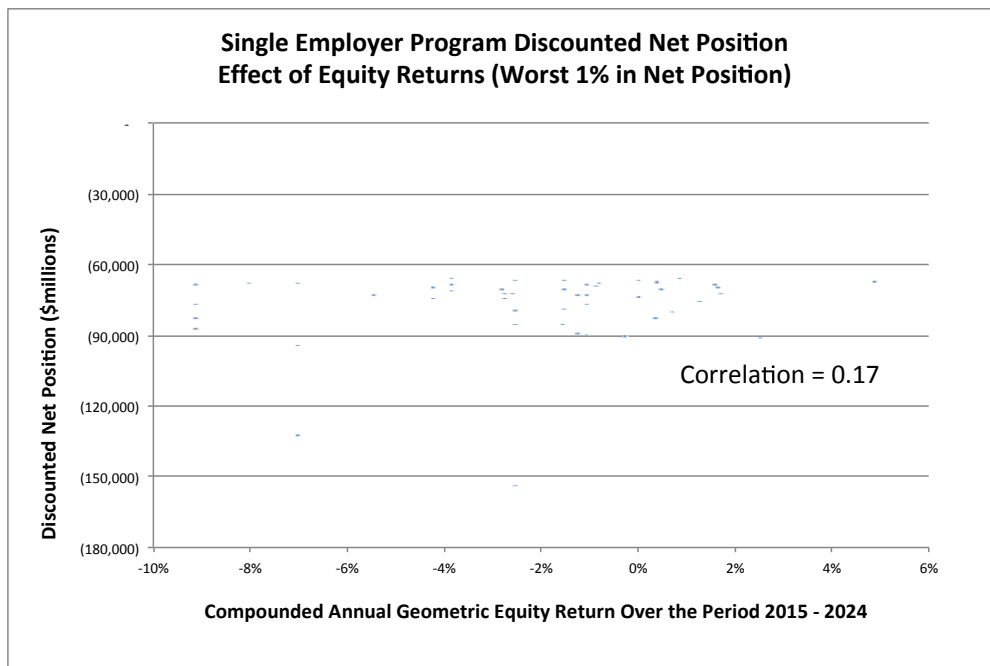
As the next set of graphs shows, the correlation disappears in the worst 5% and 1% (in the case of SE) scenarios.

Figure SE – 2a: At the worst 5% in net positions, the correlation with equity returns is greatly reduced, suggesting that idiosyncratic factors are gaining importance at the worst 5% in net positions and that equity returns have a lesser impact on the net position.



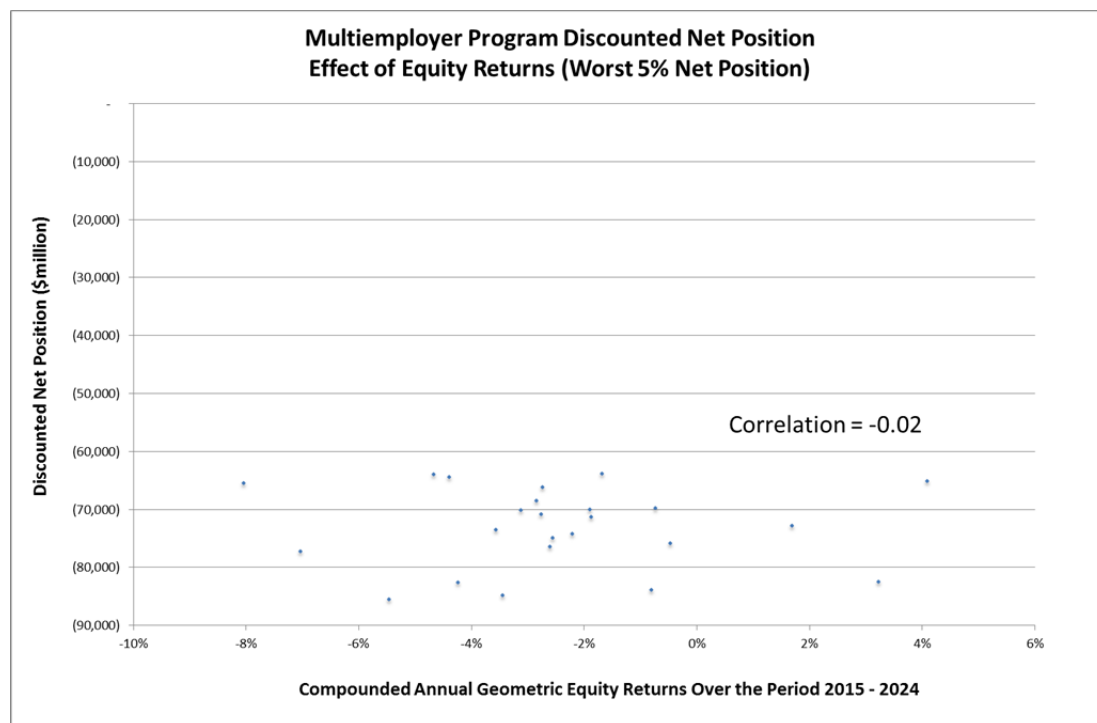
Source: Authors' compilation based on PIMS output for 2014 Projections Report

Figure SE – 2b: At the worst 1% in net positions, the correlation with equity returns is greatly reduced, suggesting that idiosyncratic factors are gaining importance at the worst 1% in net positions, which is very similar to the results in SE-2a.



Source: Authors' compilation based on PIMS output for 2014 Projections Report

Figure ME – 2: At the worst 5% in net positions, the correlation with equity returns is greatly reduced, suggesting that plan sponsor behaviors (such as suspension, partition and mass withdrawal) are more important at the extreme outcomes



Source: Authors’ compilation based on PIMS output for 2014 Projections Report

The lack of correlation between equity returns and net positions at the worst 5% of scenarios suggests that, as equity return falls, other factors become more important. In the case of SE programs, the bankruptcy model and idiosyncratic factors may be the reason for the increased volatility and reduced correlation. In the case of ME programs, plan sponsor behavior (such as MPRA implementation and mass withdrawal) and the volatility in the discount rate may be the reason for the increased volatility and reduced correlation. Further research into the volatility in the low equity return area may be warranted to see if it is consistent with the bankruptcy model and plan sponsor behaviors.

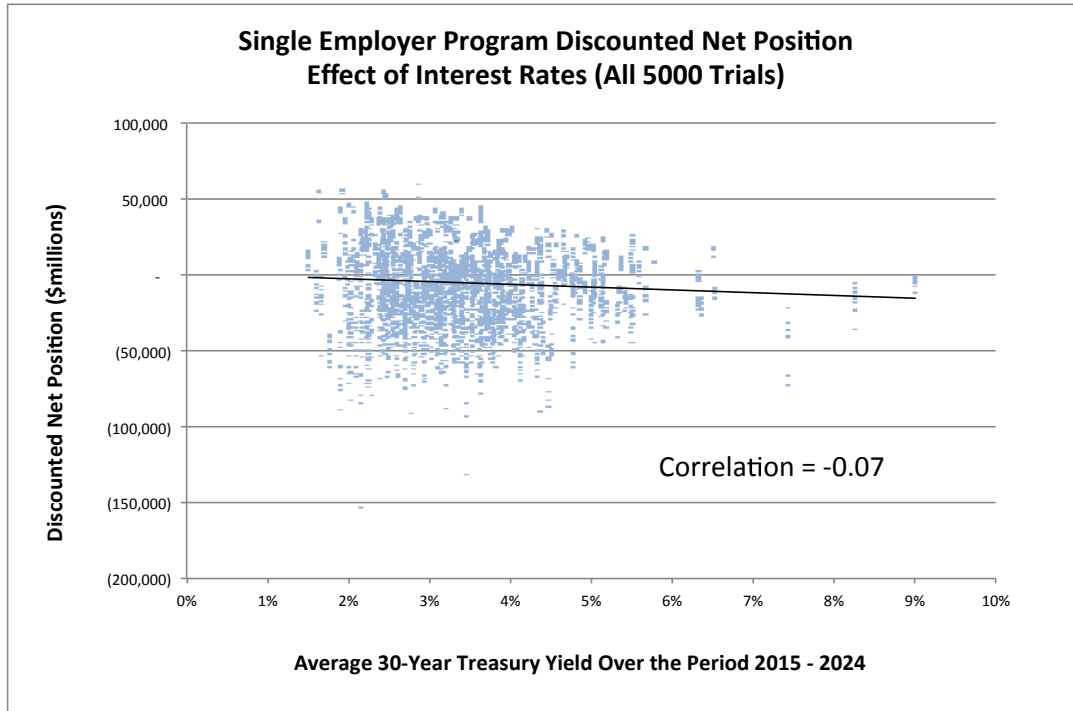
The increased volatility in the low equity return area shows that PIMS modeling does exhibit “fat tail” behavior⁴¹ through the interaction of various modeling assumptions. This is a welcomed result, since PIMS is designed to simulate “fat tail” behavior. However, additional analysis may be needed to ascertain the source of this “fat tail.” Whether the current “fat tail” captures all reasonable extreme outcomes is the subject of other reports in our analyses.

The Impact of Interest Rates

In the next series of graphs (Figures SE – 3, SE – 4a, SE – 4b, ME – 3, and ME – 4), we plot the net positions of SE and ME programs against the geometric average of 30-year Treasury rates. As in our last set of graphs showing equity returns, all scenarios, the worst 5% net position scenarios, and in the case of SE programs, the worst 1% net position scenarios are plotted.

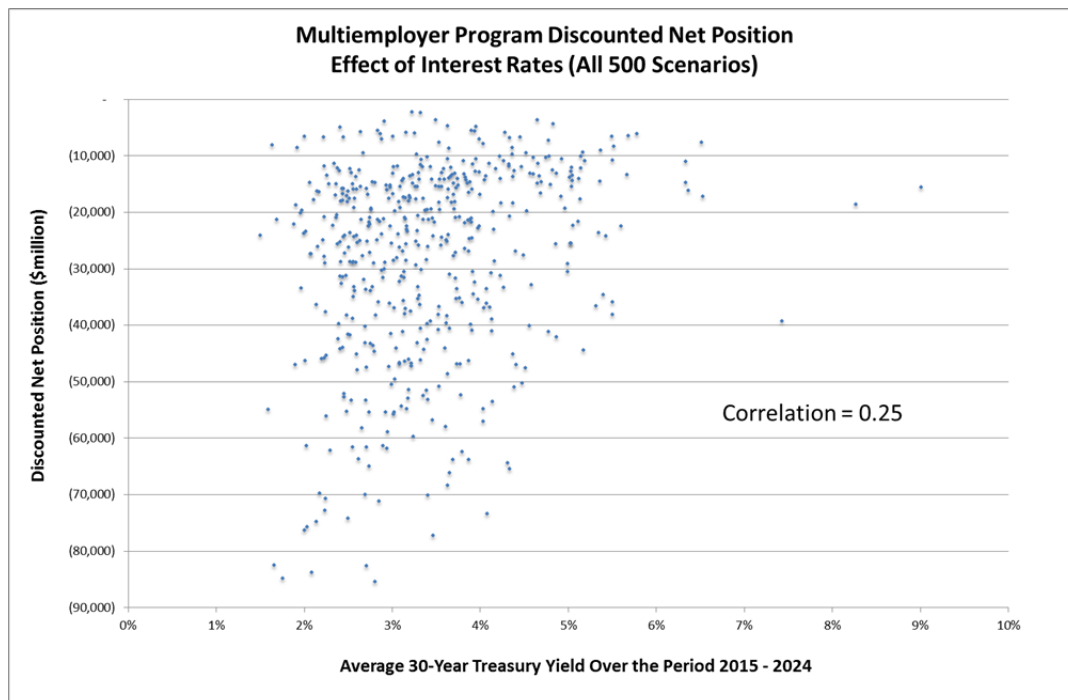
⁴¹ “Fat tail” refers to the skewness in the distribution of outcomes toward unfavorable results. The probability and severity of losses are greater than what would be realized if the distribution of outcomes were symmetric.

Figure SE – 3: The single-employer program’s net position appears to be uncorrelated with interest rates, with increased volatility at lower levels of interest rates



Source: Authors’ compilation based on PIMS output for 2014 Projections Report

Figure ME – 3: The multiemployer program’s net position appears to be weakly correlated with interest rates, with significant volatility at lower levels of interest rates

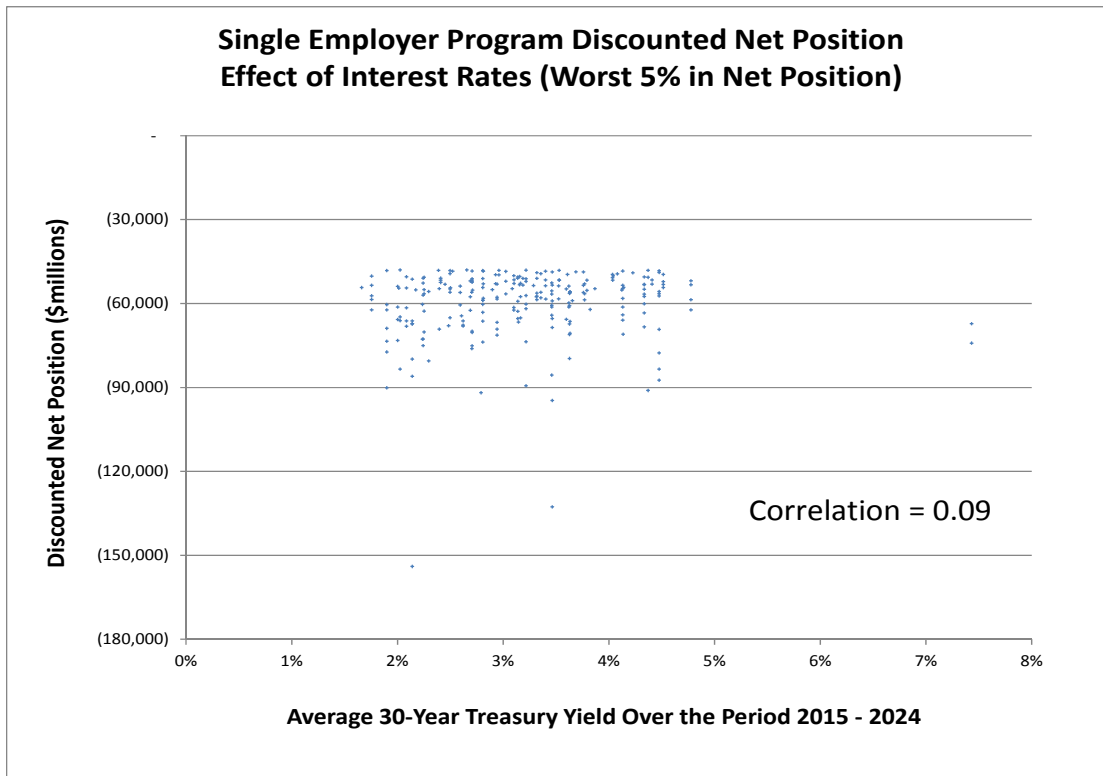


Source: Authors’ compilation based on PIMS output for 2014 Projections Report

With respect to interest rates, SE and ME exhibit different behaviors. Both SE and ME plots show increased volatility at the low levels of interest rates. This is similar to the plots using equity returns. However with the SE program, the discounted net position appears to be uncorrelated with interest rate levels. The lack of correlation of SE discounted net position with interest rates is counterintuitive, because the valuation of liabilities is interest rate sensitive. PBGC may want to investigate this further to determine if the operation of the PBGC SE program implicitly hedges most of its interest rate risks, or if there are interactions in the PIMS modeling that cause this behavior.

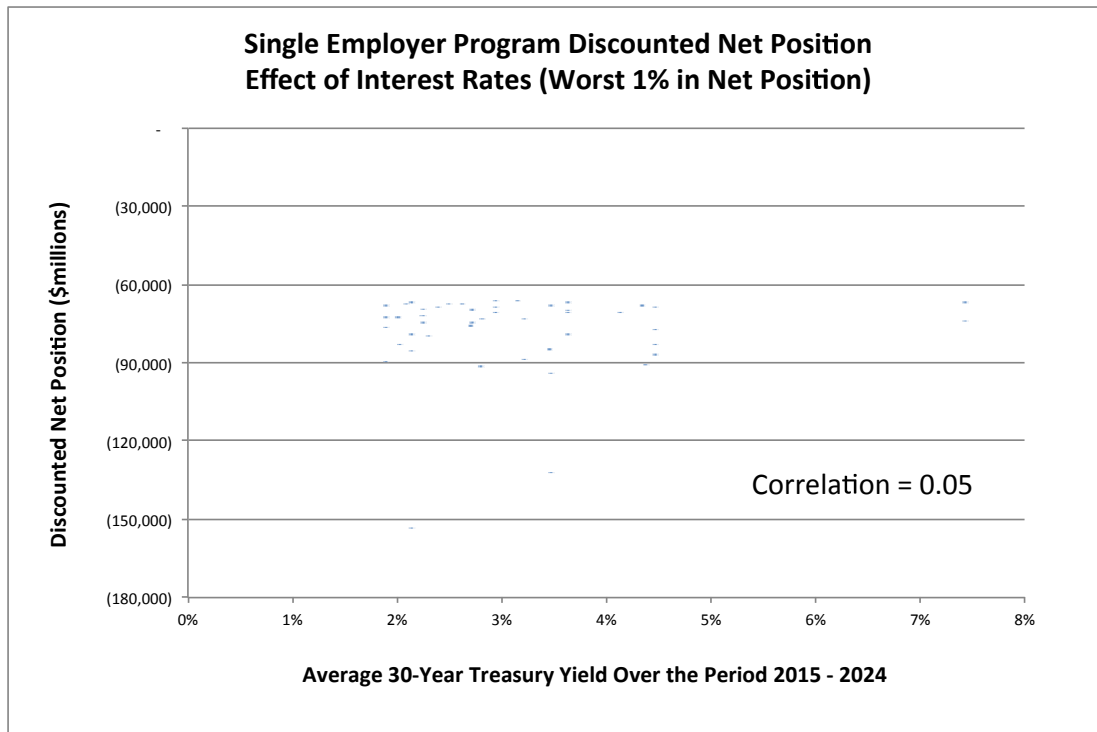
Next, we examine the same plots using the worst 5% of net positions (and in the case of the single-employer program, the worst 1% of net positions.)

Figure SE – 4a: At the worst 5% in net positions, the correlation of net positions with interest is still low



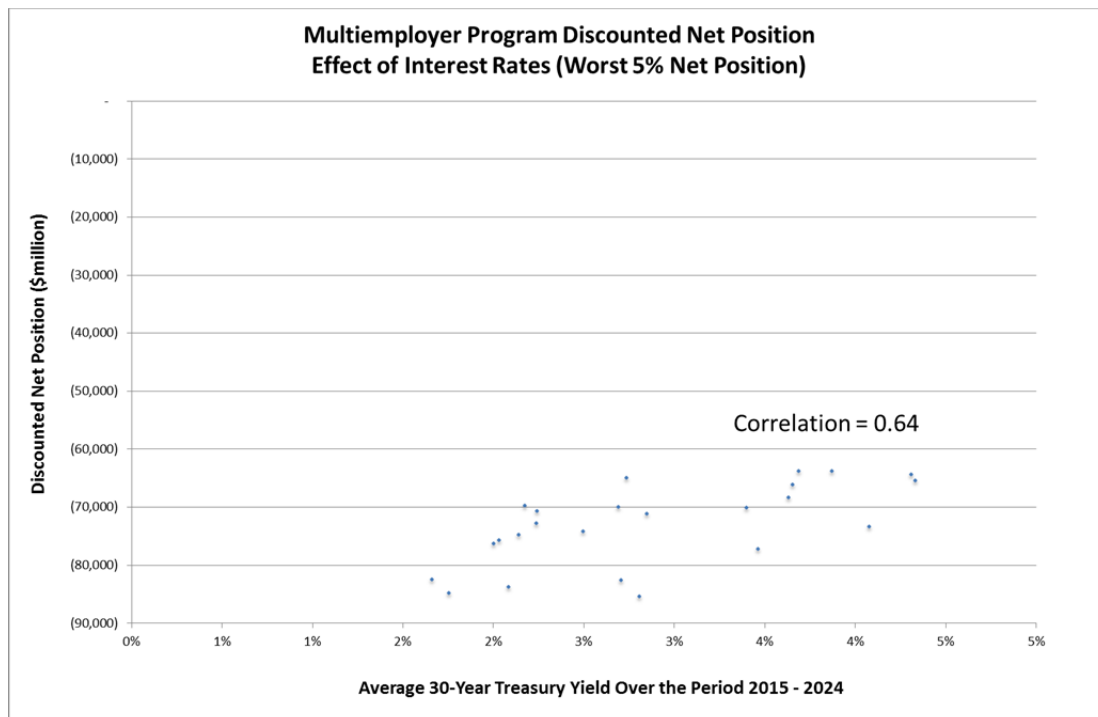
Source: Authors' compilation based on PIMS output for 2014 Projections Report

Figure SE – 4b: At the worst 1% in net positions, the correlation of net positions with interest is still low



Source: Authors' compilation based on PIMS output for 2014 Projections Report

Figure ME – 4: At the worst 5% of net positions, the correlation of multiemployer program's net position and interest rate increases



Source: Authors' compilation based on PIMS output for 2014 Projections Report

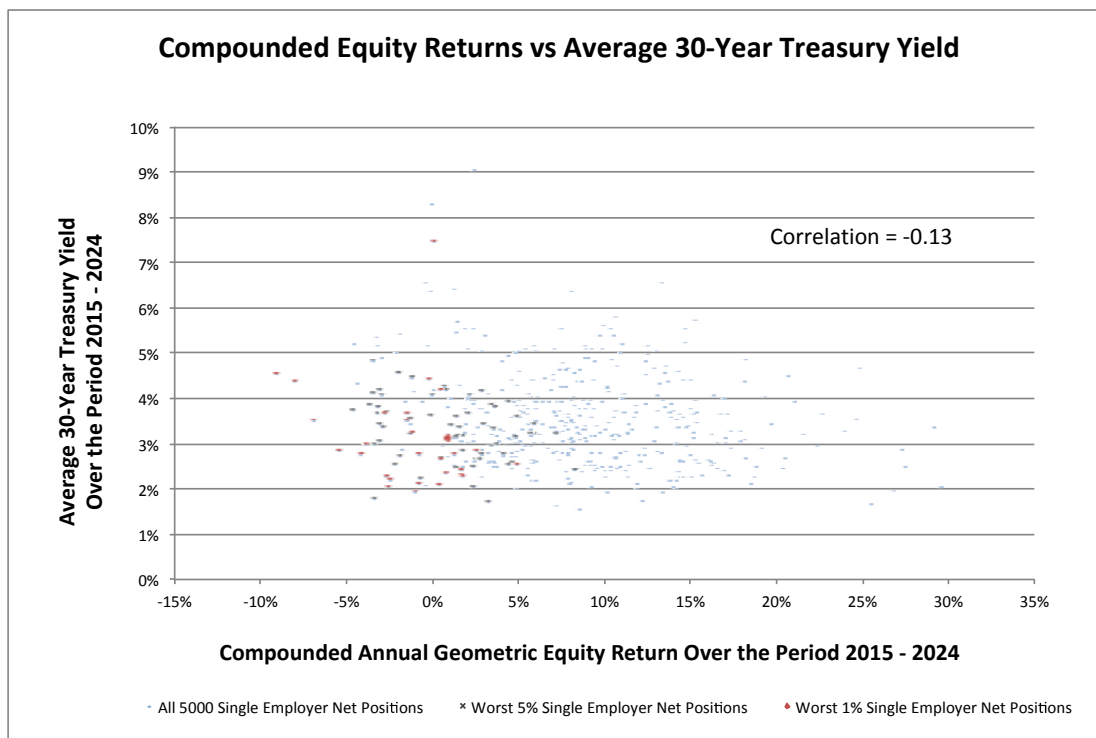
The lack of correlation between interest rates and SE program’s net positions persists in the worst 5% or 1% of the scenarios. Notably even at the worst 1% scenarios, the average 30-year Treasury rate can be as high as 7%.

However, for the ME program, the correlation between the interest rate and its net position is positive. In fact, the correlation increases at the worst 5% of the scenarios. It is likely that in the worst 5% scenarios the MPRA measures are not projected to be implemented; thus, the ME net position becomes more correlated with the valuation of its financial assistance payments. If this turns out to be the case, this is yet another way of showing the impact of MPRA.

Visualizing Equity Return and Interest Rate Scenarios

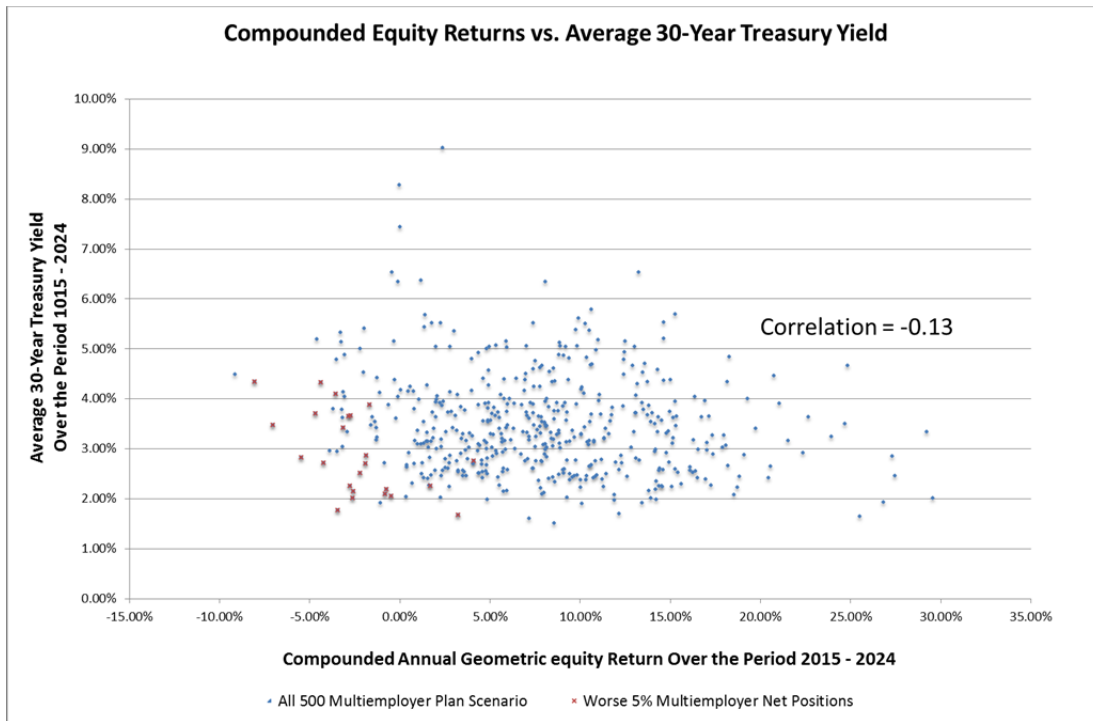
In the next set of graphs (Figures SE – 5 and ME – 5), we plot the average equity returns against average Treasury yields. The worst 5% net position scenarios and the worst 1% net position scenarios are indicated with different symbols. By identifying the worst 5% and 1% net position scenarios on the same graph, we can visually inspect the macroeconomic assumptions that produce the worst net positions.

Figure SE – 5: The assumptions that give rise to the worst 5% or 1% of the single-employer program’s net positions are at the lower left corner of the assumption set.



Source: Authors’ compilation based on PIMS output for 2014 Projections Report

Figure ME – 5: The assumptions that give rise to the worst 5% of the multiemployer program’s net positions are at the lower left corner of the assumption set.



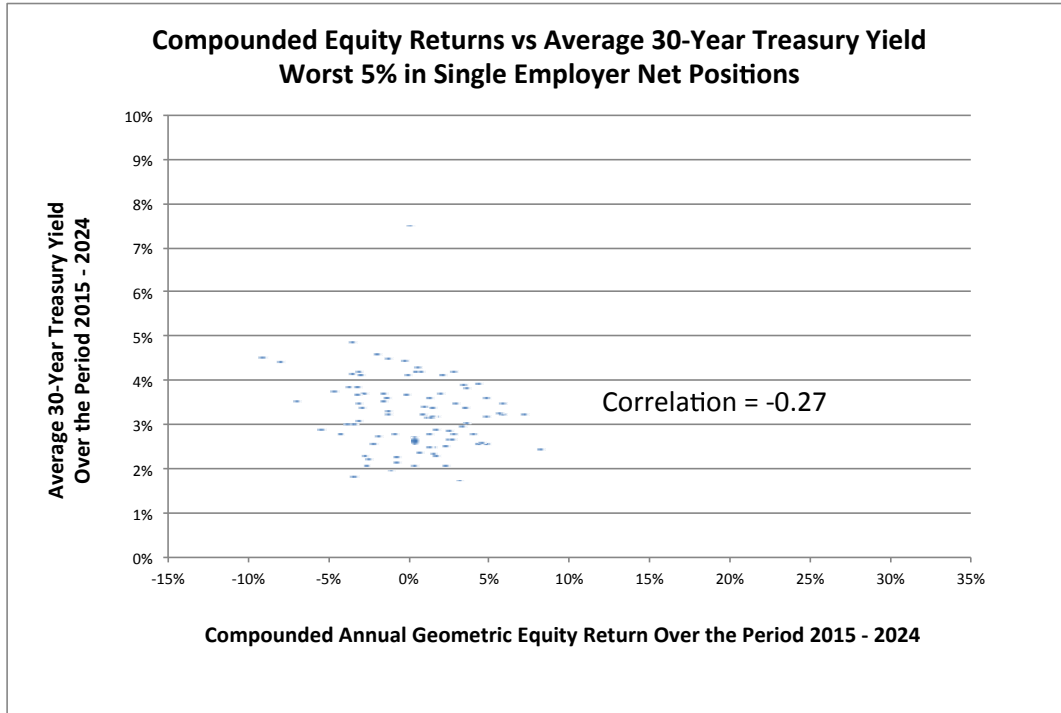
Source: Authors’ compilation based on PIMS output for 2014 Projections Report

As expected, in the worst 5% net position scenarios, the cluster of points move to the left, consistent with the positive correlation of net positions with equity returns. The correlation between equity returns and interest rates is slightly negative when we consider the entire scenario set.

However, the next set of graphs shows that the negative correlation between equity returns and interest rates increases significantly, especially in the ME program when we consider the worst 5% net position scenarios. This may suggest that the “perfect storm” in the 2000s where both Treasury yields and equity returns moved lower together may not be part of the stochastic scenario set, or this “perfect storm” scenario does not produce worse results because of other mitigating factors. This type of result shows the benefit of using a pre-defined scenario where both the equity returns and interest rates move lower together.

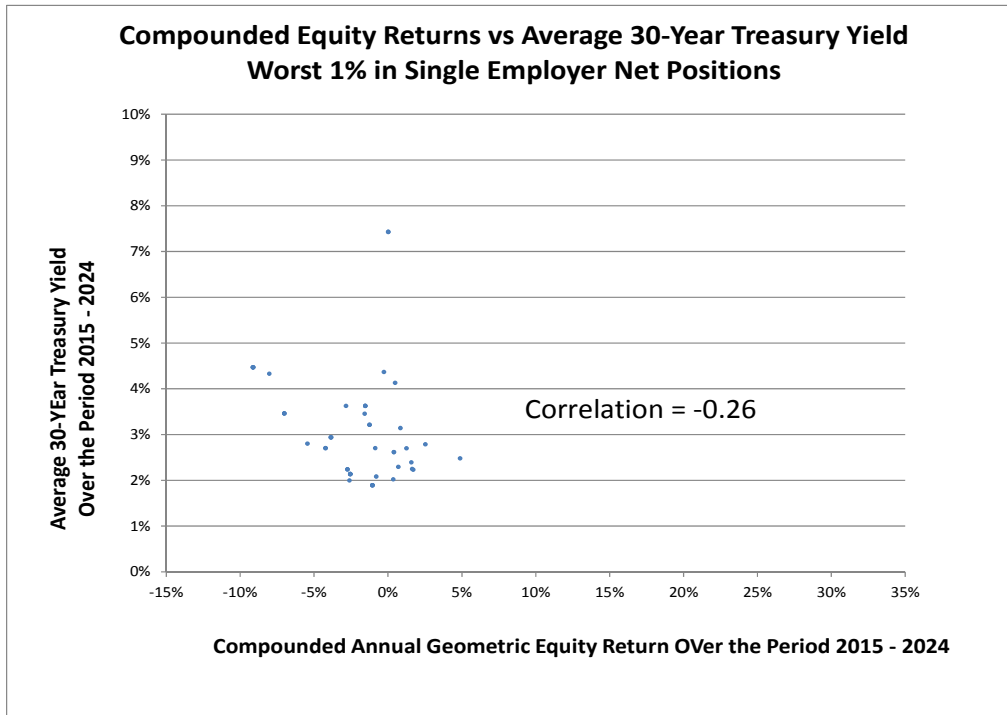
Similar graphs can be done with respect to most variables from PIMS’s output, for example, new claims.

Figure SE – 6a: Negative correlation between equity returns and interest rates increases at the worst 5% scenarios



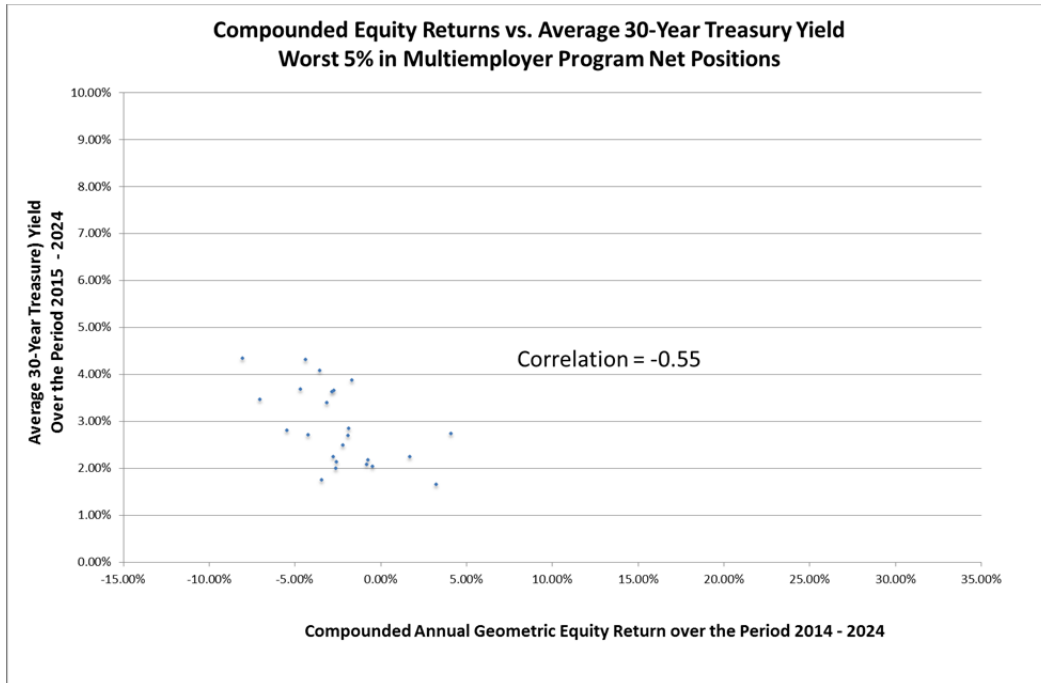
Source: Authors' compilation based on PIMS output for 2014 Projections Report

Figure SE – 6b: Negative correlation between equity returns and interest rates increases at the worst 1% scenarios



Source: Authors' compilation based on PIMS output for 2014 Projections Report

Figure ME – 6: Negative correlation between equity returns and interest rates increases at the worst 5% scenarios



Source: Authors' compilation based on PIMS output for 2014 Projections Report

Bankruptcy Modeling Within a Macroeconomic Scenario

In our last set of graphs, Figures SE – 7a through 7f show the projection of discounted net positions of the 10 different “cycles” within a macroeconomic scenario for six macroeconomic scenarios. For the single-employer program, PIMS models 10 bankruptcy scenarios for each macroeconomic scenario. These bankruptcy scenarios are called “cycles.” Examining the cycles within each macroeconomic scenario allows one to inspect the variability of results due to bankruptcy modeling. The dotted lines in the following graphs represent the 15th and 85th percentile outcome for each projection year.

Figure SE – 7a: Within a macroeconomic scenario, the divergence of projected net position is much more pronounced when the net position is trending down

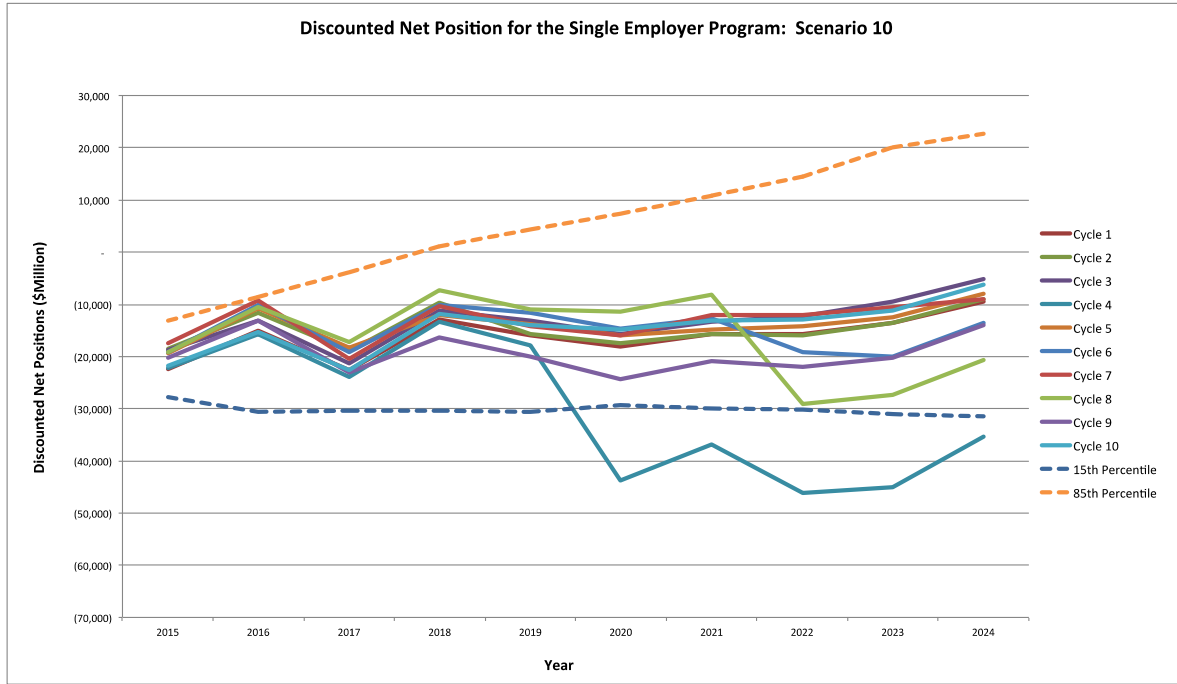


Figure SE – 7b

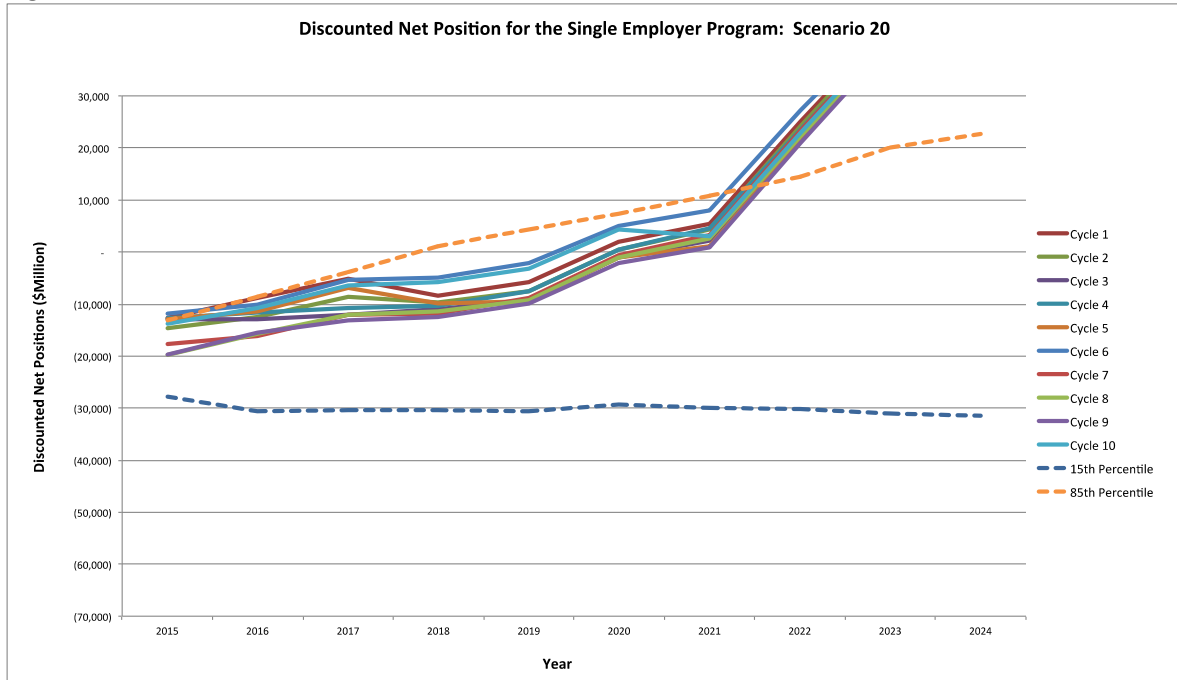


Figure SE – 7c

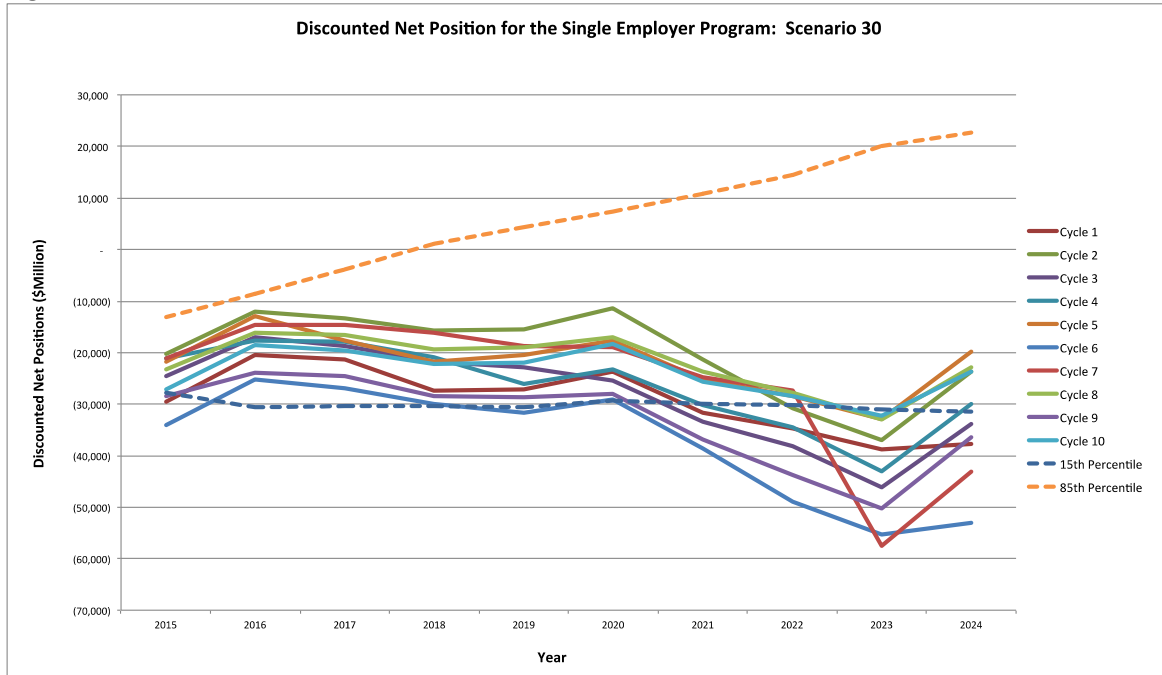


Figure SE – 7d

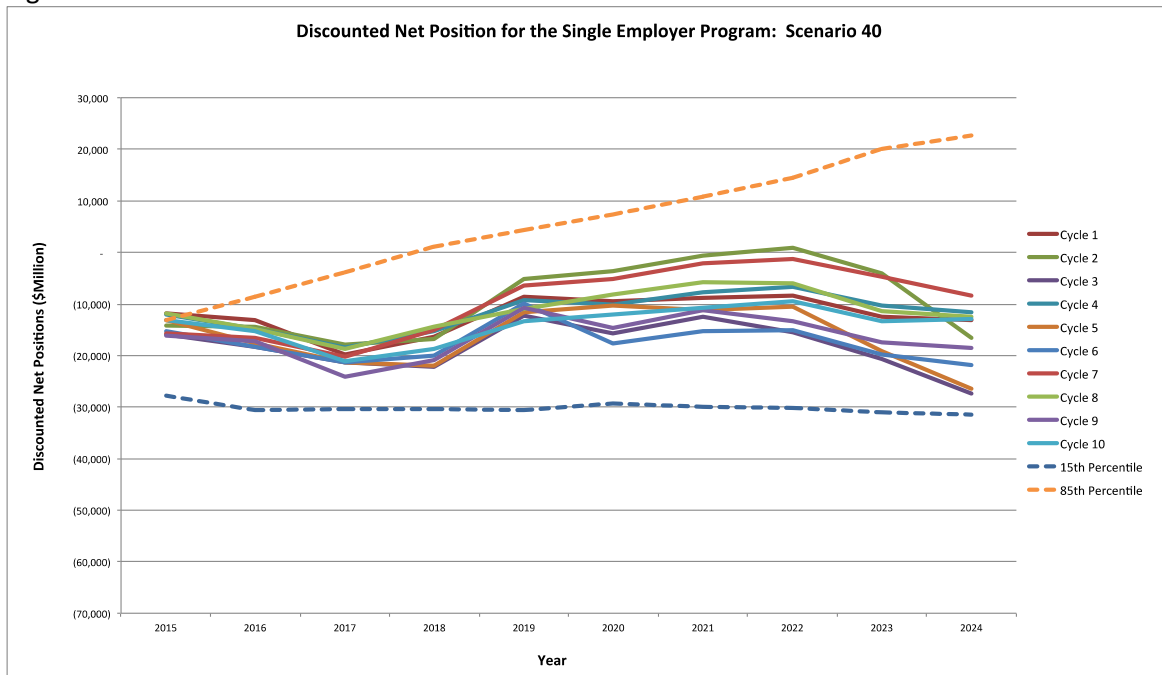


Figure SE – 7e

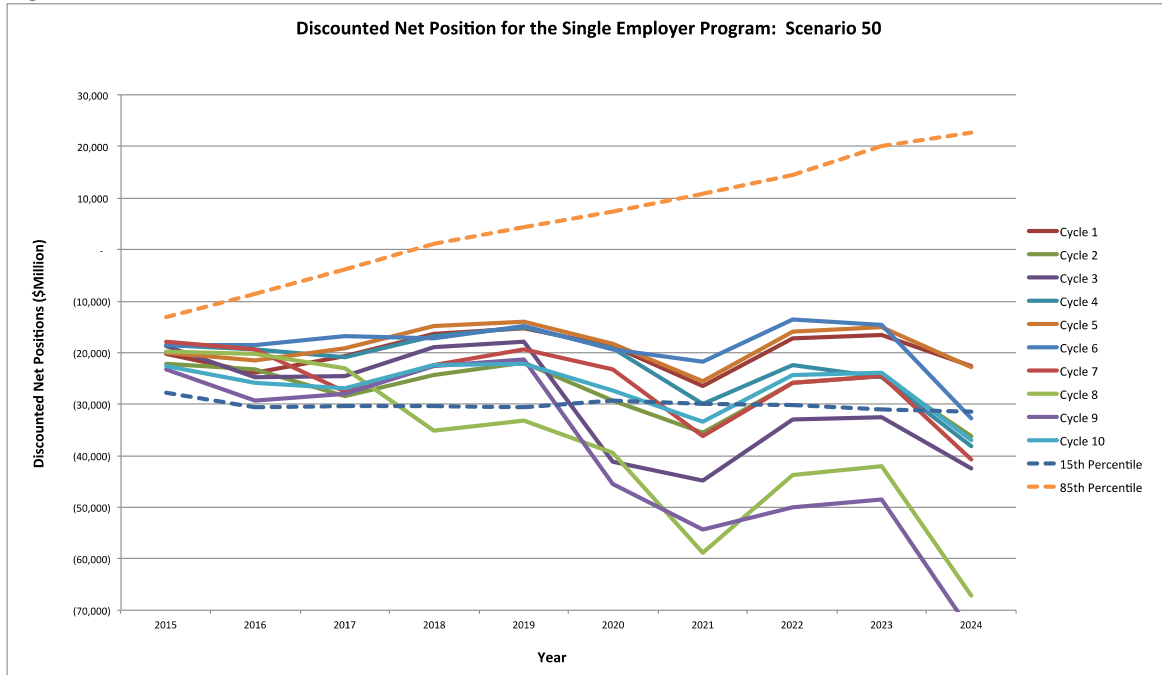
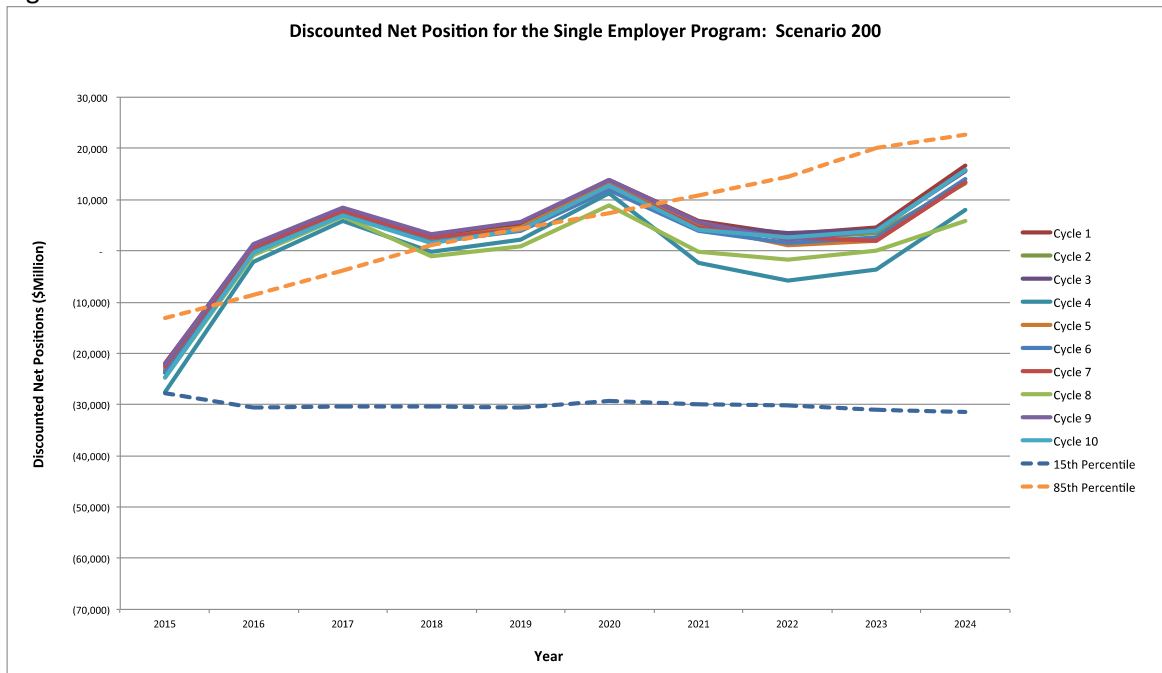


Figure SE – 7f



Source: Authors' compilation based on PIMS output for 2014 Projections Report

These graphs show that within the same macroeconomic scenario, there can be significant variability in discounted net positions due to different bankruptcy cycles. Furthermore, the variability is much more pronounced when the discounted net position is trending down. For example in the graph labeled “Scenario 50,” the results for different cycles diverge after three years, but in the graph labeled “Scenario 20,” the results for different cycles remain closely together throughout forecast. Since a fully-funded plan will not result in claims against PBGC even if the plan sponsor is bankrupt, these charts are consistent with the operation of the pension insurance system.

Another interesting feature is that in most macroeconomic scenarios, the forecast results of some cycles cross over the 15th or the 85th percentile line sometime during the next 10 years. Although the 15th to 85th percentile range represents a 70% probability that the forecasted result will stay within that range for a given year, the probability that the results will stay within that range every year is much lower over a 10-year projection period. The tendency is to treat outcomes outside of this range as unusual, something that is not typical. However, it is more likely than not that the actual outcome will lie outside this range sometime during the 10-year projection period. This is an aspect of volatility that many readers do not realize. Thus PBGC may want to include similar graphs to help the reader understand volatility. It is also possible to construct an online tool where the users can interactively step through different scenarios. We believe this would be a helpful companion to the Projections Report.

As mentioned above, the graphs in this section are presented as examples of how exploratory data analysis on PIMS’s output can be useful for:

- a. understanding the key drivers of the pension insurance program’s financial results
- b. performing reasonable checks on PIMS’s output before it is published
- c. understanding the drivers of extreme cases or “tail event” when the plot of worst 5% or 1% is compared with plots of all scenarios.

PBGC should consider incorporating these types of analysis into its PIMS post-processing.

Discussion of Risk and Extreme Outcomes

The purpose and goals of the Projections Report are to help interested parties identify and quantify the risk exposure, which leads to an understanding of the financial health of PBGC’s insurance programs. In the 2014 Projections Report, the term “uncertainties” and the phrase “range of outcomes” are used consistently throughout the report. While “uncertainties” and “range of outcomes” are accurate descriptions of the materials presented, we believe the readers will also benefit from a discussion of risks.

In financial literatures, risk is often linked to variability. However in risk management, risk is more about avoiding unfavorable extreme outcomes rather than understanding the range of outcomes.⁴² Before the last financial crisis, it was customary for the financial industry to plan for the worst 1% or 5% of the outcomes.⁴³ For our discussion, we will consider the worst 5% of the outcomes (or worst 1% in the case of the SE program) as the extreme outcomes.

⁴² For a perspective on pension risk management, see Huang, L., and Inglis, R. Evan, “Pension Management from a Risk Management Perspective”, session 22 IF, Society of Actuaries Annual Meeting & Exhibit, 2014.

⁴³ McNeil, A., and Frey, R., “Estimation of tail-related risk measures for heteroscedastic financial time series: an extreme value approach, *Journal of Empirical Finance*, 2000, p. 271 – 300.

The readers of the Projections Report will benefit from a discussion of how the extreme outcomes arise in PIMS simulations. As we have shown through the above exploratory analysis on PIMS's output, the idiosyncratic factors seem to become more important as we look at extreme outcomes. As a result, PBGC should explain how extreme outcomes arise in PIMS simulations after investigating how the bankruptcy model exacerbates the net position of the SE program when the asset returns are low, and how the MPRA mitigates the effect of low asset returns in the ME program.

Understanding Rare but Catastrophic Events

The extreme outcomes are rarely observed and do not occur regularly or in the same way. In recent literature, these extreme outcomes are called "Black Swan" events.⁴⁴ In PBGC's 1998 Databook, there is a very helpful discussion of rare but catastrophic events and how they are modeled by PIMS. We suggest that if PBGC decides to include a discussion of extreme events in the Projections Report, it would incorporate this material into the discussion.

Looking only at the worst 5% of simulated scenarios does not necessarily give readers a good sense of how rare, but catastrophic, events can occur. This is because rare but catastrophic events usually lie outside the stochastic scenario set. They may represent events that PIMS cannot reasonably be expected to capture - sometimes referred to as "model risk." Often it is more instructive to look at historical events and consider how PBGC may fare if these events were to happen today (pre-defined scenarios). For example, what would PBGC's net deficit look like if there was a systemic industry downturn impacting a large number of PBGC-insured plans and participants? Thus, we suggest that using pre-defined scenarios that mimic certain historical periods or events may be a better way to communicate rare but catastrophic events. Similarly using pre-defined stress scenarios that lie outside of the stochastic scenario set may give readers understanding as to how the rare but catastrophic events can occur.⁴⁵

Rare but catastrophic events are by their nature usually unforeseen events, but not necessarily unforeseeable. Understanding the impact of such events may require a number of different risk exposure measures. Focusing on the extreme macroeconomic scenarios and historical precedents is one way to understand rare but catastrophic events, but to plan for such events, different measures of underfunding may be useful. As mentioned prior, the PBGC's Databook has helpful information, such as the total underfunding of the insured plans, the "reasonably possible" liabilities, industry concentrations of insured plans, and the unfunded PBGC variable premium liability. While these measures may not be predictive of future claims against PBGC, they are useful when discussing rare but catastrophic events, at least over a short-term horizon.

For example, before the actual failure of steel or airline industry, many of the companies had been downgraded, and their exposures were included in the "reasonably possible" category. On page 31 of the 2014 Projections Report, it states, "No single underfunding number or range of numbers is sufficient to evaluate PBGC's exposure and expected claims over the next 10 years."⁴⁶ We agree. However, for

⁴⁴ For a discussion on "Black Swan", see Taleb, N., "The Black Swan: The Impact of the Highly Improbable", 2007. On the risk management aspect of Black Swan events, see Taleb, N. et al, "The Six Mistakes Executives Make in Risk Management", Harvard Business Review, 2009.

⁴⁵ International Actuarial Association's report, "Stress Testing and Scenario Analysis", July 2013, provides good perspectives on using deterministic scenarios.

⁴⁶ Ibid., p. 41.

the purpose of discussing rare but catastrophic events, it may be helpful to explore how to include them in order for the readers to have a fuller picture of the potential risks to PBGC.

Discussion of the “Fat Tail” in Projections Report

As described previously, the PIMS’s output exhibits “fat tail” behavior. This can be seen through the presentation of distributions in the Projections Report (for example, Figures 5, 6, 8, 9, 14, 15 of the 2014 Projections Report), or through the type of graphs in the “Exploratory Data Analysis on PIMS’s Output” section. We define “fat tail” to mean the skewness of distribution of outcomes. The 2014 Projections Report states that the distribution of outcomes is potentially skewed.⁴⁷ However, the Projections Report does not discuss further why the distribution is skewed or how much skewness is in the distribution.

We believe the readers will benefit from a general discussion of how the distribution of outcome is skewed. In financial literature, skewed distribution can arise because of:

- stochastic volatility of asset returns;
- non-normal distribution of certain variables; or
- increasing volatility and correlation at unfavorable scenarios⁴⁸

In a complex simulation system such as PIMS, the fat tail may be due to interactions of underfunding, bankruptcy modeling, and sponsor behavior.⁴⁹ We believe a general discussion of these interactions in the Projections Report is appropriate.

Since the Projections Report displays the full distribution of outcomes, it can also report the results at the worst 5% or 1% level. PBGC may also want to consider using the type of graphs in the “Exploratory Data Analysis on PIMS’s Output” section to show the impact of volatility and idiosyncratic risk at unfavorable scenarios that can explain the “fat tail” behavior.

The measurement of the skewness of the distribution and their associated commonly used risk management measures would be useful if PBGC decides to discuss risks in the Projections Report. Such measures include:

- a. Semivariance of the distribution: the variance of the outcomes below mean.⁵⁰
- b. Value at risk (VaR): given a time horizon and a probability p , Value at risk (VaR) is defined as the threshold loss level so that the probability that losses over this time horizon will exceed this threshold level is p . The time horizon is usually one year and the probability can be 5% or 1%.⁵¹

⁴⁷ Ibid., p. 4.

⁴⁸ For a discussion of non-normal returns, see Sheikh, A., “Non-normality of Market Returns”, J.P. Morgan Asset Management, 2009. For a different view on non-normality, see Esch, D., “Non-Normality Facts and Fallacies”, 2009.

⁴⁹ See PBGC, “Pension Insurance Modeling System”, 2010, and PBGC 1998 Databook for a description of the interactions between underfunding, bankruptcy modeling and sponsor behavior.

⁵⁰ For a discussion of semivariance and other downside measures, see Nawrocki, D., “A Brief History of Downside Risk Measures”, The Journal of Investing, 1999, p. 9 – 25.

⁵¹ For a treatment of value at risk, see Sweeting, P., Financial Enterprise Risk Management, Cambridge University Press, 2011.

- c. Conditional Value at Risk (CVaR), or sometimes referred to as conditional tail expectations: the expected loss given an event outside the probability level has occurred. This measure usually gives more information on the fat tail than VaR.⁵²

These measures of skewness may not be beneficial for general readers of the Projections Report because general readers do not usually have a good intuition on these measures. We believe graphs are better ways to communicate to general readers. However, these measures can be very useful to pension and other financial professionals as they try to assess the risk of PBGC's pension insurance program.

Conclusion

In this report we have evaluated the presentation of PIMS output, including the process of converting PIMS output to the Projections Report. We find that the mechanics used to convert the PIMS output to information presented in the Projections Report are sound. Additional disclosures and analysis for the report, and documentation for the process, are suggested, but overall, our team feels the output presented in the Projections Report is reasonable.

Documentation for the output process is primarily in the SAS code and on checklists. Our recommendation is to combine all steps required to take the PIMS output to finalizing the Projections Report into one document.

Although there are quality assurance steps for the mechanics of the output and there are checks performed during the PIMS modeling process, we did not see a process by which the results are tested for overall reasonableness, that is, whether the modeling of the pension insurance system performs reasonably under different economic conditions. We have provided a few example of how results can be further reviewed.

Confidence in the results is important to all interested parties. We have provided a few examples of how the confidence can be increased by expanding discussions of the key drivers of changes to the year-to-year results and providing additional disclosures for pension professionals to make their own projections.

Additional recommendations include discussions regarding the reasonableness of the results with charts showing correlations between certain variables and the system's deficit, expanded discussions regarding the "fat tails" and the skewness that is inherent in the modeling and scenario analysis using deterministic, pre-determined scenarios or other stress testing scenarios to show movement in the results based on historic financial events.

This report is part of a comprehensive review of PBGC's Pension Insurance Modeling System. The conclusion reached in this report may be modified or enhanced as other reports of this comprehensive review are completed.

⁵² For a discussion of conditional tail expectations, see Artzner, P. et al, "Coherent Measures of Risk", *Mathematical Finance*, 1999, p. 203 – 228. See also Mhlanga, I., "Extreme conditional value at risk: a coherent scenario for risk management", 2013. and Dechert, M., Martin, E. et al., "Improving the Business of Risky Business", 2010. For a discussion of extreme value theory, see Dupuis, D., Jones, B., "Multivariate Extreme Value Theory And Its Usefulness in Understanding Risk", *North American Actuarial Journal*, 2006, p. 1 – 27.

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