Pension Insurance Modeling System (PIMS) Multi Employer (ME) Model

Peer Review

Date created: 2023-10-15
Last updated: 2024-06-24
Document version: [1.0]

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Executive Summary

1. Summary of the peer review assessment performed

The Moving Ahead for Progress in the 21st Century Act (MAP-21 requires PBGC to contract with a capable agency or organization that is independent of PBGC to conduct annual peer reviews of Single Employer (SE) Pension Insurance Modeling System (PIMS) and Multi-Employer (ME) PIMS.

The current review scope covers a comprehensive peer review of SE PIMS and ME PIMS and particularly focuses on the high-level conceptual soundness and governance review of inputs, methodology and assumptions, operations, functionality and performance and a review of the completeness of documentation for these models. In addition to recommendations from this review, the objective of the review is also to provide PBGC with best practices on model governance.

This document covers the review of ME PIMS. The review of SE PIMS is covered in a separate document.

2. Peer review observations and recommendations

The following table summarizes the observations and associated recommendations that were identified as part of the peer review.

TABLE 0-1: PEER REVIEW RECOMMENDATIONS

ID	Section, Sub-section	Observations and Recommendations	Priority[1]
R01	**Section:** Conceptual framework - data **Sub-section:** Data input: variable selection **Related chapter:** 2.2	**Observation:** The inflation rate is derived from the nominal interest rate by adjusting a real interest rate component. While the nominal interest is modeled stochastically, the real interest rate is assumed to be an input parameter and is held fixed across all simulation periods. This might lead to the outcomes being less sensitive to interest rate changes **Recommendation:** Perform an impact assessment through sensitivity analysis to understand the materiality of this variable. Further, investigate the feasibility of stochastic approach for real interest rate modeling to reflect the interest rate changes	Low
R02	**Section:** Conceptual framework - data **Sub-section:** Data input: variable selection **Related chapter:** 2.2	**Observation:** The yield on corporate bond is equal to the treasury bond yield plus a spread that reverts, over the projection period, from its starting point of a fixed spread of 110 basis points. **Recommendation:** While the approach of modeling corporate yield using a spread over the treasury yield is common, stochastic modeling of the spread can be considered to capture the actual movement of corporate bond in the real world.	Low

R03	**Section:** Conceptual framework - methodology **Sub-section:** Plan behavior assumption **Related chapter:** 2.4	**Observation:** Currently, there is no formal process defined where assumptions are reviewed, challenged, and updated as appropriate on a periodic basis. Potentially several of the ME plan behavior assumptions (e.g., benefit suspension and partitions, etc.) and capital market assumptions (e.g., correlation between Treasury yield and equity returns, etc.) have not been updated in the recent past **Recommendation:** Establish a systematic assumption review process to review the assumptions on a periodic basis and sufficiently document the review process that includes materiality, sensitivity testing, and changes to assumptions used in the ME model	Medium
R04	**Section:** Conceptual framework - methodology **Sub-section:** Calibration model **Related chapter:** 2.5	**Observation:** The same mortality table is used to project benefit cashflows forward for different sub-model calculations. In simulation model, there are a number of sub-models that may use distinct mortality assumptions but in practice the same benefit cashflows are used for all sub-models, which implicitly assumes identical mortality throughout the projection period **Recommendation:** Use different mortality tables to project benefit cashflows to reflect the distinct use of mortality table in the Simulation sub-models	Low
R05	**Section:** Conceptual framework - methodology **Sub-section:** Economic scenario generation **Related chapter:** 2.5	**Observation:** Parts of the current review process for the generated scenarios is manual through spot checks **Recommendation:** The manual review process could be reassessed to understand if automated process might be more reasonable. However, given there will be a new in-house ESG in Python, limited reassessment might be needed for the current ESG	Low
R06	**Section:** Conceptual framework - methodology **Sub-section:** post-processing **Related chapter:** 2.5	**Observation:** Although the post-processing tool offers a comprehensive view of the model outputs, it provides limited transparency in the calculation process, making it challenging to review the outputs thoroughly without clear instructions on how to navigate the workbook. **Recommendation:** Perform regular clean up or review of the post-processing to make the tool more user-friendly	Low
R07	**Section:** Assessment of operations: use **Sub-section:** Use **Related chapter:** 3.1	**Observation:** The ME-PIMS model is currently being used appropriately as each model user has specific responsibilities regarding the model and the assignment of responsibilities is clear. However, there is a lack of formally established roles and responsibilities at each phase of model development. **Recommendation:** The adoption of a roles and responsibilities matrix at each stage of model development can be considered	Low

R08	**Section:** Assessment of operations: use **Sub-section:** Result generation **Related chapter:** 3.1	**Observation:** The governance around model parameters update can be potentially enhanced as the changes to the parameters are not tracked and documented formally **Recommendation:** Consider fine-tunning model parameter and systematic documentation to ensure the accuracy of the model outputs	Medium
R09	**Section:** Assessment of operations: use **Sub-section:** Model use governance **Related chapter:** 3.1	**Observation:** PIMS models have multiple uses and multiple users of the model. A use attestation process is critical to ensure that the model is not used for unapproved/unlisted uses **Recommendation:** Consider establish a formalized model attestation process for use and creating formal documentation to track open model related issues	Low
R10	**Section:** Assessment of operations: implementation **Sub-section:** Model verification **Related chapter:** 3.2	**Observation:** PIMS model implementations are highly complex and the current training programs in place can potentially be improved. Further, given the materiality of the models, an end-to-end replication of critical components is important to ensure the accuracy of the implementation **Recommendation:** The following enhancements could be considered to enhance the implementation process: • Establishing a systematic training program on model implementation and a formal documentation on model implementation procedures	Low
R11	**Section:** Assessment of functionality and performance **Sub-section:** Economic scenario generator **Related chapter:** 4.1	**Observation:** The following observations have been noted based on the assessment of the current ESG • The existing ESG uses a core model with two variables being fully stochastically generated: the yield on 30-year Treasury bonds and the return on the S&P 500 stock index • A few economic variables are stochastically projected in the current ESG (e.g., inflation, plan investment returns, corporate bond yield, discount rate) but there are no industry segmented variables being projected • The current approach to model treasury yield eliminates the possibility of rates going below zero • The current approach to model equity return is using risk premium as excess returns over treasury yield, which limits the model's ability to capture varying relationship throughout the economic cycle • The current correlation between stock and Treasury bond returns is weakly positive (0.209) • The current approach to model long-term corporate rate uses a fixed spread of 110 basis points over the Treasury yield plus	Medium

		• The values for the nominal stock return parameters were originally based on a study done in 2008 and they only capture the period from 1973 to 2007 **Recommendation:** The following recommendations could be considered to enhance the ESG functionality as the new ESG being developed in the T-PIMS: • Incorporate additional factors such as GDP, unemployment rate, etc., to model core variables • Consider industry segmented variables in the ESG • Explore approach to allow possible negative treasury yields • Explore approach to simulate equity return independently • Recalibrate the correlation between treasury bond yield and equity return with the latest data to ensure the correlation factor reflect market observations • Consider dynamic correlation between stock and treasury yield • Explore stochastic modeling of spread over Treasury yield • Explore more frequent parameter calibration	
R12	**Section:** Assessment of functionality and performance **Sub-section:** Sensitivity analysis **Related chapter:** 4.2	**Observation:** PBGC currently performs sensitivity analysis of changes in discount rate of increase and decrease of 50 basis points in the Projection Report In addition to the sensitivity analysis currently disclosed by PBGC, other sensitivity analyses observed in the industry and would further enhance the analytics of the ME model include the following: • Wider range of changes in discount rate (i.e., +/- 100 and 200 bps) in sensitivity analysis • Sensitivity analysis around mortality improvement, key assumptions (e.g., solvency assumption, withdrawal liability) **Recommendation:** Consider expanding its sensitivity analysis to further enhance the analytics of the ME PIMS model	Medium
R13	**Section:** Assessment of functionality and performance **Sub-section:** Stress testing **Related chapter:** 4.3	**Observation:** There is currently no deterministic stress scenario for the ME-PIMS model Examples of extreme macroeconomic scenarios utilized in the industry would further enhance the analysis of the ME model include interest rate changes, liquidity crunch, pandemic, and geopolitical changes. **Recommendation:** Consider additional stress test scenarios to further enhance the analytics of the model	Low
R14	**Section:** Assessment of functionality and performance	**Observation:** Currently, there is no formal process defined for back testing of the ME-PIMS Considering the challenges of performing the back testing given the constant changing in model parameters, data sources, and frequent	Low

	Sub-section: Back testing **Related chapter:** 4.4	changes in pension regulation and policies, special considerations and techniques may be required for ME PIMS model, such as implementing a component-based back testing approach and potentially a macro-overlay to incorporate external changes in back testing **Recommendation:** Consider performing back testing and define and justify the performance metrics to support analysis of modeled vs. actual variance and identify potential model risks	
R15	**Section:** Assessment of documentation **Sub-section:** Model documentation **Related chapter:** 5.1	**Observation:** The current documentation of the ME-PIMS model is reasonable to be used as a model functional guide, yet there are opportunities for enhancement to provide a more holistic understanding. Currently, it offers insights into the model's construction, key assumptions, and utilized variables during the development process. While it covers crucial aspects such as the model purpose, approaches, and limitations, it lacks the details on the model development process and key model methodologies **Recommendation:** The following enhancements could be considered to enhance the model documentation: • Providing a clear explanation of the model methodology • Incorporating the rationale behind methodological choices • Establishing a repository of model assumptions • Clearly articulating all model limitations • Regularly updating information	Low
R16	**Section:** Assessment of documentation **Sub-section:** Governance on model documentation **Related chapter:** 5.2	**Observation:** Key governance procedures on model documentation have been observed in the ME PIMS model, including procedures on management changes, version controls, continuous enhancement, and regulatory compliance **Recommendation:** Given the current absence of explicit governance regarding the documentation around model limitation, it becomes important to incorporate appropriate and comprehensive disclosures within the model deliverables to mitigate any instances of misuse, misinterpretation, or misrepresentation	Low

1. Definition in appendix

Table 0-2: MODEL LIMITATIONS

ID	Limitation Section, Sub-section	Recommendation
ML01	**Section:** Conceptual framework - data **Sub-section:** Data input: plan database **Observation:** There is currently a one-year lag in the Form 5500 reporting (e.g., contribution data), which could result in outdated plan information used in the model. The current mitigation includes the following: • A more recent Schedule H & R (plan asset information) is used in the model starting with FY22 report, where available • Benefit payment and withdrawal liability payment cash flows collected from SFA applications are used to adjust plan-level cash flows generated by the pre-processing model, starting with FY22 report valuation • For few plans, Plan Zone Certification information (that does not have a lag) as provided by the IRS was used in the FY22 valuation **Related chapter:** 2.1 – assessment of conceptual risk	Explore potential ways to minimize the lag of Form 5500 reporting

1 Overview

1.1 Model description

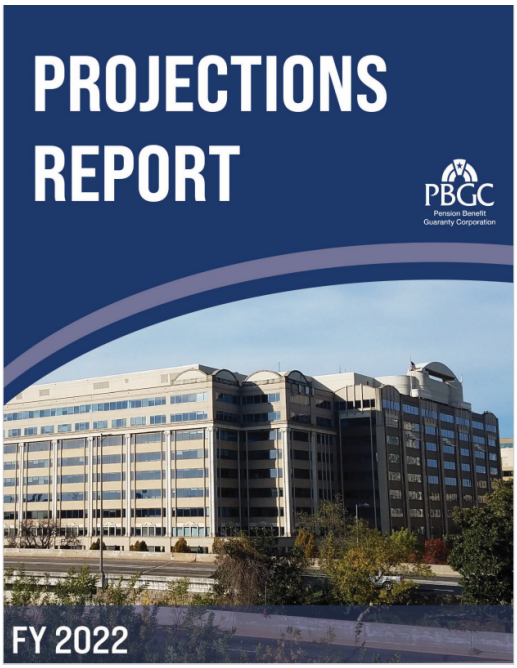
Pension Benefit Guaranty Corporation (PBGC) insures participants in private pension plans against loss of benefits in case their plan ceases to pay. PBGC employs a stochastic modeling system known as the Pension Insurance Modeling System (PIMS) to assess its future obligations and financial position each year. There are two models as part of PIMS – Single Employer (SE) PIMS model and Multi-Employer (ME) PIMS model as part of PIMS.

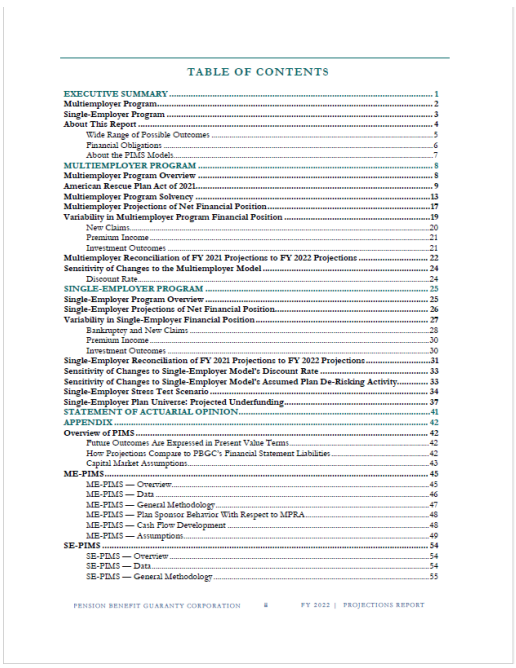
The ME-PIMS uses Form 5500 data for each plan in the universe of multiemployer plans, including terminated and insolvent plans to model future claims against the ME program that are not already booked in the current financial statements. The ME-PIMS identifies those ongoing plans that might become claims against by evaluating whether the plan is likely to become insolvent within the next 10 years. Separately for each simulation, the ME-PIMS model projects a plan's funding status, cash flow, asset base, and change in contribution base, to determine whether that plan would be booked as a liability. The outputs of these simulations are used to create the projected financial position of PBGC for the next 10 years and the solvency of the ME program which includes a 40-year projection.

1.2 Model use and scope

There are multiple uses and outputs produced from the ME PIMS model, including:

- Projection Report: PBGC's annual Projection Report is required by the Employee Retirement Income Security Act, providing all stakeholders including the public an actuarial evaluation of the future financial status of PBGC's Multiemployer and Single-Employer Programs





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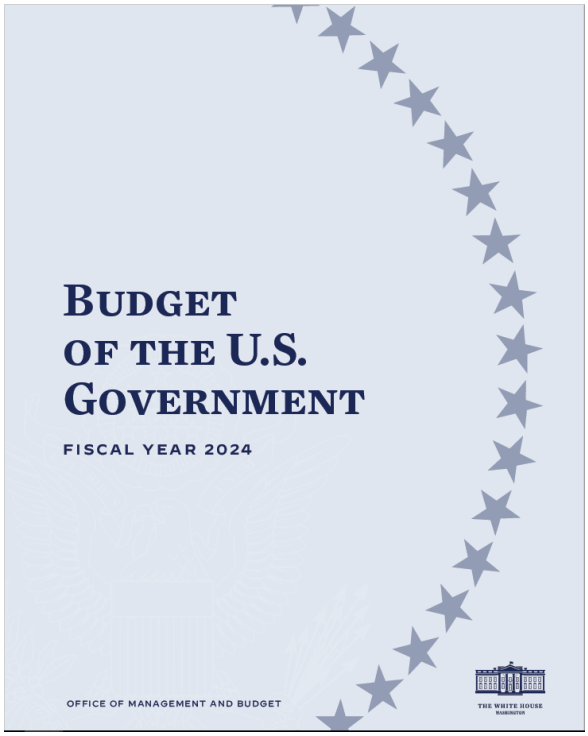
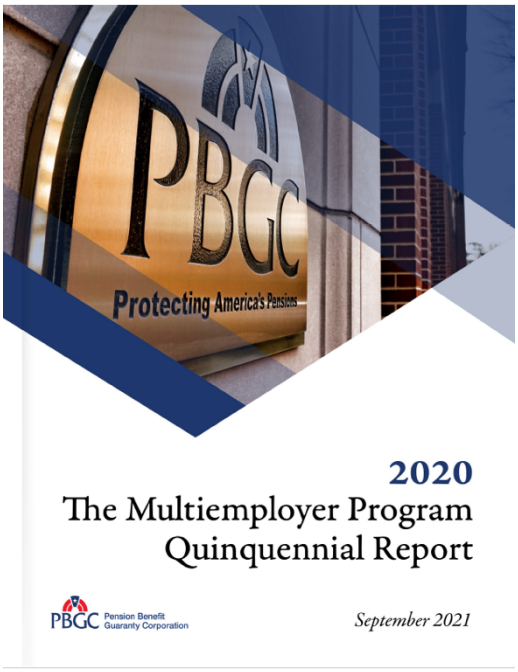
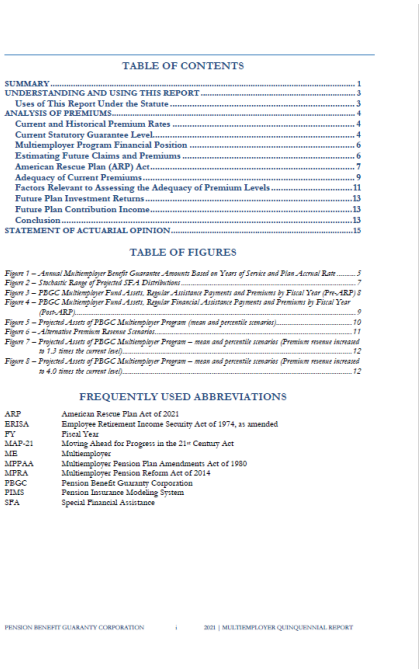
- President's budget report: The 10-year financial statement projections provide the Congress and the public the budget estimation of PBGC for the current fiscal year



- Multiemployer 5-Year Report: The 5-year financial statements determine the PBGC premiums needed to maintain the current benefit guarantee levels and whether the benefit guarantee levels may be increased without increasing PBGC premiums





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FREQUENTLY USED ABBREVIATIONS

ARP	American Rescue Plan Act of 2021
ERISA	Employee Retirement Income Security Act of 1974, as amended
FY	Fiscal Year
MAP-21	Moving Ahead for Progress in the 21st Century Act
ME	Multiemployer
MPPAA	Multiemployer Pension Plan Amendments Act of 1980
MPRA	Multiemployer Pension Reform Act of 2014
PBGC	Pension Benefit Guaranty Corporation
PIMS	Pension Insurance Modeling System
SFA	Special Financial Assistance

- Technical assistance request: The outputs provide the external legislative stakeholders estimates of the budgetary impact from legislative proposals. Possible examples include:
    - Changes to the premium structure
    - Changes to funding laws
    - Changes to the interest rates used to value liabilities
- Ad hoc internal PBGC analysis: The PIMS model outputs are used to generate internal reports for ad hoc PBGC analysis

1.3 Peer review approach

The peer review assessment for the multiemployer PIMS model focuses both on the conceptual risk assessment and governance and controls assessment for each of the model components.

The table below summarizes the review approach of the conceptual risk assessment and the governance and controls assessment:

Table 1-1: PEER REVIEW APPROACH

Dimension	Sub-section	Conceptual risk assessment	Governance and controls assessment
1. Conceptual framework: data	Data preparation	• Assess the data quality, completeness, and appropriateness based on walkthroughs with the model users • Assess whether the sources of data inputs are appropriate • Assess data format is appropriate for each variable • Assess whether any data transformation are appropriate • Verify the data quality, completeness, and appropriateness of the input datasets with existing metrics through independent replication	• Review the evidence provided for quality controls of data inputs • Sufficient data quality controls are in place for creating the initial database from Form 5500 • Assess whether the review process to spot material data quality issues is in place, and they are addressed properly when issues are identified • Verify that robust governance is in place around the data and assumptions such as a data dictionary for SE/ME models, a summary of assumptions • Evidence of review and challenge of: ○ Variable selection in the scenario generation process with supporting evidence such as presentations or meeting minutes are available ○ If any data is shared with a vendor, assess whether controls are in place for the data delivery process and responsible parties
	Variable selection	• Assess the criteria for variable selection for scenario generation and assess its appropriateness • Assess whether variables in scenarios are properly link to the risk factor of the ME plans • Assess whether the breadth of economic variables enables the model to depict full picture of the macro economy	

		• Assess how effectively model inputs support the conceptual framework of the models	• Assess whether proper monitoring procedures for data inputs are in place
2. Conceptual framework: methodology	Assumptions	• Assess the appropriateness of plan behavior assumptions and whether additional assumptions are needed to reflect plan holder behaviors at segment level • Assess the appropriateness and completeness of capital market assumptions and whether additional assumptions are needed to reflect the economy level • Assess whether the assumption setting methodology is consistent with the models' intended purposes	• Assess the evidence of review and challenge the process to approve various methodologies (demographics sampling selection, economic scenario generation, plan cashflow simulation • Assess whether changes of variables/methodologies used in the SE/ME models are properly logged and proper approval is in place of changes of variables/methodologies • Review and challenge the process of methodology change management • Assess whether proper monitoring of assumptions and methodologies are in place
	Economic scenario generation	• Assess the conceptual soundness of the economic scenario generation • Assess whether the breadth of scenarios is able to cover tail events • Assess whether variables in scenarios are properly linked to the risk factor or the ME plans • Assess identification of additional market information not currently used in models that, if combined with current inputs, would enhance model effectiveness. • Assess whether the economic scenario generation is consistent with the models' intended purposes	
	Plan cashflow simulation	• Assess the conceptual soundness of the plan cashflow simulation • Assess whether the logic used to calculate the plan liabilities and assets over projection period reflect the actual experience of a potential claim • Assess whether the fundamental methodology of plan cashflow simulation is consistent with the models' intended purposes	

	PBGC cashflow simulation	• Assess the conceptual soundness of the PBGC cashflow simulation • Assess whether the logic used to calculate the PBGC cashflows over projection period reflect the PBGC's actual experience • Assess whether the fundamental methodology of plan cashflow simulation is consistent with the models' intended purposes	
3. Operation	Use	• Review the alignment of model use with the scope and approved uses of the model • Assess whether the post-processing tool properly aggregates cashflows from the model in all scenarios to project PBGC experience • Review the format of model outputs is appropriate for different purposes	• Evaluate types of access and security controls applied to prevent unauthorized access to the SE/ME models and their supporting documents and review existing access rights on a regular basis • Assess the data output controls are in place to ensure output does not have errors and is calculated per the model requirements • Review and challenge the request process for producing model results • Evaluate how and where the results are logged and the parties that review the results on an ongoing basis • Verify model usage is consistent with approved use cases, restrictions, and limitations • Assess the existing decision-making process in place for defining, reviewing, and updating model governance procedures • Review attestation from the model users on the uses to ensure the model is used only for approved uses • Assess the tracking of progress on open model related issues and recommendations
	Implement ation	• Examine whether the current practices of testing the replicability of model are sufficient • Assess whether the current review approach to identify implementation errors of the model is appropriate • Evaluate the appropriateness of the system or platform in which the model is embedded or implemented given the model purpose and complexity	• Assess whether clear training procedures are in place • Assess whether measures are in place for knowledge retention and transfer to support maintenance and enhancement of the models

4. Functionality and performance		• Assess whether model captures the full range of potential outcomes for macroeconomic series, assets, liabilities, and cash flows • Assess whether additional deterministic functionality should be utilized to supplement the stochastic modeling in order to illustrate extreme tail-risk events • Assess whether model outputs do not correspond well to actual outcomes • Assess whether sufficient testing was performed to assess the accuracy and soundness of the implementation in production (e.g., back testing, reconciliation testing, user acceptance testing, etc.) • Assess whether the key deliverables (i.e., Projection Report, President's Budget, a sampling of Technical Assistance deliverables) are effective relative to their intended purposes and audience • Review the current model functionality relative to its intended purposes	• Assess whether controls are in place to ensure all appropriate scenarios are run • Assess whether the composition of subject matter expertise to support the model is appropriate • Assess whether proper monitoring procedures for functionality and performance are in place • Assess the review and challenge of model performance
5. Documentation		• Assess the comprehensiveness, readability, and consistency of model documentations • Assess if documentations are properly stored with appropriate version controls • Assess the accuracy, sufficiency, and clarity of content of the current PIMS webpage	• Assess whether the information documented is accurate, clear/understandable • Change management processes, including location of change log, version controls procedures, review and approval of change procedures • Assess whether archiving and retention controls are in place • Assess whether supporting documents and resources adequately inform users in order to avoid misuse, misinterpretation, or misrepresentation • Assess whether appropriate and sufficient disclosures exist in the model deliverables to avoid misuse, misinterpretation, or misrepresentation

2 Assessment of conceptual framework

The assessment of conceptual framework for the Multiemployer (ME) PIMS model is conducted along both the conceptual risk and governance and controls for each component of the model. The components of the ME PIMS model are shown in the model architecture diagram in section 2.1. The assessment of conceptual framework for the ME PIMS model is conducted for each sub-component in the model architecture diagram.

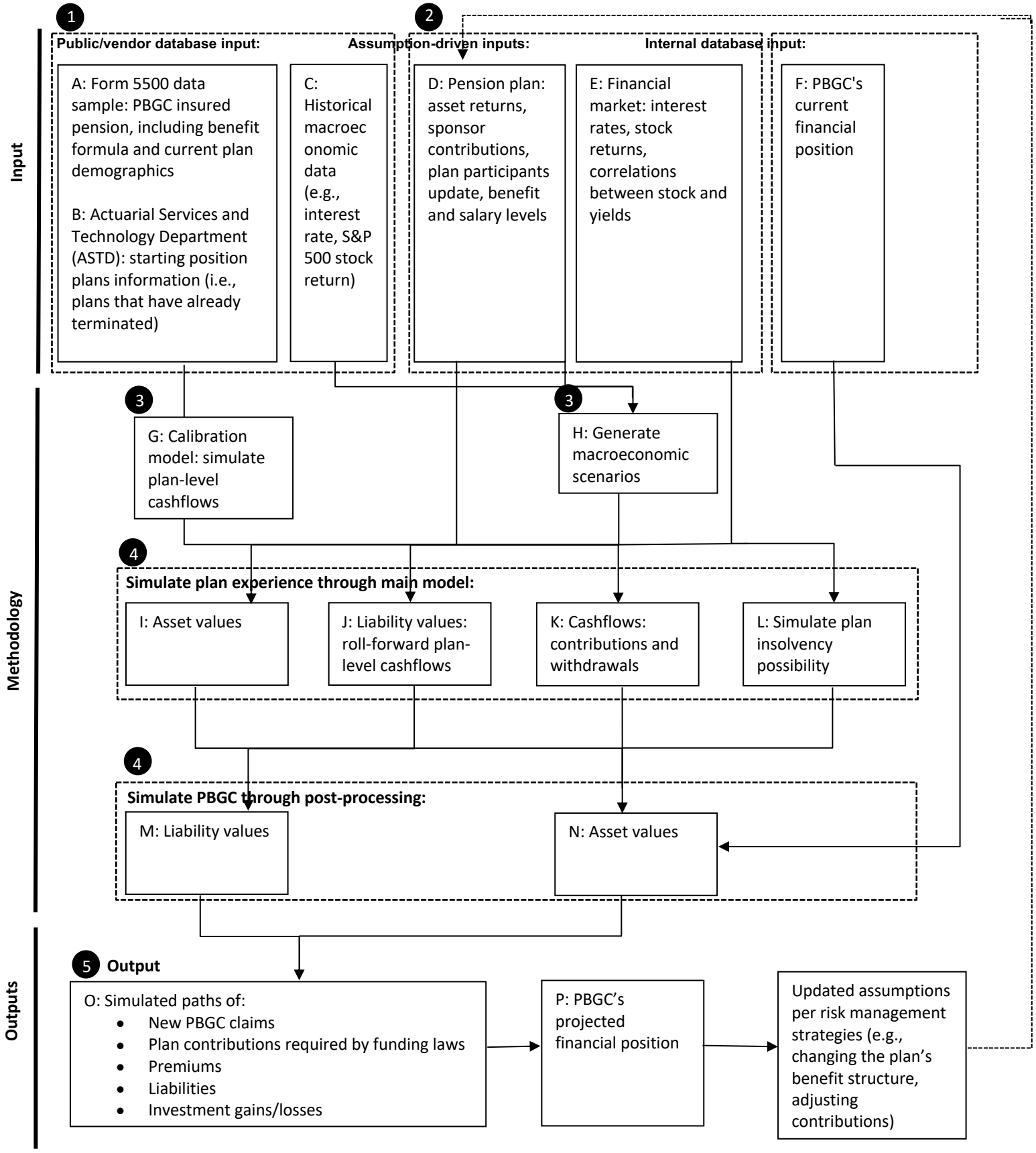
2.1 Description of high-level model architecture

ME PIMS model was entirely recoded during 2018 to make it more efficient. The ME PIMS Recoded Model provides an increased level of flexibility and allows the PBGC to better respond to congressional and other stakeholder requests. There are three components to the ME model (pre-processing, simulation model, post-processing), with the output from each component providing input for the next. Each of these components is accomplished with its own spreadsheets. As shown in the model architecture diagram below, the key components of the ME PIMS model include:

- Public/vendor database input: ME PIMS pension data obtained from Form 5500 annual pension plan reports. This data includes plan liabilities, assets, participant demographics and actuarial assumptions about demographics dynamics and investment returns
- Assumption-driven inputs: ME-PIMS uses several assumptions to estimate the stochastic and key deterministic variables. The key segments of factors for which assumptions are used include economic variables, plan level variables and PBGC specific variables
- Economic Scenario Generator (ESG): ME PIMS model uses ESG to produce simulated scenarios based on macroeconomic variables such as future economic growth, inflation, interest rates and equity returns
- Pre-processing: ME PIMS model generates plan-level aggregate cashflow streams corresponding to accruals as of MB year to be loaded into the Simulation Model and develops NC cashflow streams to project out future accruals
    - During the pre-processing, participant-level data is processed from publicly available information. For inactive calibration, this is done by using a single large plan (Central States) to represent the underlying pattern of demographics, and then adjusting age, service, and accrual rates to better match plan-specific Current Liability by participating status and benefit payment information from the Schedule MB. The active calibration matches plans without data to other plans based on industry and active-to-inactive ratio. Benefit payments are then projected under an assumed mortality table. These benefit payment streams are developed by status (active, terminated vested and retiree) for each plan based on full accruals, guaranteed accruals, and one-year accruals. TV and retiree benefit payment projections from SFA applications are used where available to apply that cashflow shape and then calibrate to reported current liability in 5500 filing

- Simulation model: ME PIMS model uses the cashflows as of Schedule MB year from pre-processing and Normal Cost cashflows to model future accruals, generates output for a specific plan/scenario. A macro is used to run the simulation model multiple times to loop through all plan/scenario combination
    - The goal of the calculation in simulation model is to estimate year-by-year PBGC claims and financial assistance payments for each plan and scenario combination. Since PBGC assistance payments to ME plans are triggered by plan insolvency, it is appropriate to use the primary model as a plan solvency projection tool. The primary model generates stochastic plan solvency projection, PBGC assistance payments (paid post-plan insolvency), and partition payments. The cashflow sub-models calculate contributions, benefit payments & admin expenses, premium increases, and Special Financial Assistance where applicable. The low-level sub-models use VBA projection to determine Multiemployer Pension Reform Act (MPRA) suspensions and partitions, Pension Protection Act (PPA) zone, and other characteristics of the plans where applicable. All modules are very interconnected
- Post-processing: ME PIMS model aggregates the plan/scenario results from the simulation Model to produce stochastic net position and distribution of projected PBGC insolvency year
    - Post-processing summarizes the simulation model output into a format that is useful for the Projection Report and processes this output to show aggregate impact on PBGC. PBGC assets, PBGC insolvency year, and PBGC net position then need to be projected using the aggregated output. PBGC assets are projected stochastically using mean cashflows, whereas the PBGC net position and insolvency year are shown as percentiles.

TABLE 2-1: MULTIEMPLOYER PIMS MODEL DIAGRAM



2.2 Assessment of data: data preparation

The table below documents the peer reviewer's assessment of the appropriateness of the inputs for use in this model and the data preparation and quality controls around the inputs.

TABLE 2-2: ASSESSMENT OF DATA: DATA PREPRATION

Data input & source	Description and usage in model	Peer review assessment description
1A. Data input: *Plan database* ***Source:*** *Form 5500*	**Description** The plan demographics and account information for ongoing multi-employer plans **Usage in the model** Form 5500 is the primary source of data for ongoing plans, which will be used to project plan-level assets and liability cashflows	**Assessment of the conceptual risk** The data source for plan database for ongoing plans is appropriate. The plan database uses Form 5500, an electronic filing for all employee benefit plans. As Form 5500 serves a disclosure document for plan participants and beneficiaries, as well as a key data source of information and data for Federal agencies, Congress, and the private sector in evaluating employee benefit, tax and economic trend and policies, it stands as an appropriate choice for plan data. The plan database includes a series of data fields to reasonably depict the characteristics of the plans, including plan demographics (i.e., cohort age, cohort service, retirement age, etc.), plan cashflows (i.e., account balance, benefit payment), and plan asset cashflows (i.e., aggregate return, asset allocation among different types of assets) There is currently a one-year lag in the Form 5500 reporting (e.g., contribution data), which could result in outdated plan information used in the model. Potential ways to minimize the lag of Form 5500 reporting could be assessed. A model limitation has been identified in this regard [ML01] The current mitigation includes the following: • A more recent Schedule H & R (plan asset information) is used in the model starting with FY22 report, where available • Benefit payment and withdrawal liability payment cash flows collected from SFA applications are used to adjust plan-level cash flows generated by the pre-processing model, starting with FY22 report valuation • For few plans, Plan Zone Certification information (that does not have a lag) as provided by the IRS was used in the FY22 valuation **Assessment of the governance and controls** Sufficient data quality controls are in place for creating the initial database from Form 5500. The manual entry process is performed by a third-party contractor and there is rigorous review process performed by the third-party contractor to examine the accuracy of the data entered. After data is received by PRAD, there is another data scrubbing process done by PRAD team

		member to ensure data quality (e.g., verify large year-over-year changes) There is sufficient governance in place around the database given there are a series of automated tools for quality control purposes and a well-documented data dictionary is available for the PIMS models
1B. Data input: *Plan database* ***Source:*** *Actuarial Services and technology Department (ASTD)*	**Description** The plan demographics and account information for starting position multi-employer plans **Usage in the model** Output from ASTD's IPVFB system is the source of data for starting position plans (i.e., plans that have already terminated or became insolvent), which will be used to project plan-level assets and liability cashflows	**Assessment of the conceptual risk** The data source for the plan database of starting position plans is appropriate. The model uses output from ASTD's IPVFB system, which provides actuarial oversight and expertise supporting PBGC benefit calculation, valuation, and administration. Given ASTD is an individual department at PBGC that provides disclosure documents for plan participants and beneficiaries, and a source of information and data for use by other departments at PBGC, it is an appropriate data source. The data quality for plan demographics is appropriate given that the data source, ASTD's IPVFB system, has required compliance disclosure with appropriate governance. **Assessment of the governance and controls** Sufficient data quality controls are in place for creating the initial database from ASTD. After data is received by PRAD, there is a data scrubbing process done by PRAD team members to ensure data quality. Data is reviewed for outliers and missing fields. There is sufficient governance in place around the database and a well-documented data dictionary is available for the PIMS models
1F. Data input: *PBGC current financial position* ***Source:*** *PBGC's annual report*	**Description** PBGC's current financial position as the starting point of the projection for PBGC's cashflows **Usage in the model** The PBGC current financial position is used as the starting point of PBGC's cashflow projection	**Assessment of the conceptual risk** The data source and data quality of PBGC's financial position is found to be appropriate as the data is directly extracted from PBGC's annual report. **Assessment of the governance and controls** Sufficient data quality controls are in place for using PBGC starting financial position. The process to extract PBGC current financial position is automated in Excel to minimize errors. PRAD team members also check the accuracy of the file path associated with the annual report, which is the data source of the PBGC financial position. There is sufficient governance in place around the PBGC current financial position given that checks are performed within the automated tool to extract the financial numbers

2.3 Assessment of data: variable selection

The table below documents the peer reviewer's assessment of the appropriateness of the variable selection for use in the scenario generation process including the assessment of the conceptual risk of the economic variable based

on the model development document supporting the use of PIMS model and the assessment of the governance of controls of the economic variable based on the model development document supporting the use of PIMS model and key insights from model user interviews.

TABLE 2-3: ASSESSMENT OF DATA: VARIABLE SELECTION

Economic variable	Description and usage in model	Peer review assessment description
1B. Nominal interest rate	**Description** In attempting to mimic economic and actuarial behavior, PIMS required a model of the long-term market interest rate, which is the yield on 30-year government bonds **Usage in the model** Nominal interest rate is used as a parameter to generate stochastic scenario	**Assessment of the conceptual risk** The selection of nominal interest rate for modeling scenarios is appropriate with potential limitation because: • Interest rate typically is correlated to the macroeconomic trends (e.g., consumer spending, commercial lending, stock fluctuation) • Interest rate affects asset values and liabilities associated with the ME plans • While the interest rate for modeling scenario is a dynamic rate changing over the projection period, the interest rate used to discount the liability cashflows for plan projection is a flat curve over the period of projection. Due to the limitation of the ME PIMS model capability, using a flat curve for discounting is considered appropriate Furthermore, the methodology used to forecast interest rate is appropriate because: • The nominal interest rate yield is modeled as a first difference of a natural logarithm, and this is a common approach of interest rate modeling in the industry • The calculation also considers the disturbance term, which is assumed to be drawn from a joint normal distribution with other economy-level disturbances to reflect randomness in interest rate forecasts **Assessment of the governance and controls** Sufficient data quality controls are in place for generating the nominal interest rate given that the modeling process of economic scenario uses an automated program in SAS, which runs the simulation of a series of economic variables and includes quality check procedures
1B. Real interest rate and inflation	**Description** PIMS uses an inflation rate in making inflationary adjustments to pension benefits and other real-to-nominal conversions	**Assessment of the conceptual risk** The selection of real interest rate and inflation for modeling scenarios is appropriate because: • Real interest rate and inflation typically is correlated to the macroeconomic trends (e.g., business investment, tax policies, and interest rates)

	Usage in the model Real interest rate and inflation are used as a parameter to generate stochastic scenario	• Real interest rate and inflation is crucial to investing and can significantly reduce the value of investment returns associated with the ME plans Furthermore, the methodology used to forecast real interest rate and inflation is appropriate with potential opportunity for enhancements: • The inflation rate is derived from the nominal interest rate by adjusting a real interest rate component with log normal distribution, and this is a common approach of inflation rate modeling in the industry • While the inflation rate follows a log normal distribution, the median of the inflation rate distribution comes from the Congressional Budget Office, which is a calibrated parameter reflects analysis and expert opinion from the CBO. The peer reviewers believe the approach is appropriate given that the parameters could easily be adjusted to reflect a different view or calibrated to produce a different set of outcomes as desired • The inflation rate is derived from the nominal interest rate by adjusting a real interest rate component. While the nominal interest is modeled stochastically, the real interest rate is not a stochastic variable, but rather is assumed to be an input parameter and is fixed across all simulation periods. Similar to nominal interest rate, a stochastic approach could be considered for real interest rate modeling in T-PIMS to ensure consistency in inflation rate calculation. An observation has been identified in this regard [R01] **Assessment of the governance and controls** Sufficient data quality controls are in place for generating the real interest rate and inflation given that the modeling process of economic scenario uses an automated program in SAS, which runs the simulation of a series of economic variables and includes quality check procedures
1B. Stock return	**Description** The rate of return on stocks is used to determine the investment return on pension plans and PBGC's assets held in equities and changes in the plan sponsor's financial condition **Usage in the model** Stock return is used as a parameter to	**Assessment of the conceptual risk** The selection of stock return for modeling scenarios is appropriate because stock return typically is correlated to the macroeconomic trends and is usually an indicator of economic growth Furthermore, the methodology used to forecast stock return is appropriate because: • Stock returns, based on the S&P 500 index, are modeled as a function of the beginning of period Treasury yield and a long-term spread parameter. The process for developing equity returns is clear and parameters are well defined. The size of the equity risk premium and the correlation between stocks and bond yields are based on standard financial theory and observed historical data

	generate stochastic scenario	• The calculation considers the disturbance term, which is assumed to be drawn from a joint normal distribution with other economy-level disturbances to reflect randomness in stock return forecasts **Assessment of the governance and controls** Sufficient data quality controls are in place for generating the stock return given that the modeling process of economic scenario uses an automated program in SAS, which runs the simulation of a series of economic variables and includes quality check procedures
1B. Corporate bond yields	**Description** The rate of return on corporate bonds is used to determine the investment return on pension plans and PBGC's assets held in non-equities and changes in the plan sponsor's financial condition **Usage in the model** Corporate bond yields are used as a parameter to generate stochastic scenario	**Assessment of the conceptual risk** The selection of corporate bond yield for modeling scenarios is appropriate because: • Similar to equity market, corporate bond yields typically are an indicator of economic growth • Corporate bond yields can significantly impact the value of assets and liabilities associated with policy plan Furthermore, the methodology used to forecast corporate bond yield is appropriate because: • The yield on corporate bond is equal to the treasury bond yield plus a spread that reverts, over the projection period, from its starting point of a fixed spread of 110 basis points. While the approach of modeling corporate yield using a spread over the treasury yield is common, stochastic modeling of the spread can be considered to capture the actual movement of corporate bond in the real world. An observation has been identified in this regard [R02] • Given that corporate bond spreads historically have shown a strong tendency toward mean reversion, the current assumption of reversion to a target credit spread is reasonable in normal market environments and serves as a rational central tendency over longer time horizon **Assessment of the governance and controls** Sufficient data quality controls are in place for generating the corporate bond yields given that the modeling process of economic scenario uses an automated program in SAS, which runs the simulation of a series of economic variables and includes quality check procedures

2.4 Assessment of methodology: assumptions

The table below documents the peer reviewer's assessment of the appropriateness of the assumptions used in the PIMS model including the assessment of the conceptual risk of the assumptions based on the model development document supporting the use of PIMS model and the assessment of the governance of controls of the assumptions based on the model development document supporting the use of PIMS model and key insights from model user interviews.

TABLE 2-4: ASSESSMENT OF METHODOLOGY: ASSUMPTIONS

Assumptions	Description and usage in model	Peer review assessment description
1C. Plan behavior assumptions	**Description** A series of plan behavior assumptions are set to project how plan related behaviors (e.g., contribution, form of payment, etc.) vary under different circumstances **Usage in the model** Plan behavior assumptions are used to model plan liability cashflows	**Assessment of the conceptual risk** The plan behavior assumptions are found to be appropriate given that a variety of plan behaviors are considered in the model such as plan contribution, benefit improvements, etc., which reasonably depict the plan holder behavior. For example: • **Per capita contribution rates:** the annual estimated per capital contribution growth is projected by types of plans, including Green Zone plans, endangered plans, critical plans, critical and declining plans, and plans projected to receive SFA. Per capita contributions for all plans will be further limited to a multiple of the baseline per capita contribution, after which inflation/wage growth becomes the underlying increase rate • **Withdrawal liability payments:** for currently terminated and insolvent plans and certain previously booked plans, a schedule of payments is received from the plan administrators. The payments are assumed to decline by 30% in the first year and phase out over 15 years These assumptions are based on internal studies conducted by PBGC based on the payment information for terminated and insolvent plans **Assessment of the governance and controls** The review and challenge process to approve the plan behavior assumption is found to be appropriate with scope for potential improvement: • PRAD team holds frequent meetings to discuss if assumption update/change is needed and there is a group review process of any assumption changes in the PIMS model • Periodic peer review is also conducted by independent third parties on selected assumptions.

		However, currently, there is no formal process defined where plan behavior assumptions are reviewed, challenged, and updated as appropriate on a periodic basis. While some plan behavior assumptions such as benefit suspension and partitions have not been updated in the recent past, they have been reviewed and discussed internally. It is recommended to establish a systematic assumption review process to review the assumptions on a periodic basis and sufficiently document the review process that includes materiality, sensitivity testing, and changes to assumptions used in the ME model. An observation has been identified in this regard [R03]
1D. Capital market assumptions	**Description** A series of economic variables are stochastically projected in PIMS (e.g. interest rate, stock return, corporate bond yield, annual wage growth) **Usage in the model** Capital market assumptions are used to model plan asset cashflows	**Assessment of the conceptual risk** The capital market assumptions are found to be appropriate given that a variety of economic variables are considered in the model such as interest rate, inflation, stock return etc., which accurately depict the stochastic movement of the macro economy. For example: • The methodology to generate interest rates, stock returns and related variables is appropriate given that they are determined by the underlying means, standard deviation, and correlation matrix establish for the PIMS projection • The methodology to generate corporate bond yields and stock returns is appropriate given that they are modeled based on risk premiums plus a disturbance term to reflect randomness. Credit spreads on investment-grade corporate bonds are assumed to regress toward their historical mean with no stochastic variation **Assessment of the governance and controls** The review and challenge process to approve the capital market assumption is found to be appropriate with scope for potential improvement: • PRAD team holds frequent meetings to discuss if assumption update/change is needed and there is a group review process of any assumption changes in the PIMS model. PRAD also holds a biweekly Economist meeting where they dive into issues related the capital market assumptions • Periodic peer review is also conducted by independent third parties on selected assumptions. However, a few capital market assumptions (e.g., correlation between Treasury yield and equity returns etc.) have not been updated in the recent past. Currently, there is no formal process defined where capital market assumptions are reviewed, challenged, and updated as appropriate on a periodic basis. An observation has been identified in this regard [R03]

1C. Mortality assumption	**Description** The number of deaths in a specific population over a specific period of time **Usage in the model** Mortality assumptions are used to model plan liability cashflows	**Assessment of the conceptual risk** The mortality assumptions are found to be reasonable given that the mortality table used in the model is based on mortality experience study of PBGC-insured participants, which estimates mortality numbers and retirees over the projected period of the PIMS model **Assessment of the governance and controls** The review and challenge process to approve the mortality assumption is found to be appropriate given: PRAD team holds frequent meetings to discuss if assumption update/change is needed and there is a group review process of any assumption changes in the PIMS model. Periodic peer review is also conducted by independent third parties on selected assumptions

2.5 Assessment of methodology: simulation

The table below documents the peer reviewer's assessment of the appropriateness of the methodologies used in the PIMS model including the assessment of the conceptual risk of the methodologies based on the model development document supporting the use of PIMS model and the assessment of the governance of controls of the methodologies based on the model development document supporting the use of PIMS model and key insights from model user interviews.

TABLE 2-5: ASSESSMENT OF METHODOLOGY: SIMULATIONS

Assumptions	Description and usage in model	Peer review assessment description
3G. Calibration model: simulate plan-level cashflows	**Description** The calibration model generates plan-level aggregate cashflow streams corresponding to accruals as of MB Year **Usage in the model** The aggregate benefit payment streams generated are fed into the simulation main model to generate asset and liability cashflows on plan level	**Assessment of the conceptual risk** The calibration model is found to be conceptually reasonable with potential limitation given that: • The benefit payment projections differ by current participant status. There are two different processes to calibrate active and inactive participants • The calibrations are run in two separate stages. The first stage is to find the optimal age/service/accrual adjustment to impute plan demographics. Then a separate process will generate these demographics for future years, which is used to calculate the benefit payment streams • Potential limitation that only one mortality table is used to project cashflows forward exists. In simulation model, there are several sub-models that may use distinct mortality assumptions but in practice the same benefit cashflows are used for all sub-models, which implicitly assumes identical mortality throughout the projection period. Potential enhancement of using different

		mortality tables can be considered. An observation has been identified in this regard [R04] The calibration model is found to be consistent with the models' intended purpose since it considers the benefit payments under different participant status, which reasonably reflect actual participant behavior **Assessment of the governance and controls** The review and challenge process to approve the calibration model is found to be appropriate • There are multiple review and reconciliation procedures conducted by both the third-party contractor and PRAD team members • The calibration process is an automated process in Excel and VBA There is also proper review process to check if there are any unexpected changes of cash flows from year to year • The calibration will be run using previous year's assumptions every year to keep track of any changes in the model • The reconciliation process is also properly logged and documented if any error is identified in the process PRAD team also holds frequent meetings to discuss if the calibrated benefit payments are reasonable. In addition, periodic peer review is also conducted by independent third parties on selected simulation procedures
3H. Economic scenario generation	**Description** Generate a large number of stochastic scenarios with various economic variables based on historical data and market expectations **Usage in the model** The economic scenario generator produces ~500 scenarios for the PIMS model to project cashflows under different economic environments	**Assessment of the conceptual risk** The conceptual soundness and functionality of the economic scenario generation is assessed in detail in Section 4 **Assessment of the governance and controls** The review and challenge process to approve the economic scenario generator is found to be appropriate with scope for potential improvement: • All generation procedures are automated in SAS, minimizing potential manual errors • Parts of the current review process for the generated scenarios is manual through spot checks. The manual review process could be reassessed to understand if automated process might be more reasonable. PRAD can explore potential review process that could include examining whether the derived average rate and derived variance from the generated scenarios match the assumptions used in the ESG. Given there will be an in-house new ESG, limited reassessment might be needed for the current ESG. An observation has been identified in this regard [R05] PRAD team holds frequent meetings to discuss if economic scenarios generated cover tail events. PRAD also holds a biweekly Economist meeting where they dive into issues related to the ESG. In

		addition, periodic peer review is also conducted by independent third parties on selected simulation procedures
4. Plan simulation	**Description** Project plan level asset and liability cashflows using the calculated benefit payment cashflows from the calibration pre-processing **Usage in the model** The plan cashflow simulation uses model inputs and scenarios to project plan level liability and asset cashflows	**Assessment of the conceptual risk** The plan cashflow simulation is found to be conceptually reasonable given that the logic used to calculate the plan liabilities and assets over the projection period tries to reflect the actual experience of a potential claim: • The primary model is a plan insolvency projection given PBGC assistance payments to ME plans are triggered by plan insolvency (not bankruptcy or distress termination as for SE plans) • The asset projection uses stochastic asset returns and calculates cashflows with "sub-models" with the logic that assets = starting point asset + contribution + WDL income – benefit payments – expenses – premiums + SFA if appliable • The goal of the calculation in the simulation model is to determine the year-by-year PBGC assistance and partition payments for one plan/scenario combination. Since PBGC assistance payments to ME plans are triggered by plan insolvency, it is appropriate to use the primary model as a plan solvency projection tool • The primary model generates stochastic plan solvency projection, PBGC assistance payments (paid post-plan insolvency), and partition payments. The cashflow sub-models calculate contributions, benefit payments & admin expenses, premium increases, and Special Financial Assistance where applicable. The low-level sub-models use VBA projection to determine MRPA suspensions and partitions, PPA zone, and other characteristics of the plans where applicable The plan cashflow simulation is found to be consistent with the models' intended purpose since it reasonably reflects how a potential claim will be generated under the circumstance of plan insolvency and how the cashflow will be impacted **Assessment of the governance and controls** The review and challenge process to approve plan cashflow is found to be appropriate given that the simulation is completely automated. Further, PRAD team holds frequent meetings to discuss if cashflows generated reasonably reflects the expected claim experience. In addition, periodic peer review is also conducted by independent third parties on selected simulation procedures
5. Post-processing	**Description** Aggregate the plan/scenario results from the simulations to	**Assessment of the conceptual risk** The post-processing is found to be conceptually reasonable given that the process aggregates plan/scenario results from the model outputs to project PBGC financial position

	produce stochastic net position and distribution of projected PBGC insolvency year **Usage in the model** Post-processing tool aggregates PBGC cashflows under various scenarios and create charts and tables for the Projection Report	• PBGC assets, insolvency year, and PBGC net position will be projected using the aggregated output • PBGC assets are projected stochastically, and the PBGC net position and insolvency year are shown as percentiles • Post-processing summarizes the simulation model output into a format that is useful for the Projection Report and processes this output to show aggregate impact on the PBGC Although the post-processing tool offers a comprehensive view of the model outputs, it provides limited transparency in the calculation process, making it challenging to review the outputs thoroughly without clear instructions on how to navigate the workbook. Frequent clean-up or review of the post-processing tool is recommended to ensure that it is more user friendly. An observation has been identified in this regard [R06] **Assessment of the governance and controls** The review and challenge process to approve post-processing is found to be appropriate given that the post-processing tool is completely automated. PRAD team holds frequent meetings to discuss if charts and tables generated reflects the expected patterns over the projection period. Projection crosswalks are also conducted to show how projections change by changing input/assumptions step by step in sequential order. In addition, periodic peer review is also conducted by independent third parties on selected simulation procedures

3 Assessment of operations

The assessment of operations for the Multiemployer (ME) PIMS model is conducted along the model use and implementation dimensions as detailed in Section 1.3.

3.1 Assessment of operations: use

ME-PIMS serves as a primary tool used by PRAD employees and relevant PBGC contractors for various purposes, including the creation of several published reports and internal analyses. On notable outcome, the annual PBGC Projection Report provides an actuarial evaluation of PBGC's anticipated future expected operations and financial status. The ME-PIMS model is instrumental in projecting PBGC's long-term financial outcomes, thereby aiding the organization's strategic planning endeavors. By projecting PBGC's financial position, the model not only informs PBGC's future planning efforts but also enhances stakeholders' comprehension of the range of financial risks faced by PBGC. Given the primary objective of the ME-PIMS model is to forecast the range of Multiemployer claims for PBGC over forthcoming periods, aligning model utilization to produce an actuarial evaluation of PBGC' future financial position standing aligns appropriately with the scope and approved uses of the ME-PIMS model.

Several model users and stakeholders are involved in the process to produce an actuarial evaluation of PBGC's future financial position using the ME-PIMS model. An inventory of current/former users/stakeholder, roles of users/stakeholders, and their responsibilities regarding the use of the model is included below:

Type of users/stakeholder	Uses of the ME-PIMS model
Model developer 1	• Support data contractors update plan data from Form 5500 and perform reviews their work for ME • Review ME runs, outputs, and post-processing files
Model reviewer 1	• Review and challenge the model outcomes by participating in PRAD weekly meetings and discussing model results for reasonability • Work on specific legislative impacts on the model and incorporating legislation into the model as applicable
Model developer and economist 1	• Set and update economic assumptions and generate economic scenarios
Model developer 2	• Handle the communication with contracts regarding ME coding changes, ensure that the modification makes sense and proper documentation of the model changes is in place • Run ME model, sub models and post-processing models to test all changes made to the ME model and compare model results prior and after the change to see if the directional impacts make sense • Receive ME plan data and feed the data into the ME model

Model owner and reviewer 2	• Oversee the PIMS modeling process by reviewing results, directing assumption setting, and sign reports and help establish project plans and timelines of the overall Projection Report process
Model reviewer 3	• Review model assumptions and results in a group meeting format to assess reasonability of outputs
Model reviewer 4	• Review ME model outputs in PRAD meetings • Review model changes, outputs, and post-processing files
Model reviewer 5	• Review the model outcomes on the high level and use crosswalk to check for tracking unexpected trend or numbers • Develop the assumptions for ME models and review assumptions with the PRAD team
Model developers 3 as contractors	• Maintain and update ME models based on requirements and instructions provided by PRAD • Review and validate model results after model changes and document the mode changes
Model reviewer 6	• Review the model results at the high level and use crosswalk to check if the results are appropriate • Help develop the assumptions for ME models
Former model developer 1	• Handled post-processing of the PIMS model outside of the core model and check if the results are expected • Maintained and updated PIMS model to add new functionality to the model • Improved ME modeling tools in Excel
Model owner 2	• Review PIMS model results and set assumptions and methodologies of the PIMS models • Sign off the Projection Report
Key stakeholders from Department of Labor and Employee Benefit Security Administration	• Use PIMS model reports as supporting materials for policy analysis (e.g., SFA for ME plans) • Approve the investment policies for PBGC based on PIMS model outputs provided
Key stakeholders from Congressional Budget Office and Joint Committee on Taxation	• Use PIMS model reports as supporting materials to estimate the impact of new legislation proposals • Use PIMS model outputs to evaluate effect of potential new tax policies
Key stakeholders from Department of Treasury	• Use PIMS model reports as supporting materials for policy analysis • Use PIMS model reports as supporting materials to review impact of new legislation and regulation (e.g., SFA for ME plans)
Key stakeholders from PBGC	• Approve the projection report • Review investment policy provided in the annual projection report

	• Review the impact of potential policy changes
Key stakeholders from PBGC	• Review the projection report • Use Technical assistance on requests regarding the model outputs

The ME-PIMS model is currently being used appropriately as each model user has specific responsibilities regarding the model and the assignment of responsibilities is clear. However, there is a lack of formally established roles and responsibilities at each phase of model development. The adoption of a roles and responsibilities matrix at each stage of model development is a common practice in the industry [R07]. Presented below is an industry-standard roles and responsibilities matrix.

Category	Model owner	Model developer	Model implementer	Model user
Model design & development	• Ensure the design and development of model occurs in line with the policy	• Provide leadership for model development activities comprising methodology, design, and prototyping	• Use the input provided from leadership	• Provide business specifications to leadership
Model implementation	• Ensure the implementation of the model occurs in line with the policy	• Provide input to model implementer	• Develop the implementation plan and ensure correct implementation	• N/A
Model monitoring & use	• Explain to model users and model output users assumptions and limitations of the model • Collect ongoing monitoring results	• Propose ongoing monitoring plan	• Discuss proactively environmental changes with stakeholders	• Use the model and communicate issues to leadership • Provide ongoing monitoring data

	and submit to leadership			
Periodic peer review	• Ensure that the model fits its purpose • Ensure the model change is appropriate for its intended use • Ensure the model change is communicated to business leadership	• Provide the monitoring report to submit for periodic review • Provide updated model change documentation if applicable	• Provide implementation tests and controls to submit for periodic review • Provide implementation tests due to model change	• Use the model and confirms its fir for purpose • Perform the user acceptance test once model change is implemented
Monitoring of remediation	• Ensure the remediation actions are implemented within timelines	• Provide input to model implementer	• Implement the remediation action if applicable	• Understand the limitations of the model for its use
Compensating controls decisions	• Ensure the mitigation actions/compensating controls are in place for the model	• Implement the compensating controls	• N/A	• Understand the mitigation actions/compensating controls for its use
Regulatory responses	• Responsible for all regulatory requests	• Provide input for preparing the regulatory response if applicable	• Provide input for preparing the regulatory response if applicable	• N/A
Risk management	• Understand the model risk related of the model	• Understand the model risk related to the model they develop	• Understand the model risk related to the model they implement	• Understand the model risk related to the model they use

Further, the scope of work for third-party contractors is clearly defined and the review process to examine their work is reasonable.

Assessment of existing process to generate results

The process to produce model results for the forthcoming year commences after the release of the previous Projections Report. PRAD collaborates with its contractor to establish a list of desired model enhancements for the ME-PIMS models. PRAD monitors the existing issues or desired refinements within the model, taking into account the feedback from PRAD's debriefing on the most recent Projections Report. The contractor team implements model changes, while the PRAD team performs the user acceptance testing.

The existing outputs of the ME-PIMS include PBGC's net financial position, investment income, and net new claims, as well as percentile ranges. The current procedures to generate the model outputs are described below:

- PRAD obtains the PIMS run model, which provides specified data produced by PIMS.
- PRAD then obtains the scenario template and corresponding run output files for each model run. The output log files indicate unique identifiers of the run, such as the report run date, time, by which user, the run name, run identification number, the number of scenarios used in the run, the file to which the results were extracted to track down the source of the data, and the various input tables used within the PIMS run.
- The PIMS Run Report can be obtained and extracted from the Microsoft Excel tool that PRAD staff uses to analyze multiemployer PIMS output data. Documentation is in place describing the data that could be extracted for the Projections Report.

The current process to produce model results is appropriate given that there is clearly defined ownership for each step of the process and establish review process to review the reasonableness of the results. Specifically, the third-party contractor is responsible for drafting a list of desired model enhancements at the beginning of the process and making model changes accordingly based on decisions made by PBGC. There is a primary owner in PRAD of the ME-PIMS model responsible for reviewing the parameters that feed into the runs and running the models. While the output generation process is appropriate, there are potential areas of improvement as described below:

- **Governance around fine-tuning of model parameters**: Fine-tuning model parameters is an important step in producing accurate model outputs. While there is existing process in plan to review and update the parameters each year, PBGC could create a documentation that specifies what parameters have been reviewed and updated in the recent past and what parameters are planned to be reviewed in the near future [R08]

The ME-PIMS generates aggregate output files, which are used to produce a series of charts and tables used in the Projection Report. The current process to produce the relevant charts and tables is to use Excel spreadsheet to import the raw model output, make necessary calculations to arrive at the required results, and summarize the calculated results in chart or table format.

Assessment of the existing controls

Several controls are in place around the ME-PIMS model that mitigate the risk in the operational environment.

- **Security control related to model access:**
    - Access to ME-PIMS is controlled through the SharePoint folders where the ME-PIMS is housed. As there are many versions of the spreadsheets, there is generally less risk of potential unauthorized access to the ME model.
- **Change management process and controls:**
    - The ME-PIMS programming staff is responsible for preparing a software change request and requesting changes to PIMS. Changes to programming code will be made in the spreadsheet environment. After completion, a PRAD staff member will review the changes to ensure the changes are implemented appropriately and to assess whether any other changes were made to the existing version.
    - If additional work is necessary, PRAD will inform the PIMS programming contractor. Each item raised by the PRAD staff member is resolved or otherwise addressed to the satisfaction of the PRAD staff member and appropriately documented.
- Process to log model results:
    - Different versions of the model results are organized on SharePoint site and are reviewed internally. Each folder is named appropriately to reflect the purpose of the model run (e.g., used for internal purposes or official release of the report, or sequential changes of the model across crosswalk). The files are also labeled appropriately to reflect version controls.
    - Any numbers from these excel files that are used in the Projections Report are subject to a detailed transcription process that traces every number to its root source and is reviewed by PBGC's contractor and an actuary from a different PBGC department.
- Process to track open model related issues:
    - A running list of potential model improvements is maintained for the ME-PIMS model and is discussed with the model owners and contractors. Each year after the Projections Report is issued, PRAD reviews this list and prioritizes the model enhancements. This is performed based on the assessed materiality of the potential changes.

The current controls in place to ensure the operational stability of the ME-PIMS model is appropriate with potential scope of improvements:

- **Establish a formalized model attestation process for use**: to ensure the ME-PIMS model is appropriately used by users, it is ideal to implement a formalized model attestation process for each use. This process can be continuously updated and maintained to ensure the model uses are appropriate and up to date. This establishes transparency and accountability in the model usage [R09]

- **Create formal documentation to track open model related issues**: while there is a running list of known issues for the ME-PIMS model, it is important to establish a continuous tracking mechanism. This involves documenting closed issues and creating a mitigation plan for open issues [R09]

3.2 Assessment of operations: implementation

Assessment of model replication and implementation

Replicating the ME-PIMS model is important for testing its accuracy and reliability and identifying errors and inconsistencies in implementation. Currently, the ME model is implemented in Excel VBA, which is the main model used to generate financial projections of the Multiemployer plan. In parallel, there is an independent Excel spreadsheet model that is mainly used for Technical Assistance, mostly because it is much easier to update under tight time frames. The Excel model is also used as a tool to check the VBA model by replicating the model results.

Further, to ensure the implementation of ME-PIMS does not contain errors, both inputs and outputs are reviewed and documented. ME-PIMS inputs are saved in spreadsheets that are prepared in a similar fashion from year to year and saved on SharePoint. Any inputs that were changed from the prior year's version of PIMS are checked/reviewed and documented on SharePoint. To facilitate a review of changed parameters, a "diff tool" such as Beyond Compare or Exam Pro Diff is used to compare ME-PIMS files. Due to file size considerations, the comparison may be performed after removing larger input tables and saved in shared location. PRAD internal review of ME-PIMS input data includes economy data, regulatory inputs, and plan data. The review typically includes the following:

- Verify correct/properly estimated historic data is entered into the ME-PIMS input data fields
- Verify correct updates were entered into the database tables
- Verify modeled values for stochastic projection were correctly entered
- Regulatory changes are programmed directly into Excel. ME-PIMS is updated and version control is maintained
- Validate cash flow calibration of all plans

The ME-PIMS outputs are reviewed to ensure reasonableness. The review typically includes the following:

- The growth of liabilities over the projection period, and its distribution over the plans in the sample.
- Distributions of actual contributions among plans and across years in the projection.
- Distributions of funding levels and of actuarial charges and credits.
- The projection of plan insolvencies
- The change in outcomes related to the solvency of the Multiemployer Program
- Examination of plans with results showing strong deviation from average patterns ("outliers") to justify unusual results for specific plans where appropriate. Exceptions are noted, and corrections made, where appropriate.

The current implementation of the ME-PIMS model is appropriate given that there are clearly defined review procedures in place to ensure the accuracy of the data input process and the reasonableness of the outputs generated.

Given the complexity of implementation, it is important to establish a systematic training process that includes industry-standard training approaches. This involves conducting in-person training sessions, with a proper trainer-to-trainee ratio, to allow for thorough coaching and the practice of new procedures. The training materials could also reflect the size and expertise of the team that uses each model. It is also important to identify stakeholders and users who need to be trained, develop tailored training content with effectiveness checks and deliver training to all applicable individuals [R10].

Assessment of implementation platform

Currently, the modeling of the projected financial cashflows for the Multiemployer program is done in an VBA-based model that is easier to update compared to the Legacy ME-PIMS model. The ME recoded model handles processing the variable inputs, calculating plan-level asset and liability calculations, and generating a series of model outputs that are used for producing the Projection Report. The ME is a cashflow model and focuses on projecting plan insolvency as it is the triggering event of claims for the ME program. The existing platform in which the ME-PIMS is implemented is appropriate given it has the necessary functions to perform the required calculation and the capability to produce proper model results in a flexible and timely manner.

- There are three components to the ME model, including pre-processing, simulation model, and post processing, with the output from each component providing the input for the next. Each of these components is accomplished with its own spreadsheet(s). This components approach provides the flexibility to maintain and update the model. It also enables better collaboration among model developers, as they can work on different components simultaneously.
- The calculations in the ME model are designed to be modular. For example, since plan headcounts are needed to calculate premiums as well as contributions, it makes sense to calculate the headcounts once in a separate module and then have the other modules reference those headcounts separately. This, the ME model is itself a collection of sub-models. The modular design of the ME model allows for better scalability and flexibility, as new components can be added or removed without affecting the entire model.

4 Assessment of functionality and performance

The assessment of model functionality and performance for the Multiemployer (ME) PIMS model is conducted to examine whether the ME-PIMS model is functioning consistently with its design and documentation as well as how modeled results compared to actual outcomes. Specifically, the effectiveness of the economic scenario generating process, stress testing, sensitivity analysis, and back testing is examined to assess the suitability of the modeling approach and appropriateness of judgmental aspects of the model.

4.1 Economic scenario generator

ME-PIMS model uses stochastic based simulation to project long-term financial outcomes of the Multiemployer pension plans PBGC insures. The model then introduces random year-by-year changes to simulate economic fluctuations, producing 500 simulations for alternate economic paths through time. In this section, the assessment of the effectiveness of the current economic scenario generator (ESG) at capturing the full range of potential outcomes, including any recommended improvements and industry best practices is included.

The existing ESG uses a core model with two variables being fully stochastically generated: the yield on 30-year Treasury bonds and the return on the S&P 500 stock index. The Treasury bond yield is critical to ME-PIMS as it provides the foundations for the Treasury returns, cash rate and returns, and the discount rate for pension plan liability calculation. The return on the S&P 500 stock index also directly affects the projected pension plan returns and market value. All other economic variables that are projected (e.g., inflation, plan investment returns, corporate bond yields, PBGC's discount rate, etc.) are derived from those two core variables.

The Treasury bond yield follows a random walk:

$$ln(y_t) = ln(y_{t-1}) + \varepsilon_{y,t}$$

The disturbance term transitions the mean over time to a target expectation. Since the ESG chooses to model the logged 30-year Treasury yield, the possibility of negative yields is eliminated.

The equity return is modeled with the log of its spread over the Treasury yield equaling a fixed mean plus noise:

$$ln\left(1 + r_{s,t} - y_{t-1}\right) = s + \varepsilon_{s,t}$$

The risk-free rate is taken directly from the simulated Treasury yield while the equity excess return follows a lognormal distribution.

The core model parameters are estimated using an iterative process of running simulations using test values of core model parameters and the measuring the nominal return means, standard deviations and correlations from the simulation output. The test values are adjusted until the projection statistics match the study parameters. The values for the nominal stock return parameters were originally based on a study done for PBGC by Ibbotson Associates in 2008. The mean and standard deviation have since been slightly adjusted by PRAD using additional stock market historic data. The nominal return parameters for FY19 PIMS are:

- Mean return on stocks: 7.9%
- Stock return standard deviation: 19.8%
- Correlation between stock and treasury bond returns: 0.209

Treasury yield	Year 1	Year 5	Year 10	Year 20
25th quartile	3.18%	2.53%	2.24%	1.90%
50th quartile	3.49%	3.08%	3.03%	2.92%
75th quartile	3.86%	3.84%	4.17%	4.66%

Equity return	Year 1	Year 5	Year 10	Year 20
25th quartile	-2.55%	-4.60%	-4.29%	-6.01%
50th quartile	8.49%	7.52%	7.60%	6.10%
75th quartile	24.05%	19.61%	20.63%	20.43%

Source: 500 scenarios generated from PIMS ESG

Assessment and recommendations

It is generally expected that minimum requirements of an ESG would include the production of simulation results that reflect a relevant view of the economy and certain financial variables, the inclusion of some extreme but plausible results, and the generation of scenarios embed realistic market dynamics. The current ESG used by ME-PIMS has a sound foundation for the way the models are built and the way the variables are interrelated but potential areas for refinement are also found.

Core model approach

The core model approach provides a sound foundation to capture the economic variables of greatest importance to the risk profile of PBGC. The stochastically generated core variables with a series of derived variables are not uncommon approach to model ESG in the industry. While the core variables selected are able to capture the key risks in the capital markets, additional factors such as GDP, employment rate, and etc., can be considered to build a comprehensive view of the macroeconomy [R09]. In addition, industry segmented variables can also be considered in the ESG to reflect how different industries will be impacted differently under the same economy scenario [R11]. The ESG should be comprehensive to include the key risks to capture segment risk factors.

The ESG has clearly defined parameters and a well-articulated calibration process and. While the process for developing the stochastic variables is clear and the parameters are well defined and logical, the following potential areas for refinement can be considered to enhance the ESG functionality as the new ESG being developed in the T-PIMS model:

- **Incorporate negative treasury yield**: the current approach to model treasury yield eliminates the possibility of rates going below zero. While it is less likely to happen, Japan and European countries have experienced negative bond yields in the past. Since treasury bond exposure accounts for a significant portion of the plan and PBGC assets, PBGC could consider allowing possible negative Treasury yields in the ESG. [R11]

- **Simulate equity return independently**: the current approach to model equity return is using risk premium as excess returns over treasury yield. This process of stochastically projecting equity excess return based on the risk premium on top of the interest rates limits the model's ability to capture varying relationships throughout the economic cycle. Independently simulating the equity return instead of modeling a risk premium would better capture the randomness of equity market. The correlation between treasury bond and equity return would be captured by the correlation factor [R11]

- **Calibrate correlation between treasury bond yield and equity return:** the current correlation between stock and Treasury bond returns is weakly positive (0.209). While it is possible to experience a positive correlation between stock and treasury bond returns in left-tailed events, these two variables are generally observed to have negative correlation in normal market conditions. PBGC could consider recalibrating the correlation between treasury bond yield and equity return with the latest data to ensure the correlation factor reflect market observations [R11]

- **Assume dynamic correlation between stock and treasury bond returns:** the current correlation between stock and Treasury bond returns is using a fixed parameter of 0.209. PBGC could consider applying dynamic correlation between stock and treasury bond returns to mimic how correlation changes under different economic scenarios [R11]. Sample approaches may include:

    - **Jump-diffusion approach**: this approach implicitly captures dynamic correlation. Such approaches, at each time step, combine an initial Monte Carlo simulation step (diffusion) using the long-term historical correlation value followed by random shock events (jumps) to the simulated variables (i.e., yield and equity risk premium). Shock event frequency and magnitudes can be determined based on observed historical shock events.

    - **Regime-switching approach**: this approach switches between different explicit correlation values depending on the state of economy (e.g., expansion vs recession).

- **Consider stochastic modeling of spread of corporate rate over Treasury yield:** the current approach to model long-term corporate rate is the Treasury yield plus 110 basis points. If the starting point of the yield has spread different than 110 basis points, the initial spread is assumed to revert to mean. The flat spread may not be able to capture the actual movement of corporate bond in the real world. Since corporate bond exposure accounts for a significant portion of the plan assets, it is critical to reflect the impact of corporate bond in valuation of liabilities and funded status [R11]

- **Consider more frequent parameter calibration:** the values for the nominal stock return parameters were originally based on a study done in 2008 and they only capture the period from 1973 to 2007. While the process for modeling equity returns is logical, a best practice would be periodically tested to ensure the parameters remain consistent with the evolving nature of the markets. Common industry practice is to calibrate the parameters once a year [R11]

4.2 Sensitivity analysis

Sensitivity analysis helps examine how changes in key assumptions affect the ME model results and inform PBGC to take appropriate measures to mitigate associated risks. Sensitivity analysis involves applying shocks to specific variables and analyzing the impact of changes on the asset and liability projections.

Currently, PRAD perform and publicly disclose one sensitivity analysis for the ME program every year.

- Changes to the discount rate: only the discount rate for calculating PBGC liability values is changed; no other related variables, such as inflation or asset returns, are changed in the sensitivity calculations. The increase and decrease of 50 basis points are applied to the discount rate, and the net financial positions post shocks are compared to that in the baseline scenario to understand the impact of the changes in discount rate.

In addition to the sensitivity analysis currently disclosed by PBGC, other sensitivity analyses observed in the industry would further enhance the analytics of the ME model include the following:

- **Wider range of changes in discount rate**: The +/- 50 basis point sensitivity is helpful in that it shows what the impact is for a defined change in the interest rate used for valuing PBGC's liabilities without changing other variables (e.g., the segment rates used to calculate plans' funding targets are not affected). However, rapidly raising interest rates in the past few years have demonstrated a more volatile rate movement pattern, e.g., the starting discount rate for PBGC liability moved from 0.44% in 2021 to 5.12% in 2022. PBGC could consider performing +/-100bps and +/- 200bps to observe the marginal impact of cumulative interest rate movements .
- **Mortality improvement**: longevity risk is a key risk in defined benefit pension programs. Therefore, it is recommended PBGC perform sensitivity analysis around mortality improvement .
- **Additional sensitivity for key assumptions** including but not limited to:
    - Withdrawal Liability (WDL) and Mass Withdrawal assumptions: perform +/_ x% of change in WDL and Mass Withdrawal assumptions to assess their impact to the ME program's financial position
- **Test dynamic WDL and Mass Withdrawal assumptions for scenario analysis:** WDL and Mass Withdrawal assumptions are not explicitly dynamic assumption along scenario path for the stochastic analysis. Under the current approach, these assumptions would change based on funding and solvency of the ME plans and reflect a secondary effect of the economic scenarios. It is recommended PBGC develop and test dynamic assumptions to reflect pension sponsor and participants withdrawal behavior along different scenario paths..

PBGC may consider expanding its sensitivity analysis to continue enhancing the model functionality of the ME PIMS model [R12].

4.3 Stress testing

There is currently no stress scenario for the ME-PIMS model. While there is already a range of negative outcomes where the program runs out of money, it is informative to consider extreme events that may pose risks to the financial health of the multiemployer program.

For narrated stress scenario analysis, examples of stress scenarios utilized in the industry that would further enhance the analytics of the ME model include the following:

- Interest rate risk plays a significant role as it can have significant implications for the funding plan with fluctuation in interest rates. Therefore, a range of interest rate changes can be implemented in stressed scenarios instead of a single shock.
- Liquidity crunch: a situation where there is a sudden systemic shortfall in liquidity, similar to 2008 financial crisis. This may cause a large number of pension sponsors failure to fulfill pension obligations and PBGC premiums thus resulting in an increase in insolvency.
- Pandemic: a global outbreak of a disease, such as the COVID-19 pandemic, affects a large number of people across multiple countries or continents, and causes increase of mortality rate, extreme volatility of capital market, rising inflation, and unexpected economic shifts. The ME program may be disproportionally impacted by the potential mortality uprise under the pandemic scenario.

Besides narrated stress scenarios, the leading practice employs advanced reverse scenario stress testing approach. This approach involves generating a large number of scenarios (e.g., 10,000) with built-in shocks that covers a wide range of possible adverse scenarios. Run the model through the scenarios and examine the resulting net positions. Short-list the tail scenario to develop scenario narrative to analyze potential risk factors and management risk remediation actions. This reverse stress scenario analysis will help identify the “unknown unknown” and better prepare PGBC for unforeseen risks.

PBGC could consider a variety of stressed scenarios to stress test the model by running different shocks to key risk factors to evaluate how the Multiemployer Program would respond to a variety of adverse events [R13]. PGBC could also review key assumptions, e.g., Withdrawal Liability (WDL) and Mass Withdrawal assumptions, under each stress scenario and adjust those assumptions according to the specific scenarios in the model projection.

4.4 Back testing

Back testing is important because it would help assess the accuracy of the ME-PIMS models, identify model weaknesses, and evaluate the effectiveness of risk management strategies.

Currently, there lacks a defined formal process for conducting back testing of the ME-PIMS. Although PRAD has previously considered implementing back testing in past years, they have encountered challenges, partly due to evolving regulations that made comparing past projections to the current net position challenging. Additionally, modifications to the model over time can pose obstacles when attempting to run data from previous years with updated code reflecting legislative changes. The absence of formal back testing procedures may impede PRAD’s capacity to comprehensively assess the risks within the ME-PIMS model.

Back testing allows for a comparison of the ME-PIMS model’s performance against historical or comparable data sets. Three types of back testing are commonly observed in the industry for statistical and risk models:

- In time, in sample back testing: this is a comparison of the actual historical results there were used during the period the model is calculated to the predicted model outputs
- In-time, out-of-sample back testing: this is a sample created setting aside, for use in back-testing, data observations from the same time period as the modeled sample.
- Out-of-time back testing: this is a sample created using observations from different time period than the in-time data (e.g., the in-time data could be from 2007 to 2015 and the out-of-time data would come from either before or after that range).

Since ME PIMS is an actuarial model, the "in time, in sample" back testing methodology is deemed most suitable for PBGC, as the other approaches are more commonly utilized for statistical or advanced analytical models. "In time, in sample" method involves comparing historical results during the period the model is calculated to the predicted outputs. However, given the complexity of the ME PIMS model and frequent legislative changes, additional considerations may be necessary to implement back testing for the ME-PIMS model [R14].

- **Implement a component based back testing approach**: one approach is to adopt a component-based back testing approach, which involves conducting separate back testing on key components of the model, such as key assumptions, asset projections, liability projections. This would enable PBGC to assess the functionality of model components and identify any potential weakness.
    - Key assumptions: Back testing could focus on key assumptions of the ME PIMS model, including the following:
        - Plan contributions: compare the projected plan contributions to the actual contributions during the modeled period
        - Mortality assumption: compare the projected mortality with the actual mortality happened during the modeled period
    - Cashflows projections/model outputs: besides the key assumptions, potential external factors can also be examined during back testing
- **Implement a macro-overlay to incorporate changes in external factors**: When performing back testing for cash flow projection and model output, PBGC might employ a standard approach (e.g., comparing actual to model projected outputs), and subsequently overlay macro-level adjustments to reflect recent or anticipated external changes.
        - Changes in plan population: changes in plan population pose a challenge as plan information is refreshed annually and would not be included in past models, resulting fluctuations that are challenging to integrate into the standard back testing process. A potential solution could involve utilizing a macro-overlay to account for the impact of changes in plan populations

        - Changes in capital market: fluctuations in the capital market, including shifts in discount rates and actual equity returns, could be captured using a macro-overlay informed by pertinent sensitivity analyses
        - Pension policy changes: Analyzing the impact of policy changes would necessitate further qualitative analysis by experts to comprehend how these changes would affect the model outputs

For each test, it is important to define and justify:

- The performance metrics being used to evaluate the model's performance. Examples include the following:
    - The net financial position
    - Liability/asset projections on the aggregate levels as well as selected key plans (e.g., the largest plans, select samples from different funding levels)
- The threshold of acceptable error for each test, which could consider past performance, the methodology, and the output being modeled. Once the test passes the threshold of acceptable error, further analysis can be considered to examine the cause of the additional difference
- Whether the result of the test highlights a limitation in the model, and if so, how that limitation will be mitigated

5 Assessment of documentation

The assessment of model documentation for the Multiemployer (ME) PIMS model aims to examine whether the model documentation is comprehensive, readable and consistent, while also assessing the adequacy of the existing governance around model documentation.

5.1 Assessment of model documentation

As a key component of the model lifecycle, documentation should be maintained throughout the process, covering model context, input, methodology, outputs and implementations. Documentation for the ME PIMS model is available for most of the model life cycle. The assessment below will be conducted on the existing documentation for the ME PIMS model.

ME FY22 Model: system description document offers an extensive outline of the ME PIMS model. It elaborates on the intricacies of the ME PIMS model, including its inputs and outputs, structural framework, step-by-step instructions to run and use the model, and the post-processing procedures. The document is organized into three distinct sections.

- Section 1: Details the pre-processing stage, where the model generates plan-level aggregate cashflow streams corresponding to accruals as of MB year to be loaded into the Simulation Model. Since the ME PIMS model does not have participant-level census data, pre-processing becomes essential to produce plan-level cashflows. This involves utilizing a single large plan to represent the underlying pattern and then adjusting age, service, and accrual rates to better match plan-specific Current Liability (CL) and benefit payment information
- Section 2: Introduces the Simulation model, a single spreadsheet that takes the cashflows from pre-processing and then generates plan- and scenario-level output that is then summarized in post-processing. Thus, the simulation model contains the vast majority of the business logic used to produce the numbers for the Projections Report. This section explains the following:
    - System architecture (how Excel and VBA calculations work together)
    - Procedures for running the model
    - calculations for a given plan/scenario (both the overall design of the model as well as the details)
    - Inputs in addition to the pre-processing cashflows (data/assumptions)
    - outputs generated are summarized by post-processing
- Section 3: Outlines the post-processing spreadsheet that summarizes the simulation model output into a format that is useful for the Projections Report. The simulation model produces stochastic output that provides information on the impact that individual plans are projected to have on the PBGC. The post-processing spreadsheet processes this output to show the aggregate impact on the PBGC

A supplementary memorandum, serving as additional functional documentation alongside the ME PIMS system description document, is the *ME PIMS 2020 Methods and Assumptions Backup Final 2023*. This document describes a number of interrelated methods and assumptions in ME-PIMS that, which collectively serve as the primary determinants of the projected cash inflows from contributing employers and former contributing employers. These include:

- Projection of ongoing employer contributions and regular withdrawal liability ("WDL") payments
- Assumptions regarding mass withdrawal
- The amount and timing of WDL payments, especially under mass withdrawal.

The purpose of this memorandum is to provide a detailed description of the revised methods and assumptions adopted for the FY 2020 Projections Report. Additionally, it incorporates new assumptions and changes in assumptions related to the American Rescue Plan Act ("ARP"). Finally, at the end of this memo, there is a discussion of changes in assumptions related to benefit suspensions/partitions.

Another key document for the ME-PIMS model is *Quality Assurance Procedures for Formal PRAD Reports utilizing the PIMS*, a manual outlining policies and procedures for generating specific reports that rely on the use of the PIMS model. Additionally, it provides step-by-step instructions to run, use, monitor, and troubleshoot the ME PIMS model in a safe manner. This manual comprises eight distinct sections.

- Section 1: presents an overview of the PIMS manual, including the policy around PIMS model, the authority governing the release of PIMS reports, and roles and responsibilities for the PIMS model
- Section 2: explains the ongoing oversight and monitoring of the PIMS model
- Section 3-6: describes the procedures for reviewing PIMS inputs, outputs, Projection Report, and other uses of PIMS
- Section 7: introduces the information technology considerations regarding the PIMS model such as access to PIMS, changes made to programming code, etc.
- Section 8: explains the record retention considerations of the PIMS model

In summary, the current documentation of the ME-PIMS model is reasonable to be used as a model functional guide, yet there are opportunities for enhancement to provide a more holistic understanding. Currently, it offers insights into the model's construction, key assumptions, and utilized variables during the development process. While it covers crucial aspects such as the model purpose, approaches, and limitations, it lacks the details on the model development process and key model methodologies. This gap impedes the audience's comprehension of the underlying connections guiding the model calculation. Despite this, the documentation achieves clarity using diagrams and numerical examples to simplify the technical aspects of the ME PIMS model. Furthermore, consistency in formatting is also maintained across various sections. Below are areas identified for potential improvement [R15]:

- **Providing a clear explanation of the model methodology**: While the current *ME FY22 Model: system description* incorporates some explanations of the model methodology through its sections, the interconnections driving the model calculation are not readily apparent. Given that there is a parallel excel model to the main ME VBA model, it inherently provides a lot of transparency of the model calculations and dependencies. However, incorporating a dedicated section specifically addressing the model methodology would enhance comprehension for the audience, enabling them to grasp the operational intricacies of the model more effectively

- **Incorporating the rationale behind methodological choices**: Currently, the documentation lacks presentation of the rationale behind the choices of model methodology and key assumptions. It is crucial to document the supporting evidence and reasoning behind these model elements, as it helps the audience comprehending the logic behind the model calculation

- **Establishing a repository of model assumptions**: While the documentation outlines some key assumptions, it falls short of providing a comprehensive summary of all assumptions utilized in the model. A consolidated bank of assumptions helps model users in reviewing and validating their accuracy, thereby ensuring the model's adequacy

- **Clearly articulating all model limitations**: Although the existing model documentation lists certain model limitations, not all are addressed. Clearly stating all limitations of the model documentation is suggested to keep users informed about potential constraints affecting the model results

- **Regularly updating information:** Certain information presented in the document either requires revision by PRAD or necessitates updating. Frequent updates to the model documentation are suggested to ensure the accuracy of the information presented

The PIMS webpage serves as a key resource of information regarding the ME PIMS model, offering the following key resources:

- Archives of past PIMS reports: This includes Projection Reports, Five-Year Report, MPRA reports, and similar documents

- Information about PIMS: The webpage features published documentation pertaining to PIMS models, such as assumption memos, sensitivity tests, and the historical evolution of PIMS model

- PIMS peer review history: It presents a table documenting the final reports from previous PIMS peer reviews, as required by the MAP-21. These reviews are conducted by capable agencies or organizations that are independent of PBGC

- Publications: The webpage showcases past publications relevant to PIMS models or the broader pension industry

The existing PIMS webpage serves as a valuable supplementary documentation source for the PIMS models, offering a range of past PIMS reports and additional insights, such as assumption memos. The webpage effectively

communicates information about the PIMS model using clear language and maintaining a consistent format. Furthermore, the information presented on the webpage is transparent and easily navigable.

5.2 Assessment of governance on model documentation

For ensuring the ongoing validity of model documentation, robust governance procedures are necessary, particularly to adapt to evolving changes of the PIMS models. Key governance procedures on model documentation observed in the ME PIMS model include:

- Management process: Clear procedures for updating the documentation, approval processes, and communication protocols are crucial. In the case of the PIMS model, the PRAD director holds overall accountability for documenting system changes of PIMS. He/she ensures thorough preparation of any alterations of the PIMS documentation and oversees proper review of updated documents
- Version controls procedures: Adequate archiving and retention controls are essential to record and preserve all documentation versions. The PRAD record coordinator maintains a library of all supporting documentation, including archived versions
- Continuous enhancement: Given annual changes to the PIMS models, ongoing enhancement of documentation is vital to reflect the latest information utilized in the model. Documentation of PIMS projects displays alterations to the model, encompassing coding modifications, new parameters, data structure adjustments, and reviews of these changes. Project documentation communications primarily occur through emails, which are appropriately archived, including attachments containing relevant forms, checklists, and narratives
- Regulatory compliance of MAP-21: Ensuring documentation meets regulatory requirements and standards pertinent to model usage is paramount. PRAD ensures that statutory reports issued to Congress are indefinitely maintained, and all supporting documentation linked to PIMS reports must be retained for at least seven years

Although there are established governance procedures for model documentation, it's equally crucial to ensure that supporting documents and resources effectively educate model users to prevent any potential misuse, misinterpretation, or misrepresentation [R16].

6 Assessment of the model governance

The assessment of the governance of the ME-PIMS model has been conducted within each section of the peer review. Provided below is a summarized table detailing the assessment for each component of the model along with its corresponding reference page in the report.

Section	Summary of the assessment	Page reference
Assessment of data: data preparation	**Observations:** • There is sufficient governance in place around the database given there is a series of automated tool for quality control purposes and a well-documented data dictionary is available for the PIMS models	• P18-19
Assessment of data: variable selection	**Observations:** • Sufficient data quality controls are in place for generating the variables given that the modeling process of economic scenarios uses an automated program in SAS, which runs the simulation of a series of economic variables and includes quality check procedures as part of the automated program	• P20-22
Assessment of methodology: assumptions	**Observations:** • The review and challenge process to approve the plan behavior assumptions and capital market assumption is found to be appropriate with scope for potential improvement. • Currently, there is no formal process defined where assumptions are reviewed, challenged, and updated as appropriate on a periodic basis. Potentially several of the ME plan behavior assumptions and capital market assumptions have not been updated in the recent past **Recommendations:** • Establish a systematic assumption review process to review the assumptions on a periodic basis and sufficiently document the review process that potentially includes materiality, sensitivity testing, and changes to assumptions used in the ME model	• P23-25
Assessment of methodology: simulation	**Observations:** • The review and challenge process to approve the ME-PIMS simulation process is found to be appropriate with scope for potential improvement • PRAD team holds frequent meetings to discuss if simulation results capture the underlying risk of the plans. When issues are found, a series of meetings will be conducted to understand the materiality of the issue by using professional judgment to identify appropriate solutions. In addition, periodic peer review is also conducted by independent third parties on selected simulation procedures **Recommendations:** • The manual review process of the ESG could be reassessed to understand if automated process might be more reasonable.	• P25-28

	However, given there will be a new in-house ESG in Python, limited reassessment might be needed for the current ESG	
Assessment of model operations and performance	**Observations:** • The ME-PIMS model is currently being used appropriately as each model user has specific responsibilities regarding the model and the assignment of responsibilities is clear. However, there is a lack of formally established roles and responsibilities at each phase of model development • The governance around model parameters update can be potentially enhanced as the changes to the parameters are not tracked and documented formally • PIMS models have multiple uses and multiple users of the model. A use attestation process is critical to ensure that the model is not used for unapproved/unlisted uses • PIMS model implementations are highly complex and the current training programs in place can potentially be improved. Further, given the materiality of the models, an end-to-end replication of critical components is important to ensure the accuracy of the implementation **Recommendations:** • The adoption of a roles and responsibilities matrix at each stage of model development is a common practice in the industry • Consider fine-tuning model parameter and systematic documentation to ensure the accuracy of the model outputs • Consider establish a formalized model attestation process for use and creating formal documentation to track open model related issues • Establishing a systematic training program on model implementation and a formal documentation on model implementation procedures	• P29-37
Assessment of model documentation	**Observations:** • Key governance procedures on model documentation have been observed in the ME PIMS model, including procedures on management changes, version controls, continuous enhancement, and regulatory compliance **Recommendations:** • Given the current absence of explicit governance regarding model limitation documentation, it becomes important to incorporate appropriate and comprehensive disclosures within the model deliverables to mitigate any instances of misuse, misinterpretation, or misrepresentation	• P48

Appendix

Priority	Definition
High	The magnitude of the observation deems immediate remediation since the remediation is expected to result in significant model improvement. The observation affects the inputs, design, methodology, outputs, or use of the model materially
Medium	The magnitude of the observation is moderate and deems a timely resolution. The remediation is expected to result in moderate model improvement as it affects the structure, design, inputs, or use of one or more components of the model
Low	The magnitude of the observation is low and does not require a timely resolution, but a remediation is recommended. The remediation of the observation is not expected to materially improve the model as it does not adversely affect the outcomes of the model